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CHEMICAL AND BIOLOGICAL SURVEY OF THE WATERS OF ILLINOIS

REPORT FOR YEAR ENDING
DECEMBER 31, 1908

EDWARD BARTOW
DIRECTOR

WATER SURVEY SERIES No. 7

URBANA, ILLINOIS

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LETTER OF TRANSMITTAL

STATE WATER SURVEY,
UNIVERSITY OF ILLINOIS,

URBANA, ILLINOIS, July 1, 1909.

Edmund Janes James, Ph. D., LL. D., President University of Illinois:

SIR: Herewith I submit a report of the work of the State Water Survey for the year ending December 31, 1908, and request that it be printed as a bulletin of the University of Illinois, State Water Survey Series No. 7.

The report includes a brief description of the work done during the year ending December 31, 1908, with a summary, by years, of analyses made since the foundation of the Survey and a summary; by months, of analyses made during the year. There is also included in the report an article describing the scientific work done at the laboratories of the State Water Survey in the investigation of methods of analysis. A description is given of difficulties experienced with incrustation in the discharge pipe at the filtration plant at Quincy, Illinois. Investigations of farm water supplies in several parts of the State are described. An article entitled "Hardness of Illinois Municipal Water Supplies" shows the character of the mineral matter contained in the various municipal water supplies. Our latest conclusions concerning the methods of "Interpretation of Results" are included and there is also a chapter giving data concerning municipal water supplies which has been collected since the publication of Bulletin No. 5.

Special thanks are due to the regular laboratory staff for their assistance in this work, to Mr. J. S. Rogers for the article on "Determination of Nitrates in Drinking Water," to Dr. A. W. Sellards for the article on "Current Methods of Sanitary Water Analysis," to Mr. W. R. Gelston, Superintendent Quincy Water Works, for the description of the methods of removing incrustation from the water main at Quincy, and to Miss Mabel Bush for the compilation of the data concerning municipal water supplies.

Respectfully submitted,

EDWARD BARTOW,

Director.

GENERAL STATEMENT FOR YEAR ENDING DECEMBER 31, 1908.

From the time of its foundation to December 31, 1908, the State Water Survey has received 18,689 samples of water. Of these, 9,605 were sent by private citizens or local health officers. The remaining samples, with the exception of 2,800, collected in connection with the investigation of the Chicago Drainage Canal, have been collected by members of the staff or under their direction for the study of special problems. During the last year, 1,769 samples were received, 1,682 having been sent to the laboratories by health officers or private citizens. This number greatly exceeds the number sent during any previous year. The time which it has been possible to spare from these routine analyses has been used for the study of special problems that could be handled in the laboratory.

Some changes have been made in the technique and in the methods of analysis during the year. A trap is now used in the determination of nitrogen as nitrates by the aluminium reduction method. This modification has been adopted as a result of the investigation by Mr. J. S. Rogers on the "Determination of Nitrates in Drinking Water." The method is fully described in a later chapter.

The determination of hardness by the soap test is made on part of the samples, especially when the water is to be used for a municipal water supply and the determination of the mineral content is not made. The test for indol has been included in the bacteriological tests as a partial confirmation of the presumptive test for colon bacillus.

The circular on "Interpretation of Results" has been modified by including an explanation of the hardness and indol tests and by the substitution of the term "Gas Formers" for "Colon Bacillus." The presumptive test for colon bacillus shows the presence or absence of bacteria which form a gas, and positive statements can be made concerning this class of bacteria. It seems, on the whole, as desirable to have water free from the bacteria which form gas as to have it free from the specific colon bacillus.

TABLE I, SHOWING THE NUMBER OF WATER SAMPLES EXAMINED AT THE DIRECT REQUEST OF PRIVATE CITIZENS OR LOCAL HEALTH OFFICERS, ARRANGED BY YEARS AND ACCORDING TO THE NATURE OF THE SOURCE.

SOURCES.	October, 1895, to Dec. 31, 1896	YEARS												Totals for each source
		1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	
Surface waters, rivers, lakes and ponds.	69	72	102	54	59	61	97	75	80	107	304	336	356	1,772
Springs	16	21	34	23	22	35	28	18	28	41	63	52	68	449
Cisterns	12	19	17	7	7	3	10	6	7	5	13	29	28	163
Natural ice	4	12	1	11	9	4	9	3	12	6	......	1	5	77
Artificial ice	......	1	......	2	1	......	1	1	1	......	4	......	......	11
Water for artificial ice . . .	3	......	......	3	......	1	1	......	5	2	1	......	1	17
Water for natural ice.....	......	2	......	......	......	3	1	1	2	......	6	......	......	15
Shallow wells in rock.....	28	16	8	22	12	22	10	17	25	25	19	45	32	281
Deep wells in rock.	58	48	34	26	36	56	59	23	28	66	170	159	258	821
Flowing wells in rock.....	45	8	16	12	13	14	3	8	9	11	22	17	43	221
Shallow wells in drift.....	500	245	168	243	274	209	243	245	270	292	442	514	683	4,328
Flowing wells in drift....	63	5	4	9	4	......	3	5	5	12	19	25	2	156
Deep wells in drift........	64	68	43	30	24	36	63	54	51	40	114	154	160	901
Sewage	37	......	21	25	10	......	1	7	2	6	5	33	46	193
Total samples from citizens	899	517	448	467	471	444	529	463	525	613	1,182	1,365	1,682	9,605
Other samples	888	811	988	1,579	1,866	778	147	419	555	466	445	55	87	9,084
Total for the year....	1,787	1,328	1,436	2,046	2,337	1,222	676	882	1,080	1,079	1,627	1,420	1,769	18,689

TABLE II. SHOWING THE NUMBER OF WATER SAMPLES EXAMINED BY REQUEST DURING THE YEAR ENDING DECEMBER 31, 1908, ARRANGED BY MONTHS AND ACCORDING TO THE NATURE OF THE SOURCE.

SOURCES	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Surface waters, rivers, lakes & ponds	40	13	38	29	28	27	25	26	37	17	40	36	356
Springs	6	1	3	3	6	7	10	7	4	7	6	8	68
Cisterns	3	0	3	1	0	4	10	7	0	0	6	0	28
Natural ice	0	4	0	0	0	0	1	0	0	0	0	0	5
Artificial ice	0	0	0	0	0	0	0	0	0	0	0	0	0
Water for artificial ice	0	0	0	1	0	0	0	0	0	0	0	0	1
Water for natural ice	0	0	0	0	0	0	0	0	0	0	0	0	0
Shallow wells in rock	5	4	0	3	2	0	0	0	7	5	5	1	32
Deep wells in rock	7	9	23	18	16	14	23	25	50	17	37	19	258
Flowing wells in rock	4	6	2	3	3	3	7	1	7	5	0	2	43
Shallow wells in drift	37	18	44	41	42	59	107	109	88	49	47	42	683
Flowing wells in drift	0	0	0	0	0	0	0	0	2	0	0	0	2
Deep wells in drift	2	3	3	3	9	20	13	26	28	22	18	13	160
Sewage	6	5	4	6	0	0	8	4	4	3	3	3	46
Total samples by request	110	63	120	108	106	134	204	201	227	125	160	124	1,682
Other samples	35	6	8	16	2	0	0	0	1	3	6	10	87
TOTAL FOR THE MONTH		145 69	128	124	108	134	204	201	228	128	166	134	1,769
Bacteriological asnlyses	105	50	103	89	92	125	183	187	195	112	142	123	1,506
Mineral analyses	33	8	23	25	9	1	3	4	6	7	10	11	140

For suggested limits of impurities of Lake Michigan water there has been substituted for the limit previously used an average of analyses of water taken from the lake 12½ miles from the mouth of the Chicago river. The analyses were made by analysts in the laboratories of the State Boards of Health of Wisconsin, Michigan and Indiana, the Department of Health of Chicago and of the State Water Survey.

We have followed the method of classification used in previous bulletins and show in Table I the number of waters examined at the request of private citizens or local health officers since the foundation of the Survey. The number of waters from shallow wells is the greatest. This no doubt is due to the fact that the individual supply is more frequently obtained from shallow wells and because such wells are more frequently polluted. Surface waters are next in number because of the frequent control necessary, on account of the variation of the character of a surface water with the seasons. During a dry season the suspended matter decreases, the soluble matter increases. While during a wet season there is a larger amount of matter in suspension and less matter in solution. Frequent control tests must be made to determine the amount of chemicals required and to determine the efficiency of the treatment.

In Table II a summary of analyses is given by months for the year 1908. The demand for analyses is much greater during the summer and autumn. The minimum number of samples were sent to the laboratory during February and the maximum during September. During the latter month the typhoid fever rate is usually highest.

A table has also been prepared showing the number of well waters concerning which an opinion has been given. It may be

CHARACTER OF THE WELL WATERS EXAMINED DURING 1908.

Depth	Under 25'	25'-50'	50-100'	Over 100'	Unknown	Total
Number examined	254	395	192	312	46	1,199
Number condemned	192	250	66	31	22	561
Per cent condemned	75+	63+	34+	9+	47+	46+

said that the relative purity of the water from these wells varies with the depth. 75 per cent of those less than 25 feet deep were condemned because of probable contamination, whereas only 9 per cent of those 100 feet or more in depth were condemned. We should note that some of these deep wells were condemned because of high mineral content and not because of any possibility of the presence of disease bearing organisms. We believe that this table does not give a true idea of the general condition of the well waters of the State, because the majority of the samples sent to the Water Survey are sent because of suspected contamination. It is to be hoped that a systematic study of the wells will show that a much larger percentage of the wells is above suspicion. The special investigation of farm water supplies in several portions of the State indicates that in five out of six sections visited the well waters used on the farms are in good condition.

The work done by the Water Survey has been distributed over practically the whole of the State. Since the Survey was organized samples have been sent to the Survey from 856 towns scattered through all of the 102 counties of the State. During the year 1908 samples were sent to the Survey from 340 towns in 88 counties.

THE CO-OPERATION WITH THE STATE BOARD OF HEALTH.

The co-operation with the State Board of Health was continued through the year. Water analyses for the State Board of Health have been made when requested. Reports summarizing the work done under this co-operative agreement have been published in the monthly bulletins of the State Board of Health.

ILLINOIS CO-OPERATION.

The data obtained during the investigation of the character of the water of the streams of Illinois, carried on under the co-operative agreement,* has been prepared for publication by Mr. W. D. Collins, Assistant Hydrographer of the U. S. Geological Survey. It is expected that this data will be printed as a Water Supply paper of the U. S. Geological Survey during the year 1909.

EXPERIMENTAL INVESTIGATIONS.

During the summer of 1908, Dr. A. W. Sellards carried on experiments with a view to the improvement of "Current Methods of

*University of Illinois Bulletin, Water Survey Series, No. 3, 1906, p. 19; No. 6, 1907, p. 17.

Sanitary Water Analysis." This work is a continuation of his "Chemical Examination of Water Bacteria."k The work suggested in the first article has been carried farther. Numerous analyses have been made in order to compare current methods and a new method. The results obtained have been very satisfactory and are suggestive of further work in the same line with a view to the adoption of a modified technique in the sanitary examination of potable water.

Mr. J. S. Rogers carried on a study of the methods in use for "Determining Nitrogen as Nitrates in Water." His experiments have led to a modification of our technique in determining nitrogen as nitrates, which we have adopted with success in our routine analyses. A complete account of both of these experiments is given later.

INCRUSTATION IN WATER PIPES AT QUINCY.

The Water Survey was called upon to suggest a remedy for a thick incrustation formed in a water main at Quincy. This incrustation had been forming during several years until the cross sectional area of the opening had been decreased more than half. A study of the situation showed that the removal of the incrustation with acid while possible was not practical. On recommendation of the Water Survey the use of acid was not attempted. The incrustation was removed mechanically as described by Mr. W. R. Gelston and precautions taken to prevent a recurrence of the difficulty. Other filter plants using lime and sulphate of iron in water treatment should be warned by the Quincy experience to avoid the possibility of similar trouble.

FARM WATER SUPPLIES.

The Survey was requested to prepare a lecture on "Farm Water Supplies" for the short course in the College of Agriculture of the University. In order to determine the actual situation with regard to water supplies on some of the farms in the State, samples of water from several localities were collected by representatives of the Survey and analyses made. The results of these analyses, given in this report, indicate that the condition of the farm water supplies

*University of Illinois Bulletin, Water Survey Series, No. 6, p. 22.

in some representative sections of the State is very satisfactory. In other sections, especially where deep rock or deep drift waters are not available, the condition is unsatisfactory. It is hoped, as time permits, that surveys of this nature may be extended to cover all sections of the State. A knowledge of the true conditions will enable the Water Survey officials and health officers to give intelligent opinions concerning the character of the water and concerning the methods of improving the water when there is need for improvement.

HARDNESS OF ILLINOIS MUNICIPAL WATER SUPPLIES.

So many requests come to the Water Survey concerning methods of softening water for boiler and manufacturing uses that a summary was made of the analyses of the mineral content of the municipal water supplies that had been examined. About 100 supplies had been analyzed. From the data thus available the amount of chemicals and the approximate cost of the same for the softening of the municipal water supplies was calculated. This work has suggested the desirability of checking the theoretical cost with the actual cost where water softening plants are installed. Work of this nature will be carried on as opportunity is offered.

MUNICIPAL WATER SUPPLIES.

Bulletin No. 5 gave all the data concerning municipal water supplies available to December 31, 1906. During the years 1907 and 1908 more data was collected. Additional analyses have been made of the water from supplies which had been previously analyzed and waters from a number of supplies have been examined for the first time. The chapter entitled "Additional Data Concerning Municipal Water Supplies" gives a record of all analyses of such supplies made during the two years ending December 31, 1908. There are also included corrections of Bulletin No. 5 which have been brought to the attention of the Water Survey. It is earnestly hoped that municipal authorities in the cities and villages of the State will assist the Water Survey by informing it of mistakes or omissions in this Bulletin No. 7. There has been a greater demand for Bulletin No. 5, "Municipal Water Supplies of Illinois," than for any other bulletin prepared by the Water Survey, and the edition is already nearly exhausted.

DETERMINATION OF NITRATES BY REDUCTION WITH ALUMINIUM.*

The work described in this paper was begun with the intention of making a comparison of various methods for the determination of nitrogen as nitrates; but after a few preliminary tests and also because we noted that E. M. Chamot of Cornell University had prepared a paper on the phenol sulphonic acid method, it was determined to confine the experiments almost entirely to a study of the method which depends upon the reduction of nitrates by means of aluminium.

The first series of the preliminary tests were made on a series of ten waters chosen from the routine samples of the State Water Survey Laboratory. These, according to the analysis made by the method in use in the laboratory, contained nitrogen as nitrates in varying amounts from 0.00 to 72.00 parts per million. These ten waters were then analyzed for nitrogen as nitrates by the aluminium reduction method, by the phenol sulphonic acid method and by the Brucine method of Noll.

TABLE I.—DETERMINATION OF NITRATES IN SERIES OF TEN WATERS BY DIFFERENT METHODS.

Serial Number	Aluminium Reduction Method			Phenol Sulphonic Acid Method	Brucine Sulphuric Acid Method	
16924	0.000	0.280	5.200	0.050	0.130	0.100
16922	0.080	0.080	0.360	0.025	0.090	0.090
16948	0.360	0.360	0.440	0.215	0.150	0.190
16938	0.800	0.680	1.160	1.630	2.550	2.000
16921	2.000	3.600	10.400	8.000	6.710	6.570
16914	3.970	2.800	6.600	7.520	7.400	5.640
16926	8.000	16.000	36.000	32.000	11.100	14.080
16955	22.400	16.000	45.000	15.400	9.800	13.600
16944	35.000	20.000	60.000	70.200	11.700	15.700
16912	72.000	38.000	120.000	120.000	11.200	19.000

An examination of the results (see Table I) showed that the amount of nitrogen found by the various methods was not the same. The Brucine method gave the lowest results and the phenol sulphonic acid method the highest. Especially was this true of the samples containing the larger amounts.

*Read before the Laboratory Section of the American Public Health Association at Winnipeg, August, 1908, by Edward Bartow and Jerome Stanley Rogers.

Since we could not be certain which method gave the correct results when waters containing unknown quantities of nitrogen as nitrates were used, the second series of preliminary tests was run on ten samples of water containing known quantities of nitrogen as nitrates in amounts varying from .05 to 50.0 parts per million. (See Table II.) Duplicate analyses were made by the phenol sul-

TABLE II—DETERMINATION OF NITRATES IN A SERIES OF TEN WATERS OF KNOWN NITRATE CONTENT.

Amount of Nitrates Present in Series of Waters	Aluminium Reduction			Phenol Sulphonic Acid Method		Brucine Sulphuric Acid		
0.05	0.36	0.20	0.12	0.10	0.075	0.117	0.140	0.052
0.10	0.20	0.24	0.24	0.025	0.150	0.115	0.160	0.066
0.25	....	0.40	0.28	0.325	0.310	0.232	0.250	0.170
0.50	0.60	0.52	0.40	0.685	0.575	0.670	0.130	0.350
1.00	0.92	0.92	0.60	1.130	1.250	1.080	1.400	0.500
2.50	2.00	2.24	1.80	3.300	3.240	3.600	2.600	2.600
5.00	4.48	4.00	3.36	11.500	3.500	5.700	3.250	3.500
10.00	8.60	8.48	7.04	13.000	10.000	11.200	7.500	6.700
25.00	20.80	20.80	17.20	30.000	21.000	23.750	16.250	19.000
50.00	34.00	50.00	33.00	60.000	50.000	45.500	33.000	37.000

phonic method* and triplicate analyses by both the Brucine and aluminium reduction methods. The aluminium reduction method gave high results in the test of samples which contained less than .5 parts per million and low results in all tests in which one or more parts per million was present. In these latter results there was a recovery of only 80 to 90% of the nitrogen placed in the sample. The phenol sulphonic acid method gave high results in most of the determinations. A few of the determinations, however, were low. The check analyses differed considerably from each other. The Brucine sulphuric acid method in the majority of the tests gave low results. This was especially true of the samples containing the larger quantities of nitrogen as nitrates. These results as a rule were lower even than those obtained by the aluminium reduction method. We did not feel that the results we obtained by any of the methods were entirely satisfactory.

Since Professor E. M. Chamot of Cornell was investigating the phenol sulphonic acid method, and since the aluminium reduction method has been in use in this laboratory almost exclusively since the organization of the Survey, it was decided to determine, if

*Standard Methods of Water Analysis, p. 40.
†Chem. News, LXIV, 162.

possible, the cause of the high results in the samples containing low nitrogen and the low results in the samples containing the larger quantities.

The best discussion of this aluminium reduction is that of Hazen and Clark, and our results are in many respects in accord with theirs, though differing in some features.

Experiments were planned with a view to determining the effect of temperature upon the reduction, and of time on the completeness of the reaction. A solution containing 10 parts per million of nitrogen as nitrates was prepared. To portions of 100 c.c. each of this solution was added two c.c. of a 40 per cent. solution of sodium hydroxide, free from nitrates. The solution was concentrated to 15 to 20 c.c., the residue was washed into a test tube holding approximately 100 c.c. and was then diluted to about 75 c.c. with nitrate free water and a strip of aluminium added. Eight of these samples were allowed to stand at room temperature; eight in the incubator at about 37½°, and eight in the ice box at a temperature of from 5 to 8° C. At the end of sixteen hours half of the samples were diluted with 250 c.c. of distilled water, and the ammonia formed was distilled over and determined. The remainder of the samples were treated in the same way at the end of thirty-two hours. We noted (see Table III) that the longer the solutions were allowed to stand the less nitrogen as nitrates was recovered. We noted also that the largest amount of nitrogen was recovered when the reduction took place at the temperature of the ice box, and the smallest amount of nitrogen at a temperature of from 35 to 40° C. This agrees as far as temperature is concerned with the results obtained by Hazen and Clark.

Two of the solutions were nesslerized directly after dilution to 200 c.c., and the results agreed so closely with results obtained by distillation that in subsequent tests on standard solutions we estimated the nitrogen by direct nesslerization.

The low nitrogen would hardly he accounted for by a failure to reduce all the nitrates present as the results were lower when the solutions were kept the longer. We therefore next sought to

TABLE III.—EFFECT OF TEMPERATURE AND TIME ON THE REDUCTION OF NITRATES.

Series		Tempera-ture	Time	c. c. of Water	Volume of Distillate	Volume used	c. c. of Standard	Parts per Million
I.	Blank	Room	16 hrs.	100	200	50	0.6	0.24
	1	"	"	100	200	10	3.5	7.00
	2	"	"	100	200	10	3.8	7.60
	3	"	"	100	200	10	3.5	7.00
	4*	"	"	100	200	10	3.7	7.40
II.	Blank	35°-40°C	"	100	200	50	1.0	.40
	1	"	"	100	200	25	4.5	3.60
	2	"	"	100	200	25	4.5	3.60
	3	"	"	100	200	25	3.8	3.00
	4*	"	"	100	200	25	4.2	3.40
III.	Blank	5°-8°C	"	100	200	50	1.2	.48
	1	"	"	100	200	10	4.3	8.60
	2	"	"	100	200	10	4.3	8.60
	3	"	"	100	200	10	4.2	8.40
	4*	"	"	100	200	10	4.3	8.60
IV.	Blank	Room	32 hrs.	100	200	50	1.1	.44
	1	"	"	100	200	10	2.7	5.40
	2	"	"	100	200	10	3.0	6.00
	3	"	"	100	200	10	2.5	5.00
	4*	"	"	100	200	10	2.7	5.40
V.	Blank	35°-40°C	"	100	200	50	.6	.24
	1	"	"	100	200	25	3.2	2.56
	2	"	"	100	200	25	3.3	2.64
	3	"	"	100	200	25	3.1	2.48
	4*	"	"	100	200	25	3.0	2.40
VI.	Blank	5°-8°C	"	100	200	50	1.0	.40
	1	"	"	100	200	10	4.0	8.00
	2	"	"	100	200	10	3.8	7.60
	3	"	"	100	200	10	4.0	8.00
	4*	"	"	100	200	10	4.2	8.40

determine the amount of nitrogen which was probably carried off as ammonia gas.

A series of experiments was planned in which four solutions were run at room temperature; four at the temperature of the incubator, 37½°; and four in the ice box at the temperature of from 5 to 10° C. 100 c.c. of the standard solution containing 10 parts per million of nitrogen as nitrate were used in each case. Each solution was prepared as in the preceding experiment, and in addition the mouth of the test tube was closed with a rubber cork, through which passed a U-shaped glass tube of such a length that the outlet could be placed in a second test tube containing a small amount of dilute hydrochloric acid which served as a trap to catch any ammonia that might escape. The traps were changed at the end of each hour for six hours, and the ammonia caught in the traps was determined by direct nesslerization. Very little ammonia passed off. (See Table IV.) The average for the samples at the temperature

*Indicates that after reduction solutions diluted to 200 c.c. and nesslerized directly. All others were distilled before nesslerization.

TABLE IV.—LOSS OF AMMONIA DURING REDUCTION WITH TRAPS

Direct nesslerization, total period of time 20 hrs., ten parts per million nitrate present

Ammonia found in reduction tubes.						Ammonia in traps during six hours' reduction.*															
						1st hr.		2nd hr.		3rd hr.		4th hr.		5th hr.		6th hr.					
Number.	c. c. of water.	Volume of dilution.	Volume used.	c. c. of Standard.	Parts per Million.	c. c. of Standard.	Parts per Million.	c. c. of Standard.	Parts per Million.	c. c. of Standard.	Parts per Million.	c. c. of Standard.	Parts per Million.	c. c. of Standard.	Parts per Million.	c. c. of Standard.	Parts per Million.	Total NH_3 in Traps.	Total NH_3 found.	c. c. of Standard.**	Parts per Millicn.**
I. Room Temperature.																					
1	100	200	5	2.5	10.0	0.0	.00	.2	.02	.1	.01	.0	.00	.1	.01	.1	.01	.10	10.10	.5	.05
2	100	200	5	2.3	9.2	.0	.00	.2	.02	.0	.00	.0	.00	.1	.01	.4	.04	.11	9.31	.4	.04
3	100	200	5	2.6	10.4	.0	.00	.1	.01	.2	.02	.0	.00	.1	.01	.0	.00	.05	10.45	.1	.01
4	100	200	5	2.4	9.6	.0	.00	.3	.03	.1	.01	.0	.00	.1	.01	.1	.01	.10	9.70	.4	.04
II. Temperature 37½° C.																					
1	100	200	5	2.5	10.0	.0	.00	.2	.02	.4	.04	.1	.01	.2	.02	.1	.01	.18	10.18	.8	.08
2	100	200	5	2.5	10.0	.9	.09	.3	.03	.4	.04	.1	.01	.2	.02	.1	.01	.29	10.29	.9	.09
3	100	200	5	2.4	9.6	.2	.02	.0	.00	.3	.03	.1	.01	.1	.01	.2	.02	.17	9.77	.8	.08
4	100	200	5	2.6	10.4	.3	.03	.6	.06	.3	.03	.1	.01	.1	.01	.1	.01	.23	10.63	.8	.08
III. Ice-box Temperature (5-10° C.)																					
1	100	200	5	2.5	10.0	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.00	10.00	.0	.00
2	100	200	5	2.0	8.0	.0	.00	.0	.00	.1	.01	.0	.00	.0	.00	.0	.00	.01	8.01	.0	.00
3	100	200	5	2.4	9.6	.0	.00	.1	.01	.0	.00	.0	.00	.0	.00	.0	.00	.02	9.62	.1	.01
4	100	200	5	2.5	10.0	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.0	.00	.01	10.01	.1	.01

* Trap tubes were removed at the end of each hour for a period of six hours and nesslerized.

** Trap tubes containing NH_3 for the last 14 hours of the 20 hours' reduction.

in the ice box was .01 parts per million; for the samples at room temperature the average was .09 parts per million; and for the samples at 37½° the average was .21 parts per million. The amount found in the traps in no way agreed with the amount not recovered in the previous experiments.

The ammonia was determined in the reduction tube after a total period of 20 hours. At room temperature the average for the four solutions was 9.6. At the temperature of 37½° the average was 10.0. At the temperature of the ice box the average was 9.4. If to this we add the ammonia found in the traps the total amount recovered is slightly more than 10 parts per million. The excess was practically equal to the test of our distilled water and reagents. We were surprised at the results of this experiment, for we expected to find considerable ammonia in the traps, whereas practically none was found. We feel that this fact can be explained on the supposition that ammonia is carried out of the solution by the hydrogen evolved. When no traps are used the light gases diffuse quickly, whereas when the trap is used diffusion is slow. The more soluble ammonia is re-dissolved by the liquid while the hydrogen alone passes out through the trap. The results indicate that the temperature at which the reduction takes place is of little importance provided care is taken to prevent diffusion of the light gases.

We next carried out a series of experiments to compare directly the results of reduction with and without traps and to confirm the results of the two preceding series. The same standard solution was used and the tests were made the same as before. (See Table V.) With traps, at room temperature, 9.8 parts per million of nitrogen as nitrates was recovered from the reduction tube and 0.09 from the trap, making a total recovery of 9.89 parts per million, whereas when the traps were not used only 6.0 parts per million were recovered.

With traps, at a temperature of 37½°, 10 parts per million were recovered from the reduction tube and .14 from the traps, whereas when the traps were not used only 4.6 parts per million were recovered.

With traps, at the temperature of the ice box, 10 parts per mil-

TABLE V. COMPARISON WITH AND WITHOUT TRAPS—10 HOURS.

With Traps						Ammonia found in Traps		Without Traps				
Number.	c. c. of Water.	Vol. of Dilution.	Volume used.	c. c. of Standard.	Parts per Million.	c. c. of Standard.	Parts per Million.	c. c. of Water.	Vol. of Dilution.	Volume used.	c. c. of Standard.	Parts per Million.
I. Room Temperature.												
1	100	200	5	2.5	10.0	1.0	.10	100	200	5	1.4	5.6
2	100	200	5	2.3	9.3	0.8	.08	100	200	5	1.6	6.4
3	100	200	5	2.5	10.0	...	...	100	200	5	1.5	6.0
4	100	200	5	2.5	10.0	0.9	.09	100	200	5	1.5	6.0
II. Temperature 37½° C.												
1	100	200	5	2.5	10.0	1.3	.13	100	200	5	1.2	4.8
2	100	200	5	2.5	10.0	1.6	.16	100	200	5	1.1	4.4
3	100	200	5	2.5	10.0	1.5	.15	100	200	5	1.1	4.4
4	100	200	5	2.5	10.0	...	...	100	200	5	1.2	4.8
III. Temperature 5-8° C.												
1	100	200	5	2.5	10.0	0.8	.08	100	200	5	2.0	8.0
2	100	200	5	2.5	10.0	0.8	.08	100	200	5	2.0	8.0
3	100	200	5	2.5	10.0	0.4	.04	100	200	5	2.1	8.4
4	100	200	5	2.5	10.0	0.6	.06	100	200	5	2.1	8.4

lion were recovered from the reduction tube and .06 parts per million from the traps, whereas from the tubes without traps only 8.2 parts per million were recovered. These results confirmed our former conclusions.

One of the objections to the aluminium reduction method lies in the fact that considerable time is required for the completion of the reaction. It has been customary to allow the reduction to go on over night. We arranged tests to determine the time at which the reaction would be completed. We first planned five series of four tests each, in which the reduction would run for periods of 2, 4, 6, 8 and 10 hours at room temperature. We used a solution of the same strength as before, containing 10 parts per million of nitogen as nitrates. Traps were used during the reduction and the ammonia formed was determined by direct nesslerization. (See Table VI.) At the end of two hours 7.7 parts per million of nitrogen were recovered from the solution tubes and .02 parts per million from

TABLE VI. TIME REQUIRED FOR COMPLETE REDUCTION.

DIRECT NESSLERIZATION, USING TRAPS, ROOM TEMPERATURE, TEN PARTS PER MILLION.

TIME OF TREATMENT.

No.	c.c. of Water.	Vol. of Dilution.	c.c. Used.	c.c. of Standard.	Parts per Million.	NH_3 in Traps. c.c. of Standard.	NH_3 in Traps. Parts per Million
I.* Two Hours.							
1	100	200	5	1.9	7.6	0.3	.03
2	100	200	5	1.9	7.6	0.2	.02
3	100	200	5	2.0	8.0	0.2	.02
4	100	200	5	1.9	7.6	0.2	.02
II. Four Hours.							
1	100	200	5	2.5	10.0	0.6	.06
2	100	200	5	2.5	10.0	0.5	.05
3	100	200	5	2.6	10.4	0.6	.06
4	100	200	5	2.5	10.0	0.6	.06
III. Six Hours.							
1	100	200	5	2.6	10.4	0.8	.08
2	100	200	5	2.6	10.4	0.7	.07
3	100	200	5	2.6	10.4	0.8	.08
4	100	200	5	2.8	11.0	0.7	.07
IV. Eight Hours.							
1	100	200	5	2.6	10.4	0.9	.09
2	100	200	5	2.5	10.0	0.9	.09
3	100	200	5	2.5	10.0	0.9	.09
4	100	200	5	2.5	10.0	0.7	.07
VI. Ten Hours.							
1	100	200	5	...	....	...	...
2	100	200	5	2.6	10.4	0.8	.08
3	100	200	5	2.5	10.0	1.2	.12
4	100	200	5	2.7	10.8	1.0	.10

the traps. At the end of four hours the reduction was evidently complete as 10.1 parts per million of nitrogen as ammonia was recovered from the solution tubes and .06 parts per million from the traps. The tests which ran 6, 8 and 10 hours gave practically the same results as the four-hour test. At the end of two hours nitrites amounting to .02 parts per million were found.

Since at room temperature the reduction was completed in less than four hours, in the next series of tests, at a temperature of 37½°, it was arranged to test groups of samples of four each at the

* Nitrites were found to be present approximately 0.02 parts per million.

end of 1, 2, 3 and 4 hours. These tests were carried out in the same manner as the tests made at room temperature. (See Table VII.)

TABLE VII. TIME REQUIRED FOR COMPLETE REDUCTION.

DIRECT NESSLERIZATION, USING TRAPS, ROOM TEMPERATURE, TEN PARTS PER MILLION.

TIME OF TREATMENT.

No.	c.c. of Water.	Vol. of Dilution.	c.c. Used.	c.c. of Standard.	Parts per Million.	NH_3 in Traps. c.c. of Standard.	NH_3 in Traps. Parts per Million
I. One Hour.							
1	100	200	5	.9	3.6	.3	.03
2	100	200	5	1.2	4.8	.0	.00
3	100	200	5	1.4	5.6	.0	.00
4	100	200	5	1.1	4.4	.2	.02
II. Two Hours.							
1	100	200	5	2.3	9.2	.4	.04
2	100	200	5	2.1	8.4	.2	.02
3	100	200	5	2.2	8.8	.3	.03
4	100	200	5	2.3	9.2	.2	.03
III. Three Hours.							
1	100	200	5	2.5	10.0	.4	.04
2	100	200	5	2.6	10.4	.3	.03
3	100	200	5	2.6	10.4	.1	.01
4	100	200	5	2.6	10.4	.5	.05
IV. Four Hours.							
1	100	200	5	2.7	10.8	.4	.04
2	100	200	5	2.8	11.2	.5	.05
3	100	200	5	2.7	10.8	Cloudy	
4	100	200	5	2.7	10.8	.4	.04

At the end of one hour 4.6 parts per million of nitrogen were recovered from the solution tube and .01 parts per million from the traps. At the end of two hours 8.9 parts per million were recovered from the solution tubes and .03 parts per million from the traps. At the end of three hours 10.3 parts per million were recovered from the solution tubes and .03 parts per million from the traps.

There was a slight increase in the amount of nitrogen recovered at the end of the fourth hour. These tests indicate that the time required for solutions containing nitrates alone need not be as long as has been previously recommended.

Tests were next run with waters containing smaller amounts of nitrogen, namely, 0.5 and 2.5 parts per million. The tests were run by direct nesslerization at room temperature for four hours, using traps. (See Table VIII.) The distilled water used contained

TABLE VIII. TREATMENT OF DISTILLED WATERS CONTAINING .5 AND 2.5 PARTS PER MILLION NITRATES.*

No.	c.c of Water.	Vol. of Dilution.	c.c. Used.	c.c. of Standard.	Parts per Million.	NH_3 in Traps. c.c. of Standard.	NH_3 in Traps. Parts per Million
WATER USED—I. Distilled water + .5 of a part per million of nitrates.							
1	100	200	50	1.3	0.52	.3	.03
2	100	200	50	1.3	0.52	.3	.03
3	100	200	50	1.4	0.56	.3	.03
4	100	200	50	1.3	0.52	.4	.04
WATER USED—II. Distilled water + 2.5 parts per million of nitrates.							
1	100	200	10	1.3	2.6	.4	.04
2	100	200	10	1.35	2.7	.8	.08
3	100	200	10	1.2	2.4	.4	.04
4	100	200	10	1.2	2.4	.5	.05
WATER USED—III. Distilled water.							
1	100	200	50	0.4	.16	.2	.02
2	100	200	50	0.4	.16	.0	.00
3	100	200	50	0.8	.32	.0	.00
WATER USED—Water from Lake Michigan.							
1	100	200	50	1.1	.44	.0	.00
2	100	200	50	1.0	.40	.0	.00

.21 parts per million of nitrogen as nitrates which, after deduction from the amount of nitrogen recovered by the determination, gives .35 parts per million instead of .5 parts per million, and 2.34 parts per million instead of 2.5 parts per million.

A series of six determinations was run on waters which had been analyzed by the regular routine of the laboratory. The determinations were made by direct nesslerization at room temperature after four hours reduction, using traps. In each case a larger amount of nitrogen was recovered.

In No. I. 0.44 parts per million instead of .12 parts per million.

In No. II. 42.00 parts per million instead of 30.00 parts per million.

* Direct nesslerization, room temperature, four hours reduction, using traps.

In No. III. 0.44 parts per million instead of .32 parts per million.

In No. IV. 30.00 parts per million instead of 25.00 parts per million.

In No. V. 6.8 parts per million instead of 4.20 parts per million.

In No. VI. 3.2 parts per million instead of 1.6 parts per million.

A series of analyses in which the amount of nitrogen was unknown to the analyst was next made at room temperature. The period of reduction was four hours, traps were used and the ammonia found was determined by direct nesslerization.

	Amount of nitrogen added.	Amount of nitrogen found.
I.	22 parts per million	24 parts per million
II.	10 parts per million	10.8 parts per million
III.	2 pasts per million	2.8 parts per million
IV.	0 parts per million	.16 parts per million
V.	.28 parts per million	.4 parts per million

The foregoing series of experiments would indicate that nitrogen as nitrates should be recovered with a reasonable degree of accuracy from pure water to which nitrogen as nitrates had been added and from ordinary drinking water.

Since the phenol sulphonic acid method is said to be unsatisfactory for the determination of nitrogen as nitrates in sewages, it was decided to run a series of tests on sewages to which nitrogen as nitrates had been added. It is well known that nitrates in sewages are very low. We made determinations of nitrogen as nitrates before and after the addition of 10 parts per million to each of three samples of sewage. These were the sewage of Urbana before and after it passed through the disposal works and the water from a polluted stream which passed through the University grounds.

In the first series of tests the analysis was made 24 hours after the nitrates were added. (See Table IX.) We recovered no more nitrogen as nitrates from the samples of sewage to which 10 parts per million had been added than from the original sewages. The ten parts per million of nitrogen as nitrates had entirely disappeared. The water from the polluted stream contained originally one part per million of nitrogen as nitrates. From the sample to

TABLE IX. TREATMENT OF SEWAGES AND POLLUTED WATERS.

DIRECT NESSLERIZATION, ROOM TEMPERATURE, FOUR HOURS REDUCTION. NITRATES ADDED AT HOURS BEFORE ANALYSIS.

No.	c.c. of Water.	Vol. of Dilution.	c.c. Used.	c.c. of Standard.	Parts per Million.	NH_3 in Traps. c.c. of Standard.	NH_3 in Traps. Parts per Million
SOURCE—I. Inflow at Urbana Septic Tank.							
1	100	200	50	0.5	0.20	.1	.01
2	100	200	50	0.5	0.20	.1	.01
3	100	200	50	0.4	0.16	.0	.00
SOURCE—II: Outflow at Urbana Septic Tank.							
1	100	200	50	0.4	0.16	.1	.01
2	100	200	50	0.5	0.20	.2	.02
3	100	200	50	0.6	0.24	.3	.03
SOURCE—III. Polluted Stream (Boneyard).							
1	100	200	50	2.4	0.96	.1	.01
2	100	200	50	2.5	1.00	.1	.01
3	100	200	50	2.6	1.04	.4	.04
SOURCE—IV. Same as I. + 10. parts per million of nitrate.							
1	100	200	50	0.2	0.08	.0	.00
2	100	200	50	0.4	0.16	.8	.08
3	100	200	50	0.3	0.12	.2	.02
SOURCE—V. Same as II. + 10. parts per million of nitrate.							
1	100	200	50	0.6	0.24	.2	.02
2	100	200	50	0.5	0.20	.0	.00
3	100	200	50	0.5	0.20	.3	.03
SOURCE—VI. Same as III. + 10. parts per million of nitrate.							
1	100	200	5	2.0	8.00	.5	.05
2	100	200	5	2.0	8.00	.7	.07
3	100	200	5	...	....	..	...

which 10 parts per million had been added only 8 parts per million were recovered at the end of the four hours reduction period.

In order to check the results, the work was repeated with similar results.

A series of analyses was then run immediately after the nitrates were added. (See Table X.) Proceeding in this way 7.7 parts per million of nitrogen as nitrates were recovered from the raw sewage, to which 10 parts per million of nitrogen as nitrates had been added:

TABLE X. TREATMENT OF SEWAGES AND POLLUTED WATERS.

DIRECT NESSLERIZATION, ROOM TEMPERATURE, FOUR HOURS REDUCTION. NITRATES ADDED AT TIME OF ANALYSIS.

No.	c.c. of Water.	Vol. of Dilution.	c.c. Used.	c.c. of Standard.	Parts per Million.	NH3 in Traps. c.c. of Standard	NH3 in Traps. Parts per Million
SOURCE—I. Inflow at Urbana Septic Tank.							
1	100	200	50	0.3	0.12	.0	.0
2	100	200	50	0.4	0.16	.0	.0
3	100	200	50	0.3	0.12	.0	.0
SOURCE—II. Outflow at Urbana Septic Tank.							
1	100	200	50	0.5	0.20	.0	.0
2	100	200	50	0.4	0.16	.0	.0
3	100	200	50	0.4	0.16	.0	.0
SOURCE—III. Polluted Stream (Boneyard).							
1	100	200	50	1.2	0.48	.0	.0
2	100	200	50	1.1	0.44	.0	.0
3	100	200	..	...	....	...	..
SOURCE—IV.* Same as I. + 10. parts per million of nitrate.							
1	100	200	5	1.8	7.2	.0	.0
2	100	200	5	2.3	9.2	.0	.0
3	100	200	5	1.8	7.2	.0	.0
SOURCE—V.* Same as II. + 10. parts per million of nitrate.							
1	100	200	5	2.3	9.2	.0	.0
2	100	200	5	2.5	10.0	.0	.0
3	100	200	5	2.3	9.2	.0	.0
SOURCE—VI.* Same as III. + 10. parts per million of nitrate.							
1	100	200	5	2.4	9.6	.2	.02
2	100	200	5	1.9	7.6	.0	.00
3	100	200	5	2.2	8.8	.0	.00

9.4 parts per million were recovered from the sewage which had passed through the disposal works; 8.7 parts per million were recovered from the polluted stream. Nitrites were found in all of the somples after four hours reduction, indicating that the reduction was not yet complete. We conclude from this series of tests that in the presence of organic matter the reduction of nitrogen to ammonia is slower than when the organic matter is absent. We con-

* Nitrates were found in the solution after four hours reduction.

clude also that it would be useless to make the determination of nitrogen as nitrates in raw sewage, and also in sewage which has passed through a solution chamber similar to the one at Urbana.

GENERAL SUMMARY.

1. Because of loss of ammonia the amount of ammonia recovered in a given time in open reduction tubes varies inversely with the temperature.

2. The loss of ammonia is prevented and the temperature has no effect if the hydrogen is allowed to escape through traps.

3. The reduction is completed in less than four hours in pure water or waters of average purity; in highly polluted waters the reduction requires longer time.

4. In sewage the determination of nitrogen as nitrates is practically without value because the nitrates are reduced by the oxidation of the organic matter present.

INCRUSTATION EXPERIENCE AT QUINCY, ILLINOIS.*

W. R. Gelston.

We have had some incrustation experience at our pumping station, which will probably be of interest to all the members of the American Waterworks Association, and especially to those who may have occasion to design sedimentation and filtration systems. Our experience has brought to light serious defects in the construction of our system and it may be the means of preventing similar defects in future installations.

For a thorough comprehension of our trouble a brief descriptino of the plant is necessary. The pumping station is built on the bank of the Mississippi River from which we secure our supply of water. A Worthington horizontal triple expansion pumping engine, size 12″ & 19″ & 30″ x 24″ x 24,″ pumps the raw water from the intake well to the settling basin, which is located upon the hillside about 450 feet from the pump house and at an elevation of about 40 feet above the pump. This basin is 70 feet square and 10 feet deep. Sulphate of iron and lime are used for coagulating purposes, the iron solution being drawn through the suction of the Worthington pump and the lime solution being pumped into the discharge pipe by a small auxiliary pump. The discharge from the lime pump was connected with the discharge from the large pump in a valve well just outside the pump house and here appears a serious defect. This arrangement allowed a very thorough mixing of the two solutions with the raw water before they were finally discharged into the basin at a point 400 ft. away.

After a sedimentation period of about one hour in the settling basin, the water flows by gravity through a 20" cast iron pipe to the filter house where the purification process is completed by 14 Continental-Jewell filters. From the clear well under the filters the water flows back to the pump house and into the water chamber of a 5,000,000 gallon Gordon-Maxwell pump which discharges it directly into the distribution system, the surplus passing into a

*Proceedings, Am. Water Works Assn., 1908, p. 165.

reservoir of 18,000,000 gallon capacity. This reservoir holds easily a week's supply of water for the city and is located on a hill 230 feet above the pump house and two and one-half miles away.

The beginning of the serious trouble precedes the date of my connection with the plant and this information is supplied by Mr. F. J. Brinkoetter, who is Chief Engineer of the pumping station.

During the summer of 1906 the Worthington pump began to show signs of distress. The pressure gauge on this pump should show a head of water of about 47 feet by actual levels, whereas the gauge was indicating a rapidly increasing head. Investigation of the trouble lead to the discovery of a thick deposit of scale on the inside of the 20" discharge pipe. Taps were made at several points along the line of pipe and it was found that the incrustation extended from the point of introduction of the lime solution to the discharge end of the pipe. Mr. Brinkoetter then appealed to Mr. Edward Bartow, Director of The Illinois State Water Survey to find out whether it might be possible to remove the deposit by the use of chemicals. Mr. Bartow came to Quincy and conducted a series of experiments to determine the action of various acids upon the scale and the probable cost of removing it by acid treatment. It was decided that the cheapest and only certain method would be to cut it out with hammer and chisels. Finally, in November, 1906, the storage reservoir was filled and pumping discontinued while the discharge end of the pipe was being cleaned. At the time the pumps were stopped the pressure gauge indicated a head of 100 feet against which the pump was working.

The first 60 feet of the pipe lies exposed in the settling basin and was cleaned without difficulty by melting out the middle joint which allowed three men to work at the same time. Outside the settling basin an excavation was made over every third or fourth joint of pipe which was removed by melting out the spigot end and cutting off the bell end with a diamond-pointed chisel. After cleaning, the same pipe was replaced by using a 20" sleeve where the bell end was cut away.

A force of eight men worked one week and succeeded in cleaning about 150 feet of the pipe. The deposit averaged about 5 inches in thickness and seemed to be about the same throughout the circumference of the pipe.

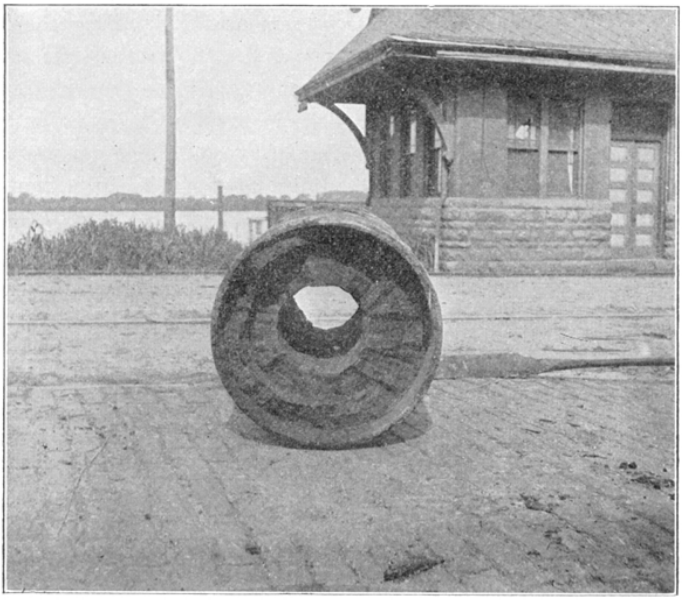
It was then necessary to begin pumping again and the pressure gauge showed a reduction of the head of water to 70 feet.

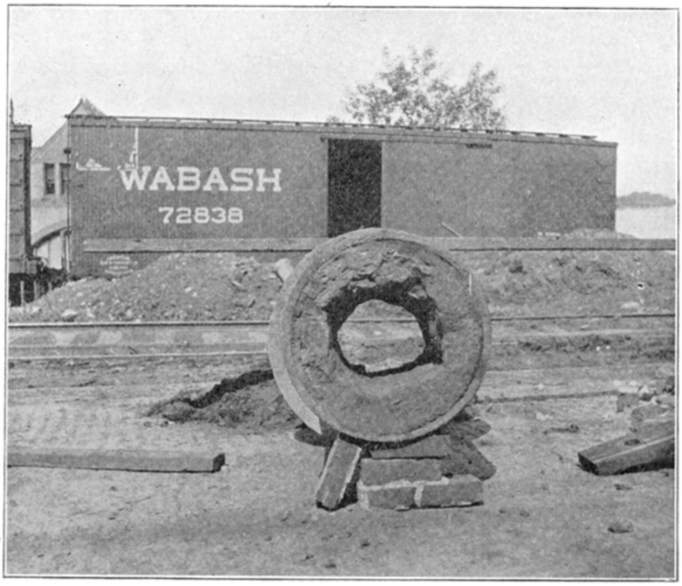
Nothing further was done until July, 1907, when the gauges indicated a steam pressure of 100 lbs. and a head of water of 91 feet while the pump was running 19 revolutions per minute. Things began to look serious again so we decided to clean the remainder of it. This end of the pipe was much more difficult to clean because it is crossed by one paved street, in which is a street car track, and by four railroad tracks. A portion of the pipe also lies at a depth of 10 feet which increased the amount of necessary excavation. The work was begun July 27th, and handled in the same manner as before. The pipe was all replaced and ready for use again August 4th. A force of from 10 to 14 men was employed and the thickness of the scale increased from nothing, at the point where the lime solution was introduced, to 6 inches at the point where work was begun. At this time 250 feet of pipe were cleaned, making a total of 400 feet, which was cleaned at a total expense of $420.00 for labor and new material used.

After this cleaning the steam gauge stood at 61 lbs. and the water gauge at 47 feet while the pump was making 22 revolutions per minute.

In order to obviate the necessity of ever cleaning all of this pipe again, the discharge pipe of the lime solution pump was extended about 300 feet and made to discharge into the large pipe at a point just outside the wall of the settling basin. This allows a distance of 80 feet in the large discharge pipe for the mixing of the two solutions before the final discharge into the basin. This 80 feet of pipe will fill up again and require cleaning, but it will be a comparatively small job. This change in the point of introduction of the lime solution has undoubtedly lessened the efficiency of the basin and thrown more work upon the filters. When the river is very turbid we still use the old discharge opening for the lime pump so as to obtain the best possible results from the basin.

I am advised by Mr. C. R. Henderson, the former superintendent





SECTIONS OF PIPE REMOVED FROM TRENCH.

of the plant, that the present arrangement for handling the lime solution was installed early in the year 1902. As the lime is undoubtedly the active agent in the formation of the incrustation, it would appear that this scale has been in process of formation only about five years, or at an average rate of over one inch per year.

During the past winter the gravity flow line leading from the basin to the filters has also become so filled up with the same deposit as to require cleaning.

This line of pipe is of cast iron, 20 inches in diameter, and it extends from the drop well in the basin, 115 feet along the outside of the north wall of the filter house, then turns a ¼ bend and runs 25 feet along the west wall to a connection with a branch line from the Worthington pump discharge pipe. From this connection the pipe runs under the filter house through a sewer spillway. From this main supply pipe five 10-inch wrought iron risers from 15 to 18 feet in length extend just above the rims of the filter tanks. These risers are capped by tees from which three 6-inch wrought iron branches supply one filter each. These 6-inch branches are, in turn, reduced to four inches and controlled by butterfly valves.

The deposit in this filter pipe system finally became so serious that we could not get water enough into the filter house to keep all the filters in operation, and the speed of the pumps had to be reduced about two revolutions per minute.

In February, 1908, we discontinued pumping for one week and cleaned a portion of the main supply pipe under the filter house, all of the five risers and the 14 filter branch pipes. This work was done by disconnecting every joint and chiseling out the deposit. Numerous difficulties were encountered. The 14 branch pipes are of wrought iron connected with screwed joints. These joints could not be disconnected until the thick incrustation on the inside was broken either by an excessive strain on the wrenches or by hammering. Had these joints been made up with flanged unions the labor would have been much reduced. The five 10-inch risers are each in one piece. Their extreme length and great weight when half filled with solid rock, together with the cramped quarters in which they had to be handled made them almost impossible. They would better be in two sections connected with a flanged union.

The deposit had reduced the inside diameter of the 10-inch risers to about six inches. The 4-inch sections just above the butterfly valves were some of them reduced to two inches.

The work was done by a force of six men in six days and the cost of labor alone amounted to $65.00.

This cleaning resulted in an increase in the filtering capacity of the plant of about 30,000 gallons per hour. The 20-inch supply pipe will soon have to be cleaned also.

During Mr. Henderson's supervision of the plant some cleaning of the filter house piping was necessary and he advised me that plans for a complete rearrangement were being considered at the time of the transfer of the property to the present owners in 1904.

Our experience at Quincy emphasizes the fact that solutions of iron and lime should not be forced together through long lines of pipe. If it is necessary to carry them in the same system, the piping should be so arranged as to be conveniently taken apart for cleaning.

Mr. Edward Bartow has made a chemical analysis of a sample of the incrustation taken from the Worthington pump discharge pipe and prepared a paper for the Association, in which he handles this matter from the point of view of the water works chemist.

CHARACTER AND COMPOSITION OF THE INCRUSTATION FROM DISCHARGE PIPE AT QUINCY.*

The paper by Mr. Gelston entitled, "Incrustation Experience at Quincy, Illinois," gives the experience with an incrusted delivery pipe at the pumping station of the Citizen's Water Works Company. Owing to the difficulty of gaining access to the interior of the pipe, they made inquiry of the State Water Survey as to the possibility of removing the incrustation with an acid. An experiment with hydrochloric acid showed that the sediment could probably be removed by means of the acid. We, however, as explained in what follows, calculated the amount needed and decided that the expense of such a treatment would be prohibitive. At the time of the experiment the incrustation in the twenty-inch pipe was four inches thick. This would give a cross section having an area of 1.4 feet. In 400 feet of the pipe there would, therefore be 560 cubic feet of incrustation, Considering that the incrustation was calcium carbonate, having a specific gravity of 2.5,† the total amount to be removed would weigh 87,500 pounds. To dissolve such an amount of calcium carbonate would require 189,500 pounds of commercial hydrochloric acid, having a specific gravity of 1.16 (20° Baumé), and containing 32 per cent. of the pure acid. If this acid could be delivered at Quincy, at one cent per pound, the cost of the acid alone, exclusive of labor, would be $1,895.00. Necessarily such a method of cleaning the main was not practicable, and the operation of cleaning was carried out as described in the paper by Mr. Gelston.

To account for the character and composition of the scale, we must consider the original composition of the river water, the chemicals used in the treatment, and the manner in which reactions take place between the various substances.

The average composition of the mineral content of the water

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*Proceedings, Am. Water Works Assn., 1908, p. 172.
†The Specific Gravity, determined later by L. I. Birdsall, was found to be 2.499.

from the Mississippi river at Quincy, for the year ending July 31, 1907, has been determined in the laboratory of the State Water Survey. Samples were collected daily at the intake well of the Quincy pumping station. These samples were combined to cover three periods per month, or thirty-six composite samples during the year. The analytical work was done by Mr. W. D. Collins and Mr. C. K. Calvert, working under a co-operative agreement between the State Water Survey, the State Geological Survey, the Engineering Experiment Station of the University of Illinois, and the Water Resources Branch of the United States Geological Survey. The average of these results must give a good idea of the general character of the Mississippi river at Quincy.

The composite analyses show the widest limits in the turbidity and suspended matter and individual samples would undoubtedly show greater extremes than the composites. The variations in the soluble matter are considerable but not so great. As the analysis of the incrustation is of a cross section, it seems necessary to give only the average of the analyses of the water at this time. The details will be published later.

With regard to the chemicals used, the records of the Water Company show that during the year 1907, the minimum amount of sulphate of iron per million gallons was 195.5 lbs., the maximum amount was 367.4 lbs., and the average was 286.37 lbs. The minimum amount of lime per million gallons was 295.2 lbs., the maximum was 452.37 lbs., and the average was 395 lbs.

Since each pound of sulphate of iron requires two-tenths (.2) of a pound of lime, there will be left 338 lbs. per million gallons to react with the bicarbonates in softening the water. This is more than enough to unite with the calcium bicarbonate and we would expect some magnesium to be removed. That such is the case is shown in two comparative analyses of the water before and after filtration.*

*Proceedings, Am. Water Works Assn., 1906, p. 136.

ANALYSIS OF THE INCRUSTATION.

A CHEMICAL ANALYSIS OF A SPECIMEN OF THE INCRUSTATION GAVE RESULTS AS FOLLOWS:

Determination Made.	Per Cent.
Moisture	.13
Loss on ignition less moisture	44.31
Silicious Matter	.30
Silica SiO_2 .15%.	
Oxides of Iron and Alumina $Fe_2O_3+Al_2O_3$	.86
Calcium Oxide CaO	53.54
Calcium Ca 38.27	
Magnesium Oxide MgO	.13
Magnesium Mg .08	
Sulphur trioxide SO_3	.33
Sulphate SO_4 .39	
Sodium Oxide Na_2O	.16
Sodium Na .12	
	99.76

Hypothetical Combinations.	Per Cent.
Sodium Sulphate Na_2SO_4	.37
Magnesium Sulphate $MgSO_4$	.17
Magnesium Carbonate $MgCO_3$	.17
Calcium Carbonate $CaCO_3$	95.53
Oxides of Iron and Alumina $Fe_2O_3+Al_2O_3$	.86
Silicious Matter	.30
Moisture	.13
Loss on ignition less water+CO_2 Organic Matter	2.23
	99.76

AVERAGE OF THIRTY-SIX COMPOSITE ANALYSRS OF THE MINERAL CONTENT OF THE WATRR FROM THE MISSISSIPPI RIVER AT QUINCY, ILLINOIS.

Constituents.	Parts per Million.
Turbidity	176.
Suspended Matter	116.
Dissolved Solids	203.
Alkalies Na	12.
Magnesium Mg.	16.
Calcium Ca.	36.
Iron Fe.	.46
Nitrate NO_3	2.2
Chlorine Cl	4.5
Sulphate SO_4	27.
Bicarbonates HCO_3	175.
Silica SiO_2	36.

Hypothetical Combinations.	Parts per Million.	Grains per Gallon.
Sodium Nitrate $NaNO_3$	3.0	.17
Sodium Chloride NaCl	7.4	.43
Sodium Sulphate Na_2SO_4	25.6	1.49
Magnesium Sulphate $MgSO_4$	12.2	.71
Magnesium Carbonate $MgCO_3$	46.7	2.72
Calcium Carbonate $CaCO_3$	89.9	5.24
Iron Carbonate $FeCO_3$	1.0	.06
Silica SiO_2	18.0	1.05
Total Mineral Matter	203.8	11.87

That the reaction between the lime and the calcium bicarbonate occurs first is shown by the very small amount of magnesium in the incrustation. The great difference in the composition of the incrustation and the residue is shown by a comparative table.

COMPARISON OF THE PERCENTAGE COMPOSITION OF THE INCRUSTATION AND THE MINERAL CONTENT OF THE MISSISSIPPI RIVER WATER.

	Incrustation. Per Cent.	Mississippi River. Per Cent.
Sodium Nitrate $NaNO_3$	....	1.5
Sodium Chloride NaCl	....	3.6
Sodium Sulphate Na_2SO_4	.37	12.6
Magnesium Sulphate $MgSO_4$	.17	6.0
Magnesium Carbonate $MgCO_3$	.10	22.9
Calcium Carbonate $CaCO_3$	95.53	44.1
Oxide of Iron and Alumina $Fe_2O_3+Al_2O_3$	.86	....
Iron Carbonate $FeCO_3$	....	.5
Silica SiO_2	.15	8.8
Bases	.15	....
Moisture	.13	....
Organic Matter	2.35	....
Total	99.81	100.00

The preponderance of the calcium carbonate over the other crystalline salts is explained by the insolubility of its crystals and the greater solubility of the other crystalline salts, namely; sodium sulphate and magnesium sulphate. These substances, therefore, remain in solution. The preponderance over the non-crystalline substances, namely: the iron hydrate, formed by the iron sulphate and lime and the hydrates of aluminium and magnesium and the silica, is because the rapidity of the flow prevents these substances from becoming enveloped by the crystals of the carbonate. The small amount of magnesium carbonate is because the lime reacts, first with the calcium salts,* and the magnesium is not precipitated till the calcium is used up.

The experience at Quincy shows that such chemical reactions should not be allowed to take place in a water main, and also indicates the advisability of sufficient sedimentation capacity to allow the reactions to be completed.

*Bartow and Lindgren, Proceedings, Am. Water Works Assn., 1907, page 505.

CURRENT METHODS OF SANITARY WATER ANALYSIS.

ANDREW WATSON SELLARDS.

In recent years the knowledge of sanitary water analysis has undergone considerable modification. The analytical procedures and the conclusions to be drawn from them have grown complex and intricate instead of becoming simple and definite. The chemical problems involved are rather different from those in the ordinary lines of chemical investigation. Attention is not directed toward the detection of dangerous constituents of a water such as injurious chemical or bacterial products, or even if the pathogenic microorganisms could be recognized with certainty, such tests would be insufficient for basing an opinion of a water supply.

The results of the chemical and bacteriological analyses may frequently bear but little direct relation to each other. For example, in a water which is in excellent bacteriological condition, the ammonia content and other constituents may be very high. The reverse situation may also occur and these factors may be comparatively low in waters which are moderately polluted. In a previous article* it was noted that this lack of correlation could be partly obviated by modifications of the current methods of analysis. When water samples are inoculated into nutrient broth, the changes which take place in the media—such as ammonia formation—depend upon the bacterial condition of the inoculated samples and are practically independent of the ammonia content, for example, of the original sample. Hence, while there may be no relation between the ammonia content and the bacteriological condition of a water sample, yet the ammonia formed in artificial culture was at least approximately proportional to the bacterial condition of the water in question.

This paper will consider the practical application of this principle in connection with the various presumptive coli tests. For ascertaining the potability of a water there are two general types of

*J. Infect. Dis., Chicago, 1907, Supple. III, 41.
Univ. of Illinois Bulletin, State Water Survey, Series No. 6, p. 22.

fairly distinct procedures, namely: The sanitary survey and laboratory analysis. The value of the sanitary survey is evident. It not only materially supplements the interpretation of the bacteriological and chemical findings, but, in special cases, it may even be the deciding factor.

The laboratory procedures are rather sharply divided into bacteriological and chemical methods. In bacteriological work, the recognition of various intestinal forms has been suggested as an index of sewage pollution. Recently the work of Mereschkowsky* has emphasized the importance of the acidophilus group in the intestinal flora. The presence of B. coli, however, is still to be regarded as the most reliable index of pollution. Equal significance should, of course, be attached to the allied intestinal organisms which may differ somewhat from B. coli in their bio-chemical reactions. Some of these allied forms, such as B. cloaca, give the usual coli tests and possess certain additional activities, such as the power to liquefy gelatine. On the other hand, some groups, for example B. cob anaerogenes, may be overlooked because they fail to give the leading reactions, such as visible fermentation of glucose, by which the attention is usually directed to B. coli. Comparatively little is known as to the relative frequency of the occurrence of the B. coli anaerogenes in the human intestinal flora, but the error which would be introduced by overlooking it is probably not great. As to the laboratory methods for the detection of B. coli, it is of importance, firstly, that they should be fairly rapid. For many laboratories a period not longer than two days is desirable. Secondly, it is of importance to form some opinion of the numbers of B. coli which are present. There is room for some difference of opinion as to the amount of B. coli which should be necessary to condemn a water supply. The city of Baltimore, Md., with a fairly low typhoid fever death rate, uses an untreated river water from which B. coli can be constantly isolated from 1 c. c. quantities. The most advisable standard for this locality, however, is that recommended by Bartow,† which requires that B. coli must be constantly absent in 1 c. c. quantities. Such a standard should

*Mereschkowsky: Centralbl. f. Bakteriol. (etc.), Jena. 1905, XXXIX, 380, 534, 696 and 1906, XL, 118.

†Chemical and Biological Survey of the Waters of Illinois. 1908, p. 59.

effectively protect a community against wide-spread epidemics of typhoid fever. From a bacteriological standpoint then, the central problem in sanitary water analysis is the recognition of the colon group in mixed cultures by rapid methods which give some approximation of the numbers of colon bacilli present.

With glucose broth as a medium in the presumtive test for B. coli, confusion may arise between the intestinal bacteria and the common saphrophytes of the surface soil. Consequently this objection has been raised against the glucose broth test. The question arises then as to whether or not it is necessary to distinguish between pollution from the surface soil and sewage pollution. That is, should not a water supply be protected against surface drainage, and what significance, if any, should be attached to the presence of gas-forming bacteria from the surface soil, such as B. proteus vulgaris? The answer to this question would apparently depend upon the type of water supply under consideration. Thus, for shallow dug wells it is to be expected that, although very well protected, they might contain some gas-forming saphrophytes. On the other hand one does not expect to find any gas-forming bacteria in the deep driven wells of Illinois. These wells are usually from 100 to 1,000 feet deep and are driven in drift or drilled in rock, and are protected with iron casing. Examination of the bacterial content of these driven wells led to the conclusion that the original water supply was not unlikely sterile, and that any bacteria found in the water as delivered from the pump could be accounted for by the technical difficulties in maintaining asepsis during the lifting of the water through the pumping machinery. It must be emphasized, however, that even in the absence of B. coli it may be necessary to condemn a water supply upon the sanitary survey or upon the chemical analysis alone. On the other hand, certain cases may represent the opposite extreme, and it may be desirable to distinguish the pollution of human origin from that due to lower animals.

METHOD OF DISTINGUISHING THE ORIGINAL SOURCE OF AMMONIA AND NITRITES.

One of the disadvantages in the direct sanitary chemical analysis of a water is the difficulty, or the impossibility, of differentiating between the products of sewage pollution and normal constituents of the soil. Thus it is not only impossible to employ universal standards for limits of impurities, but even in the case of local standards the normal quantity may be so high and so variable that the slight increase which might be caused by pollution would not be greater than the limits of error in analysis or the range of normal variation.

It might be supposed, therefore, that any method which would distinguish between normal constituents of the soil and the same substances arising from bacterial pollution would offer some assistance in the interpretation of analytical data. Since the final decomposition products are the same chemical substances as may occur naturally in the soil, any laboratory method of differentiation must rest upon a bacteriological basis. The following method has been developed with especial reference to free ammonia and nitrites. If a water contains high free ammonia which is being produced by bacterial action, one should be able to continue this production by supplying the suitable food material. On the other hand, one may have a water high in ammonia content but almost free from bacteria which produce ammonia. Hence there is no agent to cause the further production of ammonia even in the presence of suitable food material. This principle was tested first with two samples of water, one of unquestionable purity from a deep well, and the other from a polluted stream. The bacteriological analysis of the deep well water showed 80 bacteria per c. c. on gelatine at 20°, with no gas formation in glucose broth. The chemical analysis gave 4.5 parts per million of free ammonia. For the polluted stream the bacterial count was 800 per c. c., with gas formation from .01 c. c. of the sample in glucose broth. The chemical analysis gave 1.2 parts per million of free ammonia.

The high ammonia in the deep well water is presumably derived from a deposit of glacial drift. The ammonia content of these two samples bears no relation to the bacterial condition of the waters in question. On inoculation into media a direct relation was at once seen between the ammonia formed in the culture and the character of the water under examination. To test the constancy of this relation, the reaction was tested on media of somewhat varying compositions. Subsequent results would indicate that the difference in the number of bacteria in the two samples was at least partly responsible for the difference in the amount of ammonia produced by the cultures.

TABLE I.

	Free Ammonia in Culture		Parts per Mil.
	Deep well	Polluted Stream	Sterile Media
Peptone 1% Neutral	125.	200.	20.
Beef Extract ½% Neutral	200.	400.	10.
Peptone 1% and Beef Extract ½% Neutral	250.	800.	20.
Peptone 1%, Beef Extract ½%, Gelatin 2%, Reaction 1% n/1 acid	400.	1250.	160.
Peptpone 5%, Beef Extract ½%, Reaction 1% n/1 acid.	125.	1250.	50.

The above cultures were incubated 63 hrs. at 37° C. At the end of this time the microscopic appearance was practically the same. An abundant growth having taken place in all of the tubes. Analysis was made by the Nessler process. One c. c. of the culture was diluted to 250 c. c. with ammonia-free water and 50 c. c. or an aliquot part, were nesslerized directly. The first two media gave especially poor results. The 5 per cent peptone gave much the best Nessler color. In all cases the ammonia in the sterile media has been subtracted from the amount found in the culture.

This experiment not only gives a method for distinguishing the source of origin of the ammonia in the two water samples, but it furnishes a definite method for studying the significance of the free ammonia determinations. The next step of importance is the determination of classes of bacteria which are active in prpducing free ammonia, with a special reference to the comparison of the intestinal bacteria and ordinary saphrophytes. For a preliminary test several pure cultures were inoculated into a 2 per cent peptone solution and incubated forty-eight hours at 37° C. Analyses were made by direct nesslerization, using a 1-250 dilution.

TABLE II.

BACTERIAL SPECIES.	FREE AMMONIA. Parts per mil.
Bacillus lactis aerogenes	125
Bacterium aerogenes	150
Bacillus megatherium	200
Bacillus subtilis	175
Bacillus typhosus	50
Bacillus coli (1)	75
Bacillus coli (2)	125

A more extensive series of cultures was inoculated into a broth medium described subsequently in connection with the nitrite experiments. Incubations were carried on for three days at 37° C. The analyses were made by nesslerization after distillation with sodium carbonate from 500 c. c. volumes of a 1-500 dilution.

TABLE III.

BACTERIAL SPECIES.		Parts per Million	
	*Fermentation Lactose	Free Ammonia	Free Ammonia Minus NH_3 in Media
B. coli (3)	15	800	200
B. coli (4)	20	800	200
B. coli (5)	30	1000	400
B. coli (6)	20	1100	500
B. coli (7)	25	1000	400
B. coli (20)	0	1000	400
B. coli anaerogenes	0	900	300
B. paratyphosus (a)	0	900	300
B. paratyphosus (b)	0	600	0
B. typhosus (a)	0	700	100
B. typhosus (b)	0	700	100
B. lactis aerogenes (b)	25	900	300
B. enteritidis	0	700	100
B. cloaca (c)	35	1400	800
B. cloaca (e)	3	1000	400
B. proteus vulgaris	0	800	200
B. megatherium	0	2000	1400
Staphylococcus pybgenes aureus	0	760	160
B. subtilis	0	800	200
B. mycoides	0	1920	1320
Sterile media	..	600	....
Blank on apparatus	..	0.004	....

Altough ammonia production is a very general property of baceria this table would indicate that the colon group is not especially active, giving even much lower results than ordinary saphrophytes such as B. megatherium and B. mycoides. This finding is of

* Percentage of gas in closed arm of a fermentation tube after 48 hrs. at 37° C. Throughout these experiments the letters and numbers after the bacterial species indicate cultures from different sources. These cultures were furnished by the courtesy of Dr. N. Mac L. Harris of the University of Chicago.

significance in its relation to the interpretation of analytical data. High free-ammonia determinations do not, therefore, in any way indicate the presence of intestinal bacteria, but are merely an indirect qualitative test for the presence of bacteria without giving any definite idea concerning the number or species present. Direct cultivation by bacteriological methods affords a much more definite procedure for obtaining this information.

The free-ammonia determinations are practically without value for the deep driven wells of Illinois. These wells are in excellent bacteriological condition. The normal free-ammonia content for this region, however, is so high (sometimes 30 parts per million) and so variable that the slight additional amounts, such as are ordinarily caused by pollution, would be insignificant. The access of badly polluted surface waters, or even of sewages, could readily act as a diluting fluid and diminish the concentration of ammonia.

On the other hand there are cases where the free-ammonia determinations afford a very delicate index of pollution, notably in lake waters where samples from the center furnish an accurate standard and changes near the shore can be readily detected. Aside from bacteriological considerations, the presence of free-ammonia may possibly be of value as an indirect evidence of the presence of organic matter.

NITRITE INVESTIGATIONS.

This same principle of analyzing cultures is also applicable in determining the origin of nitrites in a water. In case a water is nitrite free one is probably dealing with an extreme type, though it is not possible to say from the nitrite determination alone whether a given sample is in a very good or a very bad condition because the best potable waters and some sewages are nitrite free. Such a condition can be most easily explained by the supposition that the bacteria present in sewage are capable of destroying nitrites. For distinguishing between such extreme types of water, inoculation tests were applied in a manner somewhat analogous to the ammonia determinations. One of the simplest media for obtaining nitrite production is a nitrate broth solution, but since there are so many species of bacteria which reduce nitrates to nitrites, this test, like the free ammania determination, would have comparatively little differential value. The experiment was therefore modified so as to test, not for nitrite formation, but to observe the conditions under which nitrites are destroyed. A preliminary test was made upon the same samples of water used in the free ammonia experiments; namely, a polluted creek and a deep well. Except where otherwise noted the following technique has been uniformly employed throughout these experiments:

The medium used was an ordinary meat extract broth of double concentration with an acidity of 2% of normal acid, and to this was added 2% of gelatin and 0.05% sodium nitrite. Precautions were taken to adjust the final acidity before adding the sodium nitrite in order that any loss of nitrite during heating and sterilization might be uniform in different lots of media. No attempt was made to introduce inhibiting agents into the medium though preliminary results with ammonium chloride and glucose indicated that these substances might be used to advantage. Instead of the 1% concentration of glucose used in the fermentation tests, it appeared that concentrations of 10% or even 20% might have some slight selective action in the presumptive gas tests. Five c. c. of the broth were measured accurately into test tubes. Intermittent sterilization was employed. The medium was stored at a temperature of 8° and under these conditions it was solidified. Inoculations were made with 1 c. c. quantities of the waters to be tested or where pure cultures were used, the bacteria were inoculated directly without correcting for the volume of 1 c. c. used in the water sample. As in Table III, the letters and numbers after the bacterial species indicate cultures from different sources. Incubations were carried on at from 37° to 39° C, for 48 hours.

The nitrite determinations were made by the customary napthyl-amine-hydro-chloride and sulphanilic acid color method. It was originally planned to make careful quantitative analyses but the differences were so pronounced that this was unnecessary. The data in the tables represent only approximate determinations.

Analyses of the polluted creek and the well water gave results as follows:

	Nitrogen as Nitrites parts per million
Pure Well	25
Polluted Creek	0
Sterile Media	25

This experiment was repeated three successive times with similar results. A series of tests were then made upon pure cultures to determine whether or not the reaction is of any differential value.

TABLE IV.

Bacterial Species.	% Gas in Lactose Fermentation Tube	N as Nitrites parts per Million	
		3 Days	10 Days
B. coli (3)	15	12.5	0
B. coli (4)	20	0	0
B. coli (5)	30	0	0
B. coli (6)	20	0	0
B. coli (7)	25	0	0
B. coli (20)	0	0	0
B. coli anaerogenes	0	12.5	0
B. paratyphosus (a)	0	18.7	0
B. paratyphosus (b)	0	18.7	18.7
B. typhosus (a)	0	12.5	12.5
B. typhosus (b)	0	12.5	12.5
B. lactis aerogenes (b)	25	12.5	12.5
B. enteritidis	0	12.5	12.5
B. cloaca (c)	35	12.5	12.5
B. cloaca (c)	3	9.4	12.5
B. proteus vulgaris	0	12.5	12.5
B. megatherium	0	21.2	25.0
Staphylococcus pyogenes aureus	0	16.2	21.2
B. subtilis	0	18.7	12.5
B. mycoides	0	12.5	12.5
Sterile media	..	25.0	....

From this table it appears that, taken as a class, the intestinal bacteria are very active in destroying nitrites, whereas a comparison with Table III shows that, for the species tested, those which were most active in forming ammonia did not destroy nitrites.

DELICACY OF THE NITRITE TEST.

For testing the delicacy of the reaction for use in water analysis two general methods were employed, namely: 1. Determination of, (a) the maximum time for which the nitrites can exist in a media inoculated with unpolluted waters, and (b) determination of the minimum time in which a polluted water can destroy the nitrites present in the media. 2. Comparison of the reaction with other methods in detecting slight traces of artificial pollution.

Experiments by the first method gave well marked differences. In the case of four dug wells representing moderate pollution, the time required for the complete destruction of the nitrites varied from eighteen to thirty-six hours. Upon deep driven and carefully protected dug wells the time was much longer, ranging from four days to two weeks.

For testing the delicacy of the reaction by the second method, sterilized water was polluted artificially with pure cultures of B. coli and with sewage. Two cultures of coli were used, one of which fermented and one which did not ferment saccharose. Emulsions of the bacterial growth were made in water and. successive ten-fold dilutions prepared. One c. c. quantities of these various dilutions were then inoculated into fermantation tubes containing glucose broth and into nitrite media. In the case of the broth cultures the highest dilution of the. emulsions which gave gas formation was, in every case, also sufficient to completely destroy all the nitrites in the media within at least forty-eight hours. Tests upon diluted sewages gave less definite results. Altogether four different samples were tested. One c. c. samples gave gas production in glucose broth in dilutions 10 to 100 fold greater than could be recognized by the nitrite tests. In these high dilutions; however, the amount of gas formed was not typical of B. coli, being only about 20 per cent of the closed arm of the fermentation tube. Where gas production, typical of B. coli was obtained, the same dilution also gave complete destruction of nitrites within the forty-eight hour limit.

NATURE OF THE PROCESS BY WHICH NITRITES ARE REMOVED.

No attempt has been made to determine the exact nature of the changes which take place during the destruction of the nitrites. In the presence of B. coli oxidation to nitrates could hardly occur, since nitrates are rapidly reduced to nitrites by this organism. It is not improbable that the process is a reduction resulting in the formation of amines, ammonia and elementary nitrogen. The destruction of the nitrites in the medium depends upon the growth of bacteria,. and it seems advisable to characterize the reaction as a fermentation. It is possible, of course, that reducing substances such as dissolved oxygen in the inoculated water sample might be responsible for the changes which occur. This possibility is practically eliminated in cases where pure cultures are used. For the water samples, control tests also showed that bacterial growth is the essential factor. In one series where development was inhibited by chloroform, only a minimal reduction in the nitrite content was obtained, whereas, a series without chloroform gave complete destruction of the nitrites. Cultures were also tested in a medium of simpler composition, in view of the possibility that secondary bacterial changes might result in the production of a medium unstable toward nitrites, i. e., one of such chemical composition that nitrites as such could not exist in it. Samples of pure and polluted waters were inoculated into a solution, free from acid and containing 0.1 per cent peptone and 0.05 per cent sodium nitrite. Growth took place rather slowly, but after four days the nitrites were destroyed in both samples. This result was obtained repeatedly. It is an open question, therefore, whether the destruction of nitrites results from direct bacterial action or from secondary processes. In the preparation of the original culture media it is important to note that it must, of course, be stable toward sodium nitrite. Consequently, the amount of acid which can be used in the medium depends largely upon the quantity of albumen present. In a simple broth medium the addition of the usual 1 per cent normal acid in the presence of sodium nitrite liberates nitrous acid from the solution. The addition of albuminous-like material is sufficient to bind the acid as acid-albumin and protect to a large extent the sodium nitrite. The reaction time for the destruction of a given quantity of nitrites in the cultures is a purely arbitrary period and can be varied at will by adjusting the quantity of albuminous material and the quantity of acid used in the medium. Relatively slight variations from the medium used gave results wholly without value. The optimum acidity in a culture medium depends, therefore, both upon the amount of acid and the amount of proteid present, that is, 1 per cent of free acid is a very different factor from 1 per cent acid albumen. It is hoped that by altering the amount of acid, the amount of albuminous material or the quantity of sodium nitrite, that the reaction time of forty-eight hours might be reduced to twenty-four hours.

APPLICATION OF THE NITRITE TESTS.

The estimation of the value of any tests in water analysis frequently presents considerable difficulties. If the test is applied directly in routine work, where a large number of samples are examined, extreme waters give definite results, but variation will occur in the important border line cases. Unless a special study is made of such cases no final conclusions can be drawn. A somewhat detailed examination was made on five shallow dug wells.

One complete sanitary chemical analysis was made. The bacteriological tests were repeated every twenty-four hours for five days. Glucose broth was used for the presumptive coli test, making dup1icate inoculations of 1 c. c. quantities of each sample. The confirmatory cultures were not made as it was desired more especially to test the constancy of the presumptive test.

For this series wells were chosen which, judging from the sanitary survey, might be especially subject to variation. Four of the samples are taken from shallow dug wells lined with stones, and the fifth from a cistern. A is a 20-foot dug well open at the top and poorly protected from surface drainage. B is a 25-foot dug well, rather isolated from contamination. C is a spring with a small reservoir and pump. D is a 30-foot dug well, 20 feet from an open sewer and 25 feet from a privy and stable with drainage toward the well. E is a cemented cistern collecting water from a dwelling house. The weather conditions remained constant and no rainfall occurred during the five-day period of the experiment.

Table V gives the results of the chemical analysis:

TABLE V.

Sample	A	B	C	D	E
Laboratory No.	17790	17778	17802	17801	17800
Turbidity	30.	0	0	0	30.
Color	40.	0	10.	10.	300.
Odor	0	0	0	0	0
Residue on Evaporation	366.	380.	890.	507.	119.
Chlorine in Chlorides	48.	17.	45.	26.	2.
Oxygen Consumed	3.7	2.3	3.4	2.2	26.1
N as Free Ammonia	.030	.052	.072	.086	.256
N as Alb. Ammonia	.086	.108	.146	.106	.634
N as Nitrites	.005	.000	.060	.075	.000
N as Nitrates	10.000	8.400	15.940	1.375	.240
Alkalinity	127.	204.	253.	178.	22.
Bacteria per c.c.	450.	220.	240.	380.	480.
Colon Bacillus 10 c.c.	1+	1?	1+	1+	1+
Colon Bacillus 1 c.c.	1+	2 —	2+	2+	2 +
Colon Bacillus 0.1 c.c.	1+	1—	2?	2—	1+1?
Indol	+	—	+	+	—

Some of the colony counts showed considerable variation from day to day.

TABLE VI.

Sample.	Day of Analysis.				
	First	Second	Third	Fourth	Fifth
A	450	5480	48000	50000	4000
B	220	19	106	470	280
C	7000	380	240	350	136
D	28000	640	380	800	400
E	4400	440	480	510	400

The results of the $NaNO_2$ and glucose fermentation tests are grouped in the following table. Plus and minus signs or a question mark are used to indicate whether or not the fermentation tests showed contamination or gave an indefinite result:

TABLE VII.

FERMENTATION TESTS WITH SODIUM NITRITE AND GLUCOSE BROTH.

Day of Analysis.

Sample	First		Second		Third		Fourth		Fifth	
		Glucose Broth	Nitrites parts per million	Glucose Broth	Nitrites parts per million	Glucose Broth	Nitrites parts per million	Glucose Broth	Nitrites parts per million	Glucose Broth
A	*X	+	0	+	0	+	0	+	0	+
B	*X	—	18.7	—	18.7	?	25	—	25	?
C	*X	+	0	+	0	+	0	?	0	+
D	*X	+	0	+	0	+	0	+	0	+
E	*X	+	0	+	0	+	0	?	0	?

In Tables VI and VII the analyses on successive days show some striking variations. Some of the colony counts, especially on samples A and D, are entirely inconsistent. The glucose broth tests were particularly liable to indefinite results. In Table VII the nitrite tests gave very definite end reactions and entirely consistent results.

Although incomplete routine tests are not well adapted for comparisons of the finer details of different methods, yet they afford

* Nitrite tests not made.

a ready means of forming some approximate idea of the general course of any given procedure. With this object in view the nitrite test has been carried out on the regular routine samples received for examination by the State Water Survey. These samples are shipped by various citizens from all parts of the state. The Survey supplies bottles properly prepared for collection. The bacteriological samples are packed in ice and usually reach the laboratory within twenty-four hours after collection. The routine analysis consists of complete sanitary chemical and bacteriological examination according to the methods recommended by the American Public Health Association.*

The results of the first series are shown in Table VIII:

*J. Infect. Dis., Chicago, 1905, Supple. I, 1.

TABLE VIII.

Laboratory No.	Source.	Appearance.			Total Solids.	Chlorine.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Nitrite fermentation tests. Parts per mil	Presumptive B. coli test	Bacteria per c. c.	Indol.
								Ammonia.								
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrates.	Nitrites.					
17838	Creek-Raw	60	70	Pu	304	36	20.8	3.600	3.200	.400	.000	144	0	+	....	+
17839	Creek-Filtered	0	0	Pu	238	43	4.4	4.600	.376	.231	.009	47	25	—	....	—
17840	Lake	10	0	0	155	5	1.9	.044	.248	.240	.000	114	3.7	+	....	+
17841	Well 38' drilled	0	0	0	569	58	1.5	.040	.104	1.906	.014	347	0	+	....	+
17842	Well 32' d. & b.	5	70	1E	391	14	4.4	1.600	.144	.280	.000	345	0	?	....	+
17843	Well 35' d. & b.	0	0	0	934	133	2.0	.056	.136	16.000	.000	329	0	+	....	+
17845	Well 30' dug.	0	0	0	1257	85	2.3	.070	.130	6.980	.020	312	0	+	....	+
17846	Well 20' dug.	0	0	0	1285	131	1.5	.046	.082	36.000	.002	270	25	+	....	+
17847	Well 12½' dug	0	0	0	1244	103	1.6	.022	.092	35.977	.023	231	0	+	....	+
17848	Well 20' dug	0	0	0	1378	94	1.7	.040	.088	24.000	.004	248	0	+	....	+
17849	Sanitary Well	0	0	0	388	10	.5	.040	.056	2.400	.003	265	0	+	....	+
17850	Well 52' d. & d.	0	0	0	1755	101	1.8	.032	.072	2.040	.005	355	0	+	....	+
17851	Well 25' dug	0	0	0	495	29	1.7	.058	.122	1.550	.170	214	0	+	....	+
17852	Well 35' driven	10	60	0	760	50	.9	.056	.056	.200	.001	270	25	—	60	—
17853	Well 20' dug	0	10	0	986	50	1.4	.244	.104	19.540	.460	191	0	+	350	+
17854	Well 24' dug	0	0	0	335	8	1.5	.068	.096	3.600	.001	236	0	+	240	+
17855	Well 45' dug	30	20	0	913	89	1.3	.016	.096	27.964	.036	323	0	+	....	—
17856	Well 34' dug	0	30	E	550	142	4.4	.321	.192	1.620	.260	238	0	+	27,200	+
17857	Spring	20	70	0	3496	45	3.4	1.320	.176	.160	.000	acid	25	—	....	—
17858	Cistern	0	100	0	401	39	8.0	.180	.322	3.760	.004	86	0	+	1,200	+
17859	Well 28' dug	100	120	0	474	20	7.0	10.112	.306	.120	.002	396	0	+	....	+
17860	River	90	140	0	244	3	4.6	.096	.442	.280	.003	144	0	+	1,240	+
17861	River-Filtered	0	40	0	157	3	5.3	.044	.242	.200	.000	114	25	—	38	—
17862	River-Filtered	0	30	0	169	3	5.5	.092	.246	.520	.000	110	0	+	7,200	—
17863	River	20	50	0	306	41	3.7	.086	.232	.560	.006	172	0	+	3,900	+
17864	River	20	40	0	321	41	4.1	.086	.292	.560	.005	174	0	+	1,140	+
17865	River	5	50	0	289	39	3.4	.056	.360	.640	.002	171	0	—	4,440	+
17866	Well 35' dug	0	0	0	153	10	1.1	0.32	.056	.520	.000	80	0	+	6,400	—
17867	Well 35' dug	0	0	0	398	26	1.1	.016	.064	3.200	.000	156	12.5	?	1,720	—
17868	Deep Wells	0	10	0	366	20	1.0	.032	.064	.680	.000	235	25.	—	64	—
17869	Deep Well	0	10	0	360	20	1.2	.032	.048	.680	.001	229	25.	—	28	—
17870	Well 93' drilled	100	80	0	490	3	6.6	1.400	.232	.160	.001	456	25.	—	5	—

17871	Well 107’ drilled	5	70	0	381	13	6.4	1.400	.160	.240	.000	342	25.	—	2	—
17872	Dug Well	0	10	0	1802	120	1.3	.050	.116	34.000	.002	360	25.	—	220	—
17873	Well 38’ drilled	0	0	0	658	41	1.2	.072	.080	.280	.040	297	25.	—	16	—
17874	Well 83’ drilled	20	50	0	361	3	3.8	1.600	.184	.223	.017	355	0	—	2,480	—
17875	Well 285’ drilled	20	140	0	530	47	6.5	.512	.200	1.200	.720	206	18.7	—	820	—
17876	Well 22’ dug	0	0	0	481	29	1.6	.050	.088	2.640	.000	282	0	+	4,400	+
17877	Well 25’ dug	0	0	0	777	29	1.5	.040	.098	14.000	.000	297	0	?	500	—
17878	Well 101’ drilled	0	0	0	968	204	1.5	.056	.072	14.000	.005	355	25.	—	120	—
17879	Well 101’ drilled	0	10	0	993	206	1.2	.064	.104	11.200	.006	355	18.7	—	420	—
17880	Well 101’ drilled	0	0	0	1008	206	1.2	.024	.072	16.000	.004	360	25	—	22	—
17881	Well 100’ drilled	0	0	0	534	20	.9	.024	.064	3.200	.000	329	12.5	—	52	—
17882	Well 140’ drilled	5	40	0	665	168	7.9	1.000	.288	.240	.000	355	25.	+	360	—
17883	Well 45’ bored	0	0	0	601	69	.6	.048	.088	8.000	.004	381	0	+	65	—
17884	Well 27’ dug	30	120	0	699	54	7.2	4.304	.386	.463	.017	503	0	+	10,000	+
17885	Well 257’ bored	20	300	0	1248	520	27.4	3.700	.640	.160	.000	445	18.7	—	3	—
17886	Well 30’ dug	20	80	0	535	26	5.9	6.396	.278	.160	.002	470	0	+	1,500	+
17887	29’ d. b. & d.	0	0	0	506	43	2.1	.042	.092	6.356	.044	248	18.7	?	....	
17888	Well 20’ dug	0	10	0	666	82	1.4	.032	.092	6.400	.001	336	0	?	4,000	+
17890	Well 48’ dug & bored	0	0	0	698	37	1.3	.040	.080	16.000	.001	250	18.7	?	120	+
17891	Well 38’ d. & b.	0	0	0	732	37	1.1	.072	.084	7.200	.000	218	0	+	700	+
17892	Well 30’ dug	5	10	0	634	23	2.4	.444	.074	.320	.000	475	0	?	100	—
17893	Well 47’ d. & b.	0	0	0	509	18	1.6	.016	.080	17.200	.000	223	18.7	+	120	+
17894	Well 30’ dug	0	0	1Mu	816	73	1.0	.038	.104	8.000	.000	218	0	?	500	—
17895	Well 28’ driven	0	0	0	728	13	.7	.042	.156	1.600	.000	374	18.7	—	40	—
17896	Well 64’ d. & b.	0	10	0	1549	114	2.8	.040	.136	55.968	.032	103	18.7	—	400	+
17897	Well 32’ driven	25	60	0	382	24	.7	.072	.048	.200	.000	257	18.7	+	550	+
17898	Well 664’ drilled	40	60	H S	1423	360	25.4	1.280	.064	.280	.000	740	12.5	+	100,000	—
17899	Well 59’ drilled	40	150	0	751	26	1.5	.112	.128	.200	.000	282	25.0	—	180	—
17900	Well 16’ drilled	0	10	0	812	42	1.7	.036	.126	14.991	.009	263	18.7	—	5,000	—
17901	Deep Well	20	120	0	544	57	5.4	4.000	.160	.218	.022	413	18.7	—	20,000	—
17902	Deep Well	20	120	0	513	50	6.1	4.800	.216	.188	.012	406	16.2	—	10,000	—
17903	Deep Well	20	150	0	469	4	5.8	5.200	.176	.200	.000	430	18.7	—	175	+
17904	Deep Well	10	80	0	517	47	5.8	4.640	.176	.244	.036	404	18.7	—	2,000	+
17905	Well 140’ bored	10	140	0	364	4	3.2	.768	.080	.120	.000	366	25.	—	600	—
17906	Well 30’ dug	0	10	0	2789	600	1.4	.024	.128	143.964	.036	255	18.7	?	600	+
17907	Deep Wells	0	20	0	903	270	1.1	.280	.080	.271	.009	244	18.7	?	230	+
17908	Deep Wells	0	10	0	925	270	.9	.320	.064	.280	.001	259	18.7	—	650	+
17909	Lake Michigan	20	10	0	174	6	1.7	.024	.112	.160	.000	122	16.2	—	430	+
17910	Well 1600’ drilled	0	10	0	931	330	.9	.384	.040	.160	.006	244	18.7	—	4	—
17911	Deep Wells	5	10	0	908	260	1.5	.064	.104	.240	.001	248	18.7	?	275	+
17912	Deep Wells	0	0	0	278	9	.7	.024	.064	.200	.000	157	18.7	?	320	+
17913	Well 28’ dug	40	70	0	939	8	2.7	.800	.080	.217	.023	233	0	+	2,000	+
17914	Well 30’ dug	30	0	0	349	18	2.4	.200	.064	.240	.000	137	0	+	750	+
17915	Lake Michigan	0	0	0	494	46	2.0	.024	.064	3.566	.034	246	0	—	200	+
17916	Lake Michigan	....	....	....	......	......	......	......	......	......	......	......	18.7	+	2,500	+
17917	Spring	....	....	....	......	......	......	......	......	......	......	......	18.7	—	80	—

TABLE VIII—CONTINUED.

Laboratory No.	Source.	Appearance.			Total Solids.	Chlorine.	Oxygen.	Nitrogen as				Alkalinity.	Nitrite fermentation tests. Parts per mil.	Presumptive B. coli test.	Bacteria per c. c.	Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrates.	Nitrites.					
17918	Well 35' dug	....	....	....	......	.....	......	......	....	....	......	.....	0	+	500	+
17919	Well 30' dug	....	....	....	......	.....	......	......	....	....	......	.....	0	+	3,000	+
17920	Well 40' dug	....	....	....	......	.....	......	......	....	....	......	.....	0	—	6,000	+
17921	Cistern	0	0	0	434	15	1.3	.044	.068	5.200	.000	280	0	—	40,000	+
17922	Well 30' dug	5	10	0	622	85	2.8	.016	.088	10.000	.004	280	0	?	1,500	+
17923	Well 25' bored	0	10	0	471	69	1.5	.280	.106	7.972	.028	255	12.5	—	470	+
17924	Well 22' dug	0	0	0	563	7	1.6	.016	.056	8.800	.000	203	0	+	1,000	+
17925	Well 33' dug	....	....	....	......	.....	......	......	....	....	......	.....	12.5	—	340	+
17926	Well 20' dug	....	....	....	......	.....	......	......	....	....	......	.....	12.5	+	600	+
17927	Well 140' bored	0	0	0	204	10	1.3	.010	.075	.560	.000	101	0	+	1,800	—
17928	Well 280' bored	....	....	....	......	.....	......	......	....	....	......	.....	0	+	600	+
17929	Well 26' dug	....	....	....	......	.....	......	......	....	....	......	.....	12.5	—	750	+
17930	Well 20' dug	....	....	....	......	.....	......	......	....	....	......	.....	0	+	1,200	+
17931	Well 24' dug	....	....	....	......	.....	......	......	....	....	......	.....	0	+	400	+
17932	Well 35' dug	....	....	....	......	.....	......	......	....	....	......	.....	0	+	1,350	+
17933	Well 26' dug	....	....	....	......	.....	......	......	....	....	......	.....	18.7	+	300	+
17935	Well 98' drilled	....	....	....	......	.....	......	......	....	....	......	.....	12.5	+	60	+
17936	Well 1½' dug	....	....	....	......	.....	......	......	....	....	......	.....	18.7	?	800	+
17937	Well 17' dug	....	....	....	......	.....	......	......	....	....	......	.....	0	+	400	+
17938	Well 18' dug	0	10	0	635	93	2.8	.028	.130	11.996	.004	221	0	+	8,000	+
17939	Well 22' dug	0	30	0	911	395	4.3	.066	.116	.778	.022	110	20	+	4,200	+
17940	Well	90	20	0	1795	94	6.2	.024	.160	16.000	.000	370	0	?	600	+
17941	Well 176' drilled	0	20	0	708	8	1.9	.576	.096	.200	.005	144	25	—	60	—
17942	Well 1761' drilled	0	0	0	743	7	2.2	.024	.064	.372	.028	131	0	+	18	—
17943	Well 26' dug	0	10	0	4646	117	2.0	.068	.124	.640	.000	500	25	—	700	+
17944	Well 172' drilled	20	0	0	3012	1580	4.7	.960	.040	.240	.000	439	0	—	2,400	—
17945	Well 50' bored	20	60	0	312	5	.9	.200	.040	.160	.000	297	0	?	1,200	—
17946	Well 25' dug	0	0	0	546	16	.7	.028	.064	7.200	.000	236	18.7	+	500	+

17947	Lake Michigan	10	0	0	153	6	2.8	.032	.112	.320	.000	116	18.7	—	2	+
17948	Well 1600' drilled	0	0	0	858	250	1.2	.096	.048	.360	.004	251	18.7	—	400	+
17949	Well 1600' drilled	0	10	0	858	250	2.3	.280	.112	.160	.008	255	0	+	750	+
17950	Well 1600' drilled	0	0	0	881	250	.5	.096	.072	.400	.000	250	18.7	—	100	+
17951	Well 1600' drilled	0	0	0	747	230	1.0	.304	.048	.200	.001	317	25	—	30	—
17952	Well 130' drilled	40	80	Hy.	555	4	3.2	3.040	.104	.200	.000	520	18.7	—	50	—
17953	Well 130' drilled	40	50	0	526	3	2.7	3.040	.072	.200	.000	524	25	—	10	—
17956	Well 27' dug	0	10	0	1804	340	.9	.020	.050	80.000	.003	214	18.7	?	200	+
17957	Well 24' dug	0	10	0	1633	138	2.2	.050	.456	70.000	.003	321	18.7	?	300	—
17958	Well 999' drilled	0	10	0	290	14	.8	.056	.040	.520	.005	250	18.7	?	50	—
17959	Well 40' dug	0	0	0	1068	95	.6	.032	.120	27.990	.010	214	0	+	200,000	+
17961	Well 26' dug	0	0	1 Mu	1113	138	1.2	.138	.044	1.732	.028	298	0	+	100,000	+
17962	Well 20' dug	0	0	0	724	27	.8	.052	.088	6.800	.000	210	16.2	?	....	+
17963	Lake Michigan	20	0	0	199	6	2.3	.018	.088	.240	.001	116	16.2	?	....	+
17964	Lake Michigan	0	0	0	190	6	1.0	.024	.086	.280	.000	116	18.7	—	....	+
17966	Spring	20	30	0	292	4	2.2	.314	.102	.400	.000	317	0	+	....	+
17967	River	40	50	0	266	4	8.8	.074	.362	.232	.008	146	0	+	....	+
17968	River	0	30	0	103	4	6.6	.070	.216	.320	.000	94	3.7	?	....	+
17969	Well 20' dug	....	....	....	......	.....	......	......	......	....	......	.....	0	+	....	+
17970	Well 25' dug	....	....	....	......	.....	......	......	......	....	......	.....	12.5	+	....	+
17972	Well 35' driven	0	0	0	282	10	1.3	.016	.040	7.132	.068	157	18.7	—	....	—
17973	Well 30' driven	0	0	0	304	8	1.3	.010	.046	2.594	.046	231	0	+	....	—
17974	River	40	40	0	373	10	5.0	.216	.280	.272	.008	282	0	+	....	—
17975	River	0	10	0	332	11	3.0	.056	.218	.480	.000	278	18.7	—	....	—
17976	River	0	10	0	326	10	4.0	.050	.308	.320	.000	278	18.7	+	....	—

For Norman see Table IX.

The indol tests have been carried out in accordance with the recommendation of Mason.* It will be seen that they follow a very bizarre course in regard both to the presumptive coli test and to the source of the water.

In the nitrite inoculation tests it appears that the reduction of 25 to 50 per cent of the total nitrites present is effected rather easily. Beyond this point the nitrites either persist for several days or the reduction is completed within a few hours. In two cases where 3.7 parts of nitrite is recorded it is probable that in the course of a few hours this amount would have disappeared entirely. The amount actually remaining was so small that this result did not seem indefinite and was classed as agreeing with the positive glucose broth tests. With this exception the results are considered as negative, for intestinal bacteria, where any nitrites were found and positive in those cases where the destruction was complete.

The results given in Table VIII may be classified as follows:

RESULT.	METHOD.	
	Glucose Broth	$NaNO_2$ media
	Number Per cent.	Number Per cent.
I. Positive	60-46	62-47
Negative	50 } 54	69-63
Indeterminate	21 }	None

		No.	Per cent.
II. Agreements		91	69
Disagreements		19	15
Indeterminate	Glucose media	21	16
	$NaNO_2$ media	0	0
	Total	131	

On account of the rather large indeterminate class, the presumptive coli tests were extended to include lactose bile, as well as the glucose broth medium; with the expectation of securing more decisive results. Three glucose broth tubes were inoculated, using 1 c. c. quantities for each of two tubes; and 0.1 c. c. for the third one and two tubes of lactose bile, prepared according to Jackson's† method, were inoculated with 1 c. c. quantities each. The data from

*Mason : Examination of water. 3rd Ed. 1906, p. 123.
†Jackson : Biol. Stud., W. T. Sedgewick. 25 Anniv., Best., 1900, p. 292.

TABLE IX. SANITARY WATER ANALYSIS, INCLUDING SPECIAL FERMENTATION TESTS.

Laboratory No.	Source.	Appearance.			Total Solids.	Chlorine.	Oxygen Consumed.	Nitrogen, as				Alkalinity.	Nitrite fermentation tests. Parts per mil.	Presumptive B. coli test	Bacteria per c. c.	Nitrite fermentation test on uniced sample. Parts per mil.
								Ammonia.								
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrates.	Nitrites.					
17985	Well 18' dug	5	70	0	1794	13	1.6	.066	.042	.320	.000	381	25	—	10	18.7
17986	Well 32½' dug	10	10	0	2122	92	2.2	.048	.124	6.400	.002	321	0	+	500	0
17987	Well 28' dug	0	0	0	442	54	1.9	.040	.086	24.000	.003	244	18.7	+	400	18.7
17989	Well 35' drilled	5	10	0	439	85	2.4	.016	.088	11.188	.012	270	0	+	750	25.0
17990	Well 20' bored	10	40	0	1134	56	3.5	.062	.144	23.952	.048	221	18.7	—	50	25.0
17991	Well 13' dug	0	0	Veg	861	68	2.2	.040	.068	7.189	.011	280	18.7	?	375	18.7
17992	Well 62' bored	400	30	E	818	7	21.4	.272	.640	.560	.000	289	0	+	2,500	25
17993	Well 25' bored	20	40	0	1222	132	3.2	.062	.190	23.983	.017	109	0	+	2,000	0
17994	Well 30' dug	0	0	0	497	98	1.9	.018	.058	7.185	.015	154	25	—	200	25
17996	Well 25' dug	0	0	0	1294	57	1.6	.010	.070	30.000	.000	238	25	?	600	25
17997	Deep well	0	0	0	685	220	1.6	.104	.048	.560	.002	251	25	—	80	25
17998	Lake Michigan	5	0	0	147	6	2.3	.016	.088	.440	.000	112	25	—	320	25
17999	Deep wells	0	10	0	880	216	1.3	.088	.048	.480	.000	257	25	—	10	25
18000	Well 1568' drilled	0	0	0	878	202	1.2	.320	.040	.360	.040	270	25	—	......	25
18002	Well 61' bored	30	120	0	439	18	4.5	6.000	.240	.320	.000	396	25	—	600	25
18003	Well 630' drilled	40	200	0	1047	370	1.1	1.040	.032	.200	.000	283	25	—	10	25
18004	Spring	0	0	0	351	7	2.0	.024	.064	.640	.000	272	25	—	900	25
18005	Spring	0	0	0	458	5	.5	.064	.064	1.960	000	345	25	—	18	25
18006	Well 55' driven	20	100	0	462	18	1.9	.016	.064	.240	.000	338	25	—	400	25
18007	Sewage	30	40	E	951	224	9.6	6.400	1.200	1.900	.500	370	25	—	1,000	25
18009	Spring	0	0	0	808	35	2.9	.032	096	8.785	.015	297	25	—	4,000	25
18010	Well 185' bored	100	140	0	461	4	7.9	4.800	.144	.200	.000	423	25	—	100	25
18012	Well 30' dug	5	20	0	876	53	.9	.334	.144	.800	.000	321	0	+	850	0
18013	Well 75' d. & b.	0	20	0	442	19	2.4	.640	.144	1.016	.024	374	25	—	40	18.7
Normal																
Lake Michigan		1	0	0	150	4.5	1.6	.01	.08	.04	.000	120	..	—	100	
Streams		10	.2	0	300	6	5.	.05	.15	.5	.000	200	..	—	500	
Springs and shallow wells		0	0	0	500	15	2.	.02	.05	2.00	.000	300	..	—	500	
Drift wells		0	0	0	500	15	2.-5.	.02-3.	.20	.50	.005	300	..	—	100	
Deep rock wells		0	0	0	500	5+	2.-5.	.02-3.	.15	.5	.000	300	..	—	100	

the two sets of media were not sufficiently varied to justify separate classification and the results recorded in table are the final conclusions from the two sets of media.

Although the nitrite test in any given culture has given a definite end reaction, it is desirable, of course, to know whether or not duplicate inoculations would give anomalous results, such as frequently occur in the sugar fermentation tests.

Some data upon this point were obtained in a series of inoculations to test the possibility of shipping united samples for fermentation tests. The iced sample was examined in the usual manner and then allowed to stand at summer temperature—about 20° to 28°. At the end of twenty-four hours a second tube of nitrite media was inoculated and analyzed after a forty-eight hour incubation period.

The following is a general summary of the results of the series:

	Result.		Method. Gas Tests No.	Gas Tests Percent.	$NaNO_2$ medium No.	$NaNO_2$ medium Percent.
I	Positive		6	25	5	21
	Negative		16	75 (Negative and Indeterminate)	19	21
	Indeterminate		2			
II	Agreements		21			88
	Disagreements		1			4
	Indeterminate	$NaNO_2$ media	None			8
		Gas test	2			None
	Total		24			

III. Comparison of iced and uniced samples.

	Number	Per cent
Agreements	22	92
Disagreements	2	8
Indeterminate	None	None
Total	24	

THE USE OF INHIBITING AGENTS.

The desirability of selective inhibiting agents for use in the presumptive coli tests has long been recognized. Of all such agents naturally the most rational are those which occur normally in the intestinal tract, such as phenol, for example, and the bile salts. The use of phenol has gradually fallen into disrepute in delicate work. MacConkey* first proposed the use of bile salts. This method has

*MacConkey: Thompson Yates Lab. Rep., Liverp.. 3, Part I, 41, Part II, 151, and 4, Part II, 151.

been modified and advocated especially by Jackson,* who uses undiluted bile to which 1 per cent of milk sugar has been added. This medium for the presumtive coli tests has been compared especially with 1 per cent glucose broth solution recommended by Smith. According to Jackson the chief advantages of the bile medium are that: (1) It prevents overgrowth of B. coli by other organisms, and gives positive results where the glucose medium fails. (2) It eliminates the non-intestinal forms of bacteria which imitate B. coli. (3) It gives a definite reaction and diminishes the number of anomalous results.

All the observations tend to show that the use of bile media materially diminishes the number of cultures giving gas formation. Parker,† in a very complete investigation of the method, found in a series of waters that the positive presumptive tests with broth medium averaged rather higher than when lactose bile was employed and in sub-cultures from the fermentation tubes, this excess of positive tests could not be confirmed, whereas typical B. coli could be isolated from practically all of the bile tubes which gave the presumptive test. Such a result appears, at first, as very convincing. There are, however, some possible sources of error which it is well to keep in mind. The glucose broth tubes, of course, were not pure, but were mixed cultures. The fermentation tests which are characteristic of B. coli in pure culture do not necessarily obtain in a mixed culture, but the gas formation may be atypical both with respect to the amount formed and also the rate of formation. In the tubes where the reaction could not be confirmed it is possible that the typical bacillus coli was present and may have given its characteristic reaction within the first twenty-four hours, as it usually does. Then in the subsequent overgrowth it may have been killed by antagonistic bacteria, or its proportions in comparison with the other bacteria present may have become so diminished that its isolation and recovery would be difficult or impossible. Such a course of events would be indicated in a case where no gas forming organisms were recovered in the sub-cultures from tubes giving gas production. This explanation would be analogous to a similar

*Jackson: Biol. Stud., W. T. Sedgewick. 25 Anniv., Bost., 1906, p. 202.
†Parker: Am. J. Pub. Hyg., Best., 1908, XVIII, 137.

possibility which Metchnikoff[1] has suggested in certain infectious diseases. [2]Weston and Tarbett report a similar series of comparisons together with sub-cultures for confirming presumptive tests. Including the typical and atypical cultures of bacillus coli, the glucose broth test never failed where the lactose bile gave. positive results, although the lactose bile failed in 30 per cent of the cases, as shown by the confirmatory tests from the glucose broth tubes. The presumptive test on glucose broth without the confirmatory tests would have given results which might have been 10 per cent too high. Prescott and Winslow[3] and Longley and Baton[4] also report definitely that in their experience lactose bile has proven to be a less delicate medium than glucose broth for the isolation of B, coli. Parker,[5] in the examination of 504 routine samples, obtained gas production in sugar media in 66 cases, but none of the samples gave as much as 25 per cent gas in bile media. Sawin[6] compared the relative value of these two methods and obtained better results with lactose bile for moderately polluted waters, but for slight degrees of pollution glucose broth gave equally good results. In a long series of analyses the use of lactose bile caused a reduction of two-thirds of the anomalous results.

There are several possible factors which may be active in reducing the number of positive tests obtained with lactose bile. The substitution of dextrose for lactose may exclude certain bacteria. Bile, a substance which is exceedingly variable in composition might fail, at times, to contain sufficient nutrient material. The bile salts may inhibit certain gas forming bacteria. Prescott and Winslow report that bile is not inimical to B. coli itself.

In the following experiments special attention has been directed toward the inhibitory action of bile. Inoculation into lactose bile of pure cultures of B. mycoides and B. megatherium showed no such action, but gave abundant growth within twenty-four hours. The first pure culture of B. coli which was tested formed only 5 per cent gas after three days at 37° C. Other intestinal bacteria than B.

[1]Metchnikoff: Immunity in Infectious Diseases. Tr. F. G. Binnie, 1905, p. 5.
[2]Weston and Tarbett: J. Infect. Dis., Chicago, 1907, Supple. III, 39.
[3]Prescott and Winslow: Am. J. Pub. Hyg., Bost., 1908, XVIII, 19.
[4]Longley and Baton: J. Infect. Dis., Chicago, 1907, IV, 397.
[5]Parker: Am. J. Pub. Hyg., 1909, XVIII, 137.
[6]Sawin: J. Infect. Dis., Chicago, 1907, Supple. III, 33.

coli, such as bacterium aerogenes, and B. lactis aerogenes, also formed gas in lactose bile. This result would be expected, and it is altogether desirable, as a sanitary water test, that the intestinal gas-forming bacteria should give the reaction. These experiments have been conducted according to the recommendations of Jackson.* No difficulty has been experienced in obtaining bile which conforms to the authors recommendation as regards acidity. On account of the poor results given with the pure culture of B. coli first used, it was decided to test a variety of intestinal bacteria obtained from various sources. The results of these tests after four days at 37° C. are as follows:

TABLE X.

	Amount of gas in % of closed arm of fermentation tube.	
	Lactose Broth	Lactose Bile
1. Bacillus lactis aerogenes (a)	15	20
2. " " " (b)	25	55
3. " " " (c)	30	75
4. Bacterium aerogenes	30	40
5. Bacillus cloaca (a)	20	0
6. " " (b)	20	5
7. " " (c)	35	trace
8. " " (d)	30	30
9. Bacillus coli (1)	35	3
" " (2)	25	0
" " (3)	15	20
" " (4)	20	40
" " (5)	30	35
" " (6)	20	30
" " (7)	25	10
" " (8)	15	12
" " (9)	10	0
" " (10)	35	60
" " (11)	18	20
" " (12)	20	45
" " (13)	15	20
" " (14)	20	40
" " (15)	25	50
" " (16)	10	50
" " (17)	15	0
" " (18)	25	30
" " (19)	30	60

In a number of cases it is to be noted that the per cent of gas formed by B. coli in the bile medium is much larger than in lactose broth. It might appear from this that bile favors the growth of B. coli. Freshly isolated cultures of B. coli, however, frequently fail to ferment lactose actively though this power is developed later and the larger per cent of gas in the bile tubes might be due to the fermentation of traces of glucose.

*Jackson: Am. J. Pub. Hyg., Bost., 1908, XVIII, 16.

Of the twenty-six cultures giving gas on lactose broth, seven, or about 27 per cent, failed to give more than 5 per cent of gas on lactose bile. Of the nineteen pure coli cultures, four, or 21 per cent, failed to react in the lactose bile. Comparisons were then made of the relative delicacy of the lactose bile and lactose broth for some of the cultures which had given gas formation in lactose bile when inoculated in large quantities. The following ones were selected: B. lactis aerogenes (b), B. cloaca (d), and B. coli. Nos. 3, 4, 5, 6 and 10. Emulsions were prepared in sterile water and successive ten-fold dilutions arranged. Duplicate inoculations of 1 c. c. each were made from the various dilutions into lactose broth and lactose bile. After three days at 37°C. the results were as follows:

TABLE XI.

	Bacterial Species. Highest dilution developing gas.	
	Lactose Bile	Lactose Broth
1. B. Lactis aerogenes (b)	1-10,000,000	1-10,000,000
2. B. Cloaca (d)	1-1,000	1-100,000,000
3. B. Coli (3)	1-100	1-100,000,000
4. " " (4.)	1-100,000,000	1-1,000,000,000
5. " " (5)	1-10,000,000	1-100,000,000
6. " " (6)	1-100,000,000	1-10,000,000
7. " " (10)	1-10,000,000	1-1,000,000,000

Of these seven cultures it is to be noted that the lactose bile was markedly less delicate for B. cloaca (d) and B coli (3). This theoretical evidence indicates that the lactose bile in pure cultures inhibits the growth of B. coli. A series of tests on thirty-five water samples representing various types of water from different sections of Illinois gave results similar to those reported by the observers previously cited. The number of samples giving the presumptive tests were smaller than with glucose broth and anamolous results were about equally frequent in either medium.

One c. c. quantities of each sample were inoculated in duplicate into each medium. The following is a classification of the results. Under "indeterminate" are included all contradictions between duplicate tubes on the same medium, and also those cases where the bile tubes developed from 5 to 15 per cent of gas:

MEDIUM.

Results of Tests.	Lactose Bile.	Glucose Broth.
Positive	3	8
Negative	26	20
Indeterminate	6	7

Relation between lactose bile and glucose broth results:

Agreements	23
Disagreements	3
Indeterminate	9

The conclusions, then, in regard to lactose bile depend upon the type of water in question. The bile media is to be recommended for work with sewage and badly polluted waters. In relatively slight degrees of pollution it is not sufficiently delicate. In such cases apparently no one has found that it gives positive results when glucose broth tests fail. The disadvantages of depending upon the bile test alone would rest on the dangerous side, and its use should be restricted to its value as a positive test for B. coli. In duplicate tubes, anomalous results may occur. The test occupies a rather long period of time. Frequently the three-day limit is not sufficient and must be extended for those tubes which have developed perhaps only 10 per cent of gas. The end reaction is rather doubtful in these cases if no further development occurs. Bile is only a relatively selective agent, inhibiting some traces of B. coli and permitting the growth of certain species of saphrophytes.

METHODS OF QUANTITATIVE ESTIMATION OF BACTERIA.

The presumptive tests for B. coli are still further complicated by the necessity of forming some approximate idea of the quantity of B. coli present. The direct colony counts for the enumeration of bacteria are hardlly applicable for any given organism in mixed culture. For B. coli, aside from the amount of work involved, the direct plating of a water sample on sugar-agar containing an indicator for acids gives a rather less delicate test than when the sample is first enriched in glucose broth. The enrichment, of course, destroys the original quantitative relations. One of the simplest quantitative procedures, therefore, is the determination of the minimum quantity of a sample from which B. coli can be isolated. The problem is somewhat simplified if a standard of one colon bacillus per c. c. is determined upon as a maximum limit of contamination.

The possibility of the approximate quantitative estimation of bacteria by methods other than the customary colony bount, is suggested by certain reactions which are more or less proportional to the quantity of bacteria present. Some of the biological phenomena, such as the agglutination tests, bear a remote relation to the number of bacterial cells present. Of the chemical reactions, the quantitative estimation of the products of bacterial growth in culture media, might show some proportion between the number of bacteria which were inoculated and the amount of chemical change. The rapid changes in nitrites in culture did not appear especially favorable for this quantitative work. Determinations in the usual manner of the free-ammonia in forty-eight-hour cultures of sewage dilutions of 1-1,000 and 1-10,000 gave 344 and 40 parts per million, respectively.

A series of fermentation tubes, inoculated with successive tenfold dilutions of coli cultures during the early hours of growth, showed some proportion between the amount of gas formed and the number of bacteria inoculated. Ultimately, after equilibrium had become established, the amount of gas showed little relation to the dilution employed.

TABLE XII.

Gas Formation. % Closed Arm.

Bacterial Species.	B. coli (3)		B. coli (1)		B. coli (1)	
Age of Culture.	16 hrs.	3 days	10 hrs.	20 hrs.	24 hrs.	48 hrs.
Dilution of emulsion 1 to						
0	10	30	20	25	50	50
10	tr.	15	10	20	20	25
100	0	10	5	30	40	45
1000	0	0	3	25	35	45
10000			7	20	20	30

SPECIFIC BIOLOGICAL TESTS.

A continued search for specific inhibiting agents has led to the conclusion, among most workers, that it is hardly rational to expect that any simple chemical substance will be found which will permit the growth of B. coli and restrain all the accompanying organisms.

Biologically, the various species of bacteria are very closely related, and one would hardly expect to find a more limited reaction than occurs in the development of specific immune bodies. Even these reactions are not absolutely specific. Thus, agglutinating serum formed by one race of coli may occasionally fail to agglutinate a coli culture from some other source, though it may be more or less active for other members of the coli group, such as the para-typhoid bacillus.

FIXATION OF THE COMPLEMENT.

The discovery of haemolysims by Belfanti and Carbone[1] followed by the work of Bordet[2] upon the phenomena of inactivation and reactivation led subsequently to the development by Bordet and Gengou[3] of the reaction of the fixation of the complement. Practical application of this test has been developed first by Neisser and Sachs,[4] and has subsequently been utilized in the identification of bacterial species of amboceptors and of antigens.

The following experiments were made with the special reference to the use of the reaction for the identification of B. coli. Two cytolytic sera were first prepared, namely: a bacteriolytic and a haemolytic serum. The bacteriolytic serum was readily obtained by the intravenous injection of a dilute living emulsion of B. coli into a rabbit. In order to represent the possible differences in various races of B. coli, a mixed emulsion was prepared from four pure cultures obtained from different sources. Two of these cultures fermented and two did not ferment saccharose. Only one inoculation was made and a test two weeks later showed that an active serum had developed. For the haemolytic serum erythrocytes from a chicken were injected subcutaneously into a rabbit. The first injection consisted of the corpuscles from 10 c.c. of chicken blood. Two weeks later this was followed by a second larger injection using the corpuscles from 20 c.c. of chicken blood. A test 10 days later showed development of haemolysis in the blood serum of the rabbit for chicken corpuscles.

The outline of the fixation of the complement test is briefly as

[1]Belfanti & Carbone: Gior. d. r. accad. di med. di Torino, 1898, 4,s., XLVI, 321.
[2]Bordet: Ann. de. l'Inst. Pasteur, Par., 1898, XII, 688.
[3]Bordet & Gengou: Ibid. 1901, XV.
[4]Neisser & Sachs: Berl. klin. Wchnschr., 1905, XLII, 1388.

follows: The sera of the two immunized rabbits are capable of dissolving cells corresponding to those which were injected for the immunization. The normal serum of untreated rabbits possesses practically no solvent action. If the immune serum is heated to 56° C. for thirty minutes it loses its dissolving properties. Its cytolytic action can be restored, however, by the addition of a little normal serum. The serum inactivated by heat has been reactivated by normal serum: which is in itself inactive, i. e., a mixture of the heated immune serum and the normal serum becomes active, although each serum by itself is inert. The heated serum, which contains the thermo-stabile immune-body or amboceptor, requires the thermo-labile complement found in normal serum to complete its action. Now if an emulsion of B. coli is added to the heated serum of an animal immune to B. coli, no bacteriolysis takes place, but the addition of a little complement, as found in the normal serum, causes lysis of the bacterial cells. To show that a reaction has occurred, the haemolysin test may be utilized in the following manner: If the rabbit serum, immune to chicken corpuscles, is first heated and then mixed with chicken corpuscles no haemolysis occurs. If this mixture is added to the mixture consisting of coli bacteria, coli amboceptors, and complement, no haemolysis takes place. The normal serum failed to cause haemolysis of the chicken corpuscles sensitized by the amboceptors of the immune serum. Since no haemolysis occurs it is assumed that there has been destruction or fixation of the complement in the normal serum which was added to the mixture of coli emulsion and coli amboceptors. The reaction may be stated more simply by grouping the different mixtures under a common name. Thus, a mixture of heated immune serum and an emulsion of the cells which were used for immunization may be spoken of as a "system." A mixture then of red blood corpuscles and the corresponding heated immune serum is known as a haemolytic system. Similarly for bacteria one can prepare a bacteriolytic system. If to any of these systems the complement of' a little normal serum is added, a reaction takes place and the complement is no longer able to activate a second system. If, however, complement is added to an incomplete system, either part of which is wanting, no reaction can occur, and on the addition of a complete system, such as sensitized erythrocytes, the complement is free to act upon the system just added and its effect is shown by the solution of the red corpuscles with the liberation of their coloring matter. The haemolytic system, therefore, serves merely as an indicator. In the bacteriolytic system, if the coli bacilli are present, the complement is bound and no haemolysis occurs upon the addition of the haemolytic system. If the coli bacteria are absent the complement can not be utilized and when the haemolytic system is added haemolysis occurs. This may be represented diagramatically as follows:

Inactivated Serum immune to B. Coli + Emulsion of B. Coli	=Bacteriolytic System	Complement (Normal Serum)
Inactivated Serum immune to red Corpuscles + Emulsion of red corpuscles	=Hacmolytic System	

In the above scheme suitable control tests will show that each of the five factors, the two cellular emulsions, the two immune sera and the complement, is a necessary part of the reaction. By a suitable arrangement of the known factors one may be left unknown and the test arranged to determine it. In any series of tests no definite conclusions can be drawn unless sufficient controls are carried to show that each factor is working properly.

The following are the preliminary experiments which were made for testing the materials employed:

The usual haemolytic technique has been employed throughout these experiments. Both of the immune sera have been inactivated by heating to 56°-58°C. for a period of 30 minutes. Preliminary digestions to allow fixation of the complement were carried on for 1 hr. at 37°C. The haemolytic system was then added and the incubation continued for 2 hours at 37° C. The final readings taken after the preparations have stood over night at about 8° C. For isotonic salt solution 0.85% NaCl has been employed. Corpuscles, washed twice with 10 c. c. quantities of salt solution, have been used in one-half c. c. volume of a 5% emulsion in salt solution on the basis of 100% concentration for the emulsion of corpuscles as precipitated by centrifugalization. All the different preparations have been made up to a final volume of 2½ c. c.

The following table shows a test of the haemolytic serum and the complement. One c. c. of salt solution was added to each tube in order to bring the final volume up to 2½ c. c., the dilution which is to be employed later in the fixation tests.

TABLE XIII.

Amboceptor ½ c.c. diluted 1 to

Complement 1 to	10	50	100	200	500	1000	5000	10,000	Salt Solution
10	Complete	Complete	Almost complete	Partial	Partial	Trace	Trace	0	0
50	Partial	Trace	Trace	0	0	0	0	0	0
Salt Sol	x	x	x	x	x	x	x	x	0

TABLE XIV.

Volume of Fluid					Haemolysis (determination number)	
½ c.c.	½ c.c.	½ c.c.	½ c.c.	½ c.c.	I.	II.
1. Salt Sol	Salt Sol	Complement	Salt Sol	Erythrocytes	None	None
2. Salt Sol	Salt Sol	Salt Sol	Haemolytic Serum	Erythrocytes	None	None
3. Salt Sol	Salt Sol	Complement	Haemolytic Serum	Erythrocytes	Complete	Complete
4. Emulsion B. coli	Coli Serum	Complement	Haemolytic Serum	Erythrocytes	None	None
5. Emulsion B. coli	Salt Sol	Complement	Haemolytic Serum	Erythrocytes	Complete	Complete
6. Salt Solution	Coli Serum	Complement	Haemolytic Serum	Erythrocytes	Complete	Complete
7. Emulsion B. coli	Coli Serum	Salt Sol	Haemolytic Serum	Erythrocytes	None	None

In the tests which follow both the normal serum and the inactivated immune serum have been used in 1 to 10 dilution in isotonic NaCl solution. The material for all of the following tables was collected at the same time and the experiments carried out on the same lot of material.

The object of these various controls is as follows:

No. 1. The complement alone is not active.

No. 2. The heated serum is inactivated.

No. 3. The complement is capable of activating the haemolytic system.

No. 4. Test showing the fixation of the complement.

No. 5. Normal serum alone will not unite with the coli bacteria.

No. 6. Sufficient time has elapsed since inoculation so that the coli serum is free from antigens.

No. 7. Shows that neither the coli serum nor the bacterial emulsion produces haemolysis of the erythrocytes.

As shown by these results the material is in proper condition, and it was then used for the following experiments: Firstly, some tests were made on the specificity of the reaction; secondly, on the quantity of bacteria necessary to fix the complement, and, thirdly, some samples of water were tested comparing results with those obtained by other methods.

The data given in Table XV, for the specificity of the reaction, correspond with similar tests upon the specificity of agglutinins,

TABLE XV.

SPECIFICITY OF THE FIXATION OF COMPLEMENT REACTION.

Emulsion of	½ c.c.	½ c.c.	1 c. c.	Haemolysis
	Coli serum	Complement	Haemolytic system	
B. coli (6)*	"	"	" "	None
B. coli (10)...........	"	"	" "	None
B. coli anaerogenes.....	"	"	" "	None
B. para-typhosus (a).....	"	"	" "	Trace
B. typhosus (a)	"	"	" "	Partial
B. cloaca (a)	"	"	" "	Almost Complete
B. entcritidis (a)	"	"	" "	Trace
B. lactis aerogenes (b) ...	"	"	" "	Partial
B. proteus vulgaris......	"	"	" "	Complete
B. megatherium	"	"	" "	Complete
B. mycoides	"	"	" "	Complete
B. substilis	"	"	" "	Complete

*This race was used in the production of the bacteriolytic serum.

cytolysins and other immune bodies. The reaction is, of course, highly specific and would furnish very reliable evidence of the presence of B. coli. With the serum used in this experiment, this table would not indicate that there would be any great danger of overlooking B. coli. B. cloaca, and other intestinal organisms, could probably be included in the reaction by introducing the corresponding immune serum.

CONCENTRATION OF THE BACILLARY EMULSION.

Neisser and Sachs,* in working with a precipitin system, have shown that it is possible to obtain fixation of the complement with as little as 0.000,001 c. c. of serum in a case where the serum was the antigen corresponding to the bacilliary emulsion. It would be very desirable, of course, if the fixation test were sufficiently delicate for bacteria also, so that it could be applied directly to a water sample without previously enriching it. This would not only save considerable time, but it would eliminate the danger arising from over-growth and failure of B. coli to develope.

The test was applied to a polluted stream, 0.01 c. c. of which was sufficient to give gas formation in glucose broth typical of B. coli. With the fixation test, complete haemolysis occurred and no evidence of B. coli could be obtained in samples of ½ c. c. volume.

Varying concentrations of an emulsion of B. coli were tested. One-half c. c. quantities were used in the fixation reactions and the results were compared with inoculations of the same quantity into glucose broth. The original emulsion was slightly turbid, but the

TABLE XVI.

½ c.c. of coli Emulsion diluted 1 to	Coli serum	Complement	Haemolytic system	Haemolysis	per cent gas in glucose fermentation tube
	½ c.c.	½ c.c.	1 c.c.		
10	"	"	"	None	40
100	"	"	"	Partial	45
1,000	"	"	"	Almost Complete	50
10,000	"	"	"	Complete	40
100,000	"	"	"	Complete	30
1,000,000	"	"	"	Complete	35
10,000,000	"	"	"	Complete	30
100,000,000	"	"	"	Complete	0

*Neisser & Sachs: Berl. klin. Wchnschr., 1905, XLII, 1388.

first dilution showed no visible cloudiness. The culture tested, B. coli (6) was one of the races used in immunization.

In this table complete fixation occurred only in relatively high concentration, namely, in the 1 to 10 dilution, although glucose broth was fermented by the 1-10,000,000 dilution.

Morgenroth and Sachs* have shown that the amount of complement required to effect haemolysis is in inverse ratio to the strength of amboceptor solution employed. Perhaps with a very delicately balanced haemolytic system, using just as little excess of complement as necessary to secure constant results, one might be able to detect the presence of much smaller numbers of bacteria, than Table XVI would indicate. It does not seem probable, however, that it would be practicable to make the test directly without enrichment.

Table XVII shows the results of the fixation of the complement test upon nine water samples. After eighteen hours growth in glucose broth, the mixed culture of bacteria was tested directly after adding 0.85% of sodium chloride to insure iso-tonicity with the blood corpuscles. One-half c. c. of the culture was substituted as the unknown quantity in the place of 1.2 c. c. of bacterial emulsion used in the previous experiments. Controls were also carried to test for haemolysins in the bacterial culture.

TABLE XVIII.

Serial No.	Source	Haemolysis in fixation test	Fermentation tests for contamination		Haemolysis from bacterial culture
			Glucose	$NaNO_2$	
17959	Well-40′ dug	None	+	+	None
17961	Well-26′ dug	Partial	+	+	None
17963	Lake Michigan	None	?	—	None
17964	Lake Michigan	Complete	—	—	None
17965	Sangamon River Springfield, Ill.	Trace	+	not tested	Trace
17966	Spring	Almost Complete	+	+	None
17967	Mississippi River	None	+	+	Grown discoloration
17969	Well-20′ dug	None	+	+	Grown discoloration
17970	Well-25′ dug	Partial	+	—	None

*Morgenroth & Sachs: Berl. klin. Wehnschr., 1902, 817.

The result in Table XVIII may be classified as follows:

METHOD.

Result	Fermentation of glucose	Destruction of nitrites	Fixation of complement
Positive	7	5	5
Negative	1	5	4
Indeterminate	1	0	0

Consistent results with all three methods were obtained in four cases. Disagreements by one or more of the methods occurred in four cases, and in one instance, the result was indefinite.

The agglutination of the corpuscles caused some difficulty in exposing them to the action of the serum. Any method by which a haemolytic serum could be developed without agglutinating properties might offer distinct advantages.

The fixation of the complement tests were characterized especially by (1) their specificity, (2) their adaptability to mixed cultures, and (3) the relatively short time required for completing the test.

Although the test is rather complicated for routine work it might be of importance in (1) the examination of large municipal supplies or (2) in the investigation of special problems.

SUMMARY.

I. As a general standard, B. coli should be constantly absent from 1 c. c. quantities of potable waters. Under special conditions it may be necessary to vary this standard in either direction. In a single examination, the sanitary survey or the chemical analysis may be sufficient to condemn a water even when the colon group is absent and the bacterial count is low. Cases representing the other extreme might occur when it might be desirable to distinguish between pollution of human origin and that arising from the lower animals.

II. Observers are agreed that, as a presumptive test for B. coli, bile, with the addition of sugar, affords a good medium for waters representing moderate degrees of pollution, but that it is not sufficiently delicate when the pollution is relatively slight. Our results have supported these conclusions in the practical application of the method and in theoretical experiments. Bile is only a relatively selective agent. It *does* inhibit certain *races of B. coli* and *permits* the free growth of *certain species of saphroghytes.*

III. The analyses of bacterial cultures of water samples by the usual sanitary chemical methods, affords a basis for the theoretical interpretation of results and for the development of the analytical procedures which are in current use.

1. The principal conclusions regarding the interpretation of results were reached in connection with the free ammonia determinations. Aside from any inaccuracies of the Nessler process as used in ordinary routine work, the presence of free ammonia does not indicate the presence of intestinal bacteria. The determination of the ammonia might serve as a quantitative test for bacteria, but such a method would be inferior to direct cultivation by the usual bacteriological procedures. No general rules can be adopted. In certain large classes of water supply, the free-ammonia determinations are without value.

The experimental evidence for these conclusions is almost complete and is well supported by the practical work in this laboratory on several thousand routine analyses.

2. The analyses of cultures also affords a laboratory method for distinguishing, in a given sample, between end-products, especially free-ammonia and nitrites, arising from bacterial putrefaction and the same products occurring as normal constituents of the soil.

The ordinary chemical determination of nitrites is, by itself, usually inconclusive regardless of whether or not nitrites are present. By the application of these culture methods, the nitrite determination has been developed so that it is applicable to practically all cases. This modification has been studied by theoretical experiments and by practical routine work with the following results:

1. It is apparently a very delicate and relatively specific test for intestinal bacteria.

2. Thus far the reaction has given very definite results, free from anomalies. The test has been essentially a qualitative one and not dependent on careful quantitative distinctions.

3. Comparisons with the presumptive coli test were made on a series of 155 waters. In 72% of the samples the same result was obtained with each method. In 13% the results disagreed, while 15% were indeterminate owing to indefinite presumptive coli reactions. The conditions of the experiment did not permit final conclusions in this remaining 15%.

The method requires but little time, space, or material in the laboratory and it is well adapted to routine work. The total time required is not over forty-eight hours. It is not probable that any single test would suffice to determine all of the many and various factors which determine the final condition of a water. This modification of the nitrite test, however, has been a definite additional value in this series of 155 waters representative of the State of Illinois. Where an opinion is based on a single analysis, this method should be of especial value on account of its definite reaction and its freedom from anomalous results.

IV. Of the biological method for the identification of bacteria, fixation of the complement tests are characterized (1) by their specificity, (2) by their adaptability to mixed culture, and (3) by the relative short period of time required for completing the examination.

In conclusion, further practical and theoretical investigation is especially desirable in connection with the determination of nitrites in cultures, such as experiments bearing on the specificity of the reaction, its delicacy in pure and mixed culture, and any alterations in the media leading to a reduction in the forty-eight hour time limit.

I take this occasion to recognize the very material assistance of Professor Bartow, in whose department and under whose supervision this investigation has been carried on. The analytical work has also been much facilitated by the assistance of Frank Bachmann.

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THE FARM WATER SUPPLY.*

It ought not to be necessary to attempt to prove the necessity for an abundant supply of water for the farm, and most people are convinced that the water should be pure. As many of us do not realize what pure water is, it is our purpose to explain what constitutes a *pure* water, why a pure water is needed, and how to get it.

What constitutes a pure water? The scientist will tell us that a pure water is *water* and nothing else. Pure water from his standpoint, is a difficult thing to obtain; because it will dissolve so many substances with which it comes in contact. The purest natural water is rain water. This has been evaporated from the seas, lakes, streams, and from the surface of the earth, leaving the soluble salts behind. Yet even rain water has dissolved gases from the air or has air itself in solution, and is thus not absolutely pure. The purest rain water is obtained after the first fall of rain has cleared the air. As soon as rain water touches the ground it begins to dissolve substances with which it comes in contact. Limestone, salt, and other mineral substances are dissolved in varying amounts, making the water impure from the scientific standpoint. For drinking purposes small amounts of these substances do not make the water impure, and unless present in excess are beneficial rather than harmful.

For our purpose we should ask, What constitutes an impure water? Impure drinking water contains either substances or organisms, or both, which will disturb the functions of the body and cause illness. Excess of some salts, like epsom salts or salts of lime, are injurious. More especially some organisms known as bacteria, if present in the water, will cause disease. According to the germ theory of disease, diseases like typhoid fever, malaria and cholera,

*Adapted from a lecture prepared for the Illinois Corn Growers and Stockmen's Convention, 1908, by Edward Bartow.

are caused by these germs. The cholera and typhoid germ are introduced into the system by drinking infected water. Water becomes infected from sewage and house drainage or directly from the excreta of persons who have had the disease. The excreta from *one* patient has been known to contaminate a water supply and cause an epidemic of typhoid fever to sweep an entire town. These living germs are not dissolved, but are held in suspension. They are too small to be seen by the naked eye and may be present in the clearest water. It is practically impossible to determine them directly, but a water analysis is their indirect determination. For an explanation of what an analysis is, we refer to "Interpretation of Results," page 105.

Typhoid fever is the principal water-borne disease that we have to deal with. We cannot tell how much typhoid fever occurs on the farms of Illinois. No statistics are available. It is a fact, however, that typhoid fever is at its height in the cities after the summer vacation. One way of accounting for this is that the people of the city become infected in the country or at the seaside. This may be because their body resistance is less than that of the farmer, whose system is accustomed to the impure water. As one can become accustomed to the use of a drug until a large amount can be taken without effect, so it is undoubtedly possible to resist the typhoid fever germs. The farmer is not altogether immune. Many cases occur in his family. When the body resistance is lowered by even a light illness, they become more susceptible and contract the disease.

Milk is an excellent carrier of typhoid germs because it furnishes abundant food for their growth. It is often infected by impure water which is used in washing the milk utensils.

Precautions must be taken to keep wells on dairy farms in good condition. The health departments of Boston, New York, Chicago and Philadelphia make the general requirement that wells on dairy farms "must be free from contamination." The following from the New York City regulations are quoted:

REGULATIONS OF THE DEPARTMENT OF HEALTH OF NEW YORK CITY.

CREAMERY REGULATIONS.

The water used for cleaning pails, cans and other utensils must be from a public water supply, or, if drawn from a well of spring, must be approved by this department.

RULES FOR THE DAIRY. THE WATER SUPPLY.

The water used in the barn and for washing milk utensils must be free from contamination.

RESOLUTION OF MARCH 31, 1907.

Resolved, That when typhoid fever or dysentery exists in any household of any employee of any creamery, farm or dairy, sending milk to New York City, no water from any well or spring within one hundred feet of such premises, or from any well or spring used by the household, shall be used in barns for cleaning milk utensils without the consent of the Department of Health.

I will also quote from a letter to the owner of a farm located about sixty miles from New York City, in which the statement is made, "That the privy or cesspool be located not nearer than 250 feet from the source of the water supply."

Adherence to these rules will do much to lower the typhoid fever rate.

The importance of a pure water supply on a dairy farm and also on any farm, the water from which may enter the milk supply, may be nicely illustrated by considering the rapid growth of bacteria. It has been shown that some bacteria under favorable conditions, will increase by division every eighteen minutes. This would mean that they would multiply three times in an hour, six times in two hours, etc. Starting with one bacterium, there will be two at the end of eighteen minutes, four at the end of thirty-six minutes, eight at the end of fifty-four minutes, or, say at the end of an hour. With three multiplications during the next hour, at the end of the second hour there will be sixty-four. In three hours and twenty minutes there will be 1,000. In seven hours, 1,000,000, in ten and one-half hours 1,000,000,000, and so on. We cannot expect this complete multiplication under all conditions, but even should half or one-quarter of the number grow, one can readily see what disaster may follow from a few typhoid fever germs carelessly allowed to enter a can of milk.

A large majority of the farm well waters sent to the State Water Survey for analysis, are sent because the purity of the water is suspected. It is very rare that such a sample is sent in unaccompanied by a report that there are from one to five cases of typhoid fever among the users of the water. For this reason our records give a very poor idea of the actual conditions of farm waters in the state. During 1907 the State Water Survey condemned 60 per cent of all well water analyzed, eighty-five per cent of wells condemned were less than 25 feet deep, and 77 per cent of those between 25 and 50 feet deep were condemned.

In order to have a more accurate knowledge of the condition of farm water supplies, we need to know the character of waters that are perfectly free from contamination; or, in other words, we need to determine the normal waters for each district. In order to have such an accurate knowledge, it would be necessary to make a water survey of the state, similar to the soil survey being made under the direction of Professor C. G. Hopkins. The character of the water supply varies as the soils vary, and as the rock strata vary. Since different kinds of earth and different kinds of rock are found at various depths below the surface, we may say that the character of the water also varies with the depth of the wells. Sometimes, as in the case of dug wells which are cased with brick or stone, the water may enter the wells from various levels; and while a good water might be obtained from the lowest level, there is a possibility of its becoming contaminated by water entering from near the surface or by the water itself washing back into the depths of the well through the curb carrying with it pollution from the surface.

The usefullness of germ free waters for farm water supplies varies with the hardness. A hard water contains salts of calcium and magnesium. These salts, when present in water in which meat or vegetables are cooked, form insoluble albuminates. Tea and coffee are not as good when made with hard water. A hard water is also not economical, requiring a larger amount of soap than does a soft water. It causes a scale on the vessels in which it is used, and it is unpleasant for general lavatory and laundry uses. It has been calculated that $180,000 was saved annually by the city of Glasgow by changing from a hard water to the soft Loch Katrine water. In many cases it is possible to use a soft cistern water, and this, when collected on the clean roofs of farm houses, is. quite satisfactory. When, however, the cistern water is not available, the hard well water may be easily softened by using chemicals. The most suitable are lime and soda. The lime is used in the form of a saturated solution, the soda as one part dissolved in ten parts of water. The lime removes temporary hardness, that is, hardness caused by the presence of carbonates which is mostly removed by boiling. The soda is for the permanent hardness caused by sulphates, chlorides and nitrates of calcium and magnesium, which are not removed by boiling. The lime water is prepared by slacking lime and dissolving the slacked lime in water, or, better, by dissolving hydrated lime in water. A pail of lime water added to from three to ten pails of hard water in a barrel, according to the hardness of the water, will cause the formation of. a precipitate which will soon settle, leaving a comparatively soft water suitable for domestic use. It must be noted that the lime does not remain in the water but comes out in the precipitate. In some cases it is necessary to add a little soda. When it is considered that one pound of lime will do the work of fifty pounds of soap, the economy of the practice can easily be seen. On well waters in Illinois, it is safe to use one part of lime water to ten; more should often be used, but this should not be done without preliminary tests. An example of the amount to use is seen in the table of "Hardness of Municipal Water Supplies," page 100. All the soap used before a lather forms is absolutely wasted; then, too, when hard water is used in washing cloth, a precipitate of lime soap or curd collects in the cloth and is difficult to wash out.

In order to obtain some definite knowledge of the conditions of a few farm water supplies, we have, during December, 1907, and

January, 1908, collected five series of ten samples each, from farms in different parts of the state. An endeavor has been made to obtain waters from wells in places where the conditions differ and which are typical of large sections of territory. Other conditions undoubtedly exist and we wish it might have been possible to obtain specific samples from every county in the state. Some times conditions may vary even in the same county. The collections have been made northwest of Champaign, in Champaign county, from near Centralia, in Marion county; from east of Elgin, most of the samples having been taken from Cook county; from northwest of Kankakee, in Kankakee county, and from north of Cairo, in Alexander county. These points were chosen because widely separated and also because of the differences in sources of supply.

The source and characteristics of the water used at these places on the farms follow:

CAIRO.

A series of ten samples was collected on January 20, 1908, from farms north of Cairo, in Alexander county. The water supply of these farms was quite varied in character. The ten samples included three cisterns, three shallow driven wells, with pitcher pumps; three deeper driven wells, and one deep drilled well, which was free flowing.

No. 1. (17004) is a driven well 35 feet deep. Both chemically and bacterially it was shown to be in good condition.

No. 2. (17005) is from a cistern located at same place as No. 1. The surroundings were poor and the casing was open. The analysis indicates the possibility of leakage, shown by the alkalinity and the high residue on evaporation. The consumed oxygen, albuminoid ammonia, and nitrogen as nitrites indicate the presence of organic matters. The number of bacteria was not excessive, but the chemical examination indicated the probability of rapid growth should any infection enter. This cistern water was preferred to the well water for drinking by the people living in the house. In our opinion the cistern at this time was not in satisfactory condit tion, not having been cleaned for about fifteen months.

No. 3. (17606) is from a 60-foot drilled well. The water-bearing strata, however, is from 40 to 45 feet deep. The analysis showed results comparable with No. 17004, but the water which was clear when first drawn, became turbid on standing and had an odor of hydrogen sulphide. The water is safe for use for drinking purposes, though the turbidity and odor would render it unattractive. The residents preferred the cistern water obtained from a cistern reported as No. 4.

No. 4. (17007) is from a cistern which, while well curbed, had no covering. It showed evidence of organic matter and a bacterial examination was unfavorable. The well water in this case is preferable to the cistern water.

No. 5. (17008) is a driven well 50 feet deep. The surroundings were not good, yet the chemical examination was quite favorable. From a bacterial standpoint the water was only fair. The unfavorable bacterial condition was probably due to defective casing.

No. 6. (17009) is a 60-foot driven well located at the tri-city park close to the highway. This water shows high chlorine and nitrates, indicating that surface water from the neighborhood is the source of its supply. The low consumed oxygen, free and albuminoid ammonia, and the favorable bacterial examination indicate that the water is satisfactorily filtered before entering the water-bearing strata and is safe for drinking purposes.

No. 7. (17010) is a driven well to which a pitcher pump was attached. This water, while clear when first drawn, became very turbid on standing. Aside from the turbidity, the water is excellent for drinking purposes. The people at the house preferred to use cistern water.

No. 8. (17011) is a well near to and similar in character to No. 7, and aside from its turbidity it is in good condition for drinking purposes. The people in the house use this water for drinking purposes.

No. 9. (17012) is from an artesian well about 800 to 900 feet deep. The water was shown to be excellent, though it has a slight odor of hydrogen sulphide. This water is piped to the farm houses, and is used there.

No. 10. (17013) is a cistern water which was well cared for. The surroundings are excellent and the water is filtered. The filtration, however, would not entirely remove turbidity and color. The consumed oxygen is high. Bacterially the number of bacteria per cubic centimeter is large, though no positive tests for intestinal bacteria were found.

Our conclusions concerning the ten waters taken from near Cairo are that it is possible to obtain a satisfactory water from driven wells about 40 feet deep, although there is a possibility of finding water containing iron, which causes turbidity on exposure to the air. This leads many of the people to prefer cistern water. The cisterns are usually neglected and the water is frequently foul either from washings from the roofs or because of leakages, or from unsatisfactory curbings. The deep artesian well water similar in character to the deep well water obtained at Cairo, would give the more satisfactory water. There is a possibility for several farmers to join together to drill a deep well. They can then have the water piped to their respective farms. The expense of drilling such a well is usually greater than one farmer would care to stand.

CENTRALIA.

A series of ten samples was collected on January 7, 1908, from farms near Centralia:

No. 1. (16888) is from a 30-foot dug well, Sec. 13, T. 1 N., R. 1 E. The well was about 100 feet from the privy, 150 feet from the stable, 50 feet from the feed lot, 10 feet from dumping ground for slops, dish water and wash water. There had been one case of typhoid fever about two years before. Both the chemical and bacterial examination indicated pollution.

No. 2. (16889) is an 18-foot dug well near No. 1. It is about 30 feet from the stable and is used for stock only. Both the chemical and bacteriological data indicate pollution.

No. 3. (16890) is a 24-foot dug well in Brookside township, T. 1, R. 1. The well was dug in clay and cased with brick. All the chemical and bacteriological data would indicate contamination.

SAMPLES FROM CAIRO, ILLINOIS. COLLECTED JANUARY 20, 1908.

Laboratory No.	Appearance. Turbidity.	Appearance. Color.	Appearance. Odor.	Total Solids.	Chlorine.	Oxygen Consumed.	Nitrogen as Ammonia. Free.	Nitrogen as Ammonia. Albuminoid.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Alkalinity.	Bacteria per c. c.	Colon Bacillus. 10 c. c.	Colon Bacillus. 1.0 c. c.	Colon Bacillus. 0.1 c. c.	Indol.	Depth.	Remarks.
17004	0	0	0	505	3	1.3	.038	.084	.050	1.03	466	260	1 —	2 —	2 —	+	35' driven	good
17005	0	.4	0	172	3	7.5	.004	.102	.250	.35	86	180	1 ?	1 + 1 ?	2 —	—	Cistern	poor
17006	130	.1	H S	540	3	2.7	.280	.040	.006	.074	512	380	1 —	2 —	2 —	—	60' drilled	good
17007	20.	.8	0	79	4	3.5	.146	.190	.200	.400	36	300	1 —	1 — 1 +	2 +	+	Cistern S.	poor
17008	0	0	0	345	4	1.7	.000	.024	.015	1.905	306	120	1 ?	1 ? 1 +	2 —	+	50' driven	fair
17009	0	0	0	436	15	1.4	.000	.056	.010	6.390	306	420	1 —	2 —	2 —	+	60' driven	poor
17010	170	0	0	530	7	2.1	.084	.056	.000	.000	434	210	1 —	2 —	2 —	—	30' driven	fair
17011	110	0	0	440	7	2.5	.854	.060	.002	.558	378	580	1 —	2 —	2 —	—	20' driven	fair
17012	5.	.4	H_2S	339	97	1.3	.160	.000	.000	.200	140	8	1 —	2 —	2 —	—	*800' to 900'	good
17013	10.	.5	0	85	3	4.7	.052	.092	.000	.760	58	1300	1 ?	2 ?	2 —	+	Cistern	fair

*Drilled.

SAMPLES FROM CENTRALIA, ILLINOIS, COLLECTED DECEMBER 24, 1907.

Laboratory No.	Turbidity.	Color.	Odor.	Total Solids.	Chlorine.	Oxygen Consumed.	Free.	Albuminoid.	Nitrites.	Nitrates.	Alkalinity.	Bacteria per c. c.	10 c. c.	1.0 c. c.	0.1 c. c.	Indol.	Depth.	Remarks.
16888	0	0	0	1379	240	3.2	.016	.108	.001	22.0	440	800	1 —	1 + 1 —	2 —	+	30	bad
16889	0	0	0	461	29	1.6	.052	.056	.000	8.6	310	1200	1 ?	2 +	1 + 1 —	+	18	“
16890	0	0	0	765	134	2.5	.008	.048	.000	5.12	412	650	1 +	2 +	2 +	+	24	“
16891	0	0	0	1629	122	4.8	.008	.078	.000	41.0	488	Lost	1 +	1 + 1 —	2 —	+	24	“
16892	0	0	0	441	8	1.5	.004	.028	.001	.72	364	400	1 ?	2 —	2 —	+	15	good
16893	0	0	0	1805	200	3.0	.008	.048	.001	60.00	484	16000	1 +	2 +	2 +	+	36	bad
16894	10	0	Musty	1205	118	4.0	.020	.096	.022	31.98	370	20000	1 —	1 + 1 —	2 +	+	30	“
16895	0	0	0	1546	57	2.4	.050	.114	.000	12.00	370	400	1 —	2 +	1 ? 1 —	+	35	“
16896	0	0	0	2640	380	4.0	.058	.096	.000	32.00	378	1500	1 —	1 ? 1 —	2 —	+	35	“
16897	0	0	0	1996	66	3.5	.030	.090	.050	51.95	436	4600	1 —	1 + 1 —	1 + 1 —	+	25	“

No. 4. (16891) is a 24-foot dug well near No. 3. All the data indicated surface contamination.

No. 5. (16892) is a 15-foot dug well, 50 feet from privy, 30 feet from stable, 10 feet from feed lot, and 50 feet from a pig pen. Both the chemical and bacteriological examinations indicated a satisfactory water.

No. 6. (16893) is a 36-foot dug well in Sec. 11, T. 1, R. 1, 75 feet from privy, 100 feet from stable, and 50 feet from feed lot. All the chemical and bacteriological data indicated contamination.

No. 7. (16894) is a 30-foot dug well in Sec. 11, T. 1, R. 1, 50 feet from stable and 10 feet from feed lot, practically located in a barn yard. All the data indicated that this water was unsatisfactory for drinking purposes.

No. 8. (16895) is a 35-foot dug well in Sec. 11, T. 1, R. 1, 50 feet from privy, and 50 feet from feed lot. The well was cased with brick. All the data would indicate contamination.

No. 9. (16896) is a 35-foot dug well, 100 feet from privy, 50 feet from stable, 50 feet from feed lot, and 50 feet from dumping grounds for dish water. All the data indicated that this water was polluted by surface water.

No. 10. (16897) is a 25-foot dug well in Sec. 11, R. 1, T. 1, 100 feet from privy, 40 feet from stable, and 30 feet from feed lot. The curbing in this case is poor. All the analytical data indicated pollution.

The table gives a summary of the results obtained in analyzing waters from Centralia.

An inspection of the data concerning ten wells at Centralia shows that nine are evidently polluted, and yet in only one case was a report given of typhoid fever among the users of the water.

CHAMPAIGN.

A series of ten samples was collected on December 19, 1907, from farms northwest of Champaign:

No. 1. (16873) is a 160-foot drilled well, in Sec. 2, T. 19 N., R. 8 E. This well is located in a barn yard, 60 feet from a privy, 160 feet from a cesspool, 75 feet from a stable. The anaytical results showed it to be a water similar in composition to that furnished by the Champaign and Urbana Water Company. It becomes turbid, due to the presence of soluble iron salts, which become insoluble on exposure to the air, causing not only the turbidity, but also giving a color. From a bacteriological standpoint this water was excellent. The turbidity or cloudiness would make it less attractive as a drinking water than the polluted water in a dug well close by, an account of which is seen under No. 2.

No. 2. (16874) is 25 feet deep, in Sec. 2, T. 19 N., R. 8 E.; is cased with tile and had at that time a covering which was faulty. It is located practically in the barn yard, 60 feet from the privy, 150 feet from the cesspool and 60 feet from the stable. From a physical standpoint the water was clear and colorless and had no odor. The chemical examination, however, showed that it evidently contained considerable quantities of the surface drainage. It also contained an excessive number of bacteria. Such a water should not be used for drinking purposes, though from outward appearances a more attractive water than the water from the deep well near by.

No. 3. (16873) is a 16-foot dug well, and is located in Sec. 2, T. 19 N., R. 8 E, and is located 100 feet from privy, 10 feet from the stable and is practically in a barn yard. The chemical analysis showed that this water contained surface drainage. From a bacteriological standpoint it was in fair condition, but we would suggest that such water be boiled before using it for drinking purposes.

No. 4. (16876) is a 65-foot bored well, Sec. 35, T. 20 N., R. 8 E., and is cased with cypress, with curbing in poor condition. The well is located in a feed lot about 50 feet from the stable. Physically the water appeared to be good, chemically, poor; bacteriologically poor. This water was only used for stock and should not be used for drinking purposes.

No. 5. (16877) is a 180-foot bored well, and is located in Sec. 35, T. 20 N., R. 8 E., 50 feet from privy, 30 feet from cesspool. The water was similar in character to the Champaign and Urbana supply and was excellent from a sanitary standpoint.

No. 6. (16878) is a 28-foot dug well in Sec. 34, T. 20 N., R. 8 E. Privies and cesspools do not seem to be more than 100 feet distant. It is located near the house in apparently excellent conditions. Physically it was a bright, clear water, chemically it showed evidences of having been collected on inhabited areas. From a bacteriological standpoint it was good. This water is apparently safe for drinking purposes, but contains a higher residue than is desirable and is less suitable for household use than the water from the deep well near by, which is described under the next number.

No. 7. (16879) is a 190-foot bored well located in Sec. 34, T. 20 N., R. 8 E. This water showed results similar to the deep wells of the county and is very satisfactory for drinking purposes.

No. 8. (16880) is a 170-foot drilled well in Sec. 3, T. 9 N., R. 8 E. This water shows the characteristics of a deep well of the section and is an excellent water for domestic uses. The water from this well was pumped to the tank by a gasoline engine located in the basement of the house.

No. 9. (16881) is a 28-foot dug well in Sec. 2, T. 19 N., R. 8 E. It is 50 feet from the stable. No other objectionable features seemed to be within 100 feet, but there was apparently a chance for surface water to enter through the curbing. The chemical analysis showed evidences of pollution.

No. 10. (16882) is a 160-foot driven well in Sec. 2, T. 19 N., R. 8 E., and while it is practically in the barn yard, near the privy and stable, with a dumping ground for slops near by, it had no evidences of any contamination.

An inspection of these analyses shows that the deep well waters were in excellent condition. According to the chemical analysis all of the shallow wells showed pollution. One gave a very favorable bacterial examination and may be considered good. The deep well waters contain less residue and are softer than the shallow well waters. The results of our examinations would indicate that it is advisable for the farmers in the neighborhood of Champaign to use the waters from the deep driven wells in preference to the shallow wells.

SAMPLES FROM CHAMPAIGN COUNTY, ILLINOIS, COLLECTED DECEMBER 19, 1907.

Laboratory No.	Appearance.			Total Solids.	Chlorine.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.	Depth.	Remarks.
							Ammonia.											
	Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1.0 c. c.	0.1 c. c.			
16873	10.	.2	0	377	3	7.6	.720	.144	.000	.16	346.	160	1—	2—	2—	—	160	Good
16874	0	0	0	1662	180	4.0	.024	.136	.020	50.00	360.	650	1—	2—	1— 1+	+	25	Bad
16875	0	0	0	510	30	2.3	.016	.064	.008	12.00	244.	250	1—	2—	1— 1+	+	16	Bad
16876	5.	0	0	567	37	2.8	.116	.080	.006	4.8	358.	1500	1—	2+	2—	+	65	Bad
16877	0	.4	0	513	3	8.6	2.800	.160	.000	.08	462.	40	1—	2—	2—	—	180	Good
16878	0	0	0	948	132	2.3	.024	.056	.000	3.04	350.	100	1—	2—	2—	—	28	Good
16879	0	.4	0	512	3	9.5	4.800	.224	.000	.08	496.	10	1—	2—	2—	—	190	Good
16880	0	.2	0	358	3	5.0	1.280	.096	.000	.08	340.	0	1—	2—	2—	—	170	Good
16881	0	0	0	463	20	1.8	.176	.070	.007	2.00	338.	10	1—	1—	1+		28	Bad
16882	0	.2	0	345	2	3.5	.640	.128	.000	.08	324.	10	1—	1+ 2—	1— 2—	—	160	Good

SAMPLES FROM ELGIN, ILLINOIS, COLLECTED JANUARY 3, 1908.

Laboratory No.	Turbidity.	Color.	Odor.	Total Solids.	Chlorine.	Oxygen Consumed.	Free.	Albuminoid.	Nitrites.	Nitrates.	Alkalinity.	Bacteria per c. c.	10 c. c.	1.0 c. c.	0.1 c. c.	Indol.	Depth.	Remarks.
16921	0	0	0	298	6	.6	.076	.058	.000	2.00	210	90	1—	2—	2—	—	35 dug	Good
16922	10.	.3	0	398	3	4.3	1.60	.160	.000	.08	378	30	1—	2—	2—	—	313 drilled	"
16923	0	0	0	752	32	1.7	.008	.072	.000	3.60	548	Lost	1—	2—	2—	—	27 dug	"
16924	5.	.8	0	472	2	9.2	1.75	.240	.000	.000	438	25	1—	2—	2—	—	204 drilled	"
16925	5.	.1	0	249	3	1.9	.752	.024	.000	.000	216	21	1—	2—	2—	—	175 drilled	"
16926	0	0	0	973	200	2.0	.032	.152	.002	8.00	388	600	1?	1+ 1—	1— 1+	—	27 drilled	Bad
16927	0	0	0	827	24	1.7	.056	.056	.000	.88	430	160	1—	2—	2—	—	40 dug & driven	Good
16928	0	0	0	492	36	3.2	.024	.104	.050	1.95	296	200	1—	2—	2—	+	197 bored & "	"
16929	10.	0	0	325	3	11.3	.608	.032	.000	.000	324	80	1—	2—	2—	—	165 drilled	"
16930	0	0	0	350	6	1.0	.016	.044	.000	.000	324	600	1+	2—	2—	+	25 dug	"

ELGIN.

A series of ten samples was collected on January 3, 1908, from farms near Elgin; most of them were in Hanover township, Cook county:

No. 1. (16921) is a dug and bored well 35 feet deep. The only source of contamination found was a chicken house 50 feet away, and a stable 200 feet away. One case of typhoid fever was reported six years ago. The analysis showed favorable results except in the free and albuminoid ammonia, and perfect satisfaction would undoubtedly be given if all the water were shut out from the dug part of the well.

No. 2. (16922) is from a drilled well 331 feet deep, and while it is near a stable it was shown to be excellent in every particular.

No. 3. (16923) is from a dug well 27 feet deep. The chemical analysis indicates that surface water enters the well. The absence of intestinal bacteria was shown. This water was used only for watering stock, and it would be advisable not to use it for drinking purposes.

No. 4. (16924) is a drilled well 204 feet deep. The water was excellent in every particular.

No. 5. (16925) is a drilled well 175 feet deep. The water was shown to be excellent in every particular.

No. 6. (16926) is a drilled well 27 feet deep, and showed evidence of contamination, both chemically and bacterially. The surroundings were poor, a privy being 50 feet away, cesspool 10 feet away, a stable 100 feet away, and a dumping ground for slops about 20 feet away. Such water should not be used for drinking purposes.

No. 7. (16927) is a 40-foot driven well with an iron casing extending from top to bottom. Bacterially the water was excellent. Chemically it was also good. This is an illustration of the advantage of a driven well over a dug well.

No. 8. (16928) is a driven well 197 feet deep, with very favorable surroundings. Bacterially the water was in excellent condition. Chemically there was evidence of entering surface water, and while not first class, was probably in good condition at the time of the analysis.

No. 9. (16929) is a drilled well 165 feet deep. The high consumed oxygen is rather surprising, otherwise the water shows the characteristics of deep wells and was evidently perfectly safe for use for drinking purposes.

No. 10. (16920) is a 20-foot dug well, the surroundings are not very favorable, a privy being located 10 feet away, a cesspool 10 feet, a stable 100 feet, dumping ground for slops, dish water, etc., 10 feet. The chemical examination showed the water to be in excellent condition. The bacterial results showed it to be only fair. The water was probably safe, but liable to surface contamination at any time.

The deep rock wells in the Elgin district furnish an excellent water supply for household purposes. The shallow wells, especially the dug wells, are much less desirable; the one shallow driven well was shown to be good, proving the greater desirability of this class of well over the shallow dug well.

KANKAKEE.

Ten samples were collected on January 13 from farms northeast of Kankakee, in Bourbonnais township, Kankakee county:

No. 1. (16962) is from a 45-foot well drilled in limestone. This well is about 50 feet from a privy, 100 feet from a stable and 20 feet from the barn yard. Chemically there was evidence of entering surface water. The tests for bacteria showed that the water was in excellent condition.

No. 2. (16963) is from a 68-foot well drilled in limestone. The well is located 30 feet from a privy, 100 feet from a stable, feed lot and dumping grounds for slops. There had been a case of typhoid fever last September. Chemically this water showed evidence that the water had been collected on polluted surfaces. From a bacterial standpoint the results were excellent. We can regard this as only fair water for drinking purposes.

No. 3. (16964) is from a 45-foot well drilled in limestone, 100 feet from a privy, 200 feet from feed lot, and 300 feet from stable. All the analytical data indicated that this water was in first class condition.

No. 4. (16965) is a 40-foot well drilled in limestone, 300 feet from a privy, 100 feet from a stable, and 10 feet from feed lot. While this water was used for stock only, it was shown to be in excellent condition for general drinking purposes.

No. 5. (16966) is a 45-foot well drilled in limestone. This well was 40 feet from a privy, 30 feet from a stable, and 50 feet from feed lot. It was shown to be in excellent condition for drinking purposes.

No. 6. (16967) is a 12-foot driven well, located in a barn yard, 20 feet from a stable. Chemically there was evidence of gross contamination. From a bacterial standpoint this water was shown to be good. The organic matter was so high above the average that we believe it ought not to be used for drinking purposes.

No. 7. (16968) is a 37-foot well dug and drilled in limestone, 120 feet from a privy, 75 feet from stable, 20 feet from feed lot. Two cases of typhoid fever were reported in August, 1907. While the bacterial results at this time were shown to be good, the chemical examination showed evidence of gross pollution. The residue on evaporation was excessive, and such a water should not be used for drinking purposes.

No. 8. (16969) is a 100-foot drilled well. Bacterially the water was shown to be only fair. From a chemical standpoint there was evidence of surface pollution, and either the data given us was wrong or surface water enters the well.

No. 9. (16970) is a 104-foot drilled well. All the data, both chemical and bacteriological, indicated a satisfactory water for drinking purposes. The water being very different in character from No. 8, may be regarded as a normal water for a well 100 feet deep.

No. 10. (16971) is a 50-foot dug well, reported dug in clay. The bacteriological examination showed it to be a good water. The chemical examination indicated the entering of surface water. The residue on evaporation is excessive, rendering it only a fair water for domestic use.

Considering the ten samples from Kankakee the drilled rock wells from 40 to 50 feet deep are the most satisfactory. The nor-

SAMPLES FROM KANKAKEE ILLINOIS. COLLECTED JANUARY 13, 1908.

Serial No.	Appearance			Total Solids.	Chlorine.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus			Indol.	Depth.	Remarks.
	Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.			
16962	0	0	0	488	20	.9	.036	.060	.002	7.60	274	120	1—	2—	2—	—	45' drilled	good
16963	0	0	0	826	44	1.3	.036	.062	.004	29.6	308	90	1—	2—	2—	—	60' drilled	fair
16964	0	0	0	231	5	.9	.054	.060	.000	.28	184	20	1—	2—	2—	—	45' drilled	good
16965	0	0	0	263	9	1.0	.016	.036	.000	.20	172	120	1—	2—	2—	—	40' drilled	good
16966	20.	0	0	254	3	1.3	.042	.024	.002	.28	164	160	1—	2—	2—	—	45' drilled	good
16967	0	0	0	830	90	2.0	.040	.122	.300	17.57	234	40	1—	2—	2—	—	12' drilled	poor
16968	0	0	0	1750	290	1.5	.036	.092	.003	68.00	364	200	1—	2—	2—	—	37' dug & drvn.	bad
16969	30	0	0	1117	126	3.3	.014	.118	.002	18.00	316	600	1—	2—	2—	+	100' drilled	poor
16970	5.	0	0	403	7	1.8	.450	.074	.004	.48	374	44	1—	2—	2—	—	104' drilled	good
16971	0	0	0	1016	98	2.7	.010	.116	.000	36.00	246	230	1—	1— 1+	2—	—	50' dug	fair

mal residue on evaporation is less than 400., normal chlorine 10., normal nitrates 0.3. An excess over these figures would indicate surf ace contamination.

GENERAL CONCLUSIONS.

In those parts of the state where it is possible to obtain a satisfactory water by means of driven or bored wells, such wells are much to be preferred to the dug wells. This may be easily illustrated by a little drawing. (See Fig. 1.). In a dug well the casing

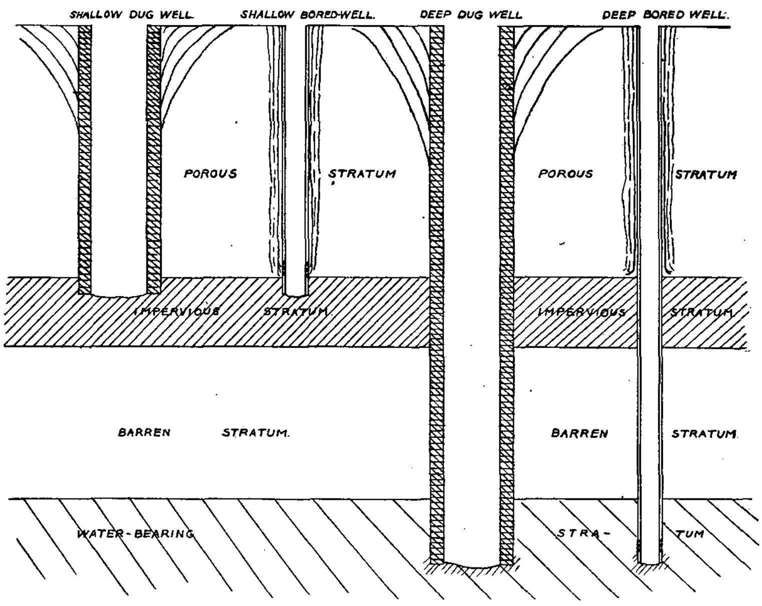

Fig. 1. Driven Wells safer than Dug Wells.

is either stone or brick, or, as in one well which I noticed, tile. Such a casing allows water to seep in through its entire depth. We all know how water will flow through the sides of a hole from top to bottom, the hole draining the earth for some distance. A similar state of affairs will be noticed with dug wells. Water flowing on the surface will carry with it any dirt or filth which may be near. In the case of the drilled, driven or bored wells, carefully cased, there is no chance for water to enter the well above the strainer.

All water which enters such a well must therefore pass through a layer of earth of a thickness equal to the distance from the surface to the top of the strainer, the earth thus serving as a natural filter. Comparative tests of dug wells and driven wells show that the driven wells are frequently free from bacteria, though often carrying large quantities of soluble substances like salt and nitrogenous compounds, indicating thus the polluted origin of the water, but showing how the water has been filtered by passing through the earth.

In some cases the drilled, driven or bored well, passes through a layer of earth through which water will not pass, and therefore the water supply must come from a considerable distance and will have a chance to become thoroughly purified during its passage through the earth. For this reason the deeper wells throughout the state, some of which have been analyzed in our series of farm well waters, are shown to be free from bacteria.

We realize that in some sections of the state, possibly at Centralia, it is not practical to obtain water from either the driven, drilled or bored wells, because the deep drilled wells are salty, and the shallower wells enter a stratum of earth of such a character that there is not sufficient flow through the small opening of the strainer. In the latter cases the dug well is needed to give reservoir capacity, so that the water may accumulate between pumpings. In such cases we would suggest that a special reinforcement of the casing be used.

Our suggestion is that the earth be excavated for four feet outside of the regular casing, that a coating of water-proofed Portland cement be placed over this casing (See Fig. 2), and that the bottom of this excavation, which should be at least four feet deep, be covered with several inches of water-proofed Portland cement, having a raised portion at the outer edge. (See Fig. 2). This will serve to divert the surface water away from the well, and it

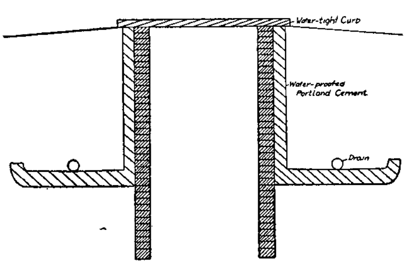

Fig. 2. Protection for Dug Wells.

may be led to a distance through a tile drain. The whole arrangement will prevent surface water that has not passed through at least four feet of earth gaining access to the water-bearing strata. Bacteria that would otherwise gain. access to the well will be filtered out.

If care be taken to use the deep drilled, driven or bored wells when such can be used, and to take the special precautions suggested where dug wells are a necessity, the general health of the farmers. and of the people of the state in general will be improved.

THE HARDNESS OF ILLINOIS MUNICIPAL WATER SUPPLIES.*

It is not the purpose of this paper to show the advantages of a soft water. We are all agreed that a soft water is best. The large majority of the municipalities of Illinois have hard water, and, therefore, what we wish to know is how to make them soft and when it is practicable to do so.

Whenever it is necessary to purify a water for drinking purposes an additional installation to soften the water is comparatively inexpensive. The same is true when it is found necessary to remove the iron from a water supply. To soften a hard but pure and clear water would mean a complete installation for softening purposes alone. In the latter case there will therefore be much hesitation on account of the expense before general softening plants are established. In all plants also there is a reluctance to treat all of the water supply when a soft water is not needed for all purposes.

Railroads are finding it profitable to soften the waters used in their locomotives, and plants for water treatment are in operation on all of the principal lines. The matter is of so much importance to them that an extended report has been made by the Committee on Water Service of the American Railway Engineering and Maintenance of Way Association.† The committee discusses the matter from the standpoint of use in locomotives quite fully. What has been found practicable in locomotive practice may be extended to general boiler uses or even to domestic practices.

The whole supply of a municipality may be softened or, where this is impracticable, plants may be established by the larger consumer, or even household softening plants may be erected. In order to furnish the chemical data necessary for such treatment the accompanying table has been prepared.

The samples of water analyzed have been sent to the State Water Survey from various towns by the waterworks men, the city officials,

*24th Annual Report, Ill. Soc. Eng. and Sur., 1909, p. 213.
† Am. Ry. Eng. & Maintenance of Way Assn., Bull. No, 83, Jan., 1907.

or by other citizens. The Water Survey has not been able to collect the samples itself, and thus cannot be absolutely certain that the samples are authentic. The probability is that most of them are all right.

The analytical work reported has been done in the laboratory of the Water Survey at the University of Illinois during the past fifteen years. There is a possibility that some of the waters have changed in character, but most of the well supplies are very stable.

Ninety-seven of the 216 separate sources of supply within the state have been examined. The analytical data which are needed to determine the method of water softening are given. Most all of the analyses are reported in full in a bulletin of the State Water Survey.*

The mineral content given in the table shows hypothetical combinations which have been calculated from the ionic content by calculating bases in the order, potassium, sodium, ammonium, magnesium, calcium, iron and aluminium, to the acid ions in the order, nitrate, chloride, sulphate and carbonate. By using this order the waters can be divided into several classes. To facilitate comparison we made three classes.

Class I. includes those waters which contain more than enough sodium to unite with all of the nitrate, chloride and sulphate ions. These waters would therefore contain sodium carbonate, and possibly the carbonates of magnesium, calcium and iron. The waters of this class will form a sludge or soft scale when used in boilers. They may have a high soap consuming power when used for laundry or in the lavatory. The hardness, which would necessarily consist of the carbonates of calcium and magnesium, will be almost entirely removed by boiling, or by treatment with the necessary amount of lime. The relative cost of softening by boiling and by lime is given by Collet* as 50 to 1.

Class II. includes those waters which have sufficient sodium to unite with all of the nitrates and chlorides and with part of the sulphates present. These waters contain the sulphate of magnesium and sometimes the sulphate of calcium, iron and aluminium. The

* University of Illinois Bulletin, State Water Survey Series, No. 5.
† Water Softening and Purification, London, 1908, p. 3.

TABLE SHOWING THE HARDNESS, AND THE AMOUNT OF LIME AND SODA ASH REQUIRED TO SOFTEN THE WATER FURNISHED TO NINETY-EIGHT ILLINOIS MUNICIPALITIES.

CITY	Class	Mineral Content—Parts per Million: Residue	Na_2CO_3	$MgCl_2$	$MgSO_4$	$MgCO_3$	$CaSO_4$	$CaCO_3$	Soda Ash: Parts per Million	Grains per Gallon	lbs. per 1000 Gals.	Lime: Parts per Million	Grains per Gallon	lbs. per 1000 Gals.	Chemicals Approximate Cost per 1000 Gallons	REMARKS
Amboy	I	389	14.1	...	...	125.2	...	212.6	...	...	...	285	16.6	2.38	$.00714	
Atlanta	I	517	46.8	...	...	154.6	...	238.5	...	...	...	340.	19.8	2.83	.00849	
Aurora	II	458	...	...	35.4	35.1	...	165.0	31.	1.8	.26	156.	9.1	1.30	.00650	
Beardstown	II	373	...	...	65.0	56.4	...	189.0	57.	3.3	.48	211.	12.3	1.76	.01008	
Belleville	I	370	201.0	...	...	53.3	...	43.4	...	...	...	...	...	...	...	Deep wells.
Belleville	II	393	...	...	21.6	95.2	...	187.2	19.	1.1	.16	211.	14.1	2.01	.0763	Edgmont.
Belvidere	II	352	...	...	1.5	116.5	...	193.4	1.3	.1	.01	264.	15.4	2.20	.00670	
Berwyn	II	735	...	...	182.4	9.7	...	256.8	160.	9.3	1.33	242.	14.1	2.02	.01936	
Bloomington	II	810	...	...	436.2	130.2	...	156.3	384.	22.4	3.20	463.	27.0	3.86	.04358	
Bushnell	II	2038	...	...	228.0	16.4	...	279.8	201.	11.7	1.67	285.	16.6	2.38	.02384	
Bryon	II	298	...	...	4.0	119.0	...	139.5	3.5	.2	.03	238.	13.9	1.99	.00627	
Cairo	II	235	...	...	7.3	21.4	...	47.4	6.4	.4	.05	58.	3.4	.48	.00194	Clay and silicious matter 103.5.
Cambridge	I	1052	49.0	...	...	18.6	...	104.9	...	...	...	177.	10.3	1.48	.00444	
Canton	II	1620	...	...	205.	...	119.3	157.8	283.0	16.5	2.36	184.	10.7	1.53	.02819	
Carbondale	I	1818	244.0	...	...	48.0	...	79.0				237.	13.8	1.98	.00594	Average of 3 analyses from different wells.
Carlyle (a)	II	248	...	...	20.0	55.4	...	117.3	17.6	1.0	.14	149.	8.7	1.24	.00512	
Carmi (a)	II	176	...	...	15.8	20.4	...	50.0	13.9	.8	.12	63.	3.7	.53	.00279	
Carrollton	II	3121	...	...	289.0	...	162.0	228.4	381.0	22.2	3.17	263.	15.3	2.20	.03830	Artesian well.
Carrollton	II	348	...	...	4.8	92.1	...	195.0	4.2	.2	.03	234.	13.6	1.95	.00615	Spring.
Chadwick	I	429	35.4	...	...	148.6	...	212.4	...	...	...	335.	19.5	2.80	.00840	
Champaign	I	408	56.0	...	...	101.0	...	202.0	...	...	...	276.	16.1	2.30	.00690	
Charleston (a)	II	270	...	...	21.1	68.0	...	127.0	18.6	1.1	.16	171.	10.0	1.43	.00589	
Chateworth	I	702	124.3	...	...	121.5	...	190.0	...	...	...	334.	19.5	2.78	.00834	
Chillicothe	III	420	...	16.9	94.4	41.1	...	202.9	102	5.9	.85	222.	12.9	1.85	.01405	
Chrisman	I	2116	343.5	...	...	30.2	...	38.6	...	...	...	...	...	...	...	Well 140'—Suspended matter 83.9—
Chrisman	III	571	...	22.1.	194.	...	1.5	290.0	197	11.5	1.64	266.	15.5	2.21	.02303	Well 17'
Clinton	I	310	18.6	...	...	118.	...	137	...	...	...	243.	14.2	2.03	.00609	Wells.
Clinton	I	431	7.2	...	...	144.	...	236.	...	...	...	327	19.1	2.73	.00819	Springs.
Collinsville	II	392	...	...	41.	104.	...	184.	36.	2.1	.30	260.	15.2	2.17	.00951	
Danville (a)	II	281	...	...	38.0	60.0	...	13.5	33.	1.9	.27	173.	10.1	1.44	.00702	
Decatur (a)	II	293	...	...	24.8	73.	...	137.	21.9	1.3	.18	185.	10.8	1.54	.00642	
DeKalb	I	301	60.	...	...	87.	...	132.	...	...	...	221.	12.9	1.84	.00552	
Dwight	II	1087	...	...	253.	...	101.	247.	222.	12.9	1.85	256.	14.9	2.14	.02492	
East Dubuque	I	361	48.3	...	...	109.5	...	113.3	...	...	...	234.	13.6	1.94	.00582	
East St. Lonis	II	233	...	...	5.5	41.3	...	90.0	4.8	.3	.04	108.	6.3	.90	.00310	
Edwardsville	II	260	...	...	55.4	23.2	...	131.1	49.	2.9	.41	130.	7.6	1.08	.00734	
Effugham	II	257	...	...	38.4	42.9	...	69.2	33.8	2.0	.29	114.	6.6	.94	.00572	
Elgin (a)	II	290	...	...	30.0	83.0	...	127.0	26.4	1.5	.21	196.	11.4	1.63	.00699	(a) U. S. G. S.
Elgin	I	347	63.0	...	...	98.	...	150.0	...	...	...	248.	14.5	2.07	.00621	Deep wells.
Elmhurst	II	478	...	...	86.	78.0	...	255.0	76.	4.4	.63	287.	16.7	2.40	.01350	
Farmer City	I	719	255.1	...	...	85.0	...	146.4	...	...	...	330.	19.2	2.75	.00825	
Freeport	II	463	...	...	62.0	109.4	...	221.4	55.	3.2	.46	298.	17.4	2.48	.01204	
Galesburg	II	951	...	...	135.1	47.9	...	259.3	119.	6.9	.99	272.	15.9	2.27	.01661	Mixture of deep and shallow wells.
Geneseo	II	396	...	...	15.6	103.3	...	192.1	14.	.8	.12	252.	14.7	2.10	.00750	
Greenville	II	552	...	...	65.1	96.4	...	277.3	57.	3.3	.48	313.	18.3	2.61	.01263	
Harvey	II	1204	...	...	239.7	...	225.2	267.5	386.	22.5	3.21	261.	15.2	2.18	.03864	
Havanna	II	196	...	...	15.5	35.9	...	96.1	14.	.8	.12	109.	6.4	.91	.00393	

Henry	I	2497	259.1	......	......	60.3	......	94.1	......	......	......	269.	15.7	2.25	.00675	
Jacksonville	II	374	......	......	33.2	96.0	......	208.0	29.	1.7	.24	260.	15.2	2.17	.00891	New supply.
Jerseyville	II	2506	......	......	250.0	......	161.0	157.0	345.	20.1	2.87	204.	11.9	1.70	.03380	
Kankakee (a)	II	288	......	......	52.0	37.4	......	145.0	46.	2.7	.38	155.	9.0	1.28	.00764	
Kewance	II	1265	......	......	87.0	......	40.0	175.0	108.	6.3	.90	138.	8.0	1.15	.01245	
Knoxville	II	1198	......	......	27.9	71.0	......	144.0	25.	1.5	.21	188.	11.0	1.57	.00681	
Lacon	III	446	......	6.4	47.0	97.0	......	218.0	49.	2.9	.41	277.	16.2	2.31	.01103	
La Grange	II	571	......	......	58.0	111.0	......	288.0	51.	3.0	.43	336.	19.6	2.80	.01270	
La Salle	II	432	......	......	80.0	56.0	......	216.0	70.	4.1	.59	233.	13.6	1.94	.01172	
Le wistown	II	293	......	......	48.8	50.0	......	153.0	43.	2.5	.36	175.	10.2	1.46	.00798	
Marshall	II	228	......	......	20.0	35.5	......	131.0	17.6	1.0	.14	130.	7.6	1.08	.00464	
Mascoutah	III	1060	......	10.2	299.0	......	119.0	453.0	368.0	21.5	3.06	399.	23.3	3.33	.04089	
Mattoon	I	611	16	......	......	185.	......	258.	......	......	......	399.	23.3	3.33	.00999	Mattoon Clear Well Water Co.
	II	222	......	......	42.	67.	......	96.	37.	2.2	.30	162.	9.4	1.34	.00702	Kickapoo Drain.
	II	298	......	......	66.	50.	......	144.	58.	3.4	.48	178.	10.4	1.48	.00924	Little Wabash Reservoir
Maywood	II	619	......	......	190.2	39.1	......	233.9	167.	9.7	1.38	272.	15.9	2.28	.02064	
Metropolis	III	233	......	2.7	20.0	17.7	......	163.0	17.6	1.0	.14	137.	8.0	1.14	.00482	
Minonk	I	2226	372.8	......	......	14.6	......	20.4	......	......	......	......	......	......	......	
Moline (a)	II	177.4	......	......	8.3	38.4	......	80.9	7.3	.4	.05	100.	5.8	.83	.00299	Suspended 108.
Morrison	I	314	6.6	......	......	110.8	......	153.9	......	......	......	237.	13.8	1.97	.00591	
Mound City	I	281	3.5	......	......	38.0	......	97.1	......	......	......	107.	6.2	.89	.00267	
Mount Morris	III	436	......	74.9	30.2	53.6	......	196.2	110.0	6.4	.91	240.	14.0	2.00	.01510	
Mt. Sterling	I	1542	88.	......	......	70.0	......	142.0	......	......	......	219.	12.8	1.83	.00549	Variable.
Newman	I	1221	76.	......	......	86.0	......	127.	......	......	......	226.	13.2	1.88	.00564	
Normal	I	410	153.	......	......	83.	......	131.	......	......	......	263.	15.3	2.20	.00660	
Oak Park	II	856	......	......	175.0	......	9.0	211.	154.	9.0	1.28	200.	11.7	1.67	.01781	Average of 2.
Onarga	II	1068	......	......	356.4	......	5.2	458.	314.0	18.3	2.61	418.	24.3	3.48	.03654	
Oregon	II	331	......	......	8.0	125.7	......	161.5	7.0	.4	.06	260.	15.2	2.16	.00708	
Ottawa	I	398	69.7	......	......	95.2	......	159.9	......	......	......	253.	14.8	2.12	.00636	
Palatine	II	701	......	......	269.4	......	62.1	118.8	237.0	13.8	1.97	192.	11.2	1.60	.02450	
Paris	II	443	......	......	58.4	102.1	......	188.2	51.4	3.0	.44	268.	15.6	2.23	.01109	
Pekin	III	416	......	41.7	82.1	46.4	......	187.5	119.0	6.9	1.00	229.	13.3	1.90	.01570	
Peoria	II	339	......	......	1.8	85.0	......	160.0	1.6	.1	.01	203.	11.8	1.70	.00520	
Peotone	II	604	......	......	126.0	35.0	......	302.8	111.0	6.5	.92	274.	16.0	2.28	.01604	
Plainfield	III	854	......	66.6	171.0	42.2	......	198.0	225.0	13.1	1.90	286.	16.7	2.38	.02614	
Polo	II	267	......	......	8.6	134.4	......	173.2	7.6	.4	.06	279.	16.3	2.33	.00759	
Prophetstown	II	339	......	......	60.8	35.7	......	195.9	53.6	3.1	.44	186.	10.8	1.54	.00902	
Quincy (a)	II	203	......	......	12.3	47.0	......	90.0	10.8	.6	.09	119.	6.9	1.00	.00390	
Rautoul	I	357	38.0	......	......	112.4	......	167.9	......	......	......	263.	15.3	2.20	.00660	
Riverside	I	807	60.0	......	......	70.0	......	157.0	......	......	......	213.	12.4	1.78	.00534	Well No. 1.
	II	689	......	......	229.	56.0	......	295.0	202.	11.8	1.70	346.	20.2	2.88	.02564	Well No. 2.
Rochelle	II	337	......	......	1.1	85.2	......	203.7	.9	.1	.01	228.	13.3	1.90	.00580	
Rockford	I	351	......	......	......	120.0	......	187.0	......	......	......	264.	15.4	2.20	.00660	
Rock Island	I	82	......	......	......	6.5	......	10.7	......	......	......	......	......	......	......	March, 1902
	II	191	......	......	11.0	40.0	......	87.0	9.7	.6	.08	107.	6.2	.89	.00347	February, 1906
Roseville	II	2591	......	......	443.8	......	480.4	194.6	765.	44.3	6.38	314.	18.3	2.61	.07163	Use $BaOH_2$
Rushville	II	4121	......	......	380.4	......	339.7	189.0	599.	34.9	5.00	283.	16.5	2.36	.05708	Use $BaOH_2$
Ste. Ahne	II	943	......	......	301.	......	105.	293.0	347.	20.2	2.90	304.	17.7	2.53	.03659	
Shelbyville	II	408	......	......	98.0	53.0	......	210.0	86.	5.0	.72	234.	13.6	1.94	.01302	City supply.
Shelbyville(a)	II	279	......	......	25.0	73.0	......	132.0	22.0	1.3	.18	183.	10.7	1.53	.00639	Auxiliary.
Sheldon	I	796	166.9	......	......	25.8	......	35.5	......	......	......	......	......	......	......	
Springfield	II	276	......	......	21.0	69.0	......	130.0	18.5	1.1	.16	174.	10.1	1.44	.00592	
Staunton	II	554	......	......	153.3	......	185.8	......	360.	20.9	3.00	......	......	......	......	Free acid and sulphates.
Sterling	II	332	......	......	25.5	107.2	......	160.6	22.4	1.3	.19	244.	14.2	2.03	.00799	
Streator(a)	II	325	......	......	61.0	59.0	......	137.0	54.0	3.1	.45	184.	10.7	1.53	.00909	
Taylorville	III	458.3	......	23.7	65.4	35.0	......	243.0	84.0	4.9	.70	227.	13.2	1.90	.01270	
Tolono	I	656	277.4	......	......	104.9	......	202.0	......	......	......	399.	23.3	3.33	.00999	
Urbana	I	408	56.0	......	......	101.0	......	202.	......	......	......	276.	16.1	2.30	.00690	
Warren	III	379	......	3.3	36.0	85.2	......	207.4	35.3	2.1	.30	248.	14.5	2.07	.00921	
West Chicago	II	381	......	......	22.0	109.1	......	151.1	19.4	1.1	.16	240.	14.0	2.00	.00760	
Wyoming	I	781	95.5	......	......	85.3	......	73.6	......	......	......	204.	11.9	1.70	.00510	
Lake Michig'n	II	140	......	......	7.3	29.4	......	81.4	6.4	.4	.05	89.	5.2	.43	.00179	Ave. for southern end.

waters of this class will form a scale more or less hard, according to the proportion of sulphate present. Their soap consuming power may be high, and boiling will not remove all of the hardness. Boiling will remove the carbonate hardness, but the sulphate hardness will remain. Lime will remove the carbonates, but soda ash or caustic soda must be used to change the sulphates to sulphates of sodium.

Class III. includes those waters, in which the sodium is not present in sufficient quantity to unite with all the nitrates and chlorides present. These waters will therefore contain magnesium chloride. The hardness may be due to chlorides, sulphates and carbonates of magnesium, calcium, etc. These waters will be corrosive, will form a hard scale and pit when used in boilers. They will also consume a considerable quantity of soap, and the hardness will not be removed by boiling. As in Class II., the lime will remove the carbonates, but soda ash or caustic soda must be used for the mineral acid hardness.

It is noted that the waters of the second class are most common, there being 64 waters in this class. The first class is next in order, with 32 waters, and the third class numbers 10.

Most of these waters will yield to treatment, the exception being those containing a large residue. These may be softened, but because of the necessary addition of sodium salts in the softening process, the foaming constituents will be increased so that they will be unsatisfactory for boiler uses. With the exception of the waters just mentioned, it is possible to so treat the Illinois waters that corrosion will be prevented and the scaling ingredients reduced to less than 85 parts per million (5 grains per gallon).

The amounts of sodium carbonate (soda ash, Na_2CO_3) and lime (CaO) needed to treat the waters were calculated, using ‘factors, as follows:

Magnesium chloride, $MgCl_2$ to Soda ash, Na_2CO_3. . . .	1.1130
Magnesium sulphate, $MgSO_4$ to Soda ash, Na_2CO_3. . .	.8811
Calcium sulphate, $CaSO_4$ to Soda ash, Na_2CO_3.	.7792
Sodium carbonate, Na_2CO_3 to Lime, CaO	.5287
Magnesium chloride, $MgCl_2$ to Lime, CaO	.5889

Magnesium sulphate, $MgSO_4$ to Lime, CaO..........	.4659
Magnesium carbonate, $MgCO_3$ to Lime, CaO.........	1.3300
Calcium carbonate, $CaCO_3$ to Lime, CaO...........	.5600
Parts per million to grains per gallon.............	.05833
Parts per million to pounds per thousand gallons..	.008345

The amounts are calculated on the basis of pure soda ash and pure lime, and no account is taken of the residual carbonate of calcium and magnesium which can not be removed. Practice would probably show that the approximate cost is therefore a trifle high. The amount of soda ash present has been included in the calculation of the lime needed for the waters of Class I. This is according to the laboratory experiments of Bartow and Lindgren.*

The results are given in parts per million, grains per gallon and pounds per thousand gallons. This will make it convenient for treatment on a large or small scale. Those desiring to soften water for use in the household, where the whole supply is not softened, may soften from a few gallons up by adding the calculated amount. We have tried the experiment with the water at the University of Illinois on a laboratory scale, using 30 liters of water; and on a household scale using 1,000 gallons of water. The Champaign and Urbana water supplies are in this way softened so that the soap consuming capacity is very much decreased and so that the possibility of staining white goods from the iron present is entirely eliminated, and there is no danger of clogging the water backs in the ranges.

As an illustration of the possibility of success in water softening, I will mention an incident.. My own cistern was dry, so I arranged to treat 1,000 gallons of water. When I was about to begin my wife expressed the wish that I experiment on some one else. The experiment was carried out, however. A few days later I was informed that the water I had treated was better. A few days later my attention was called to some curtains,. "Don't they look nice?" "They were washed in the water you treated." I had thus one convert to water softening.

*Bartow and Lindgren, Proceedings of the Am. Water Works Assn., Vol. 27, page 505, (1907).
Univ. of Illinois Bulletin, State Water Survey Series, No. 6.

Should plans be made to soften the water furnished from streams it is necessary to consider that the waters vary from day to day, that no specific rules can be laid down for the treatment. The results given are the averages. The analyses which are marked (a) are average analyses covering a period of one year, and were made by Mr. W. D. Collins, Assistant Hydrographer of the United States Geological Survey, and Mr. C. K. Calvert, Field Assistant of the United States Geological Survey under the co-operative agreement with the State Water Survey, State Geological Survey, and the University of Illinois Engineering Experiment Station in a study of the streams of Illinois.

The cost of treatment has been calculated on the basis of lime at $6.00 per ton and soda ash at $1.00 per hundred. The cost at any place can be readily calculated by noting the relation between this estimated cost and the actual cost on the spot.

The Water Survey is asking the legislature for funds to extend the work of the survey. The above shows one of the lines of work planned. We wish to make analyses of all the supplies, but we wish also to have the privilege of collecting our own samples. We hope that those interested may see our needs and that they will help us in any way they can.

INTERPRETATION OF RESULTS, 1909.

The results obtained by analyzing waters in the laboratory of the State Water Survey show that no hard and fast rules can be drawn concerning standards for all Illinois waters. Some rules, however, are needed for judging the potability of these waters. Each year the Survey issues a circular on the Interpretation of Results, which is sent with each analysis. This circular is revised as new methods are adopted or old methods are modified, and as more is known concerning the normal for the waters of the state. The circular issued December 1, 1908, is as follows:

INTERPRETATION OF RESULTS OF SANITARY WATER ANALYSIS.

The statement of chemical results is made in parts per million by weight, that is, in milligrams per liter, since one liter of water weighs 1,000,0000 milligrams. On the scale of 100, one part is equivalent to one ten-thousandth of 1 per cent. Should the data be desired in terms of the United States gallon of 231 cubic inches, multiply by .058335.

In arriving at the conclusion set forth, the following is the basis for interpretation of the analytical data:

"TURBIDITY" refers to the amount of insoluble matter in suspension. It may be perfectly harmless, though a turbid water is less attractive for drinking purposes than a perfectly clear water. The turbidity standard is silica suspended in water.

"COLOR" refers to colored substances in solution. It is due usually to an extract of vegetable matter. The color standard is the color obtained by a solution of platinum chloride and cobalt chloride in water.

"ODOR" is a descriptive term and is reported as vegetable, fishy, moldly, disagreeable, etc.

"TOTAL RESIDUE ON EVAPORATION" comprises the solid matters left on evaporating the water and drying the residue at 180 degrees Centigrade. It includes both inorganic and organic substances.

Unless the quantity is excessive or the water is to be used for industrial purposes the individual constituents are not separately determined.

"CHLORINE IN CHLORIDES" refers to the quantity of chlorine in combination with metals, for example, sodium chloride (common salt). In unpolluted waters the amount of chlorine, or the "normal chlorine" varies according to location; for example, distance from the sea coast or the presence of salt deposits.

Chlorine is a constant and considerable constituent of sewage—therefore, if it is present in a water in amounts exceeding the normal for that locality, pollution is indicated.

OXYGEN CONSUMED" refers to the quantity of oxygen required to oxidize the organic matters present in the water. However, many organic substances which may be present in water are not readily affected by the oxidizing, agent. Sometimes inorganic matter is oxidized, hence the quantity of "oxygen consumed" does not always bear a direct ratio to the total quantity of organic matters present.

"ORGANIC MATTERS." At present we have no practicable means for the accurate determination of the quantity and character of the various individual organic substances contained in water. These substances include living organisms, both vegetable and animal; products of organic life, such as fecal matters, and decaying vegetation. Because nitrogen is an essential of all living things, we therefore base the estimation of organic matters on the determination of nitrogen in four of the forms in which it may exist in water.

"NITROGEN AS ALBUMINOID AMMONIA" represents the nitrogen contained in various organic substances in an undecomposed state but which will decompose under certain conditions. These substances include products of organic life, as albuminous substances, tissues, urea, fecal matters, etc., substances which serve as nutrients for germs. The presence of much nitrogen as albuminoid ammonia usually suggests pollution with sewage or drainage from refuse animal matters.

"NITROGEN AS FREE AMMONIA" so called, represents ammonia contained in the water in either the free or saline condition. It is usually formed by the natural decomposition of nitrogenous organic matters. It is the first stage of oxidation or decomposition. Its quantity ordinarily indicates the amount of organic matters which are contained in the water in a partially decomposed state. It is a constant and considerable constituent of sewage, though it must be remembered that free ammonia occurs in considerable quantity in the deep drift wells of the State.

The above combinations of nitrogen in undergoing further decomposition are further oxidized, forming nitrous and nitric acids. These acids combine with basic mineral matters forming first nitrites and finally nitrates.

"NITROGEN AS NITRITES." The presence of any considerable quantity of nitrous acid or nitrites in a water may indicate that decomposition of living organisms is under way. Nitrites indicate pollution, but in the case of pure deep well waters containing soluble iron salts a change of the iron to insoluble compounds causes the formation of nitrites from nitrates which may be present.

"NITROGEN AS NITRATES." The presence of considerable quantities of nitrogen as nitric acid or nitrates indicates that at least correspondingly large quantities of organic matter have been previously present in the water.

The danger attending the presence of organic matter in water arises chiefly from the fact that disease germs may accompany organic matters of animal origin.

"ALKALINITY" of water helps to determine its value for household and industrial uses. It is measured in terms of calcium carbonate.

"HARDNESS" is the amount of dissolved substances that will form insoluble compounds with soap. It is measured in terms of calcium carbonate.

"SULPHATES AND IRON" are also helps to determine the household and industrial value.

BACTERIAL EXAMINATION OF WATER.

"THE NUMBER OF BACTERIA" per cubic centimeter reported is the number of bacteria that will develop colonies on gelatine at 20 degrees Centigrade unless otherwise noted.

"GAS FORMERS." Bacteria of the colon group are always present in the intestinal tract of men and of animals. They are therefore present in sewage. They will ferment dextrose and form a gas in a broth containing it. The determination of the formation or non-formation of gas, while not an absolute test for the colon bacillus, helps in the formation of an opinion concerning sewage pollution.

In the report, the amount of water used is denoted by 10 c. c.; 1.0 c. c. etc.; the number of tests made is denoted by figures directly after the amount, and the result of the test is denoted by the plus (+) sign when the test gave a positive result and by the minus (—) sign when the result was negative.

"INDOL." The bacteria of the colon group will form indol when added to a solution of peptone. The indol test is therefore a confirmation of the test for gas formers.

STANDARDS OF PURITY.

For the information and convenience of those to whom our reports are sent, the following limits have been provisionally adopted as a reasonable basis for reaching conclusions regarding the wholesomeness of waters in the State of Illinois. No absolute standards of purity whereby to judge the conditions of any and all potable waters can be justly established, because of differences due to the nature of the strata from which waters are drawn or with which they have been ni contact, the topography of the district, and the general environment of the sources.

SUGGESTED LIMITS OF IMPURITIES.

PARTS PER MILLION.

	Lake Michigan.	Streams*	Springs and Shallow Wells.	Deep Drift Wells.	Deep Rock Wells.
Turbidity	None	10.	†None	†None	†None
Color	None	.2	†None	†None	†None
Odor	None	None	None	None	None
Residue on evaporation	150.	300.	500.	500.	500.
Chlorine	4.5	6.	15.	15.	5.–100.
Oxygen consumed	1.6	5.	2.	2.–5.††	2.–5.††
Nitrogen as: Free ammonia	.01	.05	.02	.02–3.	.02–3.
Albuminoid ammonia	.08	.15	.05	.20	.15
Nitrites	.000	.000	.000	.005	.000
Nitrates	.04	.5	2.00	.50	.5
Alkalinity	120.	200.	300.	300.	300.
Bacteria per cubic centimeter	100	500	500	100	100
Colon bacillus in one c. c.	Absent	Absent	Absent	Absent	Absent

The formation of a reasonable and just opinion regarding the wholesomeness of a water requires that there be taken into consideration all the data of the analysis together with the history of the water; the nature of the source; character of the soil and earth or rock strata, and the surroundings. The interpretation of results is a task for the expert. The purpose of this sheet is, therefore, merely to present to the layman such information, touching the evidence and the line of argument, as shall aid him to an understanding and appreciation of the conclusion or opinion.

*This standard of purity is seldom found in the unfiltered water, as all streams are more or less polluted.
†None when drawn from wells. They may become turbid and develop color on standing.
††Varies as the waters contain ferrous salts.

ADDITIONAL DATA CONCERNING MUNICIPAL WATER SUPPLIES.*

Abingdon, Knox county, obtains its water supply from a well 1,300 feet deep through the St. Peter sandstone. The system is owned by the city and was established in 1903.

Albion, Edwards county, has no general supply.

Aledo, Mercer county, see Bulletin No. 5, page 12. An additional sanitary analysis of the water from the well which is 3,165 feet deep gave the following results:

Laboratory No. 16121. Collected June 10, 1997.

Turbidity	7.	Nitrogen as Free Ammonia	.376	Bacteria per c. c.	60
Color	.1	Alb. Ammonia	.112	Gas formers in 10 c. c.	1 –
Odor	Putrid	Nitrites	.900	1 c.c.	2 –
Residue on Evaporation	2592.	Nitrates	.000	0.1 c. c.	2 –
Chlorine in Chlorides	343.	Alkalinity as $CaCO_3$	231.3	Indol	—
Oxygen Consumed	7.3				

Altamont, Effingham county, has no general supply.

Alton, Madison county, see Bulletin No. 5, page 12.

Amboy, Lee county, see Bulletin No. 5, page 12.

Anna, Union county, has no municipal water supply.

Arcola, Douglas county, see Bulletin No. 5, page 12. The three wells at Arcola are from 90 to 100 feet deep. Additional analyses of the water from these wells gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF ARCOLA.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Sulphate.	Iron.	Bacteria per c.c.
								Ammonia.						
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.			
13189	1907. May 27	Decided	Yellow	0	776.8	82.24	14.55	33.60	.48	.000	.20	Very Little	Consid.	280.
13190	May 27	Decided	Yellow	0	786.4	81.25	16.45	36.00	.56	.000	.20	Very Little	Consid.	1450.

*Supplementary to Bulletin of the University of Illinois, Water Survey Series No. 5.

Arlington Heights, Cook county, see Bulletin No. 5, page 12.

Ashland, Cass county, has no general supply.

Assumption, Christian county, has no general supply.

Astoria, Fulton county, has no general supply.

Athens, Menard county, see Bulletin No. 5, page 13.

Atlanta, Logan county, see Bulletin No. 5, page 13.

Auburn, Sangamon county, has no general supply.

Augusta, Hancock county, has no general supply.

Aurora, Kane county, see Bulltetin No. 5, page 13.

Barrington, Cook county, see Bulletin No. 5, page 15.

Barry, Pike county, see Bulletin No. 5, page 15.

Batavia, Kane county, see Bulletin No. 5, page 15.

Beardstown, Cass county, see Bulletin No. 5, page 15. Addtional analyses gave the following results:

SANITARY ANALYSES OF THE. MUNICIPAL SUPPLY OF BEARDSTOWN.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia.				Alkalinity.	Bacteria per c.c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c.c.	0.1 c.c.	
	1908.																
17868	Aug. 7	0	10.	0	366.	20.	1.0	.032	.064	.000	.680	235.	64	1–	2–	2–	–
17869	Aug. 7	0	10.	0	360.	20.	1.1	.032	.048	.001	.680	229.	28	1–	2–	2–	–

An analysis of the mineral content gave the following results:

Laboratory No. 17868.

Ions	Parts Per Million	Hypothetical Combinations		Parts Per Million	Grains Per Gallon
Sodium, Na	15.8	Sodium nitrate,	$NaNO_3$	4.1	.24
Magnesium, Mg	29.4	Sodium chloride,	NaCl	33.0	1.92
Calcium, Ca	75.8	Sodium sulphate,	Na_2SO_4	5.2	.30
Oxide of Iron, Fe_2O_3		Magnesium sulphate,	$MgSO_4$	65.0	3.79
and Alumina, Al_2O_3	1.8	Magnesium carbonate,	$MgCO_3$	56.4	3.29
Nitrate, NO_3	3.0	Calcium carbonate,	$CaCO_3$	189.2	11.03
Chloride, Cl	20.0	Oxide of Iron and	Fe_2O_3+		
Sulphate, SO_4	55.4	Alumina,	Al_2O_3	1.8	.10
Silica, SiO_2	17.5	Silica,	SiO_2	17.5	1.02
Bases	.9	Bases,		.9	.05
		Total,		373.1	21.74

Belleville, St. Clair county, see Bulletin No. 5, page 15. Owing to lack of sufficient water in the deep wells new wells from 80 to 100 feet deep were dug in the drift of the American bottoms at Edgemont. This water was turned into the mains during the spring of 1908. These wells furnish an abundant supply of a pure, though hard, water. Comparative analyses of the water from these wells and from the original source are given below.

SANITARY ANALYSES OF MUNICIPAL WATER SUPPLY OF BELLEVILLE.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c.c.	Colon Bacillus.			Remarks.
								Ammonia.									
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c.c.	0.1 c.c.	
From Lake Christine or Lake No. 3*.																	
16294	1907 July 23	10	.4	1E.	165	4	14.2	.200	.592	.000	.120	89	20,000		1 + 1 –	2 – ·	(1) (2)
16295	July 23	20	.4	M.	157	4	14.5	.056	.624	.000	.000	89	10,000		2 +	1 +	(1) (3)
16295	July 23	20	.4	M.	166	4	14.3	.192	.608	.000	.080	89	30,000		1 – 1?	2 –	(2)
16297*	July 23	10	.3	M.	185	5	8.5	.040	.296	.000	.080	111	500,000		2 +	1 + 1 –	(1)
16298*	July 23	30	.3	2 0	195	4	8.2	.024	.304	.000	.000	111	290,000		2 +	1 + 1 –	(1) (2)
16299	July 23	15	.3	0	183	6	8.5	.040	.304	.325	.035	130	80,000		1 – 1 +	1 – 1 –	(2) (1)
16300	July 23	30	.3	0	186	5	9.2	.024	.296	.750	.360	130	20,000		2 –	2 –	(1) (2)
16505*	Sept. 17	30	.5	E.	189	2	13.7	.032	.720	.000	.12	87	600	1–	2 –	2 –	
16506*	Sept. 17	20	.1	E.	179	5	7.	.072	.452	.000	.120	109	400	1–	1 ? 1 +	1 + 1 –	
16507*	Sept. 17	5	.4	E.	163	4	7.1	.384	.360	.005	.195	89	1,500	1+	1 + 1 –	1 – 1 –	
16508*	Sept. 17	3	.6	E.	180	2	13.8	.072	.720	.000	.200	87	1,000	1+	1 – 1 +	1 – 1 +	
From Deep Wells.																	
15687	1907 Feb. 11	CIr.	.2	0	401	16	1.75	.008	.048	.008	.752	297	50+	1 –	2 –	2 –	(3)
15688	Feb. 11	Sli.	.2	0	398	16	2.2	.008	.032	.000	.640	302	650	1 –	2 –	2 –	
15689	Feb. 11	VS.	.2	0	413	21	1.8	.048	.048	.003	.400	345	200+	1 –	1 + 1 –	2 –	(3)
15690	Feb. 11	VS.	.2	0	382	17	2.1	.008	.048	.000	.720	291	500	1 –	2 –	2 –	(3)
15950	Apr. 16	0	.0	0	409	19	2.65	.024	.056	.000	.320	329					
16293	July 23	0	.0	0	403	22	1.1	.016	.040	.002	.360	318	16,000		2 –	2 –	(1) (2)
16301	July 23	0	.0	2P.	388	17	1.7	.000	.056	.000	.120	308	13,000		1? 1 –	2 –	(1) (2)
16302	July 23	35	.1	2 M.	457	18	2.7	.000	.072	.000	.160	235	40,000		1?	2 –	(1)
17167	1908 Mar. 6	0	.2	M.	443	19	3.5	.280	.056	.000	.000	366					(2)
17168*	Mar. 6	80	.2	0	11888	20	11.3	.056	.344	.000	9.000	9900					(4)

*Taken from boiler after fourteen days' run. (1) Estimated. (2) Ice Melted. (3) Liquified. (4) Phenolphthaleln 6040.

From Edgemont.													Iron						
16332	1907 July 30	30	.5	0	229	7	2.3	.230	.076	.000	.240	111							
17398	1908 May 5	30	60.	0	378	8	2.2	.400	.048	.000	.120	290		45	1—	2—	2—	—	(5)
17399	May 5	30	60.	0	370	8	2.2	.400	.048	.000	.120	290		38	1—	2—	2—	—	(5)
17478	May 5	0	0.	0	383	11	1.5	.120	.056	.006	.320	299		3,000	1—	2—	2—	—	(6)
17480	May 25	20	30.	0	410	9	1.6	.128	.072	.003	.480	297		3,200	1—	2—	2—	—	(7)
17536	June 9	0	20.	0	397	12	1.3	.080	.056	.000	.400	306		40	1?	2—	2—	—	
17791	July 27	30	100.	0	420	16	2.3	.512	.048	.000	.320	295							(8)
18048	Aug. 31	30	80.	0	290	6	1.8	.302	.040	.000	.240	268		----	--	--	--	--	
18131	Sept. 14	20	10.	E.	319	7	1.2	.208	.056	.001	.200	263		19	--	2—	--	--	
18133	Sept. 14	20	70.	0	322	7	1.4	.304	.056	.000	.200	266							
18134	Sept. 14	30	25.	0	328	8	1.4	.280	.048	.000	.280	261		----	--	--	--	--	
18135	Sept. 14	20	70.	0	324	7	1.9	.200	.080	.000	.160	263		24		2—		—	
18242	Sept. 28	50	50	0	396	10	1.0	.384	.032	.000	.160	291		12	1—	1—	1—	+	
18243	Sept. 28	30	50	0	372	9	1.0	.384	.048	.000	.160	287		80	1—	1—	1—	+	
18244	Sept. 28	35	50.	0	381	9	1.2	.424	.054	.000	.240	287		120	1—	1—	1—	+	
18245	Sept. 28	25	40.	0	381	9	1.1	.128	.096	.015	.305	281		24	1?	1?	1—	+	
18246	Sept. 28	5	10.	0	386	9	1.0	.040	.080	.004	.520	281		160	1?	1—	1—	+	
18313	Oct. 12	20	50.	0	392	10	1.8	.400	.128	.004	.160	296		----	--	--	--		
18314	Oct. 12	30	50.	0	356	8	1.4	.544	.160	.002	.160	296		----	--	--	--		
18506	Nov. 16	2	20.	0	376	12	2.0	.024	.056	.000	.440	298	.4	480	1 +	2 +	2—	—	
18507	Nov. 16	30	30.	0	378	11	2.1	.368	.048	.002	.200	302	2.5	30	1?	1—	2—	—	
18508	Nov. 16	30	10.	0	381	10	2.2	.392	.056	.003	.120	296	1.5	60	1 +	1 + 1—	1 +	—	
18509	Nov. 16	30	20.	0	371	10	2.2	.360	.056	.007	.233	300	3.5	60	1 +	1 + 2 +	1— 2—	—	

(5) Nitrate —. (6) Hardness 235. (7) No ice, hardness 228. (8) Bacteria bottle broken.

Analyses of the mineral content gave the following results:

MINERAL ANALYSES OF CITY WATER FROM BELLEVILLE.

HYPOTHETICAL COMBINATIONS	Amounts Are Stated in Parts Per Million.						
	Lake Christine		Deep Wells		Edgemont.		Boiler Water
	16295	17478	15688	17167	17398	17480	17168*
Potassium, K	---						
Sodium, Na	6.4	53.4	107.1	154.1	15.8	54.5	4852.5
Ammonium (NH_4)		.15		.4	.5	.2	.056
Magnesium, Mg	6.2	22.6	15.4	8.1	31.9	24.0	10.9
Calcium, Ca	26.3	59.3	17.4	7.6	75.0	58.5	7.9
Iron, Fe	.8		.4				
Oxide of Iron, Fe_2O_3 and Aluminum, Al_2O_3		1.0		4.0	7.4	5.9	16.0
Silica, SiO_2	11.2	26.6	11.2	15.4	33.1	49.3	428.
Nitrate, NO_3		1.41	2.8		.5	2.1	39.8
Nitrite, NO_2		.02					
Chloride, Cl	4.	11.	16.0	19.	8.	9.	820.0
Sulphate, SO_4	27.8	31.4	19.2	18.1	40.2	31.	388.4
Bases		.8	1.0	0.7	.6	2.1	8.

HYPOTHETICAL COMBINATIONS.	Amounts Are Stated in Parts Per Million.						
	Lake Christine		Deep Wells		Edgemont		Boiler Water
	16295	17478	15688	17167	17398	17480	17168*
Sodium Nitrate, $NaNO_3$		1.9	3.8		.7	2.9	54.6
Sodium Chloride, NaCl	6.6	18.2	26.4	31.4	13.2	14.9	1352.2
Sodium Sulphate, Na_2SO_4	11.7	46.5	28.4	26.8	32.1	45.9	574.8
Sodium Carbonate, Na_2CO_3		70.4	200.9	306.1		75.7	7144.4
Sodium Hydroxide, NaOH							1761.0
Ammonium Sulphate, $(NH_4)_2SO_4$					1.8		
Ammonium Carbonate, $(NH_4)_2CO_3$		.4		1.1		.5	
Magnesium Sulphate, $MgSO_4$	24.9				21.6		
Magnesium Carbonate, $MgCO_3$	4.2	78.3	53.3	28.1	95.2	83.1	
Magnesium Hydroxide, $Mg(OH)_2$							45.3
Calcium Carbonate, $CaCO_3$	65.6	148.0	43.4	19.0	187.2	146.0	
Calcium Hydroxide, $Ca(OH)_2$							19.3
Iron Carbonate, $FeCO_3$	1.7		.8				
Aluminium, Al_2O_3	6.6		1.0				
Oxide of Iron Fe_2O_3 and Alumina, Al_2O_3		1.0		4.0	7.4	5.9	16.0
Silica, SiO_2	11.2	26.6	11.2	15.4	33.1	49.3	428.0
Bases		.8	1.0	.7	.6	2.1	8.0
	132.5	392.1	370.2	432.6	392.9	426.3	11404.5

*Water from deep wells concentrated in boilers at the water works pumping station.

HYPOTHETICAL COMBINATIONS	Amounts Stated in Grains Per Gallon.						
	Lake Christine		Deep Wells		Edgemont		Boiler Water
	16295	17478	15688	17167	17398	17480*	17168**
Sodium Nitrate, $NaNO_3$		.11	.22		.04	.17	3.15
Sodium Chloride, NaCl	.38	1.06	1.53	1.83	.77	.87	78.92
Sodium Sulphate, Na_2SO_4	.68	2.71	1.66	1.56	1.87	2.67	33.53
Sodium Carbonate, Na_2CO_3		4.10	11.71	17.85		4.41	416.70
Sodium Hydroxide, NaOH							1?2.72
Ammonium Sulphate, $(NH_4)_2SO_4$					.10		
Ammonium Carbonate, $(NH_4)_2CO_3$		.02		.06	.?3		
Magnesium Sulphate, $MgSO_4$	1.45				1.26		
Magnesium Carbonate, $MgCO_3$	.24	4.57	3.11	1.64	5.56	4.85	
Magnesium Hydroxide, $Mg(OH)_2$							2.64
Calcium Carbonate, $CaCO_3$	3.82	8.63	2.53	1.11	10.92	8.52	
Calcium Hydroxide, $Ca(OH)_2$							1.12
Iron Carbonate, $FeCO_3$	.10		.05				
Aluminium, Al_2O_3	.38		.06				
Oxide of Iron Fe_2O_3+ and Alumina, Al_2O_3		.06		.23	.43	.34	.93
Silica, SiO_2	.65	1.55	.65	.90	1.93	2.88	24.96
Bases		.04	.06	.04	.03	.12	.46
Total,	7.70	22.85	21.58	25.23	22.91	24.86	665.13

*Sample taken before deep well water was removed from the mains. It is evidentlys a mixture of deep well water and Edgemont water.
**Water from deep wells concentrated in boilers at the water works pumping station.

Belvidere, Boone county, see Bulletin No. 5, page 16.

Bement, Piatt county, see Bulletin No. 5, page 16.

Benton, Franklin county, has no general supply.

Berwyn, Cook county, obtains its water supply from two wells 1,650 and 1,700 feet drilled in limestone. The system is owned by the South Berwyn Water Works Company and was established under the regime of the town of Cicero, about 1893. The reservoirs are situated on 30th Street and Baldwin Avenue. The pumps used are, one air compressor and two Worthington duplex and compound steam pumps. The average daily consumption is 250 thousand gallons.

For sanitary and mineral analyses of the city water supply see Bulletin No. 5, page 17.

Bloomington, McLean county, see Bulletin No. 5, page 17. Sanitary analyses of the water from the driven wells 100 feet deep gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF BLOOMINGTON.

Serial Number	Date of Collection	Appearance			Total Residue on Evaporation	Chlorine in Chlorides	Oxygen Consumed	Nitrogen as				Alkalinity
		Turbidity	Color	Odor				Ammonia: Free	Ammonia: Albuminoid	Nitrites	Nitrates	
15733	Feb. 20, 1907	Slight	.15	0	971	16	2.35	.100	.144	.010	.230	423
17074	Jan. 29, 1908	20.	.4	0	1007	16	2.0	.120	.080	.032	.488	432

An analysis of the mineral content gave the following results:

Collected February 20, 1907. Laboratory No. 15733.

Ions	Parts Per Million	Hypothetical Combinations		Parts Per Million	Grains Per Gallon
Sodium, Na	26.0	Sodium nitrate,	$NaNO_3$	1.4	.0.8
Magnesium, Mg	125.6	Sodium chloride,	NaCl	26.4	1.54
Calcium, Ca	62.6	Sodium sulphate,	Na_2SO_4	46.9	2.73
Iron, Fe	.3	Magnesium sulphate,	$MgSO_4$	436.2	25.44
Alumina, Al_2O_3	.9	Magnesium carbonate,	$MgCO_3$	130.2	7.59
Nitrate, NO_2	1.0	Calcium carbonate,	$CaCO_3$	156.3	9.10
Chloride, Cl	16.0	Iron carbonate,	$FeCO_3$	.6	.03
Sulphate, SO_4	348.0	Alumina,	Al_2O_3	.9	.05
Silica, SiO_2	8.2	Silica,	SiO_2	8.2	.47
Bases,	2.8	Bases,		2.8	.16
		Total,		809.9	47.19

Blue Island, Cook county, see Bulletin No. 5, page 17.

Braceville, Grundy county, has no general supply.

Bradley, Kankakee county, obtains its water supply from a well 380 feet deep. The pumping station and standpipe are located in the business part of the village. The pumps used are of the Gould type, with a capacity of 40 gallons.

Braidwood, Will county, obtains its water supply from driven wells. The system is owned by the city and was established in 1895, at a cost of $15,000. The reservoir and pumping station are located in the business part of the town. A Knowles pump with a capacity of 50,000 gallons is used. The daily consumption is about 10,000 gallons.

Breese, Clinton county, see Bulletin No. 5, page 17. Sanitary analyses of the water from Shoal Creek, gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF BREESE.

Serial Number	Date of Collection	Appearance			Residue on Evaporation	Chlorine in Chlorides	Oxygen Consumed	Nitrogen as				Alkalinity	Bacteria per c.c.	Colon Bacillus			Indol
		Turbidity	Color	Odor				Ammonia		Nitrites	Nitrates			10 c.c.	1 c.c.	0.1 c.c.	
								Free	Albuminoid								
	1908																
17237	March 23	20.	2.	Musty	353	9	4.8	.066	.210	.015	.600	222	225	1—	2—	2—	+
17238	March 23	30.	0	0	353	8	5.7	.064	.198	.003	.680	220	220	1—	2—	2—	+

Brooklyn, St. Clair county, has no general supply.

Brookport, Massac county, (1,500) is located on the Ohio River. The water supply is obtained from drilled wells 207 feet deep. The plant is owned by the city and was established in 1907 at a cost of $12,000. The daily consumption is about 40,000 gallons in the summer. Recent analyses of the city supply gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF BROOKPORT.

Serial Number	Date of Collection	Appearance			Residue on Evaporation	Chlorine	Oxygen Consumed	Nitrogen as				Alkalinity	Bacteria per c.c.	Colon Bacillus.			Indol
								Ammonia									
		Turbidity	Color	Odor				Free	Albuminoid	Nitrites	Nitrates			10 c.c.	1 c.c.	0.1 c.c.	
17627	1908 June 29	35.	0	0	269	9	2.2	.000	.032	.000	.160	201	12	1—	2—	2—	—
17628	June 29	10.	20	Musty	248	12	1.3	.072	.148	.000	.000	195	480	1—	2—	2—	—

Bunker Hill, Macoupin county, has no general supply.

Bushnell, McDonough county, see Bulletin No. 5, page 17, obtains its water supply from two wells, one 125 feet deep in gravel and one 1,351 feet deep in St. Peters. The system is owned by the city and was installed in 1889. The cost of installation and additions from time to time is estimated at about $27,000. The pumping station is located in the western part of the city. The system includes two impounding reservoirs and a standpipe. The water is said to be excellent.

Additional sanitary analyses of the water from these wells gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF BUSHNELL.
Samples Collected September 17, 1906.

Serial Number.	Appearance.			Residue on Evaporation.	Chloride in Chlorines.	Oxygen Consumed.	Nitrogen as				Alkalinity.
							Ammonia.				
	Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.	
1500	Distinct	1.0	5 Musty	564	2	9.5	7.4	.320	.007	.233	529
15008	Distinct	1.0	0	1917	390	5.5	1.04	.040	.007	.193	270
15009	Distinct	1.0	0	1916	397	5.3	1.04	.072	.010	.230	268

Byron, Ogle county, see Bulletin No. 5, page 17.

Cairo, Alexander county, see Bulletin No. 5, page 18, obtains its water supply from the Ohio River. The plant is owned by the

Cairo Water Company and was established in 1886. The pumping station is located on 42nd Street. The pumps used are, low service, 6,000,000 McGowan, high duty, 10,000,000, 2 Gordon, 1 Herrin. The water is treated. The daily consumption is 3,000,000 gallons.

Cambridge, Henry county, see Bulletin No. 5, page 18.

Camp Point, Adams county, has no general supply.

Canton, Fulton county, see Bulletin No. 5, page 18. Additional analyses of the water taken from the old well 1,800 feet drilled, and the new well 2,042 feet drilled, gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF CANTON.

Samples Nos. 14625, 14746, 16494 taken from old well. No. 17327. taken from new well.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c.c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c.c.	0.1 c.c.	
14625	1906. Jly. 13	Clear	0	0	1820	275	4.85	.720	.072	.001	.240	215					
14746	Aug. 7	Clear	0	0	1892	285	4.2	.456	.042	.001	.240	225					
16494	1907. Sep. 16	5.	0		1832	30	5.5	.340	.032	.008	.532	241	Liq.	1—	1?	1+	
17327	1908. Apr. 13	10.	.2		1627	300	4.2	.072	.120	.000	.200	232	7	1—	1— 2—	1 ? 2—	—

An analysis of the mineral content of the water from the old well gave the following results:

MINERAL ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF CANTON.

Laboratory No. 14625.

Ions	Parts Per Million	Hypothetical Combinations		Parts Per Million	Grains Per Gallon
* Sodium, Na	421.1	Sodium nitrate,	$NaNO_3$	1.5	.09
Ammonium, NH_4	.9	Sodium chloride,	NaCl	453.8	26.47
Magnesium, Mg	44.1	Sodium sulphate,	Na_2SO_4	745.9	43.51
Calcium, Ca	101.2	Ammonium sulphate,	$(NH_4)_2SO_4$	3.3	.19
Iron, Fe	2.2	Magnesium sulphate,	$MgSO_4$	218.0	12.72
Alumina, Al_2O_3	.8	Calcium sulphate,	$CaSO_4$	117.5	6.85
Nitrate, NO_3	1.1	Calcium carbonate,	$CaCO_3$	166.2	9.69
Chlorine, Cl	275.0	Iron carbonate,	$FeCO_3$	4.6	.27
Sulphate, SO_4	763.2	Alumina,	Al_2O_3	.8	.05
Silica, SiO_2	12.0	Silica,	SiO_2	12.0	.70
Bases	2.4	Bases,		2.4	.14
		Total,		1726.0	100.68

*Potassium and sodium not separated, all calculated as sodium.

Carbondale, Jackson county, see Bulletin No. 5, page 19.
Carbon Hill, Grundy county, see Bulletin No. 5, page 20.
Carlinville, Macoupin county, see Bulletin No. 5, page 20. Additional analyses gave the following results:

SANITARY ANALYSES OF THE MNUICIPAL WATER SUPPLY OF CARLINVILLE

Serial Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Color.	Appearance. Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia. Free.	Nitrogen as Ammonia. Albuminoid.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Alkalinity.	Bacteria per c.c.	Colon Bacillus. 10 c.c.	Colon Bacillus. 1 c.c.	Colon Bacillus. 0.1 c.c.	Indol.
15909	1907. Apr. 5	50.	.4	0	365	10	7.35	.064	.272	.000	.320	199					
15910	Apr. 5	5.	.2	0	311	10	5.9	.016	.144	.000	.480	178	320	1 +	2—	1 +	
18550	1908. Nov. 25	0.	40.	0	337	10	5.5	.128	.348	.006	.480	211	560	1 +	1— 1—	1— 1? 1—	—

Carlyle, Clinton county, see Bulletin No. 5, page 20.
Carmi, White county, see Bulletin No. (5, page 21.
Carpentersville, Kane county, has no general supply. Sanitary analyses of the proposed city supply to be obtained from a spring, gave the following results:

SANITARY ANALYSES OF THE PROPOSED MUNICIPAL WATER SUPPLY OF CARPENTERSVILE.

Sample Collected February 19, 1907.

Serial Number.	Appearance. Turbidity.	Appearance. Color.	Appearance. Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia. Free.	Nitrogen as Ammonia. Albuminoid.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Alkalinity.	Bacteria per c.c.	Colon Bacillus. 10 c.c.	Colon Bacillus. 1 c.c.	Colon Bacillus. 0.1 c.c.
15734	Clear	0	0	498	3	1.3	.066	.094	.000	.200	439	34	1—	2—	2—
15735	Clear	0	0	488	3	1.65	.052	.100	.000	.120	390	155	1—	1+ 1—	2—

Carrollton, Greene county, see Bulletin No. 5, page 22.
Carterville, Williamson county, has no general supply.
Carthage, Hancock county, see Bulletin No. 5, page 22.
Casey, Clark county, see Bulletin No. 5, page 22.
Centralia, Marion county, see Bulletin No. 5, page 22.
Cerro Gordo, Piatt county, has no general supply.
Chadwick, Carroll county, see Bulletin No. 5, page 23.
Champaign, Champaign county, see Bulletin No. 5, page 23. Additional sanitary analyses gave the following results.

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF CHAMPAIGN.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c.c.	Colon Bacillus.			Indol.
								Ammonia.									
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c.c.	0.1 c.c.	
	1905																
13869	Dec. 31	Decided	.6	0	387	3.5	4.5	3.040	.084	.001	.126	374	- - -	---	----	----	----
	1906.																
15062	Sept. 27	Decided	.5	Earthy	422	1.5	6.4	4.600	.224	.000	.320	405	153	1—	1?1—	2—	----
15067	Sept. 27	Distinct	.5	0	386	1.5	6.4	3.000	.120	.000	.080	405	185	1—	2 +	2—	----
15298	Nov. 6	Distinct	.2	0	393	1.5	5.5	3.200	.176	.002	.200	409	55	1 +	2 +	2—	----
15334	Nov. 12	Decided	.6	0	390	1.0	5.1	3.400	.128	.000	.120	397	12	1—	2—	2—	----
15335	Nov. 12	Decided	.6	0	383	1.0	5.15	3.400	.152	.006	.440	410	15	1—	2—	2—	----
15336	Nov. 12	Decided	.6	0	373	1.0	4.8	3.600	.128	.005	.040	385	240	1—	1—1+	1+1—	----
15375	Nov. 20	Decided	.4	0	397	1.0	5.1	3.400	.160	.000	.240	391	200	1—	2—	2—	----
15380	Nov. 22	Slight	.2	0	397	2.0	4.95	1.400	.096	.000	.280	372	110	1—	2—	2—	----
15382	Nov. 22	Clear	.0	2 Earthy	395	2.0	4.9	1.400	.104	.000	.200	387	40	1 +	2—	2—	----
	1907.																
15624	Jan. 28	Decided	.6	0	396	2.0	5.0	3.600	.144	.000	.160	386	4	1 +	2 +	2—	----
15650	Feb. 4	Decided	.6	0	397	2.0	6.25	4.400	.128	.000	.160	392	250	---	1?1—	2—	----
15651	Feb. 4	Decided	.6	0	441	2.0	5.2	4.000	.128	.000	.320	386	260	---	2—	2—	----
15652	Feb. 4	Decided	.6	0	392	2.0	5.7	3.600	.136	.000	.320	388	175	---	1?1—	2—	----
15653	Feb. 4	Decided	.6	2 Earthy	403	2.0	5.9	3.600	.136	.000	.320	388	106	---	2—	2—	----
15654	Feb. 4	Decided	.6	0	420	2.0	7.25	3.400	.264	.000	.240	390	175	---	2 +	1+1—	----
15655	Feb. 4	Slight	.2	0	390	2.0	5.45	3.400	.152	.000	.240	392	118	---	1+1—	2—	----
15683	Feb. 9	Distinct	.6	00	456	2.0	7.85	4.400	.200	.006	.240	392	490	1—	2 +	2 +	----
15716	Feb. 16	0	.0	0	440	3.0	5.05	2.960	.118	.000	.160	435	770	1—	2—	2—	----
15719	Feb. 16	Slight	.3	0	408	3.0	4.2	.056	.152	.025	1.015	398	10500	1—	1+1—	2 +	----
15720	Feb. 18	Slight	.4	0	347	3.0	3.75	.400	.144	.000	.240	378	80	1—	2—	2—	----
15721	Feb. 18	Slight	.4	0	388	3.0	3.4	3.600	.136	.000	.240	388	60	1—	2—	2—	----
15737	Feb. 21		.1	0	405	- - -	- - -	3.000	.168	.000	.160	400	255	1—	2—	2—	----
15738	Feb. 21		.0	0	380	- - -	- - -	2.800	.160	.000	.560	401	1750	1—	2—	2—	----
15775	March 1	Distinct	.4	0	401	1.5	5.4	1.440	.136	.005	.315	378	150	1—	2—	2—	----
15776	March 1	Clear	.3	0	441	1.5	6.0	.448	.120	.006	1.714	369	11000	1—	2—	2—	----
15779	March 5	Slight	.3	0	414	2.0	5.65	3.400	.136	.000	.000	386	320	1—	2—	2—	----
15780	March 5	Clear	.1	0	414	2.0	5.45	1.520	.088	.054	.426	378	3300	1—	2—	2—	----
15829	March 18	Distinct	.5	0	6	30.	- - -	3.800	.152	.000	- - -	390	325	1—	2—	2—	----
15830	March 18	--------	- - -	--------	- - -	- - -	- - -	- - - -	- - -	- - -	- - -	- - -	40000	1—	2—	2—	----
15834	March 19	--------	- - -	--------	- - -	- - -	- - -	- - - -	- - -	- - -	- - -	- - -	360	1 ?	2—	2—	----
15835	March 19	--------	- - -	--------	- - -	- - -	- - -	- - - -	- - -	- - -	- - -	- - -	400	1 ?	2—	2—	----
15848	March 19	--------	- - -	--------	- - -	- - -	- - -	- - - -	- - -	- - -	- - -	- - -	400	1—	2—	2—	----
15849	March 19	--------	- - -	--------	- - -	- - -	- - -	- - - -	- - -	- - -	- - -	- - -	600	1—	1?1—	1?1—	----
15992	April 29	30.	.4	0	372	2.0	4.7	4.600	.144	.002	.200	384	120	1—	2—	1+1—	----
15993	April 29	30.	.4	0	372	2.0	3.7	3.600	.152	.001	.200	386	105	1—	2—	2—	----
15994	April 29	30.	.4	0	373	2.0	4.55	3.600	.152	.001	.200	386	160	1—	2—	1+1—	----
15995	April 29	30.	.4	0	379	2.0	4.7	3.500	.144	.001	.200	380	200	1—	2—	1+1—	----
15996	April 29	15.	.2	1 Earthy	382	2.0	4.75	3.600	.144	.000	.240	384	125	1—	2—	1+1—	----
16086	June 4	10.	.0	0	377	2.0	5.05	3.600	.128	.000	.120	381	300	1—	2—	2—	----
16178	July 1	45.	.6	0	413	2.0	6.65	3.200	.152	.003	.120	369	320	1—	1?1—	2—	----
	1908																
18102	Sept. 14	30.	25.	Earthy	401	2.0	5.6	4.000	.256	.001	.280	385	60	1 ?	1 ? 1 +	2—	----
18203	Sept. 23	5.	10.	0	387	4.0	4.4	3.400	.128	.000	.200	370	110	1—	2—	2—	+
18688	Dec. 31	4.	30.	0	415	3.5	3.8	3.200	.160	.001	.560	384	100	1—	3—1?	- - - -	+

Charleston, Coles county, see Bulletin No. 5, page 23.

Chatsworth, Livingston county, see Bulletin No. 5, page 23, obtains its water supply from a well 1,315 feet deep. The plant is owned by the city and was established in 1908 at a cost of $4,500. One deep well pump with a capacity of 150 gallons per minute, and one direct pressure pump with a capacity of 325 gallons per minute are used. The air pressure plant was constructed by the National Company of South Bend, Ind., and has two iron pressure tanks 9 ft. x 38 ft., and a cement reservoir, 30 ft. x 12 ft. deep. The daily consumption is about 15,000 gallons. An analysis of the old supply and an analysis of the new supply gave the following results:

SANITARY ANALYSES OF THE OLD AND NEW MUNICIPAL WATER SUPPLY OF CHATSWORTH.

No. 17459 collected May 23, 1908, from old well. No. 18438 collected November 5, 1908, from new well; 1315 drilled.

Serial Number.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
	Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
17459	20.	0	0	556	6	2.1	.200	.120	.100	.420	336	-----	- -	- -	- -	- -
18438	10.	30	0	696	9	8.9	3.600	.320	.068	.092	477	18,000	1+	2+	1— 1+	+

An analysis of the mineral content of the water from the new well gave the following results:

MINERAL ANALYSIS OF CITY WATER FROM CHATSWORTH.

Laboratory No. 18438.

Ions	Parts Per Million	Hypothetical Combinations		Parts Per Million	Grains Per Gallon
Sodium, Na	131.0	Sodium nitrate,	$NaNO_3$	.5	.03
Ammonium, NH_4	4.6	Sodium chloride,	$NaCl$	14.9	.87
Magnesium, Mg	35.1	Sodium sulphate,	Na_2SO_4	219.0	12.77
Calcium, Ca	76.3	Sodium carbonate,	Na_2CO_3	124.3	7.25
Iron, Fe	.3	Ammonium carbonate,	$(NH_4)_2CO_3$	12.2	.71
Alumina, Al	3.5	Magnesium carbonate,	$MgCO_3$	121.5	7.09
Nitrate, NO_3	.4	Calcium carbonate,	$CaCO_3$	190.0	11.08
Chloride, Cl	9.0	Iron carbonate,	$FeCO_3$	.6	.03
Sulphate, SO_4	148.0	Alumina,	Al_2O_3	3.5	.20
Silica, SiO_2	11.7	Silica,	SiO_2	11.7	.68
Bases	3.5	Bases,		3.6	.21
		Total,		701.8	40.92

Chenoa, McLean county, see Bulletin No. 5, page 24.

Chester, Randolph county, see Bulletin No. 5, page 24.

Chicago, Cook county, see Bulletin No. 5, page 24. Additional sanitary analyses of the city water supply gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF CHICAGO.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c.c.	Colon Bacillus.			Indol.	Location.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.		
	1908.																	
17315	April 11	10.	0 .	0 .	135	5	2.9	.032	.080	.000	.240	120	490	1 ?	2—	2—	+	Stock Yards.
17338	April 20	60.	0 .	0 .	230	7	3.2	.036	.126	.000	.160	124	300	1 +	2 ?	2—	—	Stock Yards.
17387	April 30	30.	0 .	0 .	165	5	4.7	.046	.190	.001	.160	120	160	1 +	2—	2—	—	Lake View.
17388	April 30	20.	0 .	0 .	154	5	2.7	.026	.118	.001	.240	116	1300	1—	2 +	1?1—	+	Rogers Park Raw.
17389	April 30	0 .	0 .	0 .	145	5	2.3	.018	.068	.000	.160	114	800	1 +	2 +	2—	—	Rogers Park Filtered.
17390	April 30	30.	0 .	0 .	168	5	3.1	.014	.102	.001	.20	120	158	1 ?	1?1—	2—	—	215 Madison St.
17391	April 30	20.	0 .	0 .	142	5	2.6	.056	.114	.000	.16	120	90	1—	2—	2—	—	68th St.—Main.
17909	Aug. 10	20.	10.	0 .	174	6	1.7	.024	.112	.000	.160	122	430	1—	1—	1—	+	Austin.
17947	Aug. 17	10.	0 .	0 .	153	6	2.8	.032	.112	.000	.320	116	2	1—	2—	2—	—	Austin.
17998	Aug. 24	5 .	0 .	0 .	147	6	2.3	.016	.088	.000	.440	112	320	1—	2—	2—		Austin.
18042	Aug. 31	5 .	0 .	Earthy	145	9	2.6	.056	.112	.000	.280	118	0					Austin.
18069	Sept. 8	5 .	10.	0 .	142	6	2.7	.112	.050	.000	.320	118	6500	1 +	2—	2—		Stock Yards.
18164	Sept. 16												164	1 +	2 +	1—1+	+	Stock Yards.
18261	Sept. 29	0 .	0 .	0 .	147	7	1.2	.038	.110	.000	.240	114	26	1—	1—	1—		Austin.
18318	Oct. 14	0 .	0 .	0 .	145	6	2.4	.016	.080	.000	.520	122	0	1—	2—	2—	—	Lake View Filtered.
18319	Oct. 14	5 .	0 .	0 .	161	5	3.2	.016	.112	.000	.800	122	75	1—	1+1—	2—	—	Tank at Factory Build'g.
18422	Nov. 3	5 .	0 .	0 .	147	6	2.9	.016	.080	.000	.240	116	160	1—	2—	2—	+	Austin.
18567	Nov. 30	0 .	0 .	0 .	134	6	1.4	.000	.080	.001	.240	120	145	1—	2—	2—	—	Austin.
18685	Dec. 29	5 .	15.	0 .	157	7	1.4	.064	.144	.002	.320	116	200	1—	2—	2—	—	Austin.

Chicago Heights, Cook county, see Bulletin No. 5, page 24.

Chillicothe, Peria county, see Bulletin No. 5, page 25.

Chrisman, Edgar county, see Bulletin No. 5, page 25.

Clinton, DeWitt county, see Bullettin No. 5, page 25. Additional sanitary analyses of the city water supply gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF CLINTON.

Serial Number.	Date of Collection. 1907.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c.c.	Colon Bacillus.			Indol.	
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c.c.	0.1 c.c.		
16336	Aug. 5	100.	1.0	0	517	6	3.0	.040	.048	.003	.317	415	31	1 +	2—	1 + 1—		
16337	Aug. 5	25.	.4	0	491	3	6.2	2.154	.312	.030	.250	415	42	1 +	2—	1— 1 +		
16338	Aug. 5	35.	.8	0	460	3	8.2	1.840	.232	.000	.120	445	19	1—	2—	2—		
16340	Aug. 5	245.	.6	0	800	3	9.9	6.400	.160	.000	.120	442	280	1—	2—	2—		
	1908.																	
17875	Aug. 4	20.	140.	0	530	47	6.5	.512	.200	.720	1.200	406	820	1—	2—	2—	—	
17901	Aug. 10	20.	120.	0	544	57	5.4	4.000	.160	.022	.218	413	20000	1—	2—	2—	—	Ice melted.
17902	Aug. 10	20.	120.	0	513	50	6.1	4.800	.216	.012	.188	406	10000	1—	2—	2—	—	Ice melted.
17903	Aug. 10	20.	150.	0	469	4	5.8	5.200	.176	.000	.200	430	175	1 ?	2—	1—	—	
17904	Aug. 10	10.	80.	0	517	47	5.8	4.640	.176	.036	.244	404	2000	1—	1 ?	1 ? 2—	+	Ice melted.

Coal City, Grundy county, has supply for fire protection only.

Cobden, Union county, has no general supply.

Colchester, McDonough county, has no general supply.

Colfax, McLean county, has no general supply.

Collinsville, Madison county, see Bulletin No. 5, page 26. An additional mineral analysis of the city supply gave the following results:

MINERAL ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF COLLINSVILLE.

Samples collected June 18, 1906. No. 14529 from well 90' driven. No. 14530 from well 70' driven.

Ions	Parts Per Million		Hypothetical Combinations		Parts Per Million		Grains Per Gallon	
	14529	14530			14529	14530	14529	14530
Potassium, K	1.7	2.2	Potassium nitrate,	KNO_3	.3	5.7	.02	.33
Sodium, Na	9.0	12.6	Potassium chloride,	KCl	3.0		.17	
Ammonium, NH_4	.3		Sodium nitrate,	$NaNO_3$		.5		.03
Magnesium, Mg	34.7	41.8	Sodium chloride,	$NaCl$	5.9	9.1	.34	.53
Calcium, Ca	82.8	65.2	Sodium sulphate,	Na_2SO_4	20.7	27.4	1.21	1.60
Iron, Fe	.6	2.5	Ammonium sulphate,	$(NH_4)_2SO_4$	1.1		.06	
Alumina, Al_2O_3	1.6	1.6	Magnesium sulphate,	$MgSO_4$	41.7	41.0	2.43	2.39
Nitrate, NO_3	.2	3.9	Magnesium carbonate,	$MgCO_3$	91.1	116.0	5.31	6 77
Chlorine, Cl	5.0	5.5	Calcium carbonate,	$CaCO_3$	206.7	162.7	12.06	9.49
Sulphate, SO_4	48.1	51.2	Iron carbonate,	$FeCO_3$	1.2	5.8	.07	.34
Silica, SiO_2	19.2	19.0	Alumina,	Al_2O_3	1.6	1.6	.09	.09
Bases	2.5	.7	Silica,	SiO_2	19.2	19.0	1.12	1.11
			Bases,		2.5	.7	.15	.04
			Total,		395.0	389.5	23.03	22.72

Columbia, Monroe county, has no general supply.

Creal Springs, Williamson county, see Bulletin No. 5, page 27.

Crotty, La Salle county, has made no report.

Cuba, Fulton county, has no general supply.

Cullom, Livingston county, obtains its water supply from a well 280 feet deep, located on Washington street. A sanitary analysis of water from this well gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF CULLOM.

Sample collected October 5, 1908. Laboratory No. 18273.

Turbidity	60.	Nitrogen as		Bacteria per c.c.	12
Color	70.	Free Ammonia	1.664	Colon bacillus	
Odor	0.	Alb. Ammonia	.080	Gas Formers in	
Residue on Evaporation	2056.	Nitrites	.001	10 c.c.	1—
Chlorine in Chlorides	19.	Nitrates	.080	1 c.c.	2—
Oxygen Consumed	2.0	Alkalinity	112.	0.1 c.c.	2—
				Indol	—

An analysis of the mineral content gave the following results:

MINERAL ANALYSIS OF MUNICIPAL WATER SUPPLY OF CULLOM.

Ions	Parts Per Million	Hypothetical Combinations		Parts Per Million	Grains Per Gallon
Potassium, K	19.0	Potassium nitrate,	KNO_3	.6	.03
Sodium, Na	198.0	Potassium chloride,	KCl	33.1	1.92
Ammonium, NH_4	2.2	Sodium chloride,	NaCl	5.4	.31
Magnesium, Mg	3.3	Sodium sulphate,	Na_2SO_4	604.1	35.23
Calcium, Ca	247.7	Ammonium sulphate,	$(NH_4)_2SO_4$	8.0	.47
Oxide of Iron, Fe_2O_3 and Alumina, Al_2O_3	11.5	Magnesium sulphate,	$MgSO_4$	481.5	28.05
Nitrate, NO_3	.4	Calcium sulphate,	$CaSO_4$	464.4	27.13
Chloride, Cl	19.0	Calcium carbonate,	$CaCO_3$	341.5	19.95
Sulphate, SO_4	1125.7	Oxide of Iron and Alumina,	Fe_2O_3 + Al_2O_3	11.5	.67
Silica, SiO_2	18.5	Silica,	SiO_2	18.5	1.08
Bases	1.5	Bases,		1.5	.09
		Total,		1970.1	114.93

Danville, Vermilion county, see Bulletin No. 5, page 27. Additional sanitary analyses of the raw and treated water from the Vermilion River, gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF DANVILLE.

Raw.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c.c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c.c.	0.1 c.c.	
	1907.																
15514	Jan. 2	De.	Mu.	2 E.	312	4	6.8	.040	.224	.005	2.960	172.3	3,700	1+	1+1—	2—	
15859	March 25	De.	.4	0	307	3	4.3	.048	.136	.010	2.230	201.6	1,500	1+	2+	1+1—	
15970	April 22	15.	.2	0	365	4	3.05	.012	.056	.009	2.000	197.4	2,000	1+	1+1—	2+	
16067	May 27	110.	.4	0	329	6	6.45	.096	.224	.025	1.455	193.0	12,500	1—	2+	2+	
16108	June 10	1500.	Mu.	0	1336	7	19.95	.056	.432	.002	1.720	159.6	32,000	1+	2+	2+	
16187	July 1	10.	Mu.	0	344	5	5.1	.064	.112	.025	1.92	205.5	86,000	1+	2+	2+	
16269	July 22	100.	Mu.	1 E.	355	3	6.1	.056	.240	.012	1.588	205.4	25,000	1+	2+	2+	
16270	July 22	100.	Mu.	1 E.	367	3	6.1	.064	.240	.012	2.388	205.4	25,000	1+	1+1—	1+1—	
16386	Aug. 19	172.	.2	0	285	4	6.7	.040	.240	.007	.75	177.6	Liquified	1+	2+	2+	
16520	Sept. 23	120.	0	Mu.	344	4	5.7	.032	.224	.002	.160	252.5	400	1—	2+	1?1—	
16822	Dec. 2	0	0	0	305	5	3.0	.040	.050	.002	.638	246.	2,600	1+	2—	2—	—
16901	Dec. 23	230.	.4	0	430	3	6.6	.026	.194	.000	.760	200.	Lost	1—	2—	2—	
	1908.																
17069	Feb. 3	10.	0	0	319	5	2.4	.122	.112	.007	2.393	250.	1,200	1+	2+	2?	+
17144	March 3	210.	.6	0	275	5	11.2	.072	.456	.010	1.790	100.	19,000	1+	1+1?	1—1+	+
17251	March 30	110.	.0	0	303	5	6.1	.064	.180	.006	1.88	192.	520	1+	2+	2+	+
17357	April 27	100.	.0	0	325	3	6.5	.064	.256	.013	2.387	194.	6,400	1?	2+	1+1—	+
17499	June 1	35.	20.	0	325	4	4.1	.012	.168	.009	1.511	205.	1,400	1?	2+	1+1—	+
17701	July 13	20.	30.	0	304	5	5.1	.106	.210	.015	.545	216.	600	1+	2+	1+1?	+
17786	July 25	100.	60.	0	285	2	6.5	.100	.306	.030	1.77	144.	1,520	1+	2+	1+	+
18222	Sept. 28	80.	40.	E.	368	8	3.6	.054	.248	.002	.160	242.	6,400	1+	2+	1+1?	+
18398	Nov. 2	10.	30.	0	352	12	6.3	.028	.174	.000	.200	295.	-----	-----	--------	--------	
18562	Nov. 30	20.	40.	0	342	7	2.9	050	.172	.001	.360	259.	3,400	1+	1?1+	1+1—	+
18650	Dec. 28	2.	10.	0	323	8	2.3	.058	.150	.006	.320	256.	280	1—	1—1+	2—	

Filtered

	1907.																	
15515	Jan.	2	Clear	0	2 E.	238	4	2.7	.040	.080	.002	3.68	116.8	90	1—	2—	2—	
15858	March	25	Clear	0	0	232	2	2.4	.024	.064	.000	2.40	153.3	165	1—	2—	2—	
15971	April	22	0	0	0	273	4	2.1	.008	.064	.000	2.64	197.4	200	1+	2—	2—	
16068	May	27	0	.1	0	267	6	3.35	.008	.104	.002	1.52	189.	160	1+	1+1—	1+1—	
16109	June	10	0	.2	0	262	5	3.05	.008	.072	.000	1.60	155.9	1,600	1+	2+	2+	
16188	July	1	0	.2	0	259	3	2.95	.000	.040	.000	1.72	163.3	100	1+	2—	1+1—	
16271	July	22	0	.6	0	271	2	3.6	.024	.128	.000	2.	175.4	101	1+	2+	2—	
16272	July	22	0	.6	1 M.	273	3	3.1	.024	.128	.000	2.	175.4	Liquified	1—	2+	2—	
16387	Aug.	19	0	0	0	131	4	3.1	.016	.080	.000	.80	102.7	1,400	1+	1—1+	2—	
16521	Sept.	23	0	0	M.	276	4	2.8	.036	.110	.000	.160	228.9	4,500	1?	2—	2—	
16823	Dec.	2	0	0	0	314	5	2.5	.100	.032	.002	.80	224.	50	1—	2—	2—	—
16902	Dec.	23	0	0	0	274	4	3.4	.038	.060	.000	.76	204.	9,000	1—	2—	2—	—
	1908.																	
17068	Feb.	2	0	0	0	287	5	2.6	.068	.074	.002	1.000	196.	105	1—	2—	2—	—
17145	March	3	0	0	0	118	6	4.0	.132	.150	.006	1.84	84.	2,400	1—	1—1?	2—	+
17252	March	30	0	0	0	208	5	2.9	.060	.094	.000	2.00	128.	82	1+	2—	2—	—
17358	April	27	0	0	0	192	3	3.1	.054	.106	.000	2.40	130.	650	1+	1—1+	2—	+
17500	June	1	0	10.	0	266	4	4.0	.048	.126	.000	1.600	159.	11	1+	1—1+	2—	—
17702	July	13	0	0	0	216	5	3.9	.024	.182	.000	.560	142.	8	1?	1—1?	2—	—
17787	July	26	0	20.	0	170	2	3.	.032	.160	.000	1.680	97.	108	1+	2+	1—	—
18223	Sept.	28	0	0	0	309	8	2.6	.036	.156	.000	.200	228.	98	1?	2?	2+	+
18399	Nov.	2	0	0	0	339	12	3.9	.004	.088	.000	.240	271.	2	1—	2—	2—	—
18563	Nov.	30	0	20.	0	327	7	1.4	.032	.100	.000	.008	258.	160	1+	1+1—	2—	+
18651	Dec.	28	2.	10.	Mo.	317	8	2.5	.042	.170	.001	.520	242.	13	1+	2—	2—	—

Decatur, Macon county, see Bulletin No. 5, page 31, Additional analyses of the water from the Sangamon River gave the following results

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF DECATUR.

Raw.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c.c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c.c.	0.1 c.c.	
	1907.																
15569	Feb. 14	De.	4.	0	312	5	4.5	.480	.176	.005	1.520	211	250	1—	2+	2—	
15751	Feb. 25	V. S.	0	0	315	3	3.15	.056	.064	.007	2.560	229	490000	1—	2—	2 +	
15869	March 25	De.	Mu.	0	354	6	5.25	.072	.144	.010	2.190	224	1700	1 +	2+	2 +	
16000	April 29	35.	.3	0	280	6	3.4	.056	.240	.018	1.772	237	880	1 +	1+1—	1+1—	
16072	May 27	250.	Mu.	0	311	4	13.9	.072	.360	.010	1.310	138	8500	1 +	2+	2 +	
16111	June 10	230.	Mu.	0	436	3	9.0	.040	.264	.012	.680	181	31000	1 +	2+	2 +	
16162	June 24	260.	Mu.	2 E.	504	5	9.55	.040	.592	.040	1.120	222	5000	1?	2+	2 +	
16278	July 22	50.	1.	0	258	2	6.8	.032	.232	.040	.880	151	Liq.		2+	2 +	
16375	Aug. 12	208.	Mu.	0	454	5	10.3	.016	.320	.014	1.220	243	2500	1 +	2+	2 +	
16518	Sept. 23	120.	0	0	356	2	4.0	.056	.260	.005	.635	295	800	1?	1?1+	2—	
16692	Nov. 4	30.	.2	0	359	8	5.1	.040	.152	.002	.000	272	2400	1 +	2+	1+1?	+
	1908.																
17000	Jan. 20	30.	0	0	320	5	2.7	.052	.074	.006	1.32	256	1200	1—	2—	2—	+
17140	March 2	50.	.4	0	253	5	4.9	.038	.128	.008	1.96	174	Bacteria bottle broken				
17236	March 23	100.	0	0	310	4	4.9	.052	.150	.005	2.64	202	2100	1?	2+	1+1—	+
17341	April 20	60.	0	0	360	5	4.1	.058	.148	.012	1.73	232	1800	1 +	2+	2—	+
17472	May 25	60.	30.	0	308	3	5.4	.070	.176	.055	1.305	174	11500	1 +	1+1?	2 +	+
17583	June 22	290.	70.	0	1125	5	10.8	.084	.208	.040	1.000	242	1500	1 +	2+	2 +	+
17755	July 20	60.	50.	0	346	9	5.6	.040	.154	.030	.770	219	650	1 +	1+1—	1+1—	+
17974	Aug. 19	40.	40.	0	373	10	5.0	.216	.280	.008	.272	282	600	1 +	2+	1—1?	—
18297	Oct. 12	30.	50.	Mu.	379	11	4.8	.056	.662	.000	.240	195	560	1 +	2+	2?	+
18368	Oct. 26	35.	50.	0	385	11	5.5	.094	.812	.001	240	316	940	1 +	2+	1?1—	+
18565	Nov. 30	20.	50.	0	364	12	3.7	.092	.230	.000	.200	304	7200	1?	2+	2 +	+
18678	Dec. 28	30.	30.	E.	373	21	3.9	.012	.242	003	.120	281	380	1 +	2—	2—	+

Filtered

	1907.																
15570	Feb. 14	Clear 0	0	0	290	5	3.0	.480	.160	.006	2.000	207	930	1+	2+	2—	
15729	Feb. 18	Slight 10	.2	0	290	2	1.9	.128	.120	.004	1.800	217	-----	-----	-----	-----	
15752	Feb. 25	Slight 10	0	0	310	3	2.4	.056	.056	.007	2.200	235	490	1—	1+1—	2—	
15870	March 25	Clear 0	.1	0	305	4	2.75	.072	.080	.017	2.38	220	290	1+	2+	1+1—	
16001	April 29	20.	.2	2 Pe.	290	6	2.95	.016	.112	.014	1.146	237	180	1—	2—	2—	
16073	May 27	10.	.2	2 Mu.	191	3	3.85	.000	.112	.011	1.10	90	320	1+	1+1—	1+1—	
16112	June 10	0	.3	5 Mu.	251	3	3.55	.024	.096	.012	1.12	183	800	1+	2+	2+	
16163	June 24	3.	.1	2 Mu.	202	4	3.0	.008	.080	.006	.800	225	80	1+	1+1—	2?	
16279	July 22	20.	.6	0	221	2	4.0	.024	.144	.000	.440	128	12500	1—	2+	2+	
16376	Aug. 12	20.	.1	E.	303	5	3.5	.000	.128	.002	.760	224	Liq.	1+	2+	2+	
16519	Sept. 23	0	0	0	343	3	4.5	.000	.128	.002	.718	288	600	1?	1+1?	2?	
16693	Nov. 4	0	.2	0	327	8	5.0	.006	.188	.000	.080	274	300	1—	2—	2—	—
	1908																
16999	Jan. 20	5.	0	0	305	4	2.3	.044	.052	.010	1.19	250	740	1+	1—1+	2—	+
17141	March 2	5.	0	0	225	5	3.1	.042	.096	.005	1.88	160	900	1+	1?1+	2—	+
17235	March 23	0	0	0	243	4	2.4	.024	.094	.005	2.64	194	140	1+	1—1?	2—	+
17342	April 20	0	0	0	290	4	2.6	.062	.116	.012	1.81	226	450	1+	1+1—	2—	+
17473	May 25	0	0	0	263	3	2.7	.052	.190	.023	1.577	173	1120	1+	1+1?	2+	+
17584	June 22	0	0	0	286	5	.4	.020	.110	.001	.880	225	65	1+	1+1?	1?1—	+
17756	July 20	0	0	0	319	8	4.1	.052	.112	.000	.640	212	65	1?	2—	2—	+
17975	Aug. 19	0	10.	0	332	11	3.0	.056	.218	.000	.480	278	75	1+	2—	2—	—
17976	Aug. 19	0	10.	0	326	10	4.0	.050	.308	.000	.320	278	150	1+	1—1?	1?1+	—
18298	Oct. 12	0	20.	Mu.	355	11	3.4	.058	.310	.000	.320	310	15	1+	1—1?	2—	—
18367	Oct. 26	0	10.	0	367	13	4.7	.052	.232	.001	.160	312	97	1+	1?1+	2—	+
18566	Nov. 30	0	20.	0	338	13	3.0	.040	.160	.000	.200	306	560	1+	2+	2—	+
18679	Dec. 28	0	10.	Mu.	376	21	2.5	.056	.174	.002	.200	281	27	1—	2—	2—	+

A boiler analysis of the water of the Sangamon River gave the following results:

BOILER ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF DECATUR.
Sample Collected February 18, 1907.

Laboratory No. 15729.		Parts per Million	Grains per Gallon
Residue on Evaporation		290.	16.9
Alkalinity (as $CaCO_3$)		225.	13.1
Incrustants (as $CaCO_3$)		56.	3.2
Magnesium (as $CaCO_3$)		108.	6.3
Chlorine		4.	.2
Possible Hypothetical Combinations are as follows:			
Sodium chloride	NaCl	6.	.3
Magnesium sulphate	$MgSO_4$	68.	4.0
Magnesium carbonate	$MgCO_3$	45.	2.6
Calcium carbonate	$CaCO_3$	173.	10.1
Total		292.	17.0

DeKalb, DeKalb county, see Bulletin No. 5, page 35, obtains its water supply from wells 135 feet to 1,300 feet deep. The plant is owned by the city, and has been established and improved during the last fifteen years. The plant is located near the city limits, and one Downey Pump, and one American Well Works Air Compressor are used. The daily consumption is about 450,000 gallons. Additional sanitary analyses of the city water gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF DE KALB.

Serial number.	Date of Collection	Appearance			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus			Indol.
		Turbidity.	Color.	Odor.				Ammonia: Free.	Ammonia: Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
16166	1907 June 24	0	0	0	288	2	1.0	.176	.040	.007	.320	279	100	1—	2—	2—	
17793	1908 July 27	5.	60	0	350	3	2.7	.524	.066	.000	.240	388	32	1—	2—	2—	—
17794	July 27	0	0	0	295	3	3.2	.352	.056	.000	.240	293	4	1 ?	2—	2—	—

Delavan, Tazewell county, see Bulletin No. 5, page 36.

Desplaines, Cook county, see Bulletin No. 5, page 36.

Dixon, Lee county, see Bulletin No. 5, page 36, obtains its water supply from three artesian wells, the water coming from Potsdam sandstone. The plant is located near the river, and compound condensing engines, 2,500,000 gallons capacity, are used. The daily consumption is 250,000 gallons. An additional analysis of the city water supply gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF DIXON.
Sample collected September 22, 1908.

Laboratory Number	18204	Nitrogen as	
Turbidity	0	Free Ammonia	.040
Color	0	Albuminoid Ammonia	.032
Odor	0	Nitrites	.005
Residue on Evaporation	313.	Nitrates	.560
Chlorine in Chlorides	5.	Alkalinity	289.
Oxygen Consumed	.4		

Dolton Station, Cook county, see Bulletin No. 5, page 36.

Downers Grove, Cook county, obtains its water supply from wells. Analyses of the water gave the following results:

SANITARY CHEMICAL ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF DOWNERS GROVE.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen consumed.	Nitrogen as				Alkalinity.
								Ammonia.				
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.	
	1907.											
15710	Jan. 7	Distinct	.0	2 Moldy	729	66	4.9	.280	.120	.007	3.84	366
15713	Feb. 11	Distinct	.2	0	540	70	2.3	.120	.040	.010	.150	316
15803	Mar. 2	Distinct	.0	0	732	66	3.6	.560	.072	.000	.120	371
16412	Aug. 20	10.	.1	Musty	511	41	1.9	.296	.056	.000	.04	329
16413	Aug. 19	10.	.0	Musty	501	41	2.2	.304	.040	.000	.20	325

Dundee, Kane county, see Bulletin No. 5, page 36.

DuQuoin, Perry county, has no general supply.

Dwight, Livingston county, see Bulletin No. 5, page 36. An additional analysis of the city supply gave the following results:

MINERAL ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF DWIGHT.
Sample collected May 8, 1906. Mineral—Laboratory No. 14337.

Ions.	Parts per Million	Hypothetical Combinations.		Parts per Million	Grains per Gallon
Potassium K	4.8	Potassium nitrate	KNO_3	8.6	.50
Sodium Na	161.5	Potassium chloride	KCl	2.9	.17
Ammonium NH_4	3.6	Sodium chloride	NaCl	52.1	3.04
Magnesium Mg	526.0	Sodium sulphate	Na_2SO_4	434.8	25.36
Calcium Ca	123.5	Ammonium sulphate	$(NH_4)_2SO_4$	13.2	.77
Iron Fe	2.9	Magnesium sulphate	$MgSO_4$	260.0	15.17
Alumina Al_2O_3	6.8	Calcium sulphate	$CaSO_4$	25.8	1.50
Nitrate NO_3	5.3	Calcium carbonate	$CaCO_3$	289.3	16.87
Chloride Cl	33.0	Iron carbonate	$FeCO_3$	6.0	.35
Sulphate SO_4	529.0	Alumina	Al_2O_3	6.8	.40
Silica SiO_2	10.4	Silica	SiO_2	10.4	.60
Bases	2.4	Bases + 1		2.4	.14
		Total		1,112.3	64.87

Earlville, La Salle county, see Bulletin No. 5, page 36.

East Dubuque, Jo Daviess county, see Bulletin No. 5, page 36.

A recent analysis of the city water supply gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF EAST DUBUQUE.

Laboratory No. 17958. Collected August 17, 1908.

Turbidity	.0	Nitrogen as		Bacteria per c. c.	50
Color	10.0	Free ammonia.	.056	Gas formers in—	
Odor	.0	Alb. ammonia.	.040	10 c. c.	1 ?
Residue on evaporation	290.	Nitrites	.005	1 c. c	1+1—
Chlorine in chlorides	14.	Nitrates	.520	0.1 c. c.	2—
Oxygen consumed	.8	Alkalinity (as $CaCO_3$)	250.000	Indol	—

An analysis of the mineral content gave the following results:

MINERAL ANALYSIS OF CITY WATER FROM EAST DUBUQUE.

Laboratory No. 17958. Collected August 17, 1908.

Ions.	Parts per Million	Hypothetical Combinations.		Parts per Million	Grains per Gallon
Potassium K	14.0	Potassium nitrate	KNO_3	3.9	.23
Sodium Na	34.7	Potassium chloride	KCl	23.8	1.39
Magnesium Mg	31.6	Sodium chloride	NaCl	4.4	.26
Calcium Ca	45.4	Sodium sulphate	Na_2SO_4	36.6	2.13
Oxide of Iron Fe_2O_3 and Alumina Al_2O_3	1.6	Sodium carbonate	Na_2CO_3	48.3	2.81
Nitrate NO_3	2.4	Magnesium carbonate	$MgCO_3$	109.5	6.39
Chloride Cl	14.0	Calcium carbonate	$CaCO_3$	113.3	6.61
Sulphate SO_4	24.7	Oxide of Iron and Alumina	Fe_2O_3 + Al_2O_3	1.6	.09
Silica SiO_2	17.9	Silica	SiO_2	17.9	1.04
Bases	1.9	Bases	....	1.9	.11
		Total		361.2	21.06

East St. Louis, St. Clair county, see Bulletin No. 5, page 36.

Edinburg, Christian county, see Bulletin No. 5, page 37.

Edwardsville, Madison county, see Bulletin No. 5, page 37, obtains its water supply from six wells located at Poag, four miles from Edwardsville. The plant is owned by a local company and was established in 1898. The plant, with extensions has cost the company $120,000. An emergency reservoir with about 500,000 gallons capacity, is located at the pumping station. Two Gardner Compound Duplex pumps, each of 1,000,000 gallons capacity, are used. The daily consumption is 250,000 to 300,000 gallons. Additional analyses of the city water gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF EDWARDSVILLE.

Serial No.	Date of Collection.	Appearance			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen *as*				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
								Ammonia									
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
	1907																
16863	Dec. 9	60	10	D	278	8	5 .6	.100	.336	.000	1.600	152	. . . .	1+	1+ 1—	2—	+
16864	Dec. 9	30	.2	D	200	8	3 .0	.070	.188	.000	1.600	152	1500	1+	2—	2—	+
	1908																
17143	Mar. 2	0	0	0	240	10	1 .9	.032	.040	.004	1.88	170	175	1—	2—	2—	—
17146	Mar. 2	0	0	0	230	10	.9	.018	.042	.000	1.760	160	400	1—	2—	2—	—
17178	Mar. 9	0	0	0	270	7	1 .3	.036	.046	.000	1.320	164	620	1—	2—	2—	—
17239	Mar. 23	0	0	0	246	7	1 .3	.050	.050	.000	1.400	160	12	1—	2—	2—	—
17433	May 11	0	10	0	265	8	.6	.032	.064	.000	1.800	162	. . .	. . .	. . .	...	. .
17460	May 25	0	0	0	269	7	1 .2	.024	.040	.000	1.320	160	1200	1—	2—	2—	—
17461	May 25	0	0	0	273	7	1 .2	.016	.064	.000	1.480	160	160	1—	2—	2—	—
17515	June 2	0	0	0	349	8	1 .0	.016	.064	.000	1.200	178	. . . .	. . .	. . .	. . .	. .
17912	Aug. 11	0	0	0	278	9	.7	.0 24	.0 64	.000	.200	157	320	1—	1+	1—	+

Effingham, Effingham county, see Bulletin No. 5, page 38.
Eldorado, Saline county, has no general supply.

Elgin, Kane county, see Bulletin No. 5, 38. Additional analyses of the city supply from the Fox River, the artesian wells and the filters, gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF ELGIN.

FOX RIVER

Serial No.	Date of Collection.	Appearance. Turbidity.	Appearance. Color.	Appearance. Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia Free.	Nitrogen as Ammonia Albuminoid.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Alkalinity.	Bacteria per c. c.	Colon Bacillus. 10 c. c.	Colon Bacillus. 1 c. c.	Colon Bacillus. 0.1 c. c.	Indol.
	1907.																
15549	Jan. 6	De.	.8	0	284	2	9.15	.048	.296	.006	.680	200	5,600	1—	2+	2—	. .
15727	Feb. 18	De.	.2	Mu	301	4	7.55	.200	.280	.000	.640	207	2,400	1—	2+	1+1—	. .
15819	Mar. 11	Sl.	.6	2 E	271	3	7.95	.056	.268	.000	.760	193	700	1+	2+	2—	. .
15947	April. 16	25	.4	0	291	3	11.45	.064	.360	.002	.200	241	200	1—	2—	2—	. .
16032	May 13	30	.6	0	339	3	12.65	.080	.240	.003	.560	227	18,000	1+	2+	2—	. .
16116	June 10	60	.6	0	287	2	11.75	.056	.440	.010	.800	203	. . . .	. . . .	. . . .	. . . . . .	. .
16128	June 10	. . . . . .	. . . . . .	. . . . . .	. . . .	. . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . .	. . . . . .	8,000	1+	2+	1? 1+	. .
16222	July 9	100	.6	0	319	2	13.15	.088	.400	.020	.240	233	1,700	1+	1? 1—	2+	. .
16365	Aug. 12	80	.3	2 E	308	2	13.9	.120	.528	.003	.231	243	4,400	1+	2+	2—	. .
16443	Sept. 2	60	.3	E	304	2	12.6	.040	.496	.001	.16	222	3,500	1+	2+	2+	. .
16850	Dec. 9	5	.2	E	325	. . .	7.2	.072	.216	.004	.556	272	340	1—	2+	2—	—
	1908																
16986	Jan. 13	0	.4	0	369	5	8.1	.070	.310	.007	.720	294	*	. . . . . .	. . . .	. . . . . .	. .
17073	Feb. 3	5	.0	0	371	5	6.8	.102	.414	.008	.672	312	4,000	1—	2+	1—1+	+
17108	Feb. 17	30	.8	0	226	4	2.8	.2 6	.402	.012	.112	148	94,000	1+	2+	2+	+
17223	Mar. 16	30	.3	Mo	167	3	8.9	.104	.264	.005	.32	124	1,600	1+	2—	2—	+
17320	April 13	30	.4	0	303	3	13.0	.066	3.46	.002	.360	220	760	1+	1+ 1—	2—	—
17476	May 25	30	80.	0	329	4	21.6	.122	.320	.003	.360	233	3,200	1+	1+ 1—	1?1—	+
17557	June 15	100	70.	E	377	2	2.0	.168	.680	.010	.390	218	36,000	1+	2+	2+	+
17708	July 13	20	70.	0	300	3	10.1	.096	.520	.002	.320	227	860	1+	1—1+	2?	+
18155	Sept. 14	80	55.	E	334	5	8.5	.128	.480	.005	1.200	235	1,240	1+	2+	1—1+	+
18342	Oct. 19	40	30.	0	354	5	8.6	.102	.452	.006	.400	252	1,800	1+	2+	2+	+
18493	Nov. 16	0	30.	0	308	8	5.0	.048	.280	.002	.720	258	8,400	1+	2+	1—1+	+
18617	Dec. 14	5	25.	E	352	8	15.4	.040	.224	.015	.465	273	120,000	1+	2+	1? 1+	+
	ARTESIAN WELLS.																
	1907																
15550	Jan. 6	De	.8	0	368	5	3.6	2.56	.096	.000	.160	332	0	1—	2—	2—	. .
15726	Feb. 16	Di	.3	0	388	6	1.0	2.400	.096	.000	.240	338	0	1—	2—	2—	. .

* Bottle broken.

15817	Mar. 11	Di	.4	0	373	5	3.6	2.56	.072	.000	.200	331	12	1—	1—	1—	. .
15946	April 15	30	.4	0	371	6	3.65	3.00	.088	.001	.160	336	0	1—	1+1—	2—	. .
16034	May 13	20	.5	0	399	5	3.40	2.640	.160	.000	.080	340	15	1—	2—	2—	. .
16118	June 10	35	.4	0	400	9	5.1	2.24	.224	.000	.24	332	....	....	....	....	. .
16223	July 9	35	.4	0	373	7	3.25	2.60	.080	.001	.080	304	0	1—	2—	2—	. .
16366	Aug. 12	25	.2	0	382	6	3.2	3.	.072	.000	.200	348	20	1—	2—	2—	. .
16444	Sept. 2	30	.3	0	384	6	4.9	2.6	.104	.000	.160	348	*20	1—	2—	2—	. .
16849	Dec. 9	0	.6	0	387	6	3.0	2.40	.112	.000	.000	326		....	....	....	. .
	1908.								.144	.000	.080	348	20	1—	2—	2—	—
16983	Jan. 13	20	.2	0	385	6	3.1	2.60									
17077	Feb. 3	20	.4	0	385	7	3.2	2.24	.088	.000	.080	346	60	1—	2—	2—	—
17107	Feb. 17	30	.4	0	350	8	3.4	1.60	.112	.000	.032	352	0	1—	2—	2—	—
17221	Mar. 16	30	0	0	357	7	2.9	1.12	.064	.000	.120	330	8	1—	2—	2—	—
17319	April 13	10	.2	0	383	6	2.5	1.720	.192	.000	.020	348	*8 8	1—	2—	2—	—
17474	May 25	20	60.	0	379	6	2.5	1.800	.160	.000	.160	330		....	....	....	. .
17558	June 15	20	60.	0	386	6	2.7	2.000	.104	.000	.360	332	1	1—	2—	2—	—
17705	July 13	5	110.	0	436	6	3.5	2.400	.148	.000	.400	355	17	1—	2—	2—	—
18152	Sept. 14	20	65.	0	380	6	2.9	2.080	.112	.000	.520	334	4	......	2—	....	—
18343	Oct. 19	0	30.	0	363	7	3.1	1.200	.080	.000	.240	325	2	1—	2—	2—	—
18492	Nov. 16	30	30.	0	408	7	2.8	2.320	.120	.008	.232	341	220	1—	2—	2—	—
18615	Dec. 14	10	60.	0	370	10	14.7	1.600	.056	.003	.120	360	6	1—	2—	2—	—

FILTERS.

	1907.															
15547	Jan. 6	Sl.	.4	0	307	3	6.5	.080	.264	.006	.680	233	1,500	1+	1? 1—	2—	
15548	Jan. 6	Sl.	.4	2 E	315	6	6.6	.096	.264	.003	.560	269	1,500	1+	2+	2—	. .
15724	Feb. 18	0	0	0	339	5	3.1	.560	.112	.010	.59	247	1,480	1—	2+	1+1—	—
15725	Feb. 18	0	0	0	334	5	3.0	.640	.200	.007	.633	249	1,920	1—	2+	1+1—	—
15818	Mar. 11	0	.3	0	318	4	4.85	.136	.176	.022	.720	216	75	1—	1—	1—	. .
15820	Mar. 11	0	.3	0	312	4	5.05	.104	.112	.030	.680	214	31	1—	1+1—	2—	. .
15948	April 15	0	.2	0	334	3	8.0	.040	.240	.023	.257	237	55	1?	2—	2—	. .
15949	Apr. 15	0	.4	2 Mu	344	3	7.1	.096	.184	.018	.380	235	12	1—	2—	2—	. .
16033	May 13	20	.5	0	437	5	5.65	.528	.160	.003	.360	266	200	1 +	2—	2—	. .
16035	May 13	20	.5	0	357	4	5.5	.528	.216	.007	.313	259	90	1—	2—	2—	. .
16117	June 10	0	.3	0	276	2	8.45	.016	.240	.004	.56	209	....	....	....	....	. .
16119	June 10	3	.3	0	291	2	8.2	.008	.240	.008	.560	209	....	....	....	....	. .
16125	June 10	....	....	....	....	....	....	....	....	....	....	....	240	1—	1+1—	2—	. .
16126	June 10	....	....	....	....	....	....	....	....	....	....	....	75	1—	2—	2—	. .
16127	June 10	....	....	....	....	....	....	....	....	....	....	....	550	1—	1+1—	2—	. .
16224	July 8	3	.4	0	280	5	7.9	.264	.272	.240	.160	247	**	....	....	....	. .
16225	July 9	3	.4	0	296	2	7.4	.280	.232	.220	.160	238	250	1—	1+1—	2—	. .
16367	Aug. 12	0	.2	0	323	2	8.2	.040	.284	.120	.240	258	†	1+	2 +	2 +	. .
16368	Aug. 12	0	.2	1 Mu	334	2	7.9	.072	.264	.140	.220	254	†	1 +	2 +	2—	. .

* Bottle broken.
** Bacteria bottle empty.
† Liquified.

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF ELGIN—CONTINUED.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c.c.	0.1 c.c.	
16445	Sept. 2	0	.3	0	322	5	6.3	.960	.216	.026	.000	265	20	1+	2—	2—	..
16446	Sept. 2	0	.3	0	330	4	7.2	.270	.280	.056	.040	250	*				..
16851	Dec. 9	8	.2	E	389	6	5.3	.704	.168	.030	.370	318	*				..
16852	Dec. 9	0	0	0	305	6	5.8	1.950	.246	.030	.130	320	30	1—	2?	2—	+
16984	1908.																
16985	Jan. 13	0	.2	0	365	5	5.3	.280	.184	.015	.700	294	40	1—	1+ 1—	2—	+
17072	Jan. 13	0	.2	0	371	5	5.5	.320	.200	.005	.640	294	20	1—	2—	2—	—
17078	Feb. 3	0	0	0	353	5	4.8	.564	.226	.008	.432	318	500	1—	2+	1—1+	+
17109	Feb. 3	0	0	0	375	6	5.1	.496	.228	.008	.552	316	200	1—	1—1+	2—	—
17110	Feb. 17	0	.2	0	251	4	5.5	.560	.176	.022	.112	200	3,200	1—	2—	2—	+
17220	Feb. 17	5	.4	0	244	6	5.9	1.120	.208	.010	.104	200	6,000	1?	1—1?	2—	—
17222	Mar. 16	30	0	0	350	7	3.2	.640	.064	.000	.000	330	14	1—	2—	2—	—
17321	Mar. 16	10	0	Mu	365	5	2.2	1.120	.088	.000	.120	352	*				..
17322	Apr. 13	0	.2	0	320	5	5.3	.526	.162	.046	.014	274	42	1+	2—	2—	—
17475	Apr. 13	0	.2	0	310	5	5.8	.514	.150	.048	.272	274	45	1+	2—	2—	+
17477	May 25	0	40.	0	297	3	7.1	.066	.142	.080	.280	330	120	1—	2—	2—	—
17559	May 25	0	50.	0	315	4	7.2	.042	.144	.024	.296	248	100	1+	2—	2—	—
17560	June 15	0	40.	0	328	3	3.9	.240	.240	.200	.200	259	420	1+	2+	1? 1+	+
17706	June 15	0	30.	0	316	3	4.4	.264	.224	.160	.320	259	420	1+	2+	2?	+
17707	July 13	0	10.	0	313	6	5.9	.752	.240	.080	.080	276	102	1—	1—1?	2?	+
17713	July 13	0	20.	0	312	6	5.9	.720	.280	.100	.100	270					..
18153	July 13												85	1—	1+1—	2—	—
18154	Sept. 14	0	30.	Mo	299	6	4.5	.144	.184	.250	.030	263	*				..
18344	Sept. 14	0	20.	Mo	286	5	5.2	.104	.208	.140	.700	257	8		2—		—
18345	Oct. 19	0	10.	0	331	6	4.9	.080	.184	.140	.580	281	90	1+	1? 1—	2+	+
18494	Oct. 19	0	20.	0	330	6	4.6	.072	.200	.120	.800	275	120	1?	1? 1+	2—	+
18495	Nov. 16	20	50.	0	326	9	2.7	1.280	.112	.006	.360	325	360	1—	2—	2—	—
18616	Nov. 16	20	60.	0	360	8	2.9	1.120	.112	.008	.232	318	320	1—	2—	2—	—
18618	Dec. 14	0	10.	0	387	10	13.7	.480	.048	.088	.312	318	120	1—	2—	2—	—
	Dec. 14												92	1—	2—	2—	—

* Bottle broken.

Elmhurst, DuPage county, see Bulletin No. 5, page 44, obtains its water supply from Mammoth Spring. The plant is owned by a private corporation and was established in 1890 at a cost of $75,000. A standpipe of 30,000 gallons capacity is located in the village, but the pumping station is located at the spring. Two Ramsey triplex 6½x10 pumps are used. The daily consumption is 200,000 gallons. Additional analyses of the city water supply gave the following results:

SANITARY ANALYSES OF MUNICIPAL WATER SUPPLY OF ELMHURST.

Serial Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Color.	Appearance. Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia. Free.	Nitrogen as Ammonia. Albuminoid.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Alkalinity.	Bacteria per c. c.	Colon Bacillus. 10 c. c.	Colon Bacillus. 1 c. c.	Colon Bacillus. 0.1 c. c.	Indol.
	1906.																
14890	Sept. 1	Dis	.3	0	469	2.5	2.75	.304	.104	.001	.160	355	1440	1—	2—	2—	..
15403	Nov. 27	Sl	.1	0	472	3.0	2.55	.184	.040	.003	.160	358	1000	1—	2—	2—	..
	1908.																
18632	Dec. 20	20.	30.	H_2S	479	5.0	.9	.276	.064	.000	.320	353	25	1—	2—	2—	—

An analysis of the mineral content gave the following results:

MINERAL ANALYSIS OF ELMHURST CITY SUPPLY.

Laboratory No. 18632. Sample collected December 20, 1908.

Ions.	Parts per Million	Hypothetical Combinations.		Parts per Million	Grains per Gallon
Potassium K	2.0	Potassium nitrate	KNO_3	2.3	.13
Sodium Na	11.2	Potassium chloride	KCl	2.1	.12
Ammonium NH_4	.3	Sodium chloride	$NaCl$	3.3	.19
Magnesium Mg	39.8	Sodium sulphate	Na_2SO_4	30.5	1.78
Calcium Ca	102.0	Ammonium sulphate	$(NH_4)_2SO_4$	1.0	.06
Iron Fe	.6	Magnesium sulphate	$MgSO_4$	86.1	5.02
Alumina Al_2O_3	2.4	Magnesium carbonate	$MgCO_3$	77.6	4.52
Nitrate NO_3	1.4	Calcium carbonate	$CaCO_3$	255.0	14.87
Chloride Cl	3.0	Iron carbonate	$FeCO_3$	1.2	.07
Sulphate SO_4	90.	Alumina	Al_2O_3	2.4	.14
Silica SiO_2	15.6	Silica	SiO_2	15.6	.91
Bases	1.1	Bases	....	1.1	.06
		Total		478.2	27.87

Elmwood, Peoria county, see Bulletin No. 5, page 45.

El Paso, Woodford county, see Bulletin No. 5, page 45, obtains its water supply from three wells 115 feet deep. The plant is owned

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF EVANSTON.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c.c.	0.1 c.c.	
								Raw.									
	1907.																
15551	Jan. 7	De.	.2	0	146	4	3.9	.054	.120	.002	.280	118	310	1+	1+1—	2—	. .
15871	Mar. 25	Di	.1	2 E	174	4	3.1	.014	.060	.000	.240	126	650	1+	2+	1+ 1—	. .
15945	April 15	100	0	0	189	5	3.9	.024	.120	.000	.480	119	. . . .	. . . .	. . . .	. . . .	. .
16012	May 6	70	.2	0	205	5	3.9	.016	.160	.001	.240	119	13,000	1+	2+	2—	. .
16096	June 4	5	.2	0	146	6	3.5	.020	.104	.002	.520	111	5,200	1—	2—	2—	. .
16172	June 25	8	.1	0	153	5	2.95	.008	.104	.000	.200	111	4,900	1?	1? 1—	2+	. .
16425	Aug. 26	20	0	Mu	174	4	4.45	.040	.144	.001	.040	119	3,200	1—	2+	1+ 1—	. .
16465	Sept. 9	5	0	Mo	144	5	3.4	.000	.104	.000	.20	121	3,000	1+	2+	1— 1+	. .
16550	Sept. 30	40	0	0	164	3	3.7	.016	.128	.001	.200	119	150	1+	1? 1+	1— 1+	—
16608	Nov. 11	30	0	0	166	4	3.0	.008	.010	.002	.240	121	200	1—	2—	2—	. .
16727	Oct. 14	30	0	0	161	4	4.7	.028	.136	.000	.080	116	360	1+	2+	1— 1?	+
	1908.																
16978	Jan. 13	180	Mi	0	281	6	7.1	.018	.140	.007	.280	128	900	1+	2—	2—	+
17155	Mar. 2	40	0	0	177	6	2.5	.040	.140	.004	.200	124	460	1—	2+	2—	+
17290	April 6	70	0	0	196	6	3.1	.060	.110	.002	.32	124	300	1+	2+	2—	—
17397	May 25	30	0	0	172	5	2.2	.048	.108	.000	.68	120	180	1+	2—	2—	+
17465	May 4	35	20	0	190	5	2.8	.510	.260	.000	.280	118	290	1+	2—	2—	—
17758	July 20	20	10.	Mu	163	6	3.1	.034	.096	.002	.240	114	300	1—	2—	2—	—
17963	Aug. 17	20	0	0	199	6	2.3	.018	.088	.001	.240	116	500	1+	1+1—	2—	+
18225	Sept. 28	. . . . .	. . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . . .	240	1+	1+1?	1— 1+	+
18580	Nov. 30	20	10.	0	146	7	1.4	.018	.100	.003	.240	112	3,800	1+	1+1—	2—	+
18621	Dec. 14	55	20.	E	192	7	1.9	.008	.068	.001	.160	124	5,200	1+	2+1?	2—	+

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF EVANSTON.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c.c.	0.1 c.c.	
	Filtered.																
	1907.																
15552	Jan. 7	0	0	3 E	147	4	3.25	.046	.080	.002	.360	112	0	1—	2—	2—	. .
15872	Mar. 25	0	0	0	171	5	2.4	.022	.066	.000	.240	123	0	1—	2—	2—	. .
16013	May 6	0	0	0	164	5	2.5	.014	.048	.000	.32	119	14	1—	2—	2—	. .
16097	June 4	0	0	0	146	7	2.6	.024	.072	.000	.280	110	22	1—	2—	2—	. .
16173	June 25	0	0	0	141	4	2.3	.016	.056	.000	.240	115	400	1—	2—	2—	. .
16424	Aug. 26	0	0	Mu	163	4	3.2	.088	.096	.000	.280	124	60,000	1—	2—	2—	. .
16466	Sept. 9	0	0	Mu	129	5	2.9	.016	.096	.000	.200	117	50,000	1+	2—	2—	. .
16549	Sept. 30	0	0	0	137	3	2.5	.016	.080	.050	3.550	121	10	1—	2—	1+ 1—	. .
16607	Oct. 14	0	0	0	126	4	2.7	.016	.088	.002	.240	119	Liq..	1+	2+	2+	. .
16726	Nov. 11	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	.10	1—	2—	2—	—
	1908.																
16979	Jan. 13	0	0	0	142	6	1.6	.000	.038	.000	.320	124	20	1—	2—	2—	—
17156	Mar. 2	0	0	0	141	8	1.3	.028	.082	.000	.280	126	300	1—	2—	2—	—
17964	Aug. 17	0	0	0	190	6	1.0	.024	.086	.000	.280	116	150	1+	2—	2—	+
18224	Sept. 28	0	10.	0	138	5	2.6	.060	.146	.000	.240	116	160	1+	1? 1+	2—	+
18581	Nov. 30	5.	10.	0	131	8	.8	.030	.096	.002	.320	114	300	1—	2—	2—	—

by the city, and is located in the west part of the city. A Gould triplex pump, with a capacity of 228 gallons per minute, is used. The daily consumption is 30,000 gallons.

Eureka, Woodford county, see Bulletin No. 5, page 45. A recent analysis of the water gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF EUREKA.

Laboratory No. 16977. Collected January 13, 1908.

Turbidity	30.	Nitrogen as—		Bacteria per c. c.	24
Color	.2	Free ammonia.	.960	Gas formers in	
Odor	.0	Alb. ammonia.	.088	10 c. c.	1 —
Residue on evaporation	674.	Nitrites	.004	1 c. c.	2 —
Chlorine in chlorides	30.	Nitrates	.20	0.1 c. c.	2 —
Oxygen consumed	2.3	Alkalinity, $CaCO_3$	402.	Indol	—

Evanston, Cook county, see Bulletin No. 5, page 45. Additional analyses of the water from Lake Michigan are shown on pages 138 and 139.

Fairbury, Livingston county, see Bulletin No. 5, page 51. Additional analyses of the city water supply gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF FAIRBURY.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
								Ammonia.									
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
	1907.																
16364	Aug. 12	0.	0	E	1248	530	2.7	.296	.016	.009	.311	321	30	1—	2—	2 —	. .
	1908.																
17076	Feb. 4	5.	0	0	1320	545	6.3	.040	.400	.000	.000	330	. . .	. . .	. . .	. . .	. .
17418	May 11	10.	10	H_2S	1343	550	7.0	.880	.016	.000	.600	346	2	1—	2—	2 —	—
17419	May 11	0.	0	0	1316	550	3.9	.880	.024	.000	.800	342	6	2—	2—	2—	—
18237	Sept. 28	10.	0	H_2S	1288	520	1.9	.960	.040	.000	.240	322	152	1?	2?	1+ 1 —	+

Fairfield, Wayne county, see Bulletin No. 5, page 51, obtains its water supply from an artificial lake or reservoir which is supplied with water from a watershed of about 200 acres of open fields. The plant is owned by the Fairfield Water Works Company, and was established in 1894 at a cost of $5,000. The water is used for fire protection and sprinkling purposes only.

Farmer City, DeWitt county, see Bulletin No. 5, page 51.

Farmington, Fulton county, see Bulletin No. 5, page 51.

Flora, Clay county, has no general supply, though plans, specifications, etc., have been prepared. It is hoped to begin work in the spring of 1909.

Forrest, Livingston county, has a general supply. No report has been made.

Forreston, Ogle county, see Bulletin No. 5, page 51, obtains its water supply from a well 300 feet deep. The plant is owned by the city, and was established in 1890 at a cost of $8,000. The plant is located in the heart of the city, and the stand pipe in the south-west part of town.

Fort Sheridan, Lake county, see Bulletin No. 5, page 51.

Freeburg, St. Clair County, see Bulletin No. 5, page 51, obtains its water supply from a lake. The plant is owned by a private party and leased by the city. It was established in 1898 at a cost of $4,000. The plant is located at the lake, east of the city. The daily consumption is 1,000 barrels.

Freeport, Stevenson county, see Bulletin No. 5, page 51. Additional analyses of the city supply gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF FREEPORT.

Serial Number.	Date of Collection.		Apperance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus		
			Turbidity.	Color.	Odor.				Ammonia Free.	Ammonia Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.
	1907.		. .														
15794	Mar.	4	Sl	.2	0	463	18	1.40	.104	.064	.000	3.16	350	. . .	. . .	. . .	. . .
15795	Mar.	4	Cl	0	0	475	18	1.50	.000	.000	.000	3.36	365	. . .	. . .	. . .	. . .
15800	Mar.	4	. . . .	. . .	. . .	. . .	. .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	200	1—	2—	2—
15903	April	2	10	0	0	351	18	1.75	.000	.032	.002	5.20	304	. . .	. . .	. . .	. . .
15904	April	2	Cl	0	0	361	19	1.7	.000	.032	.001	3.20	276	. . .	. . .	. . .	. . .

An analysis of the mineral content gave the following results:

MINERAL ANALYSIS OF CITY WATER FROM FREEPORT.

Laboratory Nos. 15794 and 15795.

Ions.	Parts per million.	
	15794	15795
Free carbon dioxide (as $CaCO_3$)	34.	25.
Magnesium (as $CaCO_3$)	180.6	201.0
Incrustants (as $CaCO_3$)	51.	55.
Alkalinity (as $CaCO_3$)	351.	365.
Total residue on evaporation	463.	475.
Chlorine	18.	18.

Possible combinations of the above:

		Parts per million.		Grains per Gallon.	
		15794	15795	15794	15795
Sodium chloride	$NaCl$	29.7	29.7	1.73	1.73
Magnesium sulphate	$MgSO_4$	62.	67.	3.62	3.91
Magnesium carbonate	$MgCO_3$	109.4	123.2	6.38	7.18
Calcium carbonate	$CaCo_3$	221.4	219.0	12.91	12.77
Undetermined SiO_3, Na_2SO_4, etc.		40.5	36.1	2.36	2.111
Total		463.0	475.0	27.00	27.70

Fulton, Whiteside county, see Bulletin No. 5, page 52.

Galena, Jo Daviess county, see Bulletin No. 5, page 52, obtains its water supply from an artesian well 1,500 feet deep. The plant is owned by the Galena Water Company, and was established in 1879 at a cost of $3,000. Pumps are used with a capacity of a million gallons per day. The daily consumption is about 30,000 gallons.

Galesburg, Knox county, see Bulletin No. 5, page 52. Additional analyses of the city supply gave the following results: (See page 143.)

Galva, Henry county, see Bulletin No. 5, page 54, obtains its water supply from two wells 1,400 feet deep. The plant is owned by the city and was established in 1894. The plant is located in the center of the city and pumps of 1,000 gallons per hour capacity are used. The daily consumption is 10,000 gallons. Recent analyses of the city water gave the following results: (See page 144.)

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF GALESBURG.

Serial No.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
								Ammonia									
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
	1906.																
15172	Oct. 15	V.S	.1	0	659	49	7.5	1.120	.400	.000	.120	295	....	....	....	....	.....
	1907.														....	....	.....
15576	Jan. 14	Sl	.0	0	817	43	2.85	.444	.184	.001	.520	398	....	....	....	....	.....
15577	Jan. 14	De	.6	0	943	62	2.95	.304	.064	.003	.520	368	....	....	....	....	.....
16196	July 1	60.	.6	0	867	72	8.75	.464	.152	.002	.080	334	....	....	....	....	.....
	1908.																
17216	Mar. 17	20.	.3	Mu	1087	98	1.9	.080	.080	.002	.520	340	....	....	....	....	.....
17217	Mar. 17	10.	.0	0	1120	98	1.5	.048	.104	.020	.530	342	....	....	....	....	.....
17218	Mar. 17	20.	.2	0	1097	98	2.1	.096	.072	.000	.550	340	....	....	....	....	.....
17219	Mar. 17	20.	.2	Mu	1095	98	1.9	.080	.096	.000	.650	340	....	....	....	....	.....
17510	June 1	5.	20.	0	1099	104	2.0	.104	.076	.000	.800	336	240	1—	2—	2—	+
17798	July 27	0	10.	0	1054	88	3.2	.184	.104	.006	.554	347	70	1?	2—	2—	—
17799	July 27	0	0	Mo	874	98	6.6	.112	.296	.000	.240	167	760	1?	1+	1+	—
18379	Oct. 26	0	0	0	1099	99	2.3	.112	.048	.000	1.000	345	480	1?	2?	2?	—
18418	Nov. 8	2.	10.	0	1088	99	2.2	.040	.080	.000	.520	343	480	1?	2?	2?	—

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF GALVA.

No. 13843, Well No. 2. No. 13844, Well No. 1.

Serial Number.	Date of Collection.	Appearance. Turbidity.	Color.	Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia. Free.	Albuminoid.	Nitrites.	Nitrates.	Alkalinity.	Sulphates.
	1905												
13843	Dec. 18	Decided	. 2	2 Earthy	948	149	5.4	1.040	.066	.002	.08	244	Much
13844	Dec. 18	Decided	. 3	2 Earthy	958	147	5.0	.960	.034	.000	.12	244	Much

Gardner, Grundy county, has no general supply.

Geneseo, Henry county, see Bulletin No. 5, page 54. An additional analysis of the city water taken from wells and springs gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF GENESEO.

Laboratory No. 15594. Collected January 14, 1907.

Turbidity	Slight	Nitrogen as—		Bacteria per c. c.	1,000
Color	0	Free ammonia	.016	Gas formers in	
Odor	0	Alb. ammonia	.072	10 c.c.	1—
Residue on Evaporation	368.	Nitrites	.000	1 c. c.	2—
Chlorine in chlorides	6.0	Nitrates	.520	0.1 c. c.	2—
Oxygen consumed	1.7	Alkalinity	273.2		

Geneva, Kane county, see Bulletin No. 5, page 54.

Genoa, DeKalb county, see Bulletin No. 5, page 54. Additional analyses of the city water supply gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF GENOA.

Samples collected January 27, 1908.

Laboratory No. 17063 taken from dead end of water main.
Laboratory No. 17064 taken direct from well.

Serial Number	Appearance. Turbidity.	Color.	Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia. Free.	Albuminoid.	Nitrites.	Nitrates.	Alkalinity.	Bacteria per c. c.	Colon Bacillus. 10 c. c.	1 c. c.	0.1 c. c.	Indol.
17063	110	0	0	353	2	4.5	.200	.072	.008	.072	328	40	1—	2—	2—	—
17064	0	0	0	323	2	2.0	.280	.016	.002	.320	324	1500	1—	2—	2—	—

Germantown, Vermilion county, was annexed to Danville in 1907, from which town the water supply is obtained. See Bulletin No. 5, page 54.

Gibson City, Ford county, see Bulletin No. 5, page 54. Recent analyses of the city supply gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF GIBSON CITY.

Samples collected November 16, 1908.

Serial Number.	Appearance.			Residue.		Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Loss on Ignition.		Bacteria per c. c.	Colon Bacillus.			Indol.
								Ammonia.											
	Turbidity.	Color.	Odor.	Raw.	Filtered.			Free.	Albuminoid.	Nitrites.	Nitrates.		Raw.	Filtered.		10 c. c.	1 c. c.	0.1 c. c	
18499	30	10.	0	352	......	6	2.2	.384	.072	.006	.160	337	....	....	6	1—	2—	2—	—
18500	900	.50	H2S	864	338.	5	29.43	.400	.608	.005	.600	308	171	119	....	....	....	....	..
18501	0	10.	0	337	......	6	2.8	.072	.088	.004	.280	316	....	....	520	1 +	2—	2—	—

Gilman, Iroquois county, has sent no report.

Girard, Macoupin county, has no general supply.

Glencoe, Cook county, see Bulletin No. 5, page 55. The additional analyses of the Lake Michigan water furnished by the city of Winnetka gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF GLENCOE.,

Serial Number.	Date of Collection.	Appearance			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus			
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
15684	1907. Feb. 11	10	0	0	158	4	4.0	.034	.098	.001	.640	126.	500+	1 —	2 —	2—	. .
17401	1908. May 5	0	0	0	150	4	1.5	.058	.116	.000	.280	120.	85	1 —	2 —	2—	—
17402	May 5	0	0	0	151	4	1.7	.020	.098	.000	.200	120.	3	1 —	2 —	2 —	—

Golconda, Pope county, see Bulletin No. 5, page 55.

Grand Ridge, La Salle county, has no general supply. A recent analysis made of the proposed city supply, taken from a well 150 feet deep, gave the following results:

SANITARY ANALYSIS OF THE PROPOSED MUNICIPAL SUPPLY OF GRAND RIDGE.
Sample collected December 6, 1908.

Laboratory No.	18600				
Turbidity	2.	Nitrogen as		Bacteria per c.c.	3
Color	40.	Free Ammonia	1.840	Gas formers in	
Odor	0.	Alb. Amonia	.112	10 c.c	1—
Residue on evaporation	343.	Nitrites	.000	1 c.c.	2—
Chlorine in Chlorides	8.	Nitrates	.120	0.1 c.c.	2—
Oxygen consumed	3.7	Alkalinity	298.	Indol	—

An analysis of the mineral content gave the following results:

MINERAL ANALYSIS OF PROPOSED MUNICIPAL SUPPLY OF GRAND RIDGE.

Ions.	Parts per Million	Hypothetical Combinations.		Parts per Million	Grains per Gallon
Potassium K	7.6	Potassium nitrate	KNO_3	.8	.05
Sodium Na	83.5	Potassium chloride	KCl	13.9	.81
Ammonium NH_4	2.4	Sodium chloride	$NaCl$	2.3	.13
Magnesium Mg	10.8	Sodium carbonate	Na_2CO_3	190.1	11.09
Calcium Ca	20.8	Ammonium carbonate	$(NH_4)_2CO_3$	6.4	.37
Iron Fe	.4	Magnesium carbonate	$MgCO_3$	37.4	2.18
Alumina Al_2O_3	2.0	Calcium carbonate	$CaCO_3$	52.0	3.03
Nitrate NO_3	.5	Iron carbonate	$FeCO_3$	.8	.05
Chloride Cl	8.0	Alumina	Al_2O_3	2.0	.12
Sulphate SO_4	.3	Silica	SiO_2	7.7	.45
Silica SiO_2	7.7	Bases	....	.8	.05
Bases	.8				
		Total		314.2	18.33

Granite City, Madison county, see Bulletin No. 5, page 55.

Grayville, White county, see Bulletin No. 5, page 55, is located on the Wabash River, from which stream the city water supply is obtained. The plant is owned by the city, and was established in 1893 at a cost of $20,000. The plant is located near the river. Two Dean duplex steam pumps, with a capacity of 25,000 gallons per hour each, are used. The daily consumption is about 150,000 gallons.

Greenfield, Greene county, has no general supply.

Greenup, Cumberland county, see Bulletin No. 5, page 55, is located on the Embarrass River, from which stream the city water supply is obtained. The plant is owned by the city, and was established in 1897 at a cost of $15,000. The plant is located on the bank of the river. One 8x10 Dean duplex pump is used. The daily consumption is 18,000 gallons.

Greenview, Menard county, located on Green Creek, has no general supply.

Greenville, Bond county, see Bulletin No. 5, page 55. Additional analyses of the city water supply gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF GREENVILLE.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.	
18092	1908. Sept. 8	0	0	Sewer Gas	624	40	1.6	.016	.048	.000	8.800	370
18093	Sept. 8	0	0	Sewer Gas	621	40	2.0	.016	.048	.020	9.980	385

Griggsville, Pike county, has no general supply.

Grossdale, Cook county, has sent no report.

Hamilton, Hancock county, located on the Mississippi River, has no general supply.

Harrisburg, Saline county, see Bulletin No. 5, page 55, is located on the middle fork of Saline River, from which the water supply is obtained. The plant is owned by a private company. The reservoirs are located 1¼ miles east of the town. The pumps have a daily capacity of 300,000 gallons. The daily consumption is 200,000.

Harvard, McHenry county, see Bulletin No. 5, page 55, obtains the city water supply from an artesian well 1,800 feet deep. The plant is owned by the city and was established in 1893. A new tower and tank of 100,000 capacity has just been completed. The capacity of the pumps is about 360,000 gallons daily.

Harvey, Cook county, see Bulletin No. 5, page 55, obtains the city water supply from wells 1,700 feet deep. The plant is owned by the North Shore Electric Company. Centrifugal motor pumps are being installed. The daily consumption is 300,000 gallons. A recent analysis of the city supply gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF HARVEY.

Laboratory No. 18165. Collected September 15, 1908.

Turbidity	0.	Nitrogen as		Bacteria per c.c.	46
Color	0.	Free Ammonia	.106	Gas Formers in	
Odor	0.	Alb. Ammonia	.042	10 c.c.	1—
Residue on evaporation	1281.	Nitrites	.015	.1 c.c.	2—
Chlorine in chlorides	136.	Nitrates	.745	0.1 c.c.	2—
Oxygen consumed	1.5	Alkalinity	280.	Indol	

An analysis of the mineral content gave the following results:

MINERAL ANALYSIS OF THE CITY OF HARVEY.

Laboratory No. 18165. Collected September 15, 1908.

Ions.	Parts per Million	Hypothetical Combinations.		Parts per Million	Grains per Gallon
Potassium K	34.4	Potassium nitrate	KNO_3	5.4	.31
Sodium Na	138.2	Potassium chloride	KCl	61.5	3.59
Magnesium Mg	48.5	Sodium chloride	NaCl	176.2	10.28
Calcium Ca	173.5	Sodium sulphate	Na_2SO_4	212.1	12.38
Iron oxide Fe_2O_3	.2	Magnesium sulphate	$MgSO_4$	239.7	13.98
Alumina Al_2O_3	3.0	Calcium sulphate	$CaSO_4$	225.2	13.13
Nitrate NO_3	3.3	Calcium carbonate	$CaCO_3$	267.5	15.60
Chloride Cl	136.0	Iron oxide	Fe_2O_3	.2	.01
Sulphate SO_4	493.4	Alumina	Al_2O_3	3.0	.17
Silica SiO_2	8.8	Silica	SiO_2	8.8	.51
Bases	4.8	Bases		4.8	.28
		Total		1,204.2	70.24

Havana, Mason county, see Bulletin No. 5, page 55.

Henry, Marshall county, see Bulletin No. 5, page 56.

Herrin, Williamson county, has no general supply.

Highland, Madison county, see Bulletin No. 5, page 56.

Highland Park, Lake county, see Bulletin No. 5, page 56. Recent analyses of the Lake Michigan water at Highland Park gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF HIGHLAND PARK.

Laboatory No. 18214. Collected September 28, 1908.
Laboratory No. 18215. Collected September 28, 1908.

Serial Number.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
	Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
18214	5	0	0	155	5	1.2	.024	.106	.000	.200	112	480	1 ?	1 + 1 ?	1+ 1—	+
18215	0	0	0	140	5	1.3	.012	.102	.000	.200	114	400	1 +	2 +	2—	+

Hillsboro, Montgomery county, see Bulletin No. 5, page 57.

Hinsdale, DuPage county, see Bulletin No. 5, page 57.

Homer, Champaign county, has no general supply.

Hoopston, Vermilion county, see Bulletin No. 5, page 57.

Jacksonville, Morgan county, see Buletin No. 5, page 57, has obtained its supply from wells, a creek, and a lake near the city. The system was owned by the city and was established in 1868 at a cost of $400,000. Smith Vaile and Worthington pumps, each of 2,000,000 gallons capacity are used. The daily consumption is 1,000,000 gallons. The capacity of the reservoir is 2,660,000 gallons. A new supply is obtained from wells 66 feet deep in the Illinois River bottoms west of Bluffs. The new supply is furnished by a corporation known as the Jacksonville Water Works Company, which has been granted a franchise to furnish water for 30 years to the city. The company has installed a pumping station west of Bluffs, 18 miles from Jacksonville, and with two 3,000,000 gallon pumps are forcing water through a 20-inch main and supplying the city. As soon as the company can demonstrate that it can furnish 3,000,000 gallons every 24 hours, under the terms of the franchise, the municipal plant is to be turned over to it. Additional analyses of the water from the old supply gave the following results:

SANITARY ANALYSES OF THE OLD MUNICIPAL WATER SUPPLY OF JACKSONVILLE.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c.c.	0.1 c.c.	
	1908.																
17118	Feb. 17	240	0	0	1226	325	15.6	.112	.224	.075	.280	206	8,400	1—	2—	2—	+
17149	Mar. 2	30	0	0	362	5	1.6	.032	.074	.000	.160	332	40	1—	2—	2—	—
18193	Sept. 21	5	40	Mo.	422	113	5.8	.302	.516	.008	.192	154	6,400	1+	2+	1? 1+	+
18194	Sept. 21	20	70	Mo.	227	6	8.0	.144	.856	.003	.200	154	8,800	1+	2+	2+	+
18195	Sept. 21	10	40	Mo.	183	5	6.8	.170	.862	.001	.160	148	720	1—	2?	2+	+

Additional sanitary analyses of the new supply from Bluffs gave the following results:

Serial Number.	Date of Collection.	Turbidity.	Color.	Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.	Alkalinity.	Bacteria per c. c.	10 c.c.	1 c.c.	0.1 c.c.	Indol.
	1907.																
15643	Jan. 30	De	.6	0	383	3	1.7	.040	.032	.002	.200	324	900	1—	1? 1—	1? 1—	...
15644	Jan. 30	"	.6	0	357	4	2.0	.024	.040	.001	.200	334	1,000	1+	2?	2—	...
15645	Jan. 30	"	.6	0	360	3	1.7	.008	.040	.000	.200	338	1,000	1+	1+ 1—	1? 1—	...
15646	Jan. 30	"	.6	0	361	4	1.6	.024	.040	.000	.200	324	1,000	1+	1? 1—	2?	...
16217	July 8	15.	.3	2 V.	418	10	2.0	.008	.112	.000	.200	279	15,000	1?	2—	2—	...
16218	July 8	25.	.3	0	428	6	1.1	.016	.112	.000	.200	291	10,000	1?	1—	1—	...
16219	July 8	25.	.3	2 V.	462	5	2.3	.024	.112	.000	.120	291	11,500	1—	2+	2+	...
	1908.																
17070	Feb. 4	0	0	0	373	5	2.4	.016	.000	.000	.080	340	40	1+	2—	2—	—
17147	Mar. 2	5	Fe0	0	339	5	1.0	.058	.064	.000	.160	334	90	1—	2—	2—	—
17148	Mar. 8	5	0	0	360	5	.9	.030	.052	.000	.000	336	75	1—	2—	2—	+

An examination of the mineral content gave the following results:

MINERAL ANALYSES OF THE CITY WATER OF JACKSONVILLE.

Ions		Parts per Million		
		17070	17147	17148
Sodium,	Na	.8	5.2	7.4
Magnesium,	Mg	36.6	20.8	33.3
Calcium,	Ca	84.1	100.3	82.6
Oxide of Iron, and Alumina,	$Fe_2O_3 +$ Al_2O_3	2.4	3.8	9.3
Nitrate,	NO_3	.4	5.0	---
Chloride,	Cl	5.0	5.0	5.0
Sulphate,	SO_4	26.4	26.0	35.1
Silica,	SiO_2	38.7	55.2	13.0
Bases,		.5	2.6	1.5

Hypothetical Combinations.		Parts per Million			Grains per Gallon		
		17070	17147	17148	17070	17147	17148
Sodium nitrate,	$NaNO_3$	.5	----	----	.03	----	----
Sodium chloride,	NaCl	1.8	8.3	8.3	.10	.48	.48
Sodium sulphate,	Na_2SO_4	----	5.9	12.6	----	.34	.73
Magnesium chloride,	$MgCl_2$	5.2	----	----	.30	----	1.94
Magnesium sulphate,	$MgSO_4$	33.1	27.6	33.3	1.93	1.61	----
Magnesium carbonate,	$MgCO_3$	99.0	52.6	92.1	5.77	3.07	5.37
Calcium carbonate,	$CaCO_3$	209.9	250.4	206.2	12.24	14.60	12.03
Oxide of Iron and Alumina,	$Fe_2O_3 +$ Al_2O_3	2.4	3.8	9.3	.14	.22	.54
Silica,	SiO_2	18.8	15.6	13.0	1.10	.91	.76
Bases,		.5	2.6	1.5	.03	.15	.09
Total,		371.2	366.8	376.3	21.64	21.38	21.94

Jerseyville, Jersey county, see Bulletin No. 5, page 58. An additional analysis of the city supply gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF JERSEYVILLE.

Sample Collected July 24, 1908. Laboratory No. 17687.

Turbidity,	30.	Nitrogen as	
Color,	30.	Free Ammonia,	3.600
Odor,	Oily	Albuminoid Ammonia,	.096
Residue on Evaporation,	2648.	Nitrites,	.001
Chlorine in Chlorides,	1400.	Nitrates,	.480
Oxygen Consumed,	8.2	Alkalinity,	268.

An examination of the mineral content gave the following results:

MINERAL ANALYSIS OF THE CITY SUPPLY OF JERSEYVILLE.

Ions	Parts Per Million	Hypothetical Combinations.		Parts Per Million	Parts Per Gallon
Sodium, Na	798.7	Sodium nitrate,	$NaNO_3$	2.9	.17
Ammonium, NH_4	4.6	Sodium chloride,	NaCl	1980.3	115.51
Magnesium, Mg	57.8	Sodium sulphate,	Na_2SO_4	54.3	3.17
Calcium, Ca	99.8	Ammonium sulphate,	$(NH_4)_2SO$	16.8	.98
Oxide of Iron Fe_2O_3 + and Alumina, Al_2O_3	3.2	Magnesium sulphate,	$MgSO_4$	285.7	16.66
Nitrate, NO_3	2.1	Calcium sulphate,	$CaSO_4$	122.5	7.15
Chloride, Cl	1200.0	Calcium carbonate,	$CaCO_3$	159.0	9.27
Sulphate, SO_4	363.2	Oxide of Iron, and Alumina,	Fe_2O_3 + Al_2O_3	3.2	.19
Silica, SiO_2	11.2	Silica,	SiO_2	11.2	.65
Bases,	1.8	Bases,		1.8	.10
		Total,		2637.7	153.85

Joliet, Will county, see Bulletin No. 5, page 58. Additional analyses of the city supply are shown on page 153.

Jonesboro, Union county, see Bulletin No. 5, page 58, obtains a water supply from a well 400 feet deep. The plant is owned by the city and was established in 1900. The water is used to supply mills, elevators, etc., and not for drinking purposes.

Kankakee, Kankakee county, see Bulletin No. 5, page 58. Additional analyses of the raw and filtered water from the Kankakee River are shown on page 154.

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF JOLIET.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c.c.	0.1 c.c.	
	1908.																
15765	Feb. 25	10	.2	0	509	15	3.05	.024	.072	.013	1.107	221	115	1—	2—	2—	..
17103	Feb. 17	5	0	0	488	20	3.2	.056	.094	.018	.200	232	720	1?	2—	1?	+
17415	May 12	10	20	0	526	15	2.7	.016	.088	.009	1.191	236	240	1+	2?	1— 2—	—
17625	June 20	0	0	Mu	475	14	2.7	.036	.148	.000	.640	266	3,000	1?	1?	2+	—
17626	June 29	0	0	Mu	497	15	3.1	.048	.190	.000	.640	236	1,160	1—	1— 1?	2—	—
17717	July 14	10	0	0	499	16	3.2	.016	.080	.002	.800	263	16,000	1—	2—	2—	—
18080	Sept. 8	5	20	E.	484	15	1.6	.056	.128	.003	.400	265	....	.....	.....		...
18483	Nov. 11	3	10	0	486	38	1.7	.400	.064	.052	.468	287	38	1—	2—	2—	—

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF KANKAKEE.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.				Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.	
	Raw.																	
	1907.																	
15545	Jan. 7	V.S.	.2	0	262	2	4.1	.048	.152	.000	1.720	89	7,600	1—	1? 1+	1 ? 1 +	. . . . .	. .
15749	Feb. 25	Di.	.5	0	300	2	8.4	.056	.224	.002	1.000	150	230,000	1—	2—	1+ 1—	. . . . .	. .
15855	Mar. 21	De.	.6	0	301	2	10.9	.040	.128	.003	.520	168	1,500	1+	2+	1+ 1—	. . . . .	. .
15896	April 2	Di.	.6	0	266	4	14.1	.048	.384	.003	.560	142	500	1+	2+	2 +	. . . . .	. .
15841	April 15	40	.6	0	357	3	13.3	.128	.384	.002	.480	161	1,900	1 ?	2+	1—1+	. . . . . .	. .
15953	April 17	60	.2	0	321	3	8.35	.072	.256	.006	.180	182	5,600	. . .	1—	1 + 1 —	1 + 1 —	. .
16052	May 21	45	.6	0	322	3	12.1	.056	.344	.008	1.072	189	1,500	1+	1 + 1—	2 +	. . . . . .	. .
16230	July 10	80	.4	0	326	2	15.0	.056	.400	.010	.870	173	5,000	1+	2+	2 +	. . . . . .	. .
16357	Aug. 11	0	.1	Pu.	341	1	7.2	.024	.200	.000	.600	218	Liq.	1+	2+	1 —	. . . . . .	. .
16462	Sept. 9	280	.2	0	429	3	12.6	.032	.328	.003	.68	205	4,000	1+	2+	2 +	. . . . . .	. .
16524	Sept. 24	100	.8	0	259	2	14.5	.064	.400	.000	.24	113	5,000	1 ?	2+	1 + 1 ?	. . . . . .	. .
16865	Dec. 16	20	.6	E.	306	5	7.7	.052	.200	.004	.920	180	800	1—	2—	2 +	. . . . . .	+
	1908.																	
16996	Jan. 20	30	.6	E.	322	3	11.9	.052	.236	.010	1.07	184	1,100	1 ?	1 ? 1—	1 ? 1 —	. . . . . .	+
17130	Feb. 24	30	.6	Mu.	230	4	8.3	.096	.278	.007	.790	132	2,300	1+	2+	2 —	. . . . . .	+
17245	Mar. 25	25	.5	0	187	2	11.6	.094	.286	.002	.520	106	900	1+	1—1+	2 +	. . . . . .	+
17384	April 28	100	120.	0	298	3	3.5	.028	.440	.004	1.04	166	3,600	1+	2+	2 +	. . . . . .	+
17528	June 8	30	70.	E.	285	3	13.4	.084	.462	.006	.320	178	820	1+	1 + 1 ?	1 ? 1+	. . . . . .	+
17602	June 23	50	100.	0	381	3	7.8	.166	.300	.005	.320	195	5,000	1 ?	2+	2 ?	. . . . . .	+
17753	July 20	20	80.	Ma.	321	4	9.2	.024	.280	.004	.240	210	2,400	1 ?	2+	2 +	. . . . . .	+
18425	Nov. 3	20	40.	0	306	8	6.0	.020	.172	.010	.590	199	1,520	1+	2+	2 +	. . . . . .	+
18589	Dec. 3	10	35.	0	309	7	3.9	.016	.152	.008	.472	197	4,400	1+	1 ? 1+	1 ? 1 —	. . . .	+

FILTERED.

	1907.															
15543	Jan. 7	5	.4	1 E.	275	2	5.4	.080	.240	.000	1.360	91	1,900	1 +	2 +	1 + 1 —	....	. .
15750	Feb. 25	0	.3	2 E.	280	3	6.2	.064	.240	.000	1.000	142	7,900	1 +	1 — 1 +	2 —	....	. .
15856	Mar. 21	5	.3	2 M.	280	2	5.1	.112	.256	.000	.680	159	350	1 —	1 ? 1 —	1 + 1 —	....	. .
15897	April 2	0	0	0	257	4	8.4	.008	.200	.000	.560	136	65	1 +	2 +	2 —	....	. .
15942	April 15	5	.5	0	275	3	11.3	.080	.264	.000	.480	161	95	1 +	1 ? 1 +	2 —	....	. .
16053	May 21	0	.4	0	333	3	9.7	.024	.304	.000	1.080	187	89	1 +	2 —	2 —	....	. .
16231	July 10	5	.4	3 E.	312	2	8.5	.024	.176	.000	.680	175	120	1 —	1 + 1 —	1 ? 1 +	....	. .
16463	Sept. 9	0	.2	0	319	2	6.75	.000	.152	.000	.520	205	100	1 +	2 +	2 +	....	. .
16425	Sept. 24	5	.6	0	214	2	11.6	.032	.240	.016	.304	124	600	1 ?	1 ? 1 +	1 + 1 ?	....	. .
16866	Dec. 16	0	0	E.	327	5	5.4	.056	.140	.002	.920	170	Lost	1 +	1 — 1 +	2 —	....	+
	1908.															
16995	Jan. 20	0	.1	E.	304	4	6.9	.060	.192	.010	.99	162	19	1 —	2 —	2 —	....	—
16998	Jan. 20	.....	....	......	......	......	....	....	......	......	....	......	300	1 —	2 —	2 —	....	+
17131	Feb. 24	0	.6	Mu.	247	4	6.0	.072	.210	.007	.63	154	860	1 ?	1 + 1 —	2 —	....	—
17244	Mar. 25	0	.2	0	150	2	6.5	.062	.200	.002	.520	70	18	1 —	2 —	2 —	....	—
17385	April 28	0	55.	0	194	3	6.5	.022	.246	.008	.672	106	210	1 +	1 + 1 ?	2 —	....	—
17529	June 8	0	60.	0	256	3	10.1	.080	.300	.000	.320	159	74	1 +	1 ? 1 —	2 —	....	—
17603	June 23	0	50.	0	283	3	4.8	.056	.240	.000	.320	188	880	1 +	1 + 1 —	2 —	....	+
17754	July 20	0	30.	0	365	4	6.2	.032	.172	.000	.280	204	48	1 —	2 —	2 —	....	+
18456	Nov. 3	0	5.	0	274	8	4.2	.028	.140	.001	.520	174	11	1 +	2 —	2 —	....	+
18590	Dec. 3	0	20.	0	281	7	2.9	.022	.136	.001	.679	172	240	1 +	2 +	2 —	....	—

Kansas, Edgar county, has no general supply.

Keithsburg, Mercer county, see Bulletin No. 5, page 63. Recent analyses of the city supply gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF KEITHSBURG.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
	1907.																
16456	Sept 3	0	0	0	920	89	3.75	.000	.088	.013	17.000	238	200	1—	2—	2—	. .
	1908.																
18231	Sept. 29	0	0	0	900	110	1.8	.336	.104	.052	15.948	318	7	1—	2—	2—	—
18233	Sept. 29	0	0	0	548	34	1.1	.032	.064	.001	3.840	195	8	1—	2—	2—	—

Kenilworth, Cook county, obtains its water supply from Lake Michigan. Recent analyses of the Lake Michigan water, raw and filtered, taken at Kenilworth, are shown on page 157.

Kewanee, Henry county, see Bulletin No. 5, page 63. Additional analyses of the water from the deep well gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF KEWANEE.

Samples Collected December 7, 1907.

Serial Number.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
	Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
16831	0	0	0	1269	410	3.8	.128	.016	.004	1.396	248	30	1 —	2—	2 —	—
16832	0	0	0	1273	410	5.3	.720	.016	.080	.420	248	0	1 —	2—	2 —	—
16833	0	0	0	1287	410	5.2	.880	.016	.080	.160	248	0	1 —	2—	2—	. .
16834	0	0	0	1269	410	4.3	.800	.016	.050	.110	248	30	1 —	2—	2 —	—

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF KENILWORTH.

Serial Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Color.	Appearance. Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia. Free.	Nitrogen as Ammonia. Albuminoid.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Alkalinity.	Bacteria per c. c.	Colon Bacillus. 10 c. c.	Colon Bacillus. 1 c. c.	Colon Bacillus. 0.1 c. c.	Indol.
	Raw.																
	1907.																
16135	June 15	10.	.2	0	153	5	3.0	.034	.124	.000	.160	86	1,000+	1?	2+	1? 1—	. .
	1908.																
16949	Jan. 7	30.	Mi	0	174	5	2.3	.022	.062	.003	.360	120	Lost	1+	2+	2—	—
17159	March 3	50.	0	0	177	5	2.5	.040	.102	.000	.280	126	800	1+	2+	2—	+
17471	May 25	0	0	0	147	5	1.7	.028	.152	.000	.320	112	280	1—	2—	2—	—
18464	Nov. 9	20.	30.	0	156	9	2.0	.016	.112	.001	.200	126	380,000	1+	1—1+	1? 1—	+
18536	Nov. 23	20.	20.	0	203	7	2.1	.042	.138	.003	.280	122	9,600	1+	2+	1? 1+	+
18637	Dec. 21	…	…	…	…	…	…	…	…	…	…	…	2,800	1+	1—1+	1—1+	+
	Filtered.																
	1907.																
16136	June 15	0	0	0	143	5	2.0	.008	.072	.000	.240	102	1,000+	1—	2—	2—	. .
	1908.																
16950	Jan. 7	0	0	0	152	5	1.3	.026	.076	.003	.360	114	30	1—	2—	2—	—
16951	Jan. 7	0	0	0	135	5	1.5	.022	.078	.002	.680	114	600	1+	2—	2—	—
16952	Jan. 7	0	0	0	134	4	1.5	.020	.066	.000	.360	114	80	1—	2—	2—	—
17160	March 3	0	0	0	132	5	1.0	.036	.086	.000	.160	120	200	1?	2—	2—	—
17161	March 3	0	0	0	122	5	1.5	.036	.092	.000	.160	120	380	1?	2—	2—	—
17162	March 3	0	0	0	135	5	1.3	.050	.084	.000	.000	120	250	1—	2—	2—	—
17470	May 25	0	0	0	154	5	1.8	.016	.120	.000	.280	112	260	1—	2—	2—	—
18463	Nov. 9	0	10	0	146	8	1.9	.016	.080	.000	.360	116	4,080	1—	2—	2—	—
18535	Nov. 23	0	0	0	165	5	.7	.016	.058	.000	.400	108	240	1—	2—	2—	—
18638	Dec. 21	0	0	0	134	7	.9	.040	.080	.001	.320	110	52	1—	2—	2—	—

Kinmundy, Marion county, has sent no report.

Kirkwood, Warren county, see Bulletin No. 5, page 65. Recent analyses of the water from the well 130 feet deep gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF KIRKWOOD.

Samples collected August 22, 1908.

Serial Number.	Appearance. Turbidity.	Appearance. Color.	Appearance. Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia. Free.	Nitrogen as Ammonia. Albuminoid.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Alkalinity.	Bacteria per c. c.	Colon Bacillus. 10 c. c.	Colon Bacillus. 1 c. c.	Colon Bacillus. 0.1 c. c.	Indol.
17952	40.	80.	0	555	4	3.2	3.040	.104	.000	.200	520	50	1—	2—	2—	—
17953	40.	50.	0	526	3	2.7	3.040	.072	.000	.200	524	10	1+	2—	2—	—

Knoxville, Knox county, see Bulletin No. 5, page 65.

Lacon, Marshall county, see Bulletin No. 5, page 65.

Ladd, Bureau county, see Bulletin No. 5, page 66.

La Grange, Cook county, see Bulletin No. 5, page 66. Recent analyses of the water from the well 2,040 feet drilled gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF LA GRANGE.

15475 collected December 18, 1906. Other samples collected February 17, 1908.

Serial Number.	Appearance. Turbidity.	Appearance. Color.	Appearance. Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia. Free.	Nitrogen as Ammonia. Albuminoid.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Alkalinity.	Bacteria per c. c.	Colon Bacillus. 10 c. c.	Colon Bacillus. 1 c. c.	Colon Bacillus. 0.1 c. c.	Indol.
15475	. . .	.4	0	498	12	2.3	.184	.048	.001	.240	364	0	1—	2—	2—	. .
17112	20	0	0	452	15	1.8	.096	.064	.006	.032	366	720	1—	2—	2—	+
17113	10	0	0	523	16	1.7	.104	.088	.003	.048	366	880	1—	2—	2—	+
17114	5	0	0	533	15	1.8	.072	.048	.006	.064	366	80	1—	2—	2—	+
17115	5	0	0	511	14	1.7	.048	.048	.006	.064	366	40	1—	2—	2—	—

Analyses of the mineral content gave the following results:

MINERAL ANALYSES OF THE CITY SUPPLY OF LA GRANGE.

December 18, 1906 (well 2024' drilled).

Samples collected February 17, 1908 (well 2040').

Ions.		Parts per Million	
		15475	17115
Sodium	Na	38.8	30.7
Ammonium	NH_4	....	.2
Magnesium	Mg	44.0	43.9
Calcium	Ca	99.6	131.6
Iron	Fe	....	.2
Alumina	Al_2O_3	....	1.9
Oxide of Iron & Alumina	$Fe_2O_3+Al_2O_3$	.4	....
Nitrate	NO_3	1.4	1.1
Chloride	Cl	14.0	12.0
Sulphate	SO_4	97.5	99.2
Silica	SiO_2	10.2	9.1
Bases	....	....	3.3

Hypothetical Combinations.		Parts per Million.		Grains per Gallon.	
		15475	17115	15475	17115
Sodium nitrate	$NaNO_3$	1.5	1.9	.09	.11
Sodium chloride	NaCl	18.8	23.1	1.15	1.35
Sodium sulphate	Na_2SO_4	64.9	90.0	3.78	5.25
Ammonium sulphate	$(NH_4)_2SO_4$	.7	....	.04	....
Magnesium sulphate	$MgSO_4$	69.3	46.0	4.04	2.68
Magnesium carbonate	$MgCO_3$	103.	120.2	6.03	7.01
Calcium carbonate	$CaCO_3$	328.5	248.6	19.16	14.50
Iron carbonate	$FeCO_3$	.4	....	.02	....
Alumina	Al_2O_3	1.9	....	.11	....
Oxide of Iron and Alumina	$Fe_2O_3+Al_2O_3$	....	.4	....	.02
Silica	SiO_2	9.1	10.2	.53	.59
Bases		3.3	....	.19	....
Total		603.0	540.4	35.14	31.51

La Harpe, Hancock county, see Bulletin No. 5, page 66.

Lake Forest, Lake county, see Bulletin No. 5, page 66. Additional analyses of the water from Lake Michigan, raw and treated, gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF LAKE FOREST.

RAW.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
								Ammonia.									
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
	1906.																
15507	Dec. 31	De.	.1	4 Mu	251	4	5.4	.064	.180	.002	.360	122	24,000	1+	2 +	1+1—	. .
	1907.																
15672	Feb. 5	De.	.2	5 Ve.	129	5	4.0	.112	.260	.002	.480	142	3,200+	. . . . .	2 +	1+1—	. .
15798	Mar. 4	Sl.	.2	3 Mu.	171	4	5.35	.104	.200	.004	.480	115	200	1—	2 +	1+1—	. .
15902	April 1	De.	.1	5 E.	400	6	6.1	.384	.296	.003	.200	121	1,000+	1—	2 +	2—	. .
16027	May 6	45	0	0	195	4	3.45	.030	.096	.000	.400	116	850	1+	1 + 1 —	2—	. .
16094	June 3	40	.2	0	189	6	3.8	.040	.112	.002	.280	91	2,900	1+	1? 1 —	1+1—	. .
16200	July 1	20	.2	0	156	5	4.95	.064	.280	.000	.200	119	9,800	1—	2—	1—1?	. .
16329	July 29	15	0	0	165	4	2.9	.006	.100	.001	.200	127	300	1+	2—	2—	. .
16437	Aug. 26	5	.0	Mu.	131	4	3.2	.048	.280	.001	.160	190	†	1+	2—	2 —	. .
16612	Oct. 14	25	0	0	163	5	3.4	.028	.134	.004	.156	121	††	. . . . .	. . . . . .	. . . . .	. .
16854	Dec. 9	. . . . .	. . . . . .	. . . . .	. . . . .	. . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . .	. . . . . .	. . . . .	470	1 ?	1—1?	2—	—
	1908.																
16954	Jan. 6	50	0	Mu.	217	5	3.0	.046	.132	.000	.360	116	Lost	1—	1—1+	1+1—	+
17059	Jan. 27	170	0	Mu.	630	5	10.6	.132	.236	.020	.060	130	5,600	1+	2 +	2+	+
17175	Mar. 9	100	0	0	214	4	4.4	.030	.096	.002	.200	124	600	1+	2 +	2—	+
17302	April 6	60	0	0	176	6	3.1	.046	.114	.001	.200	124	4,000	1?	2—	2—	+
17364	April 27	0	0	0	4187	5	1.1	.020	.114	.006	.280	126	1,600	1+	1 + 1 —	2—	+
17436	May 11	90	0	0	223	4	3.5	.038	.120	.010	5.190	126	80,000	1+	1—1?	2—	—
17574	June 15	10	10	0	148	6	2.4	.038	.172	.000	.640	112	21,000	1+	2 +	2+	+
17677	July 6	5	0	0	143	6	1.6	.160	.080	.002	.160	122	80,000	1?	2—	2 —	—
17915	Aug. 10	3	0	0	146	7	1.2	.038	.140	.000	.200	110	200	1—	1—	1 —	+
18086	Sept. 8	5	0	Mo.	139	5	2.9	.058	.124	.000	.080	112	400	1—	2—	2—	. .
18315	Oct. 13	30	10	Mu.	186	6	8.2	.040	.166	.001	.360	118	7,200	1+	2 +	1—1+	+

FILTERED.

	1906.																
15508	Dec. 31	De.	.1	0	170	4	3.2	.060	.172	.001	.400	114	6,500	1 +	2+	2 —	. .
	1907.																
15671	Feb. 5	Di.	.1	3 Ve.	163	7	3.9	.126	.154	.000	.720	130	1,000+	......	1+ 1—	2+	. .
15799	Mar. 4	Sl.	.1	0	170	4	3.0	.152	.104	.001	.360	128	57	1 —	2—	2 —	. .
15901	April 1	Di.	0	2 E.	139	12	4.45	.200	.128	.002	.200	121	10,000+	1 +	2+	1+ 1—	. .
16026	May 6	35	0	0	178	5	3.0	.028	.112	.000	.480	116	750	1 +	1+ 1—	2 —	. .
16095	June 3	3	.1	0	138	6	2.7	.018	.128	.000	.320	91	3,000+	1 —	2 —	2 —	. .
16201	July 1	5	0	3 Mu	182	5	2.85	.056	.152	.000	.320	117	1,200	1 +	1+ 1—	2 —	. .
16328	July 29	0	0	0	142	5	2.5	.020	.088	.000	.320	119	1,075	1 +	1+ 1 —	1—1+	. .
16438	Aug. 26	2	0	Mu.	151	5	3.1	.016	.112	.001	.160	115	†	1 —	2 —	2 —	. .
16611	Oct. 14	10	0	0	154	4	2.6	.008	.108	.002	.000	121	10	1 +	2 +	1— 1+	. .
16853	Dec. 9.	......	......	......	......	......	......	......	......	......	......	......	8	1 —	2 —	2 —	. .
	1908																
16953	Jan. 6	20	0	Mu.	140	5	2.2	.034	.096	.000	.320	116	Lost	1 —	2 —	2 —	+
17058	Jan. 29	30	0	0	165	5	4.5	.084	.154	.018	.142	124	1,200	1 —	1+ 1?	2 —	?
17174	Mar. 9	50	0	0	170	4	3.1	.080	.088	.002	.240	122	130	1?	1+ 1?	2 —	+
17303	April 6	20	0	0	150	6	2.2	.034	.074	.001	.280	124	220	1 —	2 —	2 —	—
17365	April 27	20	0	0	208	5	1.5	.042	.152	.001	.320	124	50	1 +	2 —	2 —	—
17366	April 27	......	......	......	......	......	......	......	......	......	......	......	1	1 —	2 —	2 —	— *
17437	May 11	60	0	0	190	5	2.3	.010	.094	.010	.270	124	30,400	1 +	2 —	2 —	—
17575	June 15	0	0	0	140	5	1.8	.070	.138	.000	.200	116	2,400	1 +	1? 1—	2 —	—
17635	June 29	......	......	......	......	......	......	......	......	......	......	......	100	1 —	2—	2 —	. . *
17678	July 6	0	0	0	144	6	2.5	.032	.144	.000	.560	120	16,000	1 +	2 —	2 —	—
17916	Aug. 10	0	0	0	141	7	1.4	.022	.098	.000	.160	110	2,500	1 —	1 +	1 —	+
18087	Sept. 8	0	0	0	142	5	3.5	.012	.074	.000	.240	112	100	1 —	2 —	2 —	. .
18251	Sept. 20	......	......	......	......	......	......	......	......	......	......	......	0	1 —	1 —	1 —	. . *
18252	Sept. 28	......	......	......	......	......	......	......	......	......	......	......	0	1 —	1 —	1 —	. .
18316	Oct. 13	0	0	0	154	6	3.1	.028	.102	.000	.360	116	880	1 +	2 +	2 —	+
18557	Nov. 30	......	......	......	......	......	......	......	......	......	......	......	1,520	1 —	2—	2 —	— **
18558	Nov. 30	......	......	......	......	......	......	......	......	......	......	......	4	1 —	2 —	2 —	— *

† No count. †† Bottle broken. * Berkfeld filter used. ** Pasteur filter used.

Lanark, Carroll county, see Bulletin No. 5, page 69.

La Salle, La Salle county, see Bulletin No. 5, page 69. Later analysis shows that the water is not deteriorating in quality as stated in Bulletin No. 5.

Lawrenceville, Lawrence county, see Bulletin No. 5, page 70.

Lebanon, St. Clair county, has no general supply.

Lemont, Cook County, see Bulletin No. 5, page 70, obtains a water supply from two wells, one 224 feet deep and one 1,260 feet deep. The plant is owned by the city and was established in 1884 at a cost of $20,000. Smith-Vaile pumps are used. The daily consumption is 90,000 gallons.

Lena, Stephenson county, see Bulletin No. 5, page 70.

LeRoy, McLean county, see Bulletin No. 5, page 70.

Lewiston, Fulton county, see Bulletin No. 5, page 70.

Lexington McLean county, see Bulletin No. 5, page 70.

Lincoln, Logan county, see Bulletin No. 5, page 70. Additional analyses of the city water gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF LINCOLN.

Samples collected August 13, 1908.

Serial Number.	Appearance.			Residue on Evaporation	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.
	Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.	
14768	Distinct	.2	0	303	6	2.50	.136	.082	.000	.440	238
14769	Distinct	.2	0	320	6	3.05	.080	.048	.000	.400	240

Litchfield, Montgomery county, see Bulletin No. 5, page 71, obtains a water supply from a reservoir and creek. The plant is owned by a private company and was established in 1874 at a cost of $90,000. Two pumps with a capacity of 1,500,000 gallons each are used. The daily consumption is 1,250,000 gallons.

Lockport, Will county, see Bulletin No. 5, page 71.

McHenry, McHenry county, see Bulletin No. 5, page 71.

McLeansboro, Hamilton county, see Bulletin No. 5, page 71.

Macomb, McDonough county, see Bulletin No. 5, page 71.

Madison, Madison county, see Bulletin No. 5, page 71.

Marengo, McHenry county, see Bulletin No. 5, page 71.
Marion, Williamson county, has sent no report.
Marissa, St. Clair county, has no general supply.
Maroa, Macon county, see Bulletin No. 5, page 71.
Marseilles, LaSalle county, see Bulletin No. 5, page 71. Recent analyses of the water from the 600 foot drilled well gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF MARSEILLES.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
	1906.																
15529	Dec. 31	V.S.	.2	0	473	62	2.25	.264	.072	.022	.300	304	...	...	...	...	..
	1907.																
15603	Jan. 21	0	.2	0	464	61	2.25	.080	.032	.004	.400	297	0	1—	2—	2—	..
	1908.																
17225	Mar. 17	0	0	0	479	67	.9	.040	.032	.002	.320	304	125	1—	2—	2—	—
17226	Mar. 17	0	0	0	463	67	.8	.000	.000	.000	.440	306	90	1—	2—	2—	—
17227	Mar. 17	0	0	0	511	67	.8	.040	.048	.000	.320	306	82	1—	2—	2—	—

Marshall, Clark county, see Bulletin No. 5, page 71. Additional sanitary analyses of the water from the 200 foot bored well gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF MARSHALL.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
	1908.																
18304	Oct. 12	0	0	0	255	7	.5	.032	.064	.000	1.00	211	900	1 +	2 +	2 +	+
18462	Nov. 9	....	....	...	...	....	....	....	....	....	....	...	2	1—	2—	2—	—

Martinsville, Clark county, located on North Fork Creek, has no general supply.

Mascoutah, St. Clair county, see Bulletin No. 5, page 71.

Mason City, Mason county, see Bulletin No. 5, page 72, obtains a water supply from deep wells. The plant is owned by the city. A Cook deep well pump with a capacity of 500 gallons per minute is used. The daily consumption is 50,000 gallons.

Mattoon, Coles county

MATTOON.

In order to determine the quality of water available as an additional source of water supply for Mattoon, three samples were obtained and forwarded to the State Water Survey for examination. No. 15911 was taken from farm drain tile located south of Mattoon on the Kickapoo drain. No. 15912 was taken from the Little Wabash Creek on Section 33, Twp. 12, R. 7. No. 15913 was taken from a pipe entering the Big Four pumping station sump, at the west end of the city. Below is given the comparative analyses to determine their availability for use in boilers.

Comparing these waters, the water from the farm drain tile, No. 15911, is seen to be the best water. The water from the Little Wabash Creek, No. 15912, is next best. Either of these waters would be satisfactory for manufacturing or boiler use. The water from the pipe entering the Big Four pumping sump, No. 15913, should not be considered for boiler use. It would form a hard scale and treatment would give a water liable to foam.

During 1907 the Little Wabash River was dammed, creating a reservoir 100 acres in extent, having a capacity of 165,000,000 gallons, and a depth of 123 feet at its deepest point. During part of the year the water from the Kickapoo tile drainage system is used. Pumping stations were erected at the Little Wabash reservoir, five miles southwest of the city, and one in the City of Mattoon. Fairbanks-Morse compound duplex pumps are used, having a total capacity of 2,000,000 gallons per day. The daily consumption is 700,000 gallons. The plant supplies only the large consumers.

Drinking water is obtained as heretofore from the Mattoon Clear Well Water Company, which is described on page 72 of Bulletin No. 5.

Below are found analyses of the two supplies:

Boiler Analysis—Water from Farm Drain Tile No. 15911. Water from Little Wabash Creek, No. 15912. Water from pipe entering Big Four Pumping Sump, No. 15913. Samples collected April 8, 1907.

Ions	Parts per Million		
	15911	15912	15913
Alkalinity (as $CaCO_3$)	175.	203.	260.
Chlorine, Cl	6.	8.	119.
Magnesium (as $CaCO_3$)	113.	113.	181.
Incrustants (as $CaCO_3$)	34.	54.	212.
Total Solids,	222.	298.	1148.
Free Carbonic Acid (CO_2)	24.	12.	27.

Hypothetical Combinations.		Parts per Million			Grains per Gallon		
		15911	15912	15913	15911	15912	15913
Sodium chloride,	NaCl	9.9	13.2	196.4	.58	.77	11.5
Magnesium sulphate,	$MgSO_4$	41.6	65.9	220.8	2.40	3.84	12.9
Magnesium carbonate,	$MgCO_3$	66.7	49.8	----	3.89	2.90	----
Calcium carbonate,	$CaCO_3$	96.0	144.0	260.	5.60	8.40	15.2
Alkaline sulphates and suspended matter undetermined		10.0	25.1	428.7	.58	1.46	25.0
Calcium sulphate,	$CaSO_4$	----	----	42.1	----	----	2.5
Totals,		222.0	298.0	1148.0	13.06	17.37	67.1

Sanitary and bacteriological analyses of the water taken from the Little Wabash Reservoir gave the following results:

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
	1908.																
17548	June 15	5	20	Pu	236	5	2.3	.090	.202	.006	1.720	172	360	1 +	2 +	1 ?	+
*17550	June 15	0	0	0	235	3	1.1	.040	.080	.016	1.584	165	280	1—	2—	2—	—
17552	June 15	20	30	0	250	4	1.8	.098	.122	.030	1.690	172	810	1 +	2 +	2 ?	+
17611	June 29	20	20	Pu	236	4	2.6	.138	.168	.009	1.591	171	...	...	...	...	..
17934	Aug. 17	10	30	Mu	203	6	6.7	.300	.124	.000	.280	169	...	...	...	...	..
18466	Nov. 9	30	60	Mo	260	9	6.6	.658	.516	.012	.148	190	710	1 +	2 ?	2—	+

* Filter on tap.

Sanitary and bacteriological analysis of the city water supply used for drinking purposes, taken from the wells of the Clear Well Water Co., gave the following results:

Sample Collected June 15, 1908. Laboratory No. 17549.

Turbidity	50.	Nitrogen as		Bacteria per c.c.	8
Color,	60.	Free Ammonia,	9.600	Gas formers in	
Odor,	0.	Alb. Ammonia,	.176	10 c.c.	1—
Residue on Evaporation,	517.	Nitrites,	.000	1 c.c.	2—
Chlorine in Chlorides,	19.	Nitrates,	.280	0.1 c.c.	2—
Oxygen Consumed,	4.4	Alkalinity,	441.	Indol,	—

Maywood, Cook county, see Bulletin No. 5, page 73. Additional analyses of the water taken from the deep well gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF MAYWOOD.

Serial Number.	Date of Collection.	Appearance			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
	1908																
17788	July 27	0	0	0	635	18	1.6	.120	.048	.007	.553	265	320	1?	2—	2—	—
17789	July 27	0	0	0	609	18	1.6	.048	.056	.000	.320	269	800	1—	2—	2—	—
18409	Nov. 2	0	0	0	623	27	.9	.400	.056	.000	.280	263	1400	1+	2—	2—	+
18410	Nov. 2	---	---	---	------	----	-----	------	-----	------	-----	------	75	1—	2—	2—	+
18411	Nov. 2	0	0	0	648	14	2.0	.384	.048	.000	.480	275	2160	1+	2—	2—	+

Melrose Park, Cook county, see Bulletin No. 5, page 73.

Mendota, La Salle county, see Bulletin No. 5, page 73. Additional analyses of the city supply gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF MENDOTA.

Samples Collected June 15, 1908.

Serial Number.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
	Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
17564	30.	50.	0	376	2	4.7	1.440	.144	.003	.277	321	6	1—	2—	2—	—
17565	30.	90.	0	370	2	4.8	1.120	.144	.055	.505	321	24	1—	2—	2—	—
17566	5.	60.	0	383	2	4.5	.104	.160	.006	1.120	319	30	1—	2—	2—	—

Metropolis, Massac county, see Bulletin No. 5, page 73. Additional analyses of the water supply taken from the Ohio River gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF METROPOLIS.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
								Ammonia.									
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
18185	1908 Sept. 21	20	50	0	195	16	2.1	.040	.138	.000	.400	112	------	----	----	----	---
18407	Nov. 3	20	25	0	204	20	2.8	.014	.122	.001	.320	128	620	1+	2+	1-1?	+

A new supply to be taken from deep wells is being installed. Analysis of this supply, a well 217 feet deep at the foot of Catherine street, gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF METROPOLIS.

Laboratory No. 18647. Sample Collected December 28, 1908.

Turbidity,	3.0	Nitrogen as		Bacteria per c. c.	1
Color,	25.	Free Ammonia,	.016	Colon bacillus,	
Odor,	0.	Alb. Ammonia,	.024	Gas formers in	
Residue on Evaporation,	236.	Nitrites,	.001	10 c. c.,	1—
Chlorine in Chlorides,	8.	Nitrates,	.280	1 c. c.,	2—
Oxygen Consumed,	.8	Alkalinity,	185.	0.1 c. c.,	2—
				Indol,	—

An analysis of the mineral content of the new supply gave the following results:

MINERAL ANALYSIS OF THE NEW CITY SUPPLY OF METROPOLIS

Laboratory No. 18647.

Ions	Parts Per Million	Hypothetical Combinations.		Parts Per Million	Grains Per Gallon
Potassium, K	3.0	Potassium nitrate,	KNO_3	2.0	.12
Sodium, Na	2.6	Potassium chloride,	KCl	4.2	.24
Magnesium, Mg	9.8	Sodium chloride,	NaCl	6.6	.38
Calcium, Ca	65.1	Magnesium chloride,	$MgCl_2$	2.7	.16
Iron, Fe	.4	Magnesium sulphate,	$MgSO_4$	19:9	1.16
Alumina. Al_2O_3	2.1	Magnesium carbonate,	$MgCO_3$	17.7	1.03
Nitrate, NO_3	1.2	Calcium carbonate,	$CaCO_3$	162.5	9.47
Chloride, Cl	8.0	Iron carbonate,	$FeCO_3$	.8	.05
Sulphate, SO_4	15.9	Alumina,	Al_2O_3	2.1	.12
Silica, SiO_2	10.9	Silica,	SiO_2	10.9	.64
Bases,	3.4	Bases,		3.4	.20
		Total,		232.8	13.67

Milford, Iroquois county, see Bulletin No. 5, page 73.

Milledgeville, Carroll county, obtains its city water supply from

ANALYSES OF THE MUNICIPAL WATER SUPPLY OF MOLINE.

Serial Number.	Date of Collection.	Appearance: Turbidity.	Appearance: Color.	Appearance: Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia: Free.	Nitrogen as Ammonia: Albuminoid.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Alkalinity.	Bacteria per c.c.	Colon Bacillus: 10 c.c.	Colon Bacillus: 1 c.c.	Colon Bacillus: 0.1 c.c.	Indol.
Direct from River.																	
	1907.																
15812	March 10	De.	.5	0	205	2	11.90	.336	.256	.002	.520	115	82,000	1+	2+	2—	
15813	March 10	De.	.5	0	188	2	11.90	.224	.264	.002	.520	159	98,000	1+	1+1—	2—	
15975	April 22	60.	.6	0	157	2	13.25	.032	.264	.000	.160	71	920	1+	1?1+	2—	
15977	April 22	60.	.6	0	124	2	13.15	.024	.128	.000	.160	71	730	1+	2—	1+1—	
16090	June 3	60.	.7	0	187	4	14.3	.O80	.312	.000	.400	99	5,500	1+	2+	1+1—	
16091	June 3	60.	.7	0	193	3	14.45	.048	.280	.000	.280	73	2,600	1+	2+	1+1—	
16241	July 15	120.	Mud	0	251	3	15.8	.056	.360	.017	.120	121	3,500	1+	2+	2+	
16242	July 15	120.	Mud	0	305	3	14.5	.032	.496	.018	.200	119	9,000	1+	2+	2+	
16315	July 29	392.	Mud	0	529	2	16.4	.032	.592	.030	.410	124	1,400	1+	2+	2+	
16316	July 29	392.	Mud	0	430	2	15.0	.032	.464	.060	.460	115	1,600	1+	2+	2+	
16400	Aug. 19	429.	Mud	0	391	2	3.8	.080	.480	.060	.30	126	2,900	1+	1+	2+	
16401	Aug. 19	429.	Mud	0	511	2	15.2	.080	.528	.060	.300	126	2,600	1+	2+	2+	
16579	Oct. 7	192.	Mud	0	303	3	22.1	.048	.472	.002	.240	111	Liq.	1+	2+	2+	
16580	Oct. 7	195.	Mud	0	337	3	23.2	.036	.622	.002	.240	109	Liq.	1+	2+	2+	
Tap—Raw Water																	
	1907.																
15664	Feb. 4	De.	.4	0	281	4	8.9	.144	.224	.003	.600	154	3,300	2+	2+		
15665	Feb. 4	De.	.4	0	230	3	9.0	.152	.224	.003	.680	158	3,200		2+	2+	
15666	Feb. 4	De.	.4	0	225	4	8.95	.112	.224	.003	.720	154	400	1+	2+	2+	
15810	March 10	De.	.5	0	201	2	11.9	.264	.264	.002	.560	105	4,300	1—	1—	1—	
15974	April 22	60.	.6	0	195	2	13.0	.040	.272	.000	.120	71	400	1+	1+1—	1+1—	
16092	June 3	60.	.7	0	236	3	15.2	.048	.280	.000	.360	71	4,500	1?	2?	1?1—	
16243	July 15	120.	Mud	0	428	3	16.4	.040	.528	.017	.160	121	1,900	1—	2+	1+1—	
16317	July 29	427.	Mud	0	548	2	16.8	.032	.608	.030	.330	119	2,500	1+	2+	2+	
16318	July 29	0	0	0	159	2	5.8	.000	.168	.000	.400	49	19	1—	2—	1+1—	
16399	Aug. 19	600.	Mud	0	608	5	15.5	.080	.728	.060	.300	126	6,000	1+	2+	2+	
16581	Oct. 7	196.	Mud	0	328	3	22.2	.044	.396	.002	.240	107	2,100	1+	2+	2+	
16825	Dec. 2	20.	.2	0	195	4	8.7	.052	.236	.002	.400	150	120	1+	2+	2+	+
16899	Dec. 25	10.	.2	0	118	3	6.6	.030	.234	.000	.28	160	300	1—	2—	2—	—
	1908.																
17017	Jan. 20	10.	.1	0	225	5	5.7	.074	.232	.006	.514	174	Bacteria bottle broken				
17153	March 2	200.	1.0	Ma.	297	6	14.7	.324	.576	.012	.71	104	14,000	1?	1?1+	2—	+
17259	March 30	1.	.8	0	736	6	22.0	.062	.574	.015	.340	130	19,200	1+	2+	2+	+
17493	May 25	425.	120.	0	678	4	20.6	.082	.410	.018	.702	105	32,000	1+	2+	1?1+	+
17679	July 6	90.	140.	Mu.	318	4	16.2	.076	.334	.060	.260	112	1,800	1+	2+	2—	+
17967	Aug. 17	40.	50.	0	266	4	8.8	.074	.362	.008	.232	146	200	1+	2+	1+1—	+
18248	Sept. 28	120.	65.	0	401	5	10.1	.056	.302	.000	.400	147	12,000	1+	1+	1+	+
18427	Nov. 3	30.	60.	0	237	6	8.4	.032	.290	.001	.240	151	726	1+	1+1?	2—	+
18582	Nov. 30	20.	40.	0	212	7	5.5	.014	.330	.002	.160	147	1,200	1+	2—	2—	+
18674	Dec. 28	5.	50.	0	341	9	5.9	.046	.326	.001	.280	155	2,200	1?	1—1+	1—1+	+

Tap—Filtered Water

	1907.																
15667	Feb. 4	0	.2	0	137	3	6.75	.144	.184	.007	.160	116	705		2+	2—	
15811	March 10	0	.3	0	130	2	6.65	.200	.184	.015	.520	71	200	1—	1—	1—	
15976	April 22	7	.3	0	95	2	7.5	.024	.136	.003	.160	52	58	1—	1—1?	2—	
16093	June 3	2	.4	0	124	3	7.9	.040	.160	.006	.234	49	110	1—	2—	2—	
16244	July 15	3	.4	0	138	3	7.9	.024	.216	.000	.280	81	75	1—	1+1—	2—	
16402	Aug. 19	0	0	Mu.	144	2	5.7	.040	.184	.000	.40	87	6,300	1+	2+	2—	
16824	Oct. 7	0	1.2	0	132	3	11.1	.024	.182	.000	.240	53	40	1+	1—1?	1—1?	
16582	Dec. 2	0	.2	0	148	5	6.3	.036	.162	.004	.316	110	20	1+	1—1+	2—	+
16898	Dec. 25	0	.1	0	135	4	5.8	.024	.138	.000	.280	108	60	1—	2—	2—	—
	1908.																
17016	Jan. 20												100	1+	1—1+		+
17018	Jan. 20	5	.1	0	177	5	4.3	.040	.146	.008	.512	148	150	1—	2—	2—	+
17154	March 2	5	.0	Ma.	104	6	4.0	.298	.214	.020	.460	46	160	1—	2—	2—	—
17260	March 30	0	.2	0	108	5	5.3	.090	.140	.015	.340	64	500	1—	2—	2—	—
17494	May 25	0	40.	0	123	3	6.2	.050	.194	.009	.351	56	28,000	1 ?	1?1+	1—	+
17680	July 6	0	50.	0	170	3	9.0	.068	.268	.000	.480	103	120	1+	1+1—	1—	+
17968	Sept. 28	0	.30	0	103	4	6.6	.070	.216	.000	.320	94	150	1+	1+1?	2—	+
18249	Aug. 17	0	30.	0	177	5	2.9	.072	.178	.000	.240	116	1,800	1+	1+	1+	+
18428	Nov. 3	0	20.	0	132	7	5.3	.030	.152	.000	.400	110	48	1—	2—	2—	+
18583	Nov. 30	0	20.	0	163	7	2.6	.008	.136	.000	.080	114	65	1—	2—	2—	—
18675	Dec. 28	2	30.	Mu.	180	7	4.7	.040	.166	.002	.320	120	360	1+	2—	2—	+

a well 600 feet deep. A recent analysis of the water from this well gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF MILLEDGEVILLE.
Laboratory Number 18099. Sample Collected September 9, 1908.

Turbidity,	0	Nitrogen as	
Color,	0	Free Ammonia,	.048
Odor,	0	Alb. Ammonia,	.056
Residue on Evaporation,	322.	Nitrites,	.000
Chlorine in Chlorides,	7.	Nitrates,	.560
Oxygen Consumed,	1.0	Alkalinity,	313.0

Millstadt, St. Clair county, has no general supply.

Minonk, Woodford county, see Bulletin No. 5, page 73.

Moline, Rock Island county, see Bulletin No. 5, page 74. Additional analyses of the raw and filtered water from the Mississippi River are shown on pages 168 and 169.

Momence, Kankakee county, see Bulletin No. 5, page 77. An additional analysis of the water from the three wells gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF MOMENCE.
Sample Collected March 19, 1906. Laboratory No. 14122.

Turbidity,	Clear	Nitrogen as	
Color,	0	Free Ammonia,	.152
Odor,	0	Alb. Ammonia,	.086
Residue on Evaporation,	542.	Nitrites,	.013
Chlorine in Chlorides,	17.0	Nitrates,	.87
Oxygen Consumed,	2.2	Alkalinity,	298.8
		Sulphates,	15.

Monmouth, Warren county, see Bulletin No. 5, page 77, obtains a water supply from three wells 430 feet deep in St. Peters sandstone. The plant is owned by the city and was established in 1888 at a cost of about $200,000. The pumping station and reservoir are located inside the city limits. One air compressor, one Smedley deep well pump, one Holly distributing, and one Smedley distributing pump are used, with a capacity of about 1,000,000 gallons each. The daily consumption is about 475,000 gallons.

Monticello, Piatt county, see Bulletin No. 5, page 77.

Morgan Park, Cook county, see Bulletin No. 5, page 77. Recent analysis of the water taken from the deep wells gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF MORGAN PARK.
Sample Collected January 28, 1907. Laboratory No. 15635.

Turbidity,	Clear	Nitrogen as		Bacteria per c. c.,	14
Color,	0	Free Ammonia,	.080	Gas formers	
Odor,	0	Alb. Ammonia,	.032	10 c. c.,	1—
Residue on Evaporation,	1122.	Nitrites,	.001	1 c. c.,	2—
Chlorine in Chlorides,	130.	Nitrates,	.560	0.1 c. c.,	2—
Oxygen Consumed,	3.3	Alkalinity,	249.5	Note—Bacterial count interferred with by formaldehyde gas.	

Morris, Grundy county, see Bulletin No. 5, page 77.

Morrison, Whiteside county, see Bulletin No. 5, page 77. Additional analyses of the city water supply from the three sources, spring, artesian well and the four driven wells, gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF MORRISON.

Samples Nos. 15582 and 15583 taken from Spring 17' Dug. Collected January 14, 1907.

	Appearance.						Nitrogen as						Colon Bacillus.		
							Ammonia.								
Serial Number.	Turbidity.	Color.	Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Free.	Albuminoid.	Nitrites.	Nitrates.	Alkalinity.	Bacteria per c. c.	10 c. c.	1 c. c.	0.1 c. c.
15582	0	0	0	340	12	1.55	.080	.036	.002	1.920	287	200	1—	2—	2—
15583	0	0	0	340	11	1.25	.078	.026	.001	1.920	281	300	1—	2—	2—

Samples Nos. 15584 and 15585 taken from Artesian Well 1,645' Drilled. Collected Jan. 14, 1907.

	Appearance.						Nitrogen as						Colon Bacillus.		
							Ammonia.								
Serial Number.	Turbidity.	Color.	Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Free.	Albuminoid.	Nitrites.	Nitrates.	Alkalinity.	Bacteria per c. c.	10 c. c.	1 c. c.	0.1 c. c.
15584	0	0	0	296	3	1.15	.024	.176	.001	.120	271	1350	2—	2—	2—
15585	0	0	0	250	3	1.15	.144	.088	.000	.200	271	1800	1—	2—	2—

Samples Nos. 15586 and 15587 taken from four Wells 75' Driven. Collected Jan. 14, 1907.

	Appearance.						Nitrogen as						Colon Bacillus.		
							Ammonia.								
Serial Number.	Turbidity.	Color.	Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Free.	Albuminoid.	Nitrites.	Nitrates.	Alkalinity.	Bacteria per c. c.	10 c. c.	1 c. c.	0.1 c. c.
15586	0	0	0	352	11	1.9	.056	.040	.002	1.84	312	960	1—	2—	2—
15587	0	0	0	356	11	1.3	.016	.064	.002	3.040	310	1300	1—	2—	2—

Mound City, Pulaski county, see Bulletin No. 5, page 78.

Mount Carmel, Wabash county, see Bulletin No. 5, page 79. Recent analyses of the water taken from the Wabash River at Mount Carmel gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF MOUNT CARMEL.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
	1906																
15033	Sept. 24	De.	Mud.	0	488	90	6.6	.056	.232	.000	.160	205					
15034	Sept. 24	De.	Mud.	0	492	90	6.7	.048	.240	.006	.154	209					
15036	Sept. 24	De.	Mud.	Ea_	512	90	6.6	.024	.224	.000	.200	203					
	1908																
17863	Aug. 3	20	50.	0	306	41	3.7	.086	.232	.006	.560	172	3900	1+	2+	1 +	
17684	Aug. 3	20	40.	0	321	41	4.1	.086	.292	.005	.560	174	1140	1+	2+	1—	+
17865	Aug. 3	5	50.	0	289	39	3.4	.056	.360	.002	.640	171	4440	1+	2?	1?	+

Mount Carroll, Carroll county, see Bulletin No. 5, page 79. A recent analysis of the water supply obtained from the artesian wells gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF MOUNT CARROLL.
Sample Collected October 19, 1908. Laboratory No. 18346.

Turbidity,	0.	Nitrogen as		Bacteria per c. c.,	280
Color,	10.	Free Ammonia,	.056	Gas formers in	
Odor,	0.	Alb. Ammonia,	.056	10 c. c.,	1—
Residue on Evaporation,	337.	Nitrites,	.000	1 c. c.,	2—
Chlorine in Chlorides,	12.	Nitrates,	.280	0.1 c. c.,	2—
Oxygen Consumed,	1.8	Alkalinity,	285.	Indol.	—

The analysis of the mineral content gave the following results:

MINERAL ANALYSIS OF THE CITY WATER OF MOUNT CARROLL.
Laboratory No. 18356.

Ions	Parts Per Million	Hypothetical Combinations		Parts Per Million	Grains Per Gallon
Potassium, K	10.3	Potassium nitrate,	KNO_3	2.0	.12
Sodium, Na	19.4	Potassium chloride,	KCl	18.1	1.06
Ammonium, NH_4	.1	Sodium chloride,	NaCl	5.6	.33
Magnesium, Mg	38.1	Sodium sulphate,	Na_2SO_4	41.1	2.40
Calcium, Ca	64.4	Sodium carbonate,	Na_2CO_3	9.0	.52
Iron, Fe	.1	Ammonium carbonate,	$(NH_4)_2CO_3$	.3	.02
Alumina, Al_2O_3	1.5	Magnesium carbonate,	$MgCO_3$	132.0	7.70
Nitrate, NO_3	1.2	Calcium carbonate,	$CaCO_3$	160.6	9.36
Chloride, Cl	12.0	Iron carbonate,	$FeCO_3$	.2	.01
Sulphate, SO_4	27.8	Alumina,	Al_2O_3	1.5	.09
Silica, SiO_2	11.9	Silica,	SiO_2	11.9	.69
Bases	.7	Bases,	-----	.7	.04
		Total,		383.0	22.34

Mount Morris, Ogle county, see Bulletin No. 5, page 79.

Mount Olive, Macoupin county, see Bulletin No. 5, page 79.

Nount Pulaski, Logan county, see Bulletin No. 5, page 79. Recent analyses of the water supply taken from the shallow wells gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF MOUNT PULASKI.

		Apperance.						Nitrogen as						Colon Bacillus.			
								Ammonia.									
Serial Number.	Date of Collection.	Turbidity.	Color.	Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Free.	Albuminoid.	Nitrites.	Nitrates.	Alkalinity.	Bacteria per c. c.	10 c. c.	1 c. c.	0.1 c. c.	Indol.
	1905																
13558	Sept. 18	---	---	---	694	57	2.8	.022	.050	.000	18.000	------	------	----	------	------	------
13559	Sept. 18	---	---	---	723	53	2.8	.036	.124	.001	22.000	-------	------	----	-----	------	------
13560	Sept. 18	---	---	---	787	64	2.95	.008	.048	.001	20.000	------	------	----	------	------	------
	1907																
16586	Oct. 7	3	0	0	796	63	2.1	.032	.048	.110	19.900	370	------	----	------	------	------
16588	Oct. 7	0	0	0	797	64	2.6	.016	.096	.002	16.000	353	------	----	------	------	------
	1908																
17344	Apr. 20	0	0	0	913	68	1.2	.016	.048	.001	2.200	368					
17346	Apr. 20	---	---	---						- - -	-----	------	10	1—	2—	2—	------
17347	Apr. 20	0	0	0	832	69	1.7	.016	.064	.001	4.600	368	160	1—	2—	2—	------
18300	Oct. 12	0	0	0	778	69	.6	.024	.056	.000	32.000	360	220	1 +	1?1+	2—	+
18301	Oct. 12	0	0	0	804	69	.4	.024	.064	.000	32.000	355	------	----	------	------	------

Mount Sterling, Brown county, see Bulletin No. 5, page 79.

Mount Vernon, Jefferson county, see Bulletin No. 5, page 80. Additional analyses of the water taken from the reservoir gave the following results :

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF MOUNT VERNON.

Samples Collected October 29, 1906.

	Apperance.						Nitrogen as						Colon Bacillus.		
							Ammonia.								
Serial Number.	Turbidity.	Color.	Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Free.	Albuminoid.	Nitrites.	Nitrates.	Alkalinity.	Bacteria per c. c.	10 c. c.	1 c. c.	0.1 c. c.
15269	De.	.8	0	259	7	7.95	.304	.264	.030	.530	40	180	1+	1 + 1—	2—
15270	De.	.8	0	261	8	7.75	.528	.400	.034	.446	48	280	1?	2—	2—

Moweaqua, Shelby county, see Bulletin No. 5, page 80.

Murphysboro, Jackson county, see Bulletin No. 5, page 80.

Naperville, DuPage county, see Bulletin No. 5, page 80. An additional analysis of the supply from the deep wells gave the following results :

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF NAPERVILLE.
Laboratory No. 17443. Sample Collected May 16, 1908.

Turbidity,	0	Nitrogen as		Bacteria per c.c,.	42
Color,	0	Free Ammonia,	.000	Gas Formers in	
Odor,	0	Alb. Ammonia,	.032	10 c.c.,	1—
Residue on evaporation,	535.	Nitrites,	.001	1 c.c.,	2—
Chlorine in chlorides,	32.	Nitrates,	.800	0.1 c.c.,	2—
Ogygen consumed,	.8	Alkalinity,	310.	Indol,	—

Nashville, Washington county, has no general supply.

Nauvoo, Hancock county, see Bulletin No. 5, page 80. An unsatisfactory plant has been installed, but is not used by the city. It pumps water to St. Mary's Academy only.

Neoga, Cumberland county, has no general supply.

Newman, Douglas county, see Bulletin No. 5, page 80, obtains water supply from a well 257 feet bored, located in the city park. A recent analysis of the water from this well gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF NEWMAN.
Sample Collected August 7, 1908. Laboratory No. 17885.

Turbidity,	20.	Nitrogen as		Bacteria per c. c.	3
Color,	300.	Free Ammonia,	3.700	Gas formers in	
Odor,	0.	Alb. Ammonia,	.640	10 c. c.,	1—
Residue on Evaporation,	1248.	Nitrites,	.000	1 c. c.,	2—
Chlorine in Chlorides,	520.	Nitrates,		00.1 c. c.,	2—
Oxygen Consumed,	27.4	Alkalinity,	445.	Indol,	—

An examination of the mineral content of this water gave the following result:

MINERAL ANALYSIS OF THE CITY SUPPLY OF NEWMAN.

Ions	Parts Per Million	Hypothetical Combinations		Parts Per Million	Grains Per Gallon
Sodium, Na	376.5	Sodium nitrate,	$NaNO_3$	1.0	.06
Ammonium, NH_4	4.8	Sodium chloride,	$NaCl$	858.1	50.05
Magnesium, Mg	24.9	Sodium sulphate,	Na_2SO_4	15.1	.88
Calcium, Ca	50.9	Sodium-carbonate,	Na_2CO_3	76.4	4.46
Oxide of Iron, Fe_2O_3 + Alumina, Al_2O_3	15.2	Ammonium carbonate,	$(NH_4)_2CO_3$	12.8	.75
Nitrate, NO_3	.7	Magnesium carbonate,	$MgCO_3$	86.2	5.02
Chloride, Cl	520.	Calcium carbonate,	$CaCO_3$	127.1	7.41
Sulphate, SO_4	10.2	Oxide of Iron and Alumina,	Fe_2O_3 + Al_2O_3	15.2	.89
Silica, SiO_2	22.8	Silica,	SiO_2	22.8	1.33
Bases,	6.8	Bases,		6.8	.40
		Total,		1221.5	71.25

Newton, Jasper county, see Bulletin No. 5, page 80.

Nilwood, Macoupin county, has no general supply.

Nokomis, Montgomery county, see Bulletin No. 5, page 80.

Normal, McLean county, see Bulletin No. 5, page 80. Additional analyses of the supply from the deep wells gave the following results :

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF NORMAL.

		Appearance						Nitrogen as						Colon Bacillus.			
								Ammonia.									
Serial Number.	Date of Collection.	Turbidity.	Color.	Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Free.	Albuminoid.	Nitrites.	Nitrates.	Alkalinity.	Bacteria per c. c.	10 c. c.	1 c. c.	0.1 c. c.	Indol.
	1907																
15571	Jan. 14	5	.6	0	461	10.0	8.7	2.600	.256	.004	.120	401	60	1—	2—	2—	
16666	Oct. 28	25	.6	Tar	486	15.	11.3	2.80	.400	.000	.080	406	500	1?	2 +	1? 1—	
16669	Oct. 28	30	.6	0	490	15.0	10.5	2.00	.344	.000	.080	406	30	1?	2—	1— 1?	
*16672	Oct. 28	5	.0	0	1094	48.	4.0	.100	.076	.030	1.57	402	Liq.	1?	2?	2—	
16673	Oct. 28	10	.6	0	456	15.	10.5	3.600	.240	.000	.080	406	150	1?	2—	2—	
16784	Nov. 21	20	.4	0	432	13.	7.2	1.80	.240	.000	.320	398	50	1?	2—	2—	
16786	Nov. 21	20	.8	Oil	437	15.	9.2	1.112	.550	.000	.080	417	120	1 +	2—	2—	
16789	Nov. 21	20	.4	0	467	15.	8.55	2.00	.360	.000	.240	417	90	1?	1? 1 +	2—	+

* Old city well.

North Chicago, Lake county, see Bulletin No. 5, page 81, obtains its supply from Lake Michigan. The plant is owned by the city and was established in 1900. The plant is located on the lake shore. Worthington pumps are used. The daily consumption is 200,000 gallons. An additional analysis of the water from Lake Michigan gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF NORTH CHICAGO.

Sample Collected September 28, 1908. Laboratory No. 18216.

Turbidity,	0.	Nitrogen as		Bacteria per c. c.,	420
Color	30.	Free Ammonia,	.052	Gas formers in	
Odor,	0.	Alb. Ammonia,	.280	10 c. c..	1 +
Residue on Evaporation,	146.	Nitrites,	.000	1 c.c.,	1+ 1 ?
Chlorine in Chlorides,	5.	Nitrates,	.320	0.1 c. c.,	1— 1+
Oxygen Consumed,	1.3	Alkalinity,	116.	Indol,	+

North Peoria, Peoria county, see Bulletin No. 5, page 81.

Oakland, Coles county, has no general supply.

Oak Park, Cook county, see Bulletin No. 5, page 81. Recent analyses of the water from the deep wells gave the following results.

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF OAK PARK.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c.c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c.c.	0.1 c.c.	
	1907.																
16722	Nov. 11	0	0	0	897	200	4.0	.212	.016	.002	.080	252	30	1?	2—	2—	—
16723	Nov. 11	0	0	0	889	200	3.8	.278	.060	.012	.068	255	410	1—	2 +	1+1—	+
16724	Nov. 11	0	0	0	894	200	3.8	.162	.044	.000	.160	250	40	1—	2—	2—	—
16725	Nov. 11	0	0	0	883	200	4.0	.240	.112	.014	.146	255	380	1?	2?	2—	—
	1908.																
17254	March 30	0	0	0	879	215	2.0	.148	.042	.001	.280	248	180	1—	2—	2—	—
17255	March 30	0	0	0	865	215	2.2	.222	.038	.008	.200	254	134	1—	2—	2—	—
17256	March 30	0	0	0	867	215	2.2	.230	.048	.005	.200	254	210	1—	2—	2—	—
17588	June 22	0	10	0	892	280	.2	.280	.160	.008	.152	248	2200	1 +	2?	1+1?	+
17589	June 22	0	10	0	875	280	.1	.304	.080	.003	.200	238	1100	1 +	1 ? 1 +	1—1?	+
17590	June 22	0	10	0	873	280	.08	.280	.048	.009	.231	238	3200	1?	2?	1?1+	+
17591	June 22	0	10	0	881	260	.2	.224	.096	.004	.236	242	920	1 +	2?	1+1?	+
17672	July 7				----	----	----	----	----	----	----	----	600	1?	2—	2—	—
17673	July 7				----	----	----	----	----	----	----	----	650	1?	2?	2—	—
17674	July 7				----	----	----	----	----	----	----	----	125	1?	1?1—	2—	—
17675	July 7				----	----	----	----	----	----	----	----	162	1?	1+1—	1?1+	+
17676	July 7												160	1?	1+1—	2—	+
17764	July 21	0	0	0	931	235	2.2	.180	.064	.010	.150	251	194	1?	1?1—	2—	—
17765	July 21	0	10	0	900	235	2.8	.064	.048	.000	.240	246	115	1?	2—	2—	—
17766	July 21	0	0	0	920	210	2.5	.400	.048	.020	.060	253	14	1—	2—	2—	—
17767	July 21	0	0	0	902	235	2.6	.152	.048	.000	.320	250	360	1?	1+1—	2—	—
17803	July 27	0	0	0	889	210	2.9	.360	.064	.000	.200	261	----	----	----	----	----
17804	July 27	0	0	0	768	200	2.1	.256	.048	.044	.196	261	----	----	----	----	----
17805	July 27	0	0	0	954	290	2.6	.416	.048	.006	.200	246	----	----	----	----	----
17806	July 27	0	0	0	868	220	2.4	.336	.040	.026	.174	238	----	----	----	----	----
17807	July 27	0	0	0	885	200	2.2	.344	.032	.032	.208	244	----	----	----	----	----
17907	Aug. 10	0	20	0	903	270	1.1	.280	.080	.009	.271	244	230	1—	1—	1 +	+
17908	Aug. 10	0	10	0	925	270	.9	.320	.064	.001	.280	259	650	1—	1—	1—	+
17910	Aug. 10	0	10	0	931	330	.9	.384	.040	.006	.160	244	4	1—	1—	1—	—
17911	Aug. 10	5.	10.	0	908	260	1.5	.064	.104	.001	.240	248	275	1?	1?	1—	+
17948	Aug. 17	0	0	0	858	250	1.2	.096	.048	.004	.360	251	400	1—	2—	2—	+
17949	Aug. 17	0	10	0	858	250	2.3	.280	.112	.008	.160	255	750	1 +	1+1—	1+1—	+

17950	Aug.17	0	0	0	881	250	.5	.096	.072	.000	.400	250	100	1–	2–	2–	+
17951	Aug.17	0	0	0	747	230	1.0	.304	.048	.001	.200	317	30	1–	2–	2–	–
17997	Aug.24	0	10	0	685	220	1.6	.104	.048	.002	.560	251	80		5–		
17999	Aug.24	0	0	0	880	216	1.3	.088	.048	.000	.480	257	10		5–		
18000	Aug.24	0	0	0	878	202	1.2	.320	.040	.040	.360	270	----	----	----	----	----
18001	Aug.24	0	0	0	884	220	1.8	.256	.080	.009	.431	251	75		5–		
18034	Aug.31	5.	20	0	885	220	2.5	.256	.128	.030	.490	350	350		5–		
18035	Aug.31	0	10	0	876	218	1.1	.080	.048	.000	.520	322	5000		3+		
18036	Aug.31	0	20	0	887	218	1.6	.096	.104	.000	.480	338	40		5–		
18039	Aug.31	0	10	0	870	222	2.9	.272	.112	.010	.270	317	100		4–1+		
18040	Aug.31	0	0	0	872	216	2.1	.112	.056	.001	.320	317	75		3–2+		
18041	Aug.31	0	0	0	864	222	1.9	.240	.120	.003	.240	320	50		3–2+		
18043	Aug.31	0	0	0	924	222	1.9	.344	.056	.004	.160	409	175		5–		
18257	Sept.29	0	0	0	934	280	.5	.384	.016	.004	.120	236	0	1–	1–	1–	
18258	Sept.29	0	0	0	845	250	1.1	.288	.056	.010	.150	248	140	1–	1?	1?	
18259	Sept.29	0	0	0	914	250	.7	.200	.064	.001	.280	248	148	1?	1?	1–	
18260	Sept.29	0	0	0	906	250	.7	.152	.032	.001	.320	248	180	1?	1–	1–	
18419	Nov. 2	0	3.	0	918	222	2.5	.240	.032	.002	.200	252	120	1–	2–	2–	+
18420	Nov. 2	0	0	0	923	224	2.7	.184	.024	.005	.400	242	140	1–	2–	2–	+
18421	Nov. 2	0	0	0	902	224	3.2	.280	.040	.015	.225	244	110	1–	2–	2–	+
18423	Nov. 2	0	0	0	860	180	3.0	.368	.040	.010	.150	242	----	----	----	----	----
18568	Nov.30	0	0	0	904	206	.9	.200	.048	.004	.320	242	116	1–	2–	2–	–
18569	Nov.30	0	0	0	869	208	.8	.144	.064	.001	.280	246	100	1–	2–	2–	–
18570	Nov.30	0	0	0	881	210	1.3	.280	.064	.020	.180	256	90	1+	2–	2–	–
18571	Nov.30	0	0	0	910	177	.7	.360	.000	.015	.185	254	3	1–	2–	2–	–
18682	Dec. 29	0	10	0	895	210	1.2	.224	.032	.003	.320	236	120	1–	2–	2–	+
18683	Dec. 29	0	10	0	894	270	.9	.160	.072	.003	.320	236	160	1–	2–	2–	+
18684	Dec. 29	0	10	0	997	310	.8	.432	.032	.002	.160	240	3	1–	2–	2–	–
18686	Dec. 29	2.	10	Sil.	897	240	1.2	.224	.160	.012	.228	252	270	1–	1+1–	2–	+

Analyses of the mineral content of the water from the deep wells gave the following results:

MINERAL ANALYSES OF THE CITY SUPPLY FROM OAK PARK.

Ions	Parts per Million	
	17804	17805
Sodium, Na	149.4	194.5
Ammonium, NH_4	.3	.5
Magnesium, Mg	35.5	38.1
Calcium, Ca	83.9	86.6
Oxide of Iron and Alumina, $Fe_2O_3 + Al_2O_3$,	2.2	2.2
Nitrate, NO_3	.9	.9
Chloride, Cl	200.	290.
Sulphate, SO_4	169.0	175.9
Silica, SiO_2	14.7	13.2
Bases,	.2	.2

Hypothetical Combinations	Parts per Million		Grains per Gallon	
	17804	17805	17804	17805
Sodium nitrate, $NaNO_3$	1.2	1.2	.07	.07
Sodium chloride, NaCl	320.0	478.6	19.25	27.91
Sodium sulphate, Na_2SO_4	58.9	17.3	3.43	1.01
Ammonium sulphate $(NH_4)_2SO_4$	1.1	1.8	.06	.10
Magnesium sulphate, $MgSO_4$	161.0	188.3	9.39	10.99
Magnesium carbonate, $MgCO_3$	10.0	----	.58	----
Calcium sulphate, $CaSO_4$	----	18.0	----	1.05
Calcium carbonate, $CaCO_3$	209.5	202.9	12.22	11.83
Oxide of Iron and Alumina, $Fe_2O_3+Al_2O_3$	2.2	2.2	.13	.13
Silica, SiO_2	14.7	13.2	.86	.77
Bases,	.2	.2	.01	.01
Total,	788.8	923.7	46.00	53.87

O'Dell, Livingston county, see Bulletin No. 5, page 81.

Odin, Marion county, has no general supply.

O'Fallon, St. Clair county, see Bulletin No. 5, page 81.

Olney, Richland county, see Bulletin No. 5, page 81. A recent mineral analysis of the city supply used only for fire protection, water power, etc., gives the following results:

MINERAL ANALYSIS OF CITY SUPPLY FROM OLNEY.
Sample Collected October 21, 1907. Laboratory No. 16629.

Ions	Parts Per Million	Hypothetical Combinations		Parts Per Million	Grain Per Gallon
Nitrate, NO_3	.7	Sodium nitrate,	$NaNO_3$	1.0	.06
Chlorine, Cl	6.0	Sodium chloride,	NaCl	9.9	.58
Sulphate, SO_4	33.1	Sodium sulphate,	Na_2SO_4	28.9	1.69
Sodium, Na	13.6	Magnesium sulphate,	$MgSO_4$	17.0	.99
Ammonium, NH_4	----	Magnesium carbonate,	$MgCO_3$	2.8	.16
Magnesium, Mg	4.2	Calcium carbonate,	$CaCO_3$	34.2	1.99
Calcium, Ca	13.7	Iron carbonate,	$FeCO_3$	7.5	.44
Iron, Fe	3.6	Alumina,	Al_2O_3	6.9	.40
Alumina, Al_2O_3	6.9	Silica,	SiO_2	18.2	1.06
Silica, SiO_2	18.2	Total,		126.4	7.37

Onarga, Iroquois county, see Bulletin No. 5, page 81.

Oquawka, Henderson county, has no general supply.

Oregon, Ogle county, see Bulletin No. 5, page 81, obtains its water supply from an artesian well. The plant is owned by the city and was established in 1896. The plant is located near the well at the edge of the Rock River.

Ottawa, La Salle county, see Bulletin No. 5, page 82. Additional analyses of the water from the artesian wells gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF OTTAWA.

Serial Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Color.	Appearance. Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia. Free.	Nitrogen as Ammonia. Albuminoid.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Alkalinity.	Bacteria per c. c.	Colon Bacillus. 10 c. c.	Colon Bacillus. 1 c. c.	Colon Bacillus. 0.1 c. c.	Indol.
	1906																
14938	Sept. 10	0.	0.	0	409	31	1.80	.654	.066	.000	.240	320	0	1—	2—	2—	
14939	Sept. 10	0.	0.	0	408	28	1.25	.580	.062	.000	.040	322	0	1—	2—	2—	
	1907																
16491	Sept. 16	5.	0.	0	390	27	2.25	.448	.024	.004	.156	329	2500	1 +	2—	2—	
	1908																
18519	Nov. 21	3.	20.	0	377	32	.7	.400	.024	.016	.104	316	----	----	----	----	
18520	Nov. 21	3.	30.	0	356	30	.8	.480	.072	.000	.160	318	----	----	----	----	
18521	Nov. 21	0.	0.	0	388	41	.8	.120	.048	.040	.600	314	----	----	----	----	
18522	Nov. 21	----	----	----	----	----	----	----	----	----	----	----	3	1—	2—	2—	—
18523	Nov. 21	----	----	----	----	----	----	----	----	----	----	----	2	1—	2—	2—	—
18524	Nov. 21	----	----	----	----	----	----	----	----	----	----	----	2	1—	2—	2—	—
18526	Nov. 21	----	----	----	----	----	----	----	----	----	----	----	21	1—	2—	2—	—
18527	Nov. 21	5.	10.	0	2641	1200	2.7	1.200	.048	.000	.120	277	----	----	----	----	
18580	Dec. 29	40.	20.	0	2320	1100	3.4	1.120	.032	.003	.120	271	7	1—	2—	2—	—
18681	Dec. 29	0.	15.	0	431	55	.5	.640	.056	.002	.120	329	9	1—	2—	2—	—

Palatine, Cook county, see Bulletin No. 5, page 83. Recent analyses of the city water supply gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF PALATINE.
Sample Collected August 17, 1908.

Serial Number.	Appearance. Turbidity.	Appearance. Color.	Appearance. Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia. Free.	Nitrogen as Ammonia. Albuminoid.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Alkalinity.	Bacteria per c.c.	Colon Bacillus. 10 c.c.	Colon Bacillus. 1 c.c.	Colon Bacillus. 0.1 c.c.	Indol.
17941	0	20	0	708	8	1.9	.576	.096	.005	.200	144	60	1—	2—	2—	—
17942	0	0	0	743	7	2.2	.024	.064	.028	.372	131	18	1—	2+	2—	—

A mineral analysis of the city water gave the following results:

MINERAL ANALYSIS OF THE CITY WATER FROM PALATINE.

Laboratory No. 17941.

Ions	Parts Per Million	Hypothetical Combinations		Parts Per Million	Grains Per Gallon
Sodium, Na	73.7	Sodium nitrate,	$NaNO_3$	1.2	.07
Ammonium, NH_4	.7	Sodium chloride,	NaCl	13.2	.77
Magnesium, Mg	54.5	Sodium sulphate,	Na_2SO_4	210.3	12.27
Calcium, Ca	65.9	Ammonium sulphate,	$(NH_4)_2SO_4$	2.6	.15
Oxide of Iron Fe_2O_3 and Alumina, Al_2O_3	2.8	Magnesium sulphate,	$MgSO_4$	269.4	15.71
		Calcium sulphate,	$CaSO_4$	62.1	3.62
Nitrate, NO_3	.9	Calcium carbonate,	$CaCO_3$	118.8	6.93
Chloride, Cl	8.0	Oxide of Iron and Alumina,	Fe_2O_3 + Al_2O_3	2.8	.16
Sulphate, SO_4	402.7				
Silica, SiO_2	20.6	Silica,	SiO_2	20.6	1.20
Bases,	----	Bases,		----	----
		Total,		701.0	40.88

Pana, Christian county, see Bulletin No. 5, page 83.

Paris, Edgar county, see Bulletin No. 5, page 83.

Park Ridge, Cook county, see Bulletin No. 5, page 84.

Paxton, Ford county, see Bulletin No. 5, page 84. Recent anaylses of the supply taken from deep wells gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF PAXTON.

		Appearance.						Nitrogen as						Colon Bacillus.			
								Ammonia.									
Serial Number.	Date of Collection.	Turbidity.	Color.	Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Free.	Albuminoid.	Nitrites.	Nitrates.	Alkalinity.	Bacteria per c. c.	10 c. c.	1 c. c.	0.1 c. c.	Indol.
16305	1907. July 29	40	1.	E.	513	2	5.9	6.40	.184	.016	.000	487	310	1 +	2 +	2 +	
16388	Aug. 19	30	.8	T.	477	2	5.0	5.00	.160	.001	.200	483	850	1—	2—	2—	
16389	Aug. 19	30	.8	T.	473	2	5.4	6.20	.104	.001	.200	483	50	1 +	1 + 1—	2—	
16390	Aug. 19	30	.8	T.	447	2	6.0	5.40	.200	.000	.200	487	130	1 +	2—	2—	
16391	Aug. 19	20	.0	M.	508	2	4.8	4.60	.192	.000	.160	475	125	1—	2—	2—	
18382	1908. Oct. 27	30	120.	0	508	5	5.5	6.066	.138	.000	.280	469	10	1 +	2—	2—	—

Pecatonica, Winnebago county, see Bulletin No. 5, page 84.

Pekin, Tazewell county, see Bulletin No. 5, page 84. Additional analyses of the supply obtained from the wells gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF PEKIN

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.
								Ammonia.				
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.	
	1906											
14668	July 23	0	0	0	495	45	1.35	.040	.040	Trace	5.6	261
14814	Aug. 20	0	0	0	546	47	1.95	.028	.052	.003	5.2	259

Peoria, Peoria county, see Bulletin No. 5, page 85. Additional analyses of the city supply gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF PEORIA.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			
								Ammonia.									
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
	1907																
16155	June 17	15	.3	Mu.	376	24	2.9	.024	.080	.003	.700	214	------	------	------	------	------
16156	June 17	0	0	0	390	24	1.9	.008	.056	.000	.600	229					
16181	July 1	------	------	------	------	------	------	------	------	------	------	------	530	1?	1? 1 +	2—	
16182	July 1	0	------	------	------	------	------	------	------	------	------	------	120	1?	1? 1—	1? 1—	
16212	July 8	0	.1	0	433	29	1.8	.018	.062	.000	.600	211	102	1—	2—	2—	
16213	July 8	0	0	0	392	29	1.9	.024	.140	.006	.43	222	130	1—	2—	2—	
16214	July 8	0		0	428	28	1.8	.014	.060	.000	.520	238	45	1—	2—	2—	
16215	July 8	3	.1	0	402	29	2.1	.008	.094	.000	.480	233	250	1 +	2—	2—	
16273	July 22	0	0	0	343	18	2.0	.018	.082	.000	.320	248	500	1 +	1 + 1—	2—	
16274	July 22	5	.1	0	363	25	2.4	.032	.084	.005	.240	220	100	1 +	1 + 1—	2—	Liq.
16321	July 29	------	------	------	------	------	------	------	------	------	------	------	1000	1 ?	2—	2—	
16322	July 29	------	------	------	------	------	------	------	------	------	------	------	23	1—	2—	2—	
16323	July 29	------	------	------	------	------	------	------	------	------	------	------	19	1—	2—	2—	

Peotone, Will county, see Bulletin No. 5, page 87, obtains its supply from wells 136 feet deep.

Peru, La Salle county, see Bulletin No. 5, page 87.

Petersburg, Menard county, see Bulletin No. 5, page 87.

Pinckneyville, Perry county, see Bulletin No. 5, page 87, obtains its water supply from Baucamp Creek, with Breeze Lake as a reserve. The plant is owned by the city and was established in 1890 at a cost of $45,000 to $50,000. The plant is located on the bank of the creek northeast of the city limits. The pumps have a capacity of 1,250,000 and 1,500,000 gallons.

Plainfield, Will county, obtains its water supply from a well 100 feet drilled. Recent analyses of the water from this well gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF PLAINFIELD.

Samples Collected August 3, 1908.

Serial Number.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
							Ammonia.									
	Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
17878	0	0	0	968	204	1.5	.056	.072	.005	14.000	355	120	1—	2—	2—	—
17879	0	10	0	993	206	1.2	.064	.104	.006	11.200	355	420	1?	2—	2—	—
17880	0	0	0	1008	206	1.2	.024	.072	.004	16.000	360	22	1—	2—	2—	—

An analysis of the mineral content gave the following results:

MINERAL ANALYSIS OF THE CITY SUPPLY OF PLAINFIELD.

Ions	Parts Per Million	Hypothetical Combinations.		Parts Per Million	Grains Per Gallon
Sodium, Na	123.4	Sodium nitrate,	$NaNO_3$	84.9	4.95
Magnesium, Mg	64.2	Sodium chloride,	$NaCl$	254.8	14.87
Calcium, Ca	79.1	Magnesium sulphate,	$MgSO_4$	171.0	3.97
Oxide of Iron, Fe_2O_3 + and Alumina, Al_2O_3	13.0	Magnesium carbonate,	$MgCO_3$	42.2	2.46
Nitrate, NO_3	61.9	Magnesium chloride,	$MgCl_2$	66.6	3.88
Chloride, Cl	204.0	Calcium carbonate,	$CaCO_3$	198.0	11.55
Sulphate, SO_4	136.0	Oxide of Iron and Alumina,	Fe_2O_3 + Al_2O_3	13.0	.76
Silica, SiO_2	19.4	Silica,	SiO_2	19.4	1.13
Bases,	4.8	Bases,		4.8	.28
		Total,		854.7	49.85

Plano, Kendall county, see Bulletin No. 5, page 87. An additional analysis of the water from the spring 16 feet dug gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF PLANO.

Sample Collected November 30, 1908. Laboratory No. 18576.

Turbidity,	0	Nitrogen as		Bacteria per c.c.,	250
Color,	0	Free Ammonia,	.042	Gas Formers in	
Odor,	0	Alb. Ammonia,	.054	10 c.c.,	1—
Residue on Evaporation,	358	Nitrites,	.000	1 c.c.,	2—
Chlorine in Chlorides,	9.	Nitrates,	3.040	0.1 c.c.,	2—
Oxygen Consumed,	.5	Alkalinity,	273.	Indol,	—

Polo, Ogle county, see Bulletin No. 5, page 87, obtains its water supply from artesian wells 2,200 feet deep. The plant is owned by the city and was established in 1890. Dean horizontal duplex pumps are used. The daily consumption is 65,000 gallons.

Pontiac, Livingston county, see Bulletin No. 5, page 88. An additional analysis of the supply taken from the Vermilion River gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF PONTIAC.

Sample Collected October 5, 1908. Laboratory No. 18269.

Turbidity,	0	Nitrogen as		Bacteria per c. c.,	42
Color,	10.	Free Ammonia,	0.062	Gas formers in	
Odor,	0.	Alb. Ammonia,	.180	10 c.c.,	1—
Residue on Evaporation,	299.	Nitrites,	.000	1 c.c.,	1—1+
Chlorine in Chlorides,	9.	Nitrates,	.320	0.1 c.c.,	2—
Oxygen Consumed,	2.1	Alkalinity,	170.	Indol,	—

Princeton, Bureau county, see Bulletin No. 5, page 88. A recent analysis of the supply from the deep well gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF PRINCETON.

Sample Collected August 12, 1908. Laboratory No. 16378.

Turbidity,	0	Nitrogen as		Bacteria per c.c.,	600
Color,	0	Free Ammonia,	.720	Gas Formers in	
Odor,	0	Alb. Ammonia,	.016	10 c.c.,	1—
Residue on Evaporation,	488.	Nitrites,	.075	1 c.c.,	2—
Chlorine in Chlorides,	62.	Nitrates;	.525	0.1 c.c.,	2—
Oxygen Consumed,	3.95	Alkalinity,	299.6	No ice when received.	

Prophetstown, Whiteside county, see Bulletin No. 5, page 89.

Pullman, Cook county, see Bulletin No. 5, page 89.

Quincy, Adams county, see Bulletin No. 5, page 89. Additional analyses of the raw and treated water from the Mississippi River gave the following results:

ANALYSES OF THE MUNICIPAL WATER SUPPLY OF MOLINE.

Raw Water.

Serial Number.	Date of Collection.	Appearance: Turbidity.	Appearance: Color.	Appearance: Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia: Free.	Nitrogen as Ammonia: Albuminoid.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Alkalinity.	Bacteria per c.c.	Colon Bacillus: 10 c.c.	Colon Bacillus: 1 c.c.	Colon Bacillus: 0.1 c.c.	Indol.
	1906.																
15505	Dec. 31	De.	.4	2 E.	250	3	10.9	.056	.240	.002	.880	170	2,600	1 +	2 +	2 +	
	1907.																
15674	Feb. 5	V. D.	.5	0	247	3	9.55	.136	.240	.003	.320	140	32,006		2 +	2—	
15789	March 4	V. D.	Mud	2 E.	276	3	10.15	.240	.344	.003	.520	117	23,400	1—	2 +	2 +	
15898	April 1	V. D.	Mud	0	802	5	21.95	.120	.760	.001	.440	126	1,400	1 +	2 +	2 +	
16018	May 1	60	.6	0	214	2	10.4	.024	.368	.000	.16	118	4,800	1 +	2 +	2 +	
16098	June 4	210	Mud	0	362	4	13.45	.112	.480	.003	.480	132	28,000	1—	1 +1—	1 +1—	
16191	July 1	350	Mud	0	478	2	17.2	.024	.512	.000	.160	132	21,000	1 +	2 +	1 +1—	
16319	July 29	325	Mud	0	439	2	15.0	.040	.464	.010	.510	158	33,700	1 +	2 +	2 +	
16432	Aug. 26	300	.2	0	464	3	14.7	.072	.464	.009	.471	166	2,500	1 +	1 —1+	2 +	
16476	Sept. 9	280	.2	Mu.	365	2	11.7	.080	.432	.002	.28	160	2,000	1 +	2 +	2 +	
16734	Nov. 11	30	.2	0	240	3	12.9	.012	.284	.000	.080	160	200	1 +	2 +	2—	—
16826	Dec. 2	30	.2	0	230	4	9.0	.064	.284	.002	.240	176	210	1—	2—	2—	+
	1908.																
16947	Jan. 6	30	.2	Mu.	237	3	7.6	.058	.246	.005	.360	192	1,200	1—	2 +	2—	+
17055	Jan. 27	20	.4	0	270	5	10.8	.020	.358	.010	.47	200	630	1 +	2 +	2 +	+
17177	March 9	550	.8	Mu.	858	5	18.9	.128	.860	.015	.59	124	2,000	1 +	2 +	1 +1—	+
17299	April 6	220	.5	E.	410	4	13.7	.076	.356	.010	.59	162	2,500	1 +	2 +	2 +	+
17426	May 11	130	80.	0	334	3	13.1	.042	.056	.006	.640	122	5,200	1 +	1 +1 ?	1 +1?	+
17570	June 16	700	60.	E.	757	6	21.9	.164	1.030	.010	.550	78	2,400	1 +	2 +	2 +	+
17667	July 6	190	180.	0	296	4	14.0	.080	.430	.000	.560	116	6,000	1 +	1 ? 1+	1 ?1+	+
17860	Aug. 3	90	140.	0	244	3	4.6	.096	.442	.003	.280	144	1,240	1 +	2 +	1—	+
18141	Sept. 14	80	45.	E.	271	5	8.4	.030	.350	.000	6.400	182	900		2 +		+
18307	Oct. 12	60	40.	0	236	4	8.8	.052	.428	.004	.200	170	3,400	1 +	1+1?	1 ?1+	+
18598	Dec. 7	60	40.	0	266	7	7.0	.038	.442	.002	.320	174	2,000	1 +	2 +	2 +	+

Filtered Water

	1906.																
15506	Dec 31	0	.2	0	159	3	6.1	.048	.136	.002	.480	91	10	1—	2 +	2—	
	1907.																
15675	Feb. 5	0	.3	0	163	3	5.75	.136	.144	.006	.920	103	53		2—	2—	
15790	March 4	0	Mud	0	158	2	4.65	.096	.152	.008	.640	84	450	1—	2—	2—	
15899	April 1	0	.2	0	137	5	5.3	.080	.136	.030	.450	88	95	1 +	2 +	2 +	
16019	May 1	0	.2	0	124	2	5.0	.040	.144	.025	.220	75	300	1—	2—	2—	
16099	June 4	3	.3	0	152	4	6.2	.048	.144	.004	.480	91	99	1 +	1+1—	1+1—	
16192	July 1	5	.2	2 Mu.	171	4	6.4	.016	.152	.000	.160	84	160	1—	2—	1?1—	
16233	July 11	8	.2	3 E.	164	3	5.0	.048	.176	.002	.040	87					
16281	July 22	5	.4	1 F.	173	3	5.9	.080	.160	.001	.320	85	100	1 +	1—1+	2—	
16320	July 29	0	0	0	186	2	5.8	.016	.168	.000	.540	128	60	1—	1+1—	2—	
16433	Aug. 26	0	0	0	184	3	5.7	.032	.152	.000	.480	117	600	1 +	1—1+	2—	
16477	Sept. 9	0	0	Mu.	156	5	5.25	.056	.136	.000	.280	98	500	1 +	2—	2—	
16735	Nov. 11	0	0	0	145	3	6.8	.024	.098	.000	.400	85	30	1?	2?	2—	+
16827	Dec. 2	0	0	0	164	4	5.0	.032	.108	.000	.320	106	20	1—	2—	2—	—
	1908.																
16948	Jan. 6	0	0	0	144	4	3.3	.034	.090	.006	.360	110	400	1 +	2—	2—	—
17056	Jan. 27	0	0	0	130	4	5.4	.046	.130	.009	.720	104	230	1—	2—	2—	—
17176	March 9	0	0	Mu.	146	5	4.6	.204	.148	.006	.560	80	400	1 +	1+1—	2—	+
17300	April 6	0	.2	0	161	5	3.5	.026	.114	.007	.433	110	120	1—	2—	2—	—
17427	May 11	0	40.	0	138	4	5.3	.058	.164	.006	.360	82	250	1?	2 +	1?1—	—
17571	June 15	0	50.	0	123	2	8.9	.068	.276	.008	.992	67	400	1 +	2 +	2?	+
17668	July 6	0	40.	0	151	6	6.9	.072	.250	.000	1.000	88	300	1?	1+1—	2—	+
17861	Aug. 3	0	40.	0	157	3	5.3	.044	.242	.000	.200	114	38	1?	2—	2—	—
17862	Aug. 3	0	30.	0	169	3	5.5	.092	.246	.000	.520	110	7,200	1 +	1?1+	1 +	—
18142	Sept. 14	0	30.	0	149	5	4.4	.048	.176	.000	6.400	107					
18143	Sept. 14				—	—	—	—	—	—	—	—	103		2 +		+
18144	Sept. 14				—	—	—	—	—	—	—	—	140		2?		+
18145	Sept. 14				—	—	—	—	—	—	—	—	174		1?1+		+
18146	Sept. 14				—	—	—	—	—	—	—	—	360		2 +		+
18147	Sept. 14				—	—	—	—	—	—	—	—	280		1+1?		+
18148	Sept. 14				—	—	—	—	—	—	—	—	52		1+1—		+
18149	Sept. 14				—	—	—	—	—	—	—	—	50		1—1?		+
18308	Oct. 12	0	20.	0	144	6	3.6	.044	.158	.000	.160	102	240	1?	2 +	2—	+
18599	Dec. 7	2	0	0	150	7	2.5	.058	.136	.001	.120	98	120	1 +	1+1—	2—	+

Rantoul, Champaign county, see Bulletin No. 5, page 93.

Redbud, Randolph county, has no general supply.

Ridgely, Sangamon county, is part of the City of Springfield.

River Forest, Cook county, see Bulletin No. 5, page 93.

Riverside, Cook county, see Bulletin No. 5, page 93.

Riverton, Sangamon county, has no general supply.

Robinson, Crawford county, see Bulletin No. 5, page 93.

Rochelle, Ogle county, see Bulletin No. 5, page 93, obtains its water suply from artesian wells 1,000 feet deep. The plant is owned by the city and was established in 1906 at a cost of $75,000. The plant is located within the city limits. Worthington pumps with a capacity of 750,000 gallons each are used. The daily consumption is 300,000 gallons.

Rock Falls, Whiteside county, see Bulletin No. 5, page 94.

Rockford, Winnebago county, see Bulletin No. 5, page 94. Additional analyses of the water from the five wells gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF ROCKFORD.

Serial Number.	Date of Collection.	Appearance			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c.c.	Colon Bacillus.		
								Ammonia.								
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c. c.	0.1 c. c.
	1907															
16080	May 31	5	0	0	295	9	1.55	.024	.048	.000	.040	280	35	1—	2—	2—
16533	Sept. 23	0	0	0	280	6	1.8	.000	.032	.000	.160	293	20	1 +	2—	2—
16600	Oct. 14	0	0	0	295	6	1.2	.004	.020	.002	.160	288	0	1—	2—	2—
16601	Oct. 14	0	0	0	325	6	1.3	.004	.040	.004	.240	297	0	1—	2—	2—
16602	Oct. 14	0	18	Tar	307	6	1.6	.012	.028	.000	.000	299	0	1—	2—	2—
16604	Oct. 14	0	0	0	319	6	1.5	.020	.048	.004	.160	297	0	1?	2—	2—

Rock Island, Rock Island county, see Bulletin No. 5, page 95, Additional analyses of the raw and treated water from the Mississippi River at Rock Island gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF ROCK ISLAND.

Raw River Water.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
	1908																
18479	Nov. 9	10.	60.	0	192	6	6.0	.012	.220	.000	.120	155	8800	1?	2 +	2 +	+
18584	Nov. 30	10.	40.	Mu.	207	6	5.0	.048	.270	.002	.200	147	1300	1+	2 +	2—	+

Filtered

Serial Number.	Date of Collection.	Turbidity.	Color.	Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Free.	Albuminoid.	Nitrites.	Nitrates.	Alkalinity.	Bacteria per c. c.	10 c. c.	1 c. c.	0.1 c. c.	Indol.
17020	Jan. 20	20.	.4	0	210	4	7.5	.038	.178	.006	.074	176	800	1+	1 ? 1 +		+
18348	Oct. 19	10.	30.	0	189	6	6.4	.018	.180	.000	.000	155	480	1—	2—	2—	+
18480	Nov. 9	5.	30.	0	198	6	6.2	.014	.204	.000	.120	159	2200	1—	2—	2—	—
18585	Nov. 30	0.	20.	0	176	6	3.3	.006	.080	.000	.200	147	40	1—	2—	2—	—

Rogers Park, Cook county, see Bulletin No. 5, page 99.

Roodhouse, Green county, see Bulletin No. 5, page 99.

Roseville, Warren county, see Bulletin No. 5, page 99.

Rossville, Vermilion county, see Bulletin No. 5, page 99, obtains its water supply from three wells 85 to 100 feet in depth. The plant is owned by the village and was established in 1896.

Rushville, Schuyler county, see Bulletin No. 5, page 99.

St. Anne, Kankakee county, see Bulletin No. 5, page 100. Recent analyses of the city water supply, taken from the drilled well, gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF ST. ANNE.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
	1908																
17812	July 27	60	150	0	943	9	2.6	.672	.064	.005	.200	238	240	1—	2—	2—	—
17813	July 27	40	70	0	939	8	2.7	.800	.080	.023	.217	233	780	1—	2—	2—	—

An examination of the mineral content gave the following results:

MINERAL ANALYSIS OF THE CITY SUPPLY FROM ST. ANNE.

Laboratory No. 17813.

Ions	Parts Per Million	Hypothetical Combinations.		Parts Per Million	Grains Per Gallon
Sodium, Na	69.0	Sodium nitrate,	$NaNO_3$	1.4	.08
Ammonium, NH_4	1.0	Sodium chloride,	$NaCl$	13.2	.77
Magnesium, Mg	60.8	Sodium sulphate,	Na_2SO_4	195.5	11.40
Calcium, Ca	148.1	Ammonium sulphate,	$(NH_4)_2SO_4$	3.6	.21
Oxide of Iron Fe_2O_3 +	2.8	Magnesium sulphate,	$MgSO_4$	300.6	17.53
and Alumina, Al_2O_4		Calcium sulphate,	$CaSO_4$	104.9	6.12
Nitrate, NO_3	1.0	Calcium carbonate,	$CaCO_3$	292.6	17.06
Chloride, Cl	8.0	Oxide of Iron	Fe_2O_3 +	2.8	.16
Sulphate, SO_4	448.5	and Alumina,	Al_2O_3		
Silica, SiO_2	14.3	Silica,	SiO_2	14.3	.83
Bases,	.5	Bases,		.5	.03
		Suspended Solids,		14.	.82
		Total,		943.4	55.01

St. Charles, Kane county, see Bulletin No. 5, page 100, obtains a water supply from wells 350 feet deep. The plant is owned by the city and was established in 1907 at a cost of $45,000. The reservoirs are located on the highest point in the city. Worthington pumps, with a capacity of 600 gallons per minute, are used. Recent analyses of the supply taken from the deep wells gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF ST. CHARLES.

Samples Collected September 28, 1908.

	Appearance.						Nitrogen as						Colon Bacillus.			
							Ammonia.									
Serial Number.	Turbidity.	Color.	Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Free.	Albuminoid.	Nitrites.	Nitrates.	Alkalinity.	Bacteria per c. c.	10 c. c.	1 c. c.	0.1 c. c.	Indol.
18227	5	0	Tar	490	20	.7	.360	.056	.076	.644	394	58	1+	2—	1+1—	+
18228	0	0	0	512	20	.4	.320	.056	.019	3.021	343	60	1+	1+1—	2—	+

St. Elmo, Fayette county, see Bulletin No. 5, page 100.

Salem, Marion county, has no general supply.

Sandoval, Marion county, has no general supply.

Sandwich, DeKalb county, see Bulletin No. 5, page 100. Recent analyses of the supply taken from the deep well gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF SANDWICH.

Samples Collected September 14, 1908.

Serial Number.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
	Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
18159	5	20	0	550	20	.7	.064	.072	.005	2.800	349	140	1—	2—	2—	—
18160	10	30	0	550	22	1.1	.104	.104	.005	2.960	349	18	1—	2—	2—	—

Savanna, Carroll county, see Bulletin No. 5, page 100. Additional analyses of the water obtained from the deep well gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF SAVANNA.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
16220	1907 July 8	3	0	0	302	7	.7	.024	.024	.003	2.000	251	17	1—	2—	2—	
16961	1908 Jan. 6	0	0	0	292	7	1.0	.024	.032	.002	.120	274	120	1—	2—	2—	—
18250	Sept. 30	----	----	----	----	----	----	----	----	----	----	----	72,000	1—	1—	1—	
18415	Nov. 2	0	3.	0	282	9	1.2	.040	.024	.000	.280	267	12.	1—	2—	2—	—

Seneca, La Salle county, see Bulletin No. 5, page 100, obtains its water supply from artesian wells. The plant is owned by the village and was established in 1878 at a cost of about $1,000 for each well sunk. The wells flow constantly and no pumping station has been built. The water is stored in cisterns.

Shawneetown, Gallatin county, has no general supply.

Sheffield, Bureau county, see Bulletin No. 5, page 100.

Shelbyville, Shelby county, see Bulletin No. 5, page 100. Additional analyses of the water obtained from the shallow wells gave the following results.

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF SHELBYVILLE.

Samples Collected April 1, 1907.

Serial Number.	Appearance. Turbidity.	Color.	Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia. Free.	Albuminoid.	Nitrites.	Nitrates.	Alkalinity.	Bacteria per c. c.	Colon Bacillus. 10 c. c.	1 c. c.	0.1 c. c.
15894	V.Slight	0	0	359	15	2.0	.040	.040	.003	.280	260	0	1—	2—	2—
15895	Distinct	.2	0	355	19	2.1	.048	.040	.006	.440	266	0	1—	2—	2—

An analysis of the mineral content of this water gave the following results:

MINERAL ANALYSIS OF THE CITY WATER FROM SHELBYVILLE.

Laboratory No. 15895.

Ions	Parts Per Million	Hypothetical Combinations.		Parts Per Million	Grains Per Gallon
Sodium, Na	13.2	Sodium nitrate,	$NaNO_3$	2.6	.15
Magnesium, Mg	35.	Sodium chloride,	$NaCl$	31.4	1.83
Calcium, Ca	84.0	Magnesium sulphate,	$MgSO_4$	98.2	5.72
Iron, Fe	1.2	Magnesium carbonate,	$MgCO_3$	52.6	3.07
Alumina, Al_2O_3	3.2	Calcium carbonate,	$CaCO_3$	209.7	12.23
Nitrate, NO_3	1.9	Iron carbonate,	$FeCO_3$	2.5	.15
Chloride, Cl	19.0	Aluminium,	Al_2O_3	3.2	.19
Sulphate, SO_4	78.4	Silica,	SiO_2	6.6	.38
Silica, SiO_2	6.6	Bases,		1.1	.06
		Total,		407.9	23.78

Sheldon, Iroquois county, see Bulletin No. 5, page 102.

Sorento, Bond County, has sent no report.

Sparta, Randolph county, see Bulletin No. 5, page 102.

Springfield, Sangamon county, see Bulletin No. 5, page 102. Additional analyses of the water from the Sangamon River gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF SPRINGFIELD.

Serial Number.	Date of Collection.	Appearance			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c.c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c.c.	0.1 c.c.	
	1907																
15714	Feb. 14	0	0.	0	272	5	2.1	.024	.048	.000	1.120	217	660	1—	2—	2—	
15772	Feb. 27	De	.6	0	389	6	3.4	.024	.112	.000	.880	226	220	1—	2—	1+1—	
15787	Mar. 4	0	0.	0	25	1	1.0	.256	.072	.013	.387	31	20	1—	2—	2—	
15838	Mar. 18	De	.4	0	298	6	2.5	.016	.048	.000	.960	197	1,000	1—	2—	2—	
15862	Mar. 25	0	0.	0	250	5	1.95	.024	.096	.000	.720	182	40	1—	1+1—	2—	
16004	Apr. 29	80	4.		297	8	3.5	.072	.144	.008	2.4	222	340	1?	1+1—	2—	
16005	Apr. 29	15	.2	0	154	14	2.7	.128	.096	.044	.480	75	0	1—	2—	2—	
16434	Aug. 27	138	.2		361	5	7.5	.032	.224	.000	.320	233	800	1+	2+	1—1+	
16467	Sept. 9	260	.2		414	5	6.25	.000	.144	.003	.640	271	Liq.	1+	2+	1—1+	
16842	Dec. 9	0	.0	0	380	6	1.5	.062	.044	.002	2.800	320					
	1908																
17051	Jan. 27	5	0.	0	288	7	1.7	.004	.030	.002	1.270	232	190	1+	1+1—	2—	+
17052	Jan. 27	0	0.	0	300	7	2.2	.008	.026	.000	1.320	228	130	1+	1?1—	2—	—
17462	May 25	30	30.	0	281	5	3.1	.088	.256	.000	.400	193	870	1?	1+1—	2—	—
17965	Aug. 18	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	2,000	1+	2+	2—	+
17971	Aug. 19	20	30.	0	281	12	3.5	.062	.158	.000	.320	236	--------				
18690	Dec. 31	0	10.	0	322	13	2.0	.008	.068	.000	.600	232	390	1—	2—	2—	—

Spring Valley, Bureau county, see Bulletin No. 5, page 102.

Staunton, Macoupin county, see Bulletin No. 5, page 103, obtains its supply for sprinkling, fire protection, etc., from a large reservoir. The plant is owned by the city, and was established in 1895 at a cost of $12,000.

Sterling, Whiteside county, see Bulletin No. 5, page 103.

Stonington, Christian county, see Bulletin No. 5, page 103. Recent analyses of the city water supply gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF STONINGTON.

Samples Collected April 1, 1907.

Laboratory No.	15890	15891		15890	15891
Turbidity,	Decided	Decided	Nitrogen as		
Color,	.6	.6	Free Ammonia,	.688	.736
Odor,	.0	.0	Alb. Ammonia,	.048	.056
Residue on Evaporation,	340.	340.	Nitrites,	.002	.002
Chlorine in Chlorides,	18.0	13.0	Nitrates,	.360	.120
Oxygen Consumed,	3.55	3.65	Alkalinity,	310.8	315.

Streator, La Salle county, see Bulletin No. 5, page 103. Additional analyses of the water from the Vermilion River are shown on page 193.

Sullivan, Moultrie county, see Bulletin No. 5, page 106.

Sumner, Lawrence county, has no general supply.

Sycamore, DeKalb county, see Bulletin No. 5, page 106.

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF STREATOR.

Serial Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Color.	Appearance. Odor.	Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as Ammonia. Free.	Nitrogen as Ammonia. Albuminoid.	Nitrogen as Nitrites.	Nitrogen as Nitrates.	Alkalinity.	Bacteria per c. c.	Colon Bacillus. 10 c. c.	Colon Bacillus. 1 c. c.	Colon Bacillus. 0.1 c. c.	Indol.
	1907																
15658	Feb. 4	Di.	.2	00	321	5	3.50	.064	.096	.005	4.400	215	3,100	——	2+	1+1?	
* 15659	Feb. 4	Di.	2.	00	379	5	4.1	.048	.128	.003	4.000	227	720	——	2+	2 +	
15668	Feb. 4	Di.	.2	00	374	5	3.95	.032	.680	.010	.560	218	850	——	2+	2 +	
15696	Feb. 11	Sl.	.1	00	383	5	3.3	.008	.064	.005	2.40	227	1,430	1—	2+	2 +	
15698	Feb. 11	De.	Mud	00	445	5	15.3	.048	.640	.040	3.56	138	7,000	——	2+	2 +	
*15709	Feb. 12	Sl.	.2	2 Veg.	381	3	3.0	.080	.120	.010	4.000	217	4,100	1—	1+1—	2—	
15711	Feb. 12	Di.	.2	00	347	5	2.35	.040	.096	.001	.080	221	700	1—	2—	2—	
15744	Feb. 22	Di.	.3	00	349	2	4.6	.016	.136	.002	1.88	172	2,030	1+	1+1—	2—	
15841	Mar. 18	De.	.2	2 Earth	430	11	4.3	.120	.144	.006	2.80	170	1,950	1+	2+	2—	
15920	Apr. 8	12	.2	00	362	10	3.65	.028	.124	.002	4.00	191	920	1?	2+	2 +	
16046	May 16	10	0	2 Earth	394	13	3.85	.048	.128	.006	4.00	187	530	1+	2+	2—	
*16088	June 3	90	.2	2 Earth	368	7	4.7	.048	.128	.020	3.18	218	10,000	1+	2—	2—	
16089	June 3	0	.2	0	352	9	2.65	.008	.048	.025	3.01	214	135	1+	2—	2—	
16255	July 16	3	.2	0	436	15	3.8	.000	.088	.000	.440	145	315	1+	2+	2 +	
16362	Aug. 12	2	.0	0	330	6	3.2	.000	.112	.000	1.48	201	Liquefied	1+	1+1—	2—	
16405	Aug. 19	10	.0	Earth	289	4	3.8	.032	.128	.000	1.08	216	200	1+	1+1—	1—1?	
16526	Sept. 23	25	.2	Musty	343	3	4.5	.016	.200	.000	.720	241	1,020	1?	1 ? 1 +	1—1?	
16527	Sept. 23	0	.2	0	350	2	4.2	.016	.096	.000	.640	241	1,800	1?	2 ?	2?	
16661	Oct. 28	0	0	0	404	4	6.0	.000	.112	.000	.560	284	300	1?	1—1?	2—	
16662	Oct. 28	0	0	0	362	4	3.7	.000	.104	.000	.80	286	300	1+	2—	2—	
16829	Dec. 2	0	0	0	395	6	1.8	.024	.064	.000	1.000	280	200	1+	2—	2—	—
16830	Dec. 2	0	0	0	395	6	2.5	.036	.064	.000	.800	276	80	1+	2—	1+1?	—
	1908																
17119	Feb. 18	20	0	0	281	10	3.2	.048	.094	.014	.280	80	8,200	1+	2—	2—	—
17120	Feb. 18	20	0	0	265	10	2.5	.050	.104	.014	.336	82	6,000	1+	1 + 1 ?	2—	—
17261	Mar. 30	0	0	0	346	11	2.2	.034	.090	.000	1.400	206	280	1—	2+	2—	—
17262	Mar. 30	0	0	0	351	11	2.1	.054	.088	.000	1.48	206	200	1+	1—1+	1+1—	—
17431	May 11	0	10	0	400	18	1.1	.036	.062	.000	28.000	148	300	1+	2—	2—	—
17432	May 11	0	0	0	387	18	1.3	.022	.056	.000	18.000	148	280	1 ?	2—	2—	—
17540	June 8	0	10	0	340	5	2.2	.040	.086	.000	2.800	220	84	1+	1 + 1 ?	2—	—
17716	July 13	0	0	0	316	9	2.7	.064	.138	.000	.800	201	400	1—	2—	2—	—
18140	Sept. 14	0	20	0	311	18	3.2	.052	.210	.000	.360	214	60		2—		+
18625	Dec. 15	3	30	0	411	25	3.5	.010	.140	.000	.200	238	----------	----------	----------	----------	----------
18626	Dec. 15	3	30	0	394	25	3.4	.026	.158	.000	.240	238	----------	----------	----------	----------	----------

Taylorville, Christian county, see Bulletin No. 5, page 106. A recent analysis of the supply from Taylorville gave the following results :

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF TAYLORVILLE.

Sample Collected October 15, 1908. Laboratory No. 18327.

Turbidity,	3.	Nitrogen as	
Color,	20.	Free Ammonia,	.088
Odor,	0.	Alb. Ammonia,	.048
Residue on Evaporation,	492.	Nitrites,	.240
Chlorine in Chlorides,	37.	Nitrates,	6.560
Oxygen Consumed,	2.6	Alkalinity,	289.

An analysis of the mineral content gave the following results :

MINERAL ANALYSIS OF THE CITY WATER FROM TAYLORVILLE.

Sample Collected October 15, 1908. Laboratory No. 18327.

Ions	Parts Per Million	Hypothetical Combinations.		Parts Per Million	Grains Per Gallon
Sodium, Na	23.3	Sodium nitrate,	$NaNO_3$	39.4	2.30
Magnesium, Mg	29.3	Sodium chloride,	$NaCl$	31.9	1.86
Calcium, Ca	97.2	Magnesium chloride,	$MgCl_2$	23.7	1.38
Oxide of Iron, Fe_2O_3 and Alumina, Al_2O_3	9.0	Magnesium sulphate,	$MgSO_4$	65.4	3.81
		Magnesium carbonate,	$MgCO_3$	35.0	2.04
Nitrate, NO_3	28.7	Calcium carbonate,	$CaCO_3$	242.6	14.14
Chloride, Cl	37.	Oxide of Iron and Alumina,	$Fe_2O_3 + Al_2O_3$	9.0	.52
Sulphate, SO_4	52.2				
Silica, SiO_2	10.1	Silica,	SiO_2	10.1	.59
Bases,	1.2	Bases,		1.2	.07
		Total,		458.3	26.71

Tolono, Champaign county, see Bulletin No. 5, page 107.

Toluca, Marshall county, obtains a city supply from a new artesian well 2,000 feet drilled. A recent analysis of the water from this well gave the following results :

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF TOLUCA.

Sample Collected October 9, 1908. Laboratory No. 18289.

Turbidity,	400.	Nitrogen as		Bacteria per c. c.	
Color,	70.	Free Ammonia,	.640	Gas formers in	
Odor,	Peculiar	Alb. Ammonia,	.560	10 c. c.,	1 +
Residue on Evaporation,	3465.	Nitrites,	.000	1 c. c.,	2 +
Chlorine in Chlorides,	1500.	Nitrates,	.160	0.1 c. c.,	1— 1+
Oxygen Consumed,	31.	Alkalinity,	213.		

Toulon, Stark county, has no general supply.

Trenton, Clinton county, has no general supply.

Troy, Madison county, has no general supply.

Tuscola, Douglas county, has sent no report.

Upper Alton, Madison county, see Bulletin No. 5, page 107. An additional analysis of the supply taken from the Mississippi River gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF UPPER ALTON.

Sample Collected October 29, 1906. Laboratory No. 15274.

Turbidity,	Clear	Nitrogen as		Bacteria per. c. c.,	1500+
Color,	.1	Free Ammonia,	.024	Gas formers in	
Odor,	0.	Alb. Ammonia,	.136	10 c. c.,	1?
Residue on Evaporation,	215.	Nitrites,	.000	1 c. c.,	2—
Chlorine in Chlorides,	10.	Nitrates,	.76	0.1 c. c.,	1+ 1—
Oxygen Consumed,	5.75	Alkalinity.	140.2		

Urbana, Champaign county, see Bulletin No. 5, page 108. For additional analyses see Champaign.

Utica, La Salle county, see Bulletin No. 5, page 109.

Vandalia, Fayette county, see Bulletin No. 5, page 109.

Venice, Madison county, see Bulletin No. 5, page 109.

Vermont, Fulton county, has no general supply.

Vienna, Johnson county, has no general supply.

Virden, Macoupin county, obtains its supply from two shallow wells about 18 feet deep.

Virginia, Cass county, has no general supply.

Walnut, Bureau county, see Bulletin No. 5, page 109, obtains its water supply from a well about 265 feet drilled. The plant is owned by the village and was established in 1897 at a cost of $9,000.

Warren, Jo Daviess county, see Bulletin No. 5, page 109. Additional analyses of the water from the 700 foot well gave the following results :

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF WARREN.

Samples Collected September 22, 1908.

Laboratory No.	18196	18197		18196	18197		18196	18197
Turbidity,	0.	0.	Nitrogen as			Bacteria per c.c	18,400	2,200
Color,	0.	0.	Free Am.,	.016	.040			
Odor,	0.	0.	Alb. Am.,	.032	.016	Gas formers in		
Residue on Evaporation,	359.	363.	Nitrites,	.000	.002	10 c.c.,	1—	1—
Chlorine in Chlorides,	16.	16.	Nitrates,	.800	.680	1 c.c.,	2—	2—
Oxygen Consumed.	.2	.8	Alkalinity,	319.	327.	0.1 c.c.,	2—	2—
						Indol,	—	—

The examination of the mineral content gave the following results:

MINERAL ANALYSIS OF THE CITY WATER FROM WARREN.

Laboratory No. 18196.

Ions	Parts Per Million	Hypothetical Combinations.		Parts Per Million	Grains Per Gallon
Patassium, K	1.9	Potassium nitrate,	KNO_3	4.9	.29
Sodium, Na	9.0	Sodium nitrate,	$NaNO_3$	.7	.04
Magnesium, Mg	32.7	Sodium chloride,	NaCl	22.3	1.30
Calcium, Ca	82.8	Magnesium chloride,	$MgCl_2$	8.3	.19
Iron, Fe	.7	Magnesium sulphate,	$MgSO_4$	35.9	2.09
Aluminum Oxide Al_2O_3	.3	Magnesium carbonate,	$MgCO_3$	85.2	4.97
Nitrate, NO_3	3.5	Calcium carbonate,	$CaCO_3$	206.7	12.06
Chloride, Cl	16.0	Iron carbonate,	$FeCO_3$	1.5	.09
Sulphate, SO_4	28.6	Aluminum oxide,	Al_2O_3	.3	.02
Silica, SiO_2	16.4	Silica,	SiO_2	16.4	.96
Bases,	1.6	Bases,		1.6	.09
		Total,		378.7	22.10

Warsaw, Hancock county, see Bulletin No. 5, page 109.

Washington, Tazewell county, see Bulletin No. 5, page 109, obtains its water supply from a well 90 feet deep. The plant is owned by the city. A double-acting pump is used.

Waterloo, Monroe county, see Bulletin No. 5, page 109, obtains its water supply from Fountain Creek and a reservoir fed by springs. The plant is owned by the city and was established in 1897 at a cost of $2,000. The plant is located two miles from the city. Two Dean pumps are used.

Waterman, DeKalb county, obtains its water supply from a well 73 feet drilled. A recent analysis of the water from this well gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF WATERMAN.

Sample Collected July 23, 1907. Laboratory No. 16286.

Turbidity,	20.	Nitrogen as		Bacteria per c.c.	150
Color,	6.	Free Ammonia,	.416	Gas formers in	
Odor,	0.	Alb. Ammonia,	.056	10 c.c.,	1—
Residue on Evaporation,	393.	Nitrites,	.000	1 c.c.,	2—
Chlorine in Chlorides,	7.	Nitrates,	.280	0.1 c.c.,	2—
Oxygen Consumed,	1.2	Alkalinity,	350.9		

Watseka, Iroquoios county, see Bulletin No. 5, page 109.

An additional analysis of the supply taken from the artesian well gave the following results:

SANITARY ANALYSIS OF THE MUNICIPAL WATER SUPPLY OF WATSEKA.

Sample Collected December 10, 1906. Laboratory No. 15443.

Turbidity,	Clear	Nitrogen as	
Color,	.2	Free Ammonia,	2.28
Odor,	.0	Alb. Ammonia,	.094
Residue on Evaporation,	343.	Nitrites,	.004
Chlorine in Chlorides,	4.	Nitrates,	- - - -
Oxygen Consumed	- - - -	Alkalinity,	295.7

An examination of the mineral content gave the following results:

MINERAL ANALYSIS OF THE CITY WATER SUPPLY FROM WATSEKA.

Ions	Parts Per Million	Hypothetical Combinations.		Parts Per Million	Grains Per Gallon
Sodium, Na	76.3	Sodium chloride,	$NaCl$	6.6	.38
Ammonium, NH_4	2.9	Sodium sulphate,	Na_2SO_4	29.3	1.71
Magnesium, Mg	15.9	Sodium carbonate,	Na_2CO_3	147.7	9.61
Calcium, Ca	47.9	Ammonium carbonate,	$(NH_4)_2CO_3$	7.7	.45
Oxide of Iron, Fe_2O_3 and Alumina, Al_2O_3	1.2	Magnesium carbonate,	$MgCO_3$	55.1	3.21
Chloride, Cl	4.0	Calcium carbonate,	$CaCO_3$	119.5	6.97
Sulphate, SO_4	19.8	Oxide of Iron and Alumina,	Fe_2O_3 + Al_2O_3	1.2	.07
Silica, SiO_2	9.0	Silica,	SiO_2	9.0	.52
Bases,	3.8	Bases,		3.8	.22
		Total,		379.9	22.14

Waukegan, Lake county, see Bulletin No. 5, page 109. Additional analyses of the water from Lake Michigan gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF WAUKEGAN.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c.c.	Colon Bacillus.			Indol.
								Ammonia.									
		Turbidity.	Color.	Odor.				Free.	Albuminoid.	Nitrites.	Nitrates.			10 c.c.	1 c.c.	0.1 c.c.	
	1907.																
15538	Jan. 5	De.	.1	0	168	4	3.8	.016	.136	.002	.200	126	5,300	1 +	1+1—	2—	
15599	Jan. 22	De.	.2	3 Mo.	194	3	5.0	.088	.184	.002	.320	116	630	1 +	2 +	2 +	
15602	Jan. 22	0	0	0	141	3	3.0	.064	.104	.002	.440	106	10,000+	1—	2—	2—	
15699	Feb. 12	Di.	.2	0	179	5	3.0	.032	.096	.001	.200	122	780	1—	2—	2—	
15700	Feb. 12	Di.	.2	0	186	6	3.2	.040	.112	.001	.240	128	3,500	1—	1+1—	1+1—	
15701	Feb. 12	Di.	.2	0	147	6	3.0	.016	.096	.001	.320	128	2,300	1—	1+1—	2—	
15702	Feb. 12	Di.	.2	0	177	5	3.4	.016	.096	.002	.240	128	2,300	1—	2—	2—	
15703	Feb. 12	De.	.2	0	244	6	5.4	.024	.128	.001	.280	126	3,600	1—	2—	1+1—	
15758	Feb. 25	De.	.2	0	196	4	3.35	.008	.144	.001	.080	118	1,300	1—	1+1—	1—1+	
15759	Feb. 25	De.	.2	0	203	4	4.25	.016	.120	.001	.160	120	1,700	1—	2 +	2—	
15760	Feb. 25	De.	.2	0	191	4	4.15	.008	.120	.001	.320	120	2,200	1—	1+1—	1+1—	
15761	Feb. 25	De.	.2	0	200	4	3.4	.024	.120	.002	.080	120	2,100	1—	1+1—	1+1—	
15762	Feb. 25	Sl.	.1	0	275	4	3.0	.064	.088	.002	.120	118	11,500	1—	1+1—	2—	
16767	Feb. 26	De.	.2	0	217	4	3.8	.032	.080	.000	.080	120					
15806	March 7	Di.	.2	0	288	4	5.85	.016	.256	.002	.160	115	7,300	1—	2 +	1?1+	
16276	July 22	20	.2	2 Mu.	159	5	3.4	.120	.160	.000	.120	117	5,000	1 +	2 +	2 +	
16277	July 22	20	.2	1 Mu.	142	4	2.8	.024	.136	.000	.160	117	4,000	1—	2 +	2—	
	1908.																
17014	Jan. 18	0	0	Mu.	154	5	1.5	.042	.086	.005	.515	120	7,000	1—	2—	2—	+
17233	March 23	0	0	0	134	4	2.6	.024	.082	.002	.480	118	4,200	1 +	2—	2—	+
17599*	June 22	0	0	0	140	4	.7	.016	.084	.000	.200	116	4,000	1—	2—	2—	—
17600*	June 22	0	0	0	141	5	.08	.020	.088	.000	.760	116	200	1—	2—	2—	—

*Berkefeld filter.

Waverly, Morgan county, has no general supply.

Wenona, Marshall county, see Bulletin No. 5, page 110, obtains its water supply from an artesian well 1,850 feet deep. The plant is owned by the city and was established in 1892 at a cost of $18,000. A Downey pump, with a capacity of 6,000 gallons per hour, is used. The daily consumption is 100,000 gallons. The annual cost of pumping is $1,200.

West Chicago, DuPage county, see Bulletin No. 5, page 110.

West Hammond, Cook county, see Bulletin No. 5, page 111.

Westville, Vermilion county, has no general supply.

Wheaton, DuPage county, see Bulletin No. 5, page 111.

Whitehall, Greene county, see Bulletin No. 5, page 111.

Wilmette, Cook county, see Bulletin No. 5, page 111. Additional analyses of the water from Lake Michigan gave the following results:

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF WILMETTE.

Samples Collected December 28, 1908.

Laboratory No.	18648	18649		18648	18649		18648	18649
Turbidity,	.4	3.	Nitrogen as					
Color,	20.	25.	Free Am.,	.016	.038	Bacteria per c.c.,	45	44
Odor,	0.	0.	Alb. Am.,	.096	.090	Gas formers in		
Residue on Evaporation,	141.	133.	Nitrites,	.001	.002	10 c.c.,	1—	1—
			Nitrates,	.240	.280	1 c.c.,	2—	2—
Chlorine in Chlorides,	7.	5.	Alkalinity,	116.	116.	0.1 c.c.,	2—	2—
Oxygen Consumed,	1.4	1.4				Indol,	+	—

Wilmington, Will county, see Bulletin No. 5, page 111.

Winchester, Scott county, has no general supply.

Winnetka, Cook county, see Bulletin NO. 5, page 111. Additional analyses of the water from Lake Michigan are shown on page 200.

Winstanley Park, is part of the City of East St. Louis.

Woodstock, McHenry county, see Bulletin No. 5, page 113.

Wyoming, Stark county, see Bulletin No. 5, page 113.

Yorkville, Kendall county, see Bulletin No. 5, page 113.

SANITARY ANALYSES OF THE MUNICIPAL WATER SUPPLY OF WINNETKA.

Serial Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Chlorine in Chlorides.	Oxygen Consumed.	Nitrogen as				Alkalinity.	Bacteria per c. c.	Colon Bacillus.			Indol.
		Turbidity.	Color.	Odor.				Ammonia. Free.	Ammonia. Albuminoid.	Nitrites.	Nitrates.			10 c. c.	1 c. c.	0.1 c. c.	
	1906																
15442	Dec. 10	De	0	0	151	4	3.55	.022	.120	.001	.080	126	467	1 +	2—	1 +	
	1907																
15629	Jan. 28	De	0	0	156	4	4.55	.016	.174	.002	.160	116	290	1—	2—	2—	
16558	Sept. 30												Liq.	1 +	2 +	1+1—	
16696	Nov. 4	20	0	0	155	5	3.2	.012	.112	.000	.000	116	8,400	1 +	2—	2—	—
16805	Nov. 26	0	0	0	116	6	3.2	.008	.044	.000	.160	108	180	1 +	2—	2—	—
16868	Dec. 16	35	0	0	120	5	3.0	.016	.084	.000	.160	132	420	1 +	2 +	2—	—
16869	Dec. 16	10	0	0	94	4	2.8	.032	.076	.002	.160	96	30	1—	2—	2—	—
	1908																
17003	Jan. 20	20	0	0	164	5	4.0	.008	.082	.002	.320	126	460	1?	1—1?	2—	+
17132	Feb. 24	60	.2	0	174	5	6.0	.032	.128	.002	.760	130	520	1—	2—	2—	—
17253	Mar. 30	30	0	0	178	6	2.3	.022	.080	.001	.240	124	760	1 +	1+1?	2—	—
17348	Apr. 20	120	0	0	240	6	4.9	.048	.182	.002	.440	138	370	1?	2 +	1—1?	+
17483	May 26	5	10	0	149	5	2.7	.050	.136	.000	.360	113	780	1 +	1?1+	1—1+	+
17484	May 26	0	10	0	144	4	1.9	.042	.086	.000	.240	113	180	1 +	2—	2—	+
17601	June 24	0	0	0	151	4	1.7	.032	.098	.000	.160	112	85	1 +	2—	2—	—
17762	July 20	10	0	Musty	151	7	3.1	.032	.096	.000	.280	114	650	1—	2—	2—	—
18199	Sept. 21	5	10	0	152	5	1.4	.016	.116	.001	.200	109	76,000	1 +	2—	1—1+	+
18365	Oct. 26	5	10	0	153	5	2.4	.012	.104	.001	.200	122	840	1 +	2—	2—	+
18366	Oct. 26	5	10	0	148	7	2.3	.028	.094	.001	.360	116	20	1—	2—	2—	—
18579	Nov. 30	10	10	0	141	8	1.6	.050	.094	.002	.240	120	2,400	1 +	2—	2—	—
18640	Dec. 20	35	10	Earthy	161	8	2.1	.044	.122	.001	.240	124	12,000	1 +	2—	1+1—	—

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