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WATER SURVEY SERIES NO. 12

CHEMICAL AND BIOLOGICAL SURVEY OF THE WATERS OF ILLINOIS

REPORT FOR YEAR ENDING DECEMBER 31, 1914

EDWARD BARTOW

DIRECTOR

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[1] Till September, 1914.

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1914

LETTER OF TRANSMITTAL

Illinois State Water Survey.

University of Illinois,
Urbana, Illinois, May 24, 1916.

Edmund J. 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, 1914, and request that it be printed as a bulletin of the University of Illinois, State Water Survey Series No. 12.

The report contains an account of the work done by the State Water Survey in accordance with the laws creating the State Water Survey and imposing upon it new and additional duties (Laws of Illinois, 40th General Assembly, 1897, 12; 47th General Assembly, 1911, 43. Bull. State Water Survey Series 9, 7-8). .

Summaries of the chemical, biological, and engineering work are given, together with more complete reports on certain special investigations conducted during the year.

One extensive sanitary survey of drainage basins is reported. This work is of great value to cities that find it necessary to plan methods of sewage disposal. This work, performed in cooperation with the Rivers and Lakes Commission, should be continued to cover all the drainage basins of the State.

Several epidemics of typhoid fever have been investigated and recommendations have been made for the prevention of the spread of the disease.

Respectfully submitted,

EDWARD BARTOW, *Director.*

CHEMICAL AND BIOLOGICAL SURVEY OF THE WATERS OF ILLINOIS

REPORT FOR THE YEAR ENDING DECEMBER 31, 1914

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Director

GENERAL REPORT

ADMINISTRATION

During 1914 the laboratory and field work of the State "Water Survey has been conducted along the lines inaugurated late in 1911. A slight expansion was made possible by an increase of the appropriation by the Legislature from $15,000 to $21,500 per annum. In addition the Trustees of the University of Illinois allotted $7,500 for the educational and scientific work of the Survey for the year.

The staff has been slightly changed during the year. C. H. Spaulding, assistant chemist, resigned to accept a position with the Panama Canal Commission at Cristobal, C. Z., and Wesley Wallace Hanford, B.S., Wesleyan University, 1913, and Arthur Norton Bennett, B.S., University of Illinois, 1907, have been appointed assistant chemists.

According to authority given by the 40th General Assembly of Illinois in 1897, the Illinois State Water Survey was created by the Trustees of the University of Illinois and made a division of the Department of Chemistry. The 47th General Assembly in 1911 imposed new and additional duties on the State Water Survey authorizing and instructing it

"to employ such field men as may be necessary to visit municipal water supplies and inspect water sheds to make such field studies and to collect such samples as are necessary, to analyze and test samples and to make any investigations to the end that a pure and adequate public water supply for domestic and manufacturing purposes may be maintained in each municipality to make sanitary analyses free of charge of samples of water from municipal water supplies or from private wells, collected according to the directions of the State Water Survey and to report the result of such examination to the board of health, superintendent of waterworks, other officer or officers of the water department of the city, village or incorporated town, or to citizens by whom the samples respectively were collected."[1]

[1]Laws of the State of Illinois: 47th General Assembly, 1911.

Instruction in the analysis and purification of water and sewage has been given by members of the Water Survey staff. There is one course for undergraduates, Chemistry 10, one course for graduates, Chemistry 110, and both graduates and undergraduates are allowed to prepare theses on subjects connected with the chemistry of water. Several of the theses thus prepared have been of sufficient merit to warrant their publicaiton in the bulletins of the State Water Survey as well as in the scientific and technical press. The engineer has given a course of lectures in the College of Engineering and has conducted class work on purification of water and sewage.

The Water Survey has always occupied quarters in the Chemistry Building and in 1914 has used nine rooms in the Chemistry Building and two in Engineering Hall. Plans have been completed for an addition to the Chemistry Building, in the basement of which quarters have been assigned to the Water Survey. Funds for the construction of the building have been appropriated by the University Trustees. After it is constructed the laboratories now used by the Water Survey will be remodeled for instructional work in the chemistry of water.

ENGINEERING WORK

The engineering division was established late in 1911. Visits have been made by members of the engineering staff to cities throughout the State, and conferences have been held with local authorities regarding construction of new plants and repair of old ones. Reports describing the public water supplies, sewerage systems, and sewage-disposal works of the State have been prepared. The work done during 1911 was outlined in bulletin 9, (pp. 15-33) that during 1912 in bulletin 10, (pp. 89-185), and that during 1913 in bulletin 11, (pp. 22-141). The work of the engineering division during 1914 is outlined on pages 23 to 27 of this bulletin, and the work during 1912, 1913, and 1914 is briefly summarized in Table 1.

TABLE 1.—NUMBER OF ENGINEERING INVESTIGATIONS, CONFERENCES, INSPECTIONS, AND REPORTS PREPARED, 1912-1914.

Nature of work.	1912	1913	1914	Total
Inspections of public water supplies	60	101	101	262
Conferences concerning the installation and extension of public water supplies	1	59	34	94
Inspections of sewerage systems	25	28	34	87
Conferences concerning proposed sewerage systems	3	24	8	35
Special investigations	18	41	26	85
Reports prepared on public water supplies	60	85	82	227
Reports prepared on proposed water supplies and extensions	19	34	28	81
Reports prepared on sewerage systems	11	6	22	39
Reports prepared on proposed sewerage systems	14	10	5	29

The State Water Survey has continued its policy of encouraging the installation of municipal water supplies for the purpose of protecting the public against disease. Efforts have been directed especially toward communities whose population is 1,000 or greater, though many smaller communities might economically and safely install public water supplies. Seventy-eight municipalities whose population is less than 1,000 now have public supplies.

Waterworks were installed during 1914 at Bellwood, Pearl, Piper City, and Princeville. Bellwood formerly obtained water from Melrose Park. The installation of water supplies in several other municipalities has been suggested, and systems probably will be completed during 1915 in Benld, Carterville, Columbia, Cuba, Leaf River, Leland, Matteson, Red Bud, Stronghurst, and Winchester.

Water-purification plants installed before the end of 1913 are described in Bulletin 11, (pp. 12, 166). During 1914 purification plants were installed at Harrisburg, Centralia, and Aurora. The installation at Aurora was only to treat with hypochlorite of calcium an emergency supply from an abandoned quarry, and this supply will be abandoned after additional wells have been drilled.

Forty public water supplies were being treated at the end of 1914. Of these 32 were filtered for purification, 2 were filtered for removal of iron, 2 were treated by coagulation and sedimentation without filtration, and 4 were treated only for disinfection.

Though the State Water Survey, can make examinations of water at intervals for various municipalities, daily control, especially of surface supplies, is far more valuable than a few miscellaneous tests. Therefore it is interesting to note that to date 21 local control laboratories have been installed under the supervision of the State Water Survey. Waterworks officials thus enabled to know the condition of their water supplies readily appreciate this valuable means of efficiently controlling the supply and of economically procuring pure water.

LABORATORY WORK

From the time of its foundation, September, 1895, to December 31, 1914, 29,501 samples of water (see Table 2) have been received by the State Water Survey. Of these 18,185 were sent by private citizens, health officers, or waterworks officials, and the others, including 2,800 collected in 1899 and 1900 in connection with a study of the Chicago Drainage Canal, have been collected either by members of the staff or under their direction for the study of special problems.

The greatest number of samples from one type of source, 6,976, have been taken from shallow wells in drift, naturally enough, as such wells furnish by far the greatest number of private supplies. Only 468 samples of water from shallow wells in rock have been received because the greater part of the State is covered by 50 to 300 feet of glacial drift. Deep wells in rock have furnished 2,637 samples and deep wells in drift 1,576 samples; satisfactory water can be obtained from such sources in many parts of the State.

The large number of surface waters received (4,400) is due to the monthly control tests of filter plants, which are rapidly increasing.

The work on routine examination of ice is increasing because of the requirement of the United States Public Health Service that all ice used by the railroads in interstate traffic shall be approved by a department of health.

During 1914 2,772 samples of water were received (see Table 3), 1,667 of which were sent to the laboratory by health officers or private citizens. The number received during 1914 was greater than that in any other year since the establishment of the Survey, exceeding those received in 1913 by 20 per cent and those received in 1912 by 60 per cent. The most samples were received during July, and the least during February and April.

Well waters sent to the Survey for examination from 1907 to 1914 inclusive have been classified in Table 4[1] according to the depth of the wells. The number condemned decreases as the depth of the wells increases. The water is condemned from the data afforded by analysis considered in conjunction with information concerning the source of the water and the surroundings of the well. The condemnation is not because of the known presence" of disease germs, but because of the presence of filth and, therefore, the possibility of infection. During the 8 years mentioned 76 per cent of the samples from wells less than 25 feet deep were condemned, whereas only 12 per cent of those from wells more than 100 feet deep were condemned; and many of the deepest were condemned because of the excess of the mineral content and not because of contamination; 43 per cent of the well waters were condemned. An improvement in the quality of the waters received for analysis during the latter part of the period has been observed. The character of the wells examined does not give a true idea of the character of all the well waters in the State for by far the greater number of samples are sent because of suspected contamination. In order to obtain a knowledge of the true condition analyses should be made of many representative samples collected from all parts of the State.

[1]Illinois Univ. Bull., State Water Survey Series 10, 79.

TABLE 2—NUMBER OF WATER SAMPLES EXAMINED AT THE DIRECT REQUEST OF PRIVATE CITIZENS OR LOCAL HEALTH OFFICERS, CLASSIFIED BY YEARS AND BY SOURCE.

Source	*1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	Total.
Surface waters, rivers, lakes, and ponds	69	72	102	54	59	61	97	75	80	107	304	336	356	372	428	196	393	640	599	4400
Springs	16	21	34	23	22	35	28	18	28	41	63	52	68	62	41	29	73	50	53	757
Cisterns	12	19	17	7	7	3	10	6	7	5	13	29	28	31	21	25	27	25	46	338
Natural ice	4	12	1	11	9	4	9	3	12	6	....	1	5	1	12	9	10	19	21	149
Artificial ice	....	1	....	2	1	....	1	1	1	....	4	....	....	0	0	1	0	....	2	14
Water for artificial ice	3	....	....	3	....	1	1	....	5	2	1	....	1	2	0	2	0	....	....	21
Water for natural ice	....	2	....	....	....	3	1	1	2	....	6	....	....	3	0	3	0	....	....	21
Mine water	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	5	11	10	26
Shallow wells in rock	28	16	8	22	12	22	10	17	25	25	19	45	32	58	43	29	31	20	11	468
Deep wells in rock	58	48	34	26	36	56	59	23	28	66	170	159	258	345	207	119	299	320	326	2637
Flowing wells in rock	45	8	16	12	13	14	8	8	9	11	22	17	43	3	2	2	9	6	....	243
Shallow wells in drift	500	245	168	243	274	209	243	245	270	292	442	514	683	614	344	256	436	435	563	6976
Deep wells in drift	64	65	43	30	24	36	68	54	51	40	114	164	160	159	95	103	138	152	28	1576
Flowing wells in drift	63	5	4	9	4	....	3	5	5	12	19	25	2	1	7	....	....	....	....	164
Sewage	37	....	21	25	10	....	1	7	2	6	5	33	46	5	1	1	6	3	4	213
Distilled water	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	3	2	5
Miscellaneous	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	53	....	....	53
Unknown	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	20	30	72	2	124
Total samples examined by request	899	517	448	467	471	444	529	463	525	613	1182	1365	1682	1651	1201	795	1510	1756	1667	18185
Other samples	888	811	988	1579	1866	778	147	419	555	466	445	55	87	73	101	279	214	460	1105	11316
Total for year	1787	1328	1436	2046	2337	1222	676	882	1080	1079	1627	1420	1769	1724	1302	1074	1724	2216	2772	29501

* Includes October to December, 1895.

TABLE 3—NUMBER OF WATER SAMPLES EXAMINED DURING THE YEAR ENDING DEC. 31, 1914, CLASSIFIED BY MONTHS AND BY SOURCE.

SAMPLES BY REQUEST	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Surface waters, rivers, lakes, and ponds	40	39	62	35	45	46	52	47	49	74	43	67	599
Springs	10	9	3	2	3	2	3	9	2	6	1	3	53
Cisterns	4	4	2	1	......	2	3	6	4	12	2	6	46
Natural ice	......	1	6	1	1	......	1	1	......	4	......	6	21
Artificial ice	......	......	......	1	1	......	......	......	......	......	......	......	2
Shallow wells in rock	4	1	2	1	......	......	1	......	......	......	2	......	11
Deep wells in rock	32	19	28	22	14	34	32	34	25	32	31	23	326
Shallow wells in drift	25	30	22	28	22	55	65	86	66	61	63	40	563
Deep wells in drift	6	4	2	1	8	1	1	......	1	2	4	3	28
Sewage	......	......	2	......	......	......	......	......	1	1	......	......	4
Distilled water	......	......	1	......	......	......	1	......	......	......	......	......	2
Mine water	1	1	......	6	......	1	......	......	......	1	......	......	10
Unknown source	......	1	......	1	......	......	......	......	......	......	......	......	2
Total	122	109	130	99	89	141	159	183	148	193	146	148	1667
MADE ON INITIATIVE OF WATER SURVEY													
Surface waters, rivers, lakes, and ponds	6	......	5	8	11	5	15	18	5	5	3	10	91
Springs	1	......	......	......	2	......	2	1	......	......	......	......	6
Cisterns	......	......	1	......	......	......	......	......	......	......	......	......	1
Deep wells in rock	8	8	22	2	31	11	11	15	15	9	9	6	142
Shallow wells in rock	......	......	......	......	......	......	......	......	......	......	1	......	1
Shallow wells in drift	5	1	11	2	5	4	8	10	5	5	3	4	63
Deep wells in drift	7	21	16	9	13	......	2	9	4	4	11	1	97
Sewage	......	3	......	6	5	......	75	......	......	1	15	......	105
Mine water	......	......	2	......	......	......	2	......	......	......	......	......	4
Specials													
Illinois River	11	1	13	13	26	37	27	27	24	24	25	33	261
Railway trains	26	......	......	......	28	30	......	......	......	......	......	9	93
Chicago deep wells	23	......	......	......	......	7	49	83	38	12	......	......	212
Cannery wastes	......	6	......	......	......	......	5	......	......	6	......	......	17
Gas-house wastes	......	......	......	......	......	......	......	......	......	12	......	......	12
Total	87	35	70	40	121	94	196	163	91	78	67	63	1105
Grand total of samples by request and those on initiative of Water Survey	209	144	200	139	210	235	355	346	239	271	213	211	2772

TABLE 4.—PERCENTAGE OF WELL WATERS CONDEMNED BY THE "WATER SURVEY CLASSIFIED BY DEPTH, 1907-1914.

	1907	1908	1909	1910	1911	1912	1913	1914	Total
DEPTH LESS THAN 25 FEET									
Number examined	284	254	242	148	113	168	230	235	1674
Number condemned	240	192	183	118	74	113	155	189	1264
Percentage condemned	85	75	75	79	65	67	67	81	76
DEPTH 25 TO 50 FEET									
Number examined	224	395	354	201	196	353	262	331	2316
Number condemned	173	250	226	137	122	185	166	206	1465
Percentage condemned	77	63	63	65	62	52	63	62	63
DEPTH 50 TO 100 FEET									
Number examined	111	192	161	90	89	129	164	158	1094
Number condemned	42	66	54	46	8	28	54	47	345
Percentage condemned	37	34	53	51	9	22	33	29	32
DEPTH MORE THAN 100 FEET									
Number examined	161	312	376	205	171	339	603	633	2800
Number condemned	22	31	62	43	30	49	59	51	347
Percentage condemned	13	9	16	20	17	14	10	8	12
DEPTH UNKNOWN									
Number examined	88	46	72	67	19	27	83	65	467
Number condemned	34	22	38	35	9	6	21	24	189
Percentage condemned	38	47	52	52	47	22	25	37	40
Total number examined	868	1199	1205	711	588	1016	1342	1422	8351
Total number condemned	511	561	563	379	243	381	455	517	3610
Percentage of total condemned	60	46	47	53	41	38	34	36	43

SCIENTIFIC AND SPECIAL STUDIES

Though the members of the staff of the "Water Survey are engaged mostly in routine analysis and inspections their attention is called to many special problems relating to water, water supply, sewage, and sewerage, which usually are revealed by difficulties arising in various communities throughout the State. The following summary indicates the special work that has been done during 1914, the results of which are published elsewhere in this report. The regular staff has been assisted in this work by instructors and students in the University. During 1914 such assistance was given by H. E. Babbitt, C. R. Newell, C. Scholl, and H. J. Weiland.

Bureaus of water supplies. In an address before the laboratory section of the American Public Health Association at Jacksonville, Fla., it was pointed out that municipal, State, and Federal organizations should control public water supplies and should cooperate in enforcing regulations. As State and municipal organizations necessarily have only limited influence a national body with central and branch laboratories should be established and maintained **in** order **that** laws and regulations of general effect and importance may be properly enforced.

Possible functions of municipal laboratories. The establishment of control laboratories for water supplies is advocated in a paper read before the Illinois State Medical Society. Several such laboratories have been installed in this State ranging in size from a small laboratory to control an iron-removal plant to a large laboratory to control filtration and sterilization. A waterworks may maintain its own laboratory or it may have tests performed in a general municipal laboratory, which may be utilized by the health department for diphtheria, typhoid, and similar tests, by the street department for examining cement, limestone, and asphalt, and by the police department for analyzing alcoholic liquors, and similar materials.

Application of water analysis. The practical side of water analysis is shown in an address before the laboratory section of the American Public Health Association at Colorado Springs, Colo. In addition to aiding in protection from disease the water analyst can discover means of improving the water supplies for boilers and laundries by removing iron, manganese, and hardening or corrosive constituents, can detect pollution and obviate it for the proper support of fish life, can give reliable advice concerning the use of water from new wells, and can in general protect and improve water supplies.

Observations of some European water purification and sewage disposal plants. During the summer of 1914 European practice in sewage disposal by dilution, with different preparatory treatments, was seen at Munich, Dresden, and Hamburg. Fish ponds at Bergedorf were found to be fed by the effluent from Imhoff tanks and sprinkling filters. "Water softening by permutit at Berlin, Germany, and at Bradford and Houton, England, manganese removal at Munich, and sewage disposal by aeration in the presence of activated sludge at Manchester, England, were observed.

Examination of drinking water on railway trains. One hundred and two samples of water taken from cars entering the State from all parts of the country were analyzed. Fifty-three per cent of the waters did not pass government specifications. Better, water was found in sleeping and parlor cars than in smoking cars and coaches.

The pollution of Cedar Creek by Galesburg. Cedar Creek below Galesburg was found to contain insufficient water to make it possible to purify the sewage of Galesburg by dilution. It has therefore been advised that the city collect and dispose of its sanitary sewage and storm water in such manner that offensive conditions may be eliminated and prevented. As certain studies preliminary to the construetion of a disposal plant are necessary it has been recommended that competent engineering and other expert assistance be engaged to make the necessary studies preliminary to preparing plans, specifications, and estimates.

The disposal of canning-factory wastes at Eureka. The waste from the corn-canning factory at Eureka was satisfactorily purified by applying it to irrigation beds. During a few very rainy days the beds became water-logged and slightly odoriferous. No attempt has yet been made to grow crops on these irrigation beds.

Investigation of an outbreak of typhoid fever at Sparta. An epidemic of typhoid fever at Sparta was traced to infection of milk by a dairyman who had the disease.

Pollution of Mississippi River near Rock Island. Oily and tarry wastes from a gas house and two other factories pollute the channel of Mississippi River between Rock Island Arsenal and the cities of Moline and Rock Island. Suggestions for treatment of the wastes to abate the nuisance were formulated and submitted to one of the interested companies.

ASSOCIATIONS AND COMMISSIONS

Certain phases of Illinois water problems are of interest to several State, interstate, national, and international associations and commissions, which have been cooperating as far as possible in order to prevent duplication of work. In order to place before the citizens interested in the water supplies of the State information concerning the activity of those associations, it has been customary to publish a list of the organizations with abstracts of articles pertaining to the water supplies of Illinois. The organizations are noted below together with statements in regard to their work on water supplies in 1914. Titles and abstracts of articles published by these associations during the year are given elsewhere (pp. 249-54).

Illinois State Board of Health. (1877.) John A. Robison, M. D., Chicago, president; C. St. Clair Drake, M. D., Springfield, secretary and executive officer. By mutual consent the care of the water supplies of the State is in the hands of the State Water Survey. "Water analyses have been made for the State Board of Health when requested. The State Board of Health and the State Water Survey have cooperated in the investigation of several typhoid-fever epidemics.

Illinois State Geological Survey. (1905.) F. W. DeWolf, University of Illinois, Urbana, director. The State Geological Survey has charge of drainage investigations and is interested in the character of the water obtained from deep wells and the horizons from which the water can be obtained. Bulletin 24, "Some deep well borings in Illinois" by J. A. Udden, contains records of 43 deep wells in the State. Proper methods of sampling and interpretation of records are described.

State Public Utilities Commission of Illinois. (1913.) William L. O'Connell, 714 Insurance Exchange Bldg., Chicago, chairman. The commission, as an administrative body, has jurisdiction over all private corporations and individuals, as public utilities, owning or operating water or powen plants, but its powers do not extend to municipally-owned plants. It has extensive authority over reports, accounts, capitalization, mergers, intercorporate contracts, rates, services, and facilities. A certificate of convenience and necessity from the commission is necessary to authorize a new enterprise by a public utility, and the operation of the undertaking is brought under) its active control and regulation. Under the present law a public utility must be incorporated by the Secretary of State, before receiving a certificate of convenience and necessity from the Utilities Commission. No fees are charged by the commission in any action, except authorization of security issues. Much of the commission's work consists of the adjudication of complaints concerning the practices of public utilities.*

State Laboratory of Natural History. (1884.) Professor S. A. Forbes, University of Illinois, Urbana, director. The State Laboratory of Natural History is interested in the character of the streams of the State with respect to their effect on aquatic life. A special study is being made to determine the effect of Chicago sewage on the plankton and food fishes in Illinois River, the chemical work of which has been done under the direction of the State Water Survey.

Illinois Academy of Science. (1907.) The functions of the academy are the promotion of scientific research, the diffusion of scientific knowledge, and the unification of the scientific interests in the State. All residents of the State who are interested in scientific work are eligible to membership. Transactions have been published annually since 1907. The officers for 1914 were F. W. DeWolf, Urbana, president; E. W. Transeau, Charleston, secretary.

Illinois Society of Engineers and Surveyors. (1885.) J. A. Harman, consulting engineer, Peoria, president; E. E. R. Tratman, Wheaton, secretary-treasurer. Water-supply and sewage-disposal problems form an important part of the work of the members of this organization. The 1914 proceedings contained seven papers and reports relating to water and sewage.

Illinois Water Supply Association. (1909.) H. M. Ely, superintendent Interstate Water Co., Danville, president; Dr. Edward Bartow, Director State Water Survey, University of Illinois, Urbana, secretary-treasurer. The Illinois Water Supply Association is composed of persons interested in the waterworks and water supplies of Illinois. Papers dealing with topics of interest to. waterworks men are read at the annual meetings, which are held at the University of Illinois in February or March.

Sanitary District of Chicago. (1890.) Thomas A. Smyth, president; George *M.* Wisner, chief engineer, Karpen Bldg., Chicago. The Sanitary District of Chicago has continued its investigations of sewage disposal for Chicago during 1914.

Lake Michigan Water Commission. (1908.) Dr. G. B. Young, Health Commissioner, Chicago, president; Dr. Edward Bartow, Director State Water Survey, University of Illinois, Urbana, secretary. The Lake Michigan Water Commission, which was established in 1908, has for its object the investigation of the sanitary conditions of Lake Michigan, with a view to conserving a pure supply for cities and towns that depend on Lake Michigan for water. The commission comprises representatives from the United States Army and the United States Public Health Service and members, usually officials, are appointed by the governors of the States and the mayors of several cities which border the lake. No special appropriations are made for this commission, and no meetings were held in 1914.

Lake Michigan Sanitary Association. (1908.) A. J. Horlick, Racine, Wisconsin, president. This association, whose object is the protection of water supplies, is composed of representatives of city councils, health departments, and engineering departments of cities in Lake Michigan drainage basin.

North Shore Sanitary Association. (1908.) James O. Heyworth, Lake Forest, president; James F. King, Lake Forest, secretary. This association advocates proper sewage disposal and water supply for municipalities on the north shore of Lake Michigan, and its work until recently has consisted mainly in accumulating necessary data and promoting a campaign of education. A bill passed in 1913 by the State Legislature granted permission to organize a sanitary district in Lake County, and on April 7, 1914, the North Shore Sanitary District, extending as far north as the north limits of Waukegan, was formally organized by a vote of the people.

Rivers and Lakes Commission. (1909.) A. W. Charles, Carmi, chairman; Leroy K. Sherman, Chicago, and Thomas J. Healy, Chicago, members; Charles Christmann, State Bldg., Chicago, secretary.

Western Society of Engineers. (1895.) E. H. Lee, Chicago, president; J. H. Warder, 1735 Monadnock Bldg., Chicago, secretary. The annual meeting is held in Chicago. During 1914 the society held a symposium on the future sanitary problems of Chicago. The speakers were E. H. Lee, J. W. Alvord, G. A. Soper, J. D. Watson, and A. J. Martin.

International Joint Commission of the United States and Canada. For the United States, Obadiah Gardner, Chairman; Whitehead Kluttz, Southern Bldg., Washington, D. C, Secretary. For Canada, Charles A. Magrath, Chairman; Lawrence J. Burpee, Secretary. The sanitary condition of the boundary waters between Canada and the United States was referred to this commission, and a progress report in regard to the pollution of boundary waters was published by the commission in 1914.

United States Geological Survey. George Otis Smith, Washington, D. C, Director. The Survey has charge of stream measurements and other investigations of water resources of the country. Water-Supply Papers are issued at frequent intervals.

United States Public Health Service. Dr. Rupert Blue, Washington, D. C, Surgeon-General. The Public Health Service publishes bulletins and a weekly journal entitled "Public Health Eeports," containing current information regarding the prevalence of disease, the occurrence of epidemics, sanitary legislation, and related subjects.

American Water Works Association. (1880.) George G. Earl, New Orleans, president; J. M. Diven, Troy, N. Y., secretary. The 1914 annual meeting was held at Philadelphia. In 1914 the association began the publication of a quarterly journal which takes the place of the annual proceedings heretofore issued.

American Public Health Association. (1872.) W. C. Woodward, M. D., Washington, D. C, president; Selskar M. Gunn, 755 Boylston St., Boston, Mass., secretary. The official publication of this association is the American Journal of Public Health, a monthly magazine. "Standard Methods of Water Analysis" is also published by the association.

ENGINEERING REPORT

GENERAL SCOPE OF WORK

The investigations of the Engineering Division in 1914 may be classed broadly as relating to water supply, sewerage, and sewage disposal, and water-borne epidemics. Investigations of water supplies have been given first consideration, but the close relationship found in many places between public water supplies and sewage disposal has rendered necessary investigation of sewerage and sewage disposal as well as water supply. The studies of sewage disposal have been materially aided by the cooperative agreement with the Rivers and Lakes Commission.[1]

PUBLIC WATER SUPPLIES

The examination of the public water supplies of the State was practically completed by special effort, only a few small communities less than 1,000 not having been visited at the close of the year. A list of the water supplies visited and described to the end **of 1914 is** given in Table 5. The waterworks of places whose names are printed in Roman type are described in this bulletin, and those of places Whose names are printed in italic type have been described in preceding bulletins.

TABLE. 5.—WATER SUPPLIES VISITED AND DESCRIBED BY THE ENGINEERING DIVISION, TO DEC. 31,**1914.**

Abingdon	*Batavia*	*Cairo*
Aledo	*Beardstown*	*Cambridge*
Alton	*Belleville*	*Canton*
Amboy	Bellwood	*Carbondale*
Anna	*Belvidere*	Carbon Hill
Anna, State Hospital	*Bement*	Carlinville
Arcola	*Benton*	*Carlyle*
Arlington Heights	*Bloomington*	*Carmi*
Arthur	Blue Island	*Carrollton*
Assumption	Blue Mound	*Cedar Point*
Astoria	Braceville	*Centralia*
Atlanta	Braidwood	Cerro Gordo
Aurora	Breese	*Chadwick*
Aviston	*Brookport*	Charleston
Barrington	Bushnell	*Chatsworth*
Barry	*Byron*	Chenoa

[1] Bull. 11, 22.

Chester
Chicago Heights
Chillicothe
Clinton
Coal City
Collinsville
Creal Springs
Crystal Lake
Danvers
Danville
Decatur
Deer Creek
Delavan
Dixon
Duquoin
Dwight
Earlville
East Dubuque
East Dundee
East St. Louis
Edwardsville
Effingham
Elgin
Elgin, State Hospital
Elmhurst
Elmwood
El Paso
Eureka
Evanston
Fairbury
Fairfield
Farmer City
Farmington
Flora
Forest Park
Forreston
Fort Sheridan
Freeburg
Freeport
Fulton
Galena
Galesburg
Galva
Geneseo
Geneva
Genoa
Gibson City
Gilman
Glencoe
Glen Ellyn
Granite City
Grayville
Great Lakes, U. S. Naval Training Station
Greenup
Greenview
Hamilton
Harrisburg
Harvard
Havana
Henry
Highland Park
Hillsboro
Hinckley
Hinsdale
Homewood
Hoopeston
Ipava
Jacksonville
Jerseyville
Johnston City
Joliet
Joliet, Illinois State Penitentiary
Kankakee
Keithsburg
Kenilworth
Kewanee
Kirkwood
Knoxville
Lacon
Ladd
La Harpe
Lake Bluff
Lake Forest
Lanark
La Salle
Lawrenceville
Lena
Le Roy
Lewistown
Lexington
Libertyville
Lincoln
Lincoln, State School and Colony
Litchfield
Lostant
Lovington
McHenry
McLeansboro
Mackinaw
Macomb
Manteno
Marengo
Marion
Maroa
Marshall
Mascoutah
Mason City
Mattoon
Maywood
Melrose Park
Menard, Southern Illinois Penitentiary
Mendota
Metropolis
Milford
Minonk
Minooka
Momence
Monmouth
Monticello
Morris
Morrison
Morrisonville
Mounds
Mount Carmel
Mount Carroll
Mount Morris
Mount Olive
Mount Pulaski
Mount Sterling
Mount Vernon
Moweaqua
Murphysboro
Nauvoo
Newton
Nokomis
Normal
North Chicago
North Crystal Lake
Oakland
Odell
Olney
Onarga
Oregon
Ottawa
Palatine
Pana
Paris
Paxton
Pearl
Pecatonica
Pekin
Peoria
Peoria, State Hospital
Peotone
Peru
Petersburg
Pinckneyville
Piper City
Pittsfield
Plainfield
Plano
Polo
Pontiac
Portland
Princeton
Quincy
Rantoul
River Forest
Riverside
Robinson
Rochelle
Rockford
Rock Island, Arsenal
Roodhouse
Rossville
Rushville
St. Charles
St. Elmo

Salem
Sandwich
San Jose
Savanna
Sheffield
Shelbyville
Sheldon
Silvis
Springfield
Spring Valley
Staunton
Steger
Sterling
Stockton
Stonington
Streator
Sullivan
Sycamore
Taylorville
Tinley Park
Tiskilwa
Tolono
Toluca
Toulon
Tremont
Trenton
Tuscola
Utica
Warren
Warsaw
Waterloo
Watseka
Waukegan
West Chicago
West Dundee
West Hammond
Whitehall
Wilmette
Winnetka
Woodstock
Wyoming
Zion City

REGULATIVE INSPECTION

The regulative work of the Engineering Division includes the examination and criticism of plans and specifications of proposed installations, improvements, or additions to waterworks, filtration plants, sewerage, and sewage-disposal plants and also investigation of local conditions in relation to such projects. New water-supply projects must be investigated in order to forestall expensive installations of improper equipment. Sewerage projects must be studied in order to protect the streams of the State itself against unreasonable or dangerous pollution.

In work of this nature the State Water Survey does not attempt to act as a consulting engineer, but, on the contrary, advises employment of competent consulting engineers by local officials, thus placing the Survey in the attitude of an unprejudiced board of review. Though the work of the Engineering Division touches that of other State organizations duplication is avoided by close cooperation. Reference has already been made to the cooperation with the Rivers and Lakes Commission. The State Board of Health has referred many inquiries regarding waterworks and sewerage to the State Water Survey and has also requested assistance in the study of epidemics of typhoid fever suspected to have been caused by pollution of water supplies. Conditions relative to the occurrence of typhoid fever during 1914 were investigated at Collinsville, Marshall, Pana, and Sparta.

Places that have been visited by members of the Engineering Division for the purpose of inspecting special conditions of waterworks or sewerage or places for which plans of proposed waterworks or sewerage have been examined and criticised are named in Table 6. The places whose names are printed in Roman type were visited or plans were examined for them in 1914; the places whose names are printed in italic type were visited or plans were examined during previous years.

TABLE 6.—PLACES VISITED OR PLANS EXAMINED FOR PROPOSED INSTALLATIONS OR IMPROVEMENTS OF WATERWORKS OR SEWERAGE, TO DEC. 31, 1914.

Albion
Altamont
Alton
Anna
Anna, State Hospital
Arthur
Assumption
Astoria
Aurora
Averyville
Barrington
Barry
Belleville
Bellwood
Benld
Benton
Bloomington
Blue Island
Bradley
Breese
Cairo
Camp Point
Canton
Carlyle
Carterville
Casey
Centralia
Charleston
Chester
Chrisman
Clinton
Colfax
Collinsville
Columbia
Creal Springs
Cuba
Decatur
Deer Creek
Deland
Duquoin
East Peoria
Edwardsville
Effingham
Eldorado
Elgin
Elmhurst
Evanston
Fairfield
Farmington
Flora
Galena
Galesburg
Geneseo
Geneva
Geneva, Illinois State Training School for Girls
Genoa
Georgetown
Girard
Glen Ellyn
Grand Ridge
Greenville
Hamilton
Harmon
Harrisburg
Herrin
High Lake
Highland
Hillsboro
Jacksonville
Keithsburg
Knoxville
Lawrenceville
Leaf River
Leland
Lincoln, State School and Colony
Litchfield
Macon County Almshouse
Mansfield
Marion
Marissa
Matteson
Mattoon
Maywood
Melrose Park
Minonk
Moline
Monticello
Mounds
Mount Pulaski
Mount Sterling
Mount Vernon
New Athens
Nokomis
North Chicago
Oglesby (See Portland)
Olney
Onarga
Palatine
Pana
Peoria Heights
Peoria, State Hospital
Petersburg
Piper City
Portland
Princeville
Rankin
Red Bud
Reddick
Roanoke
Rushville
St. Anne
Salem
Sears
Sparta
Staunton
Stronghurst
Tinley Park
Tiskilwa
Toulon
Tuscola
Villa Grove
Warsaw
Watseka, Iroquois County poor farm
West Frankfort
Wheaton
Whitehall
Winchester
Witt
Yorkville

SPECIAL INVESTIGATIONS

Among the special investigations conducted in 1914, the most important of which were undertaken at the instance of the Rivers and Lakes Commission, may be enumerated the following:

Pollution of Cedar Creek by Galesburg. (p. 196)
Sanitary survey of Rock River watershed. (Not completed.)

Pollution of Sugar Creek near Bloomington. (Not completed).

Sanitary survey of Vermilion River near. Streator. (Not completed).

Investigation of an outbreak of typhoid fever at Sparta, (p. 229).

Investigation of disposal of canning-factory wastes at Eureka, (p. 235). :

Studies of special subjects also were made as noted in the following list:

Calumet River, Pollution of Grand Calumet River and Calumet Lake. (p. 42).

Elmhurst, Sewage pollution of Salt Creek. (p. 61).

Geneseo, Pollution of Geneseo Creek by city sewage. (p. 70).

Gibson City, Disposal of cannery wastes. (p. 73).

Grayslake, Pollution of watercourse by milk waste and house sewage. (p. 75).

Homer, Corrosion of boiler. (p. 84).

Jacksonville, Sanitary inspection of Chautauqua grounds. (p. 87).

Mendota, Pollution of Mendota Creek by gas-house wastes. (p. 106).

Mendota, Alleged nuisance due to wastes from corn-canning factory. (p. 106).

Pana, Nuisance by sewage disposal. (p. 120).

Pontiae, Nuisance by sewage disposal. (p. 123).

Springfield, Sanitary condition of State fair grounds. (p. 132).

EDUCATIONAL WORK

The educational work by the Engineering Division at the University comprised courses and lectures to senior students on purification of water and treatment of sewage. Public addresses on these topics were delivered and conferences were held with public officials in several cities.

ABSTRACTS OF ENGINEERING REPORTS.

The following pages contain abstracts of detailed reports of various investigations made by the Engineering Division during 1914 and references by number and page to abstracts of reports made prior to 1914 and printed in preceding bulletins of the State Water Survey. These abstracts are arranged in alphabetical order by name of city, village, or town. References to abstracts in previous reports are given in parentheses after the title of each investigation. The abstracts have been prepared from the original reports by Paul Hansen, Engineer, and have been edited by R. B. Dole. Capacities of pumps, yields of wells, and consumptions of water are stated in gallons per 24 hours unless otherwise specified. Depths of wells are given in feet from the surface of the ground unless otherwise specified. It should be understood that estimates of capacity, yield, daily consumption, consumption per capita, discharge of sewage, and similar amounts are rounded off to avoid expression of fictitious accuracy.

ABINGDON, Water supply.—(Bull. 11, 28.)

ALBION, Proposed water supply.—(Bull. 10, 89.)

ALEDO, Water supply.—(Bull. 10, 90.)

ALTAMONT, Proposed water supply.—(Bull. 11, 28.)

ALTON, Water supply.—(Bull. 9, 15; 10, 90; 11, 29). April 6, the proposed changes in waterworks equipment were studied. On May. 26, the engineer of the Alton Water Co. conferred with the State Water Survey concerning plans for the proposed modification of the purification works.

The average daily consumption of water is 4,000,000 gallons, but the daily consumption is frequently 6,000,000 or 7,000,000 gallons. Because of rapid increase of population and consequent extension of the mains consumption has rapidly increased and further increase may be anticipated.

The purification works have a rated capacity of 5,400,000 gallons, but cannot yield so much water in their present condition. The maximum reliable output is about 4,000,000 gallons a day. The clear-water basin holds 340,000 gallons, or only 2 hours' supply with a daily consumption of 4,000,000 gallons. The coagulating basin, whose capacity is 685,000 gallons, provides a sedimentation period of only 4.0 hours, an insufficient period of sedimentation for the water of Mississippi Eiver during periods of great turbidity; moreover, the basins are so arranged that their maximum effectiveness and displacement is not attained. The city is unable to obtain always a safe water free from objectionable turbidity and color. The water company officials have diligently prepared plans, but they have been greatly handicapped by the limited area of the company's property, the necessity of delivering water to consumers continuously while changes are in progress, and unusual difficulties caused by the proximity of Mississippi Eiver.

The proposed immediate changes involve construction of 10 new filters in the space now occupied by 6 wooden tub filters and part of the old coagulating and sedimentation basin. These filters are unusual in design because the space available is cramped by existing walls and other structures. The pipe galleries are underneath the filters instead of between two rows of filters. The filters are so large that it will be impracticable to wash them according to present practice from the mains and the clear-water reservoir, for the pressure in the distribution system would be unduly reduced and the limited storage would not yield sufficient water; consequently immediate installation of an elevated wash-tank was recommended. This could be inexpensively constructed on a near-by hill. A minimum capacity of 50,000 gallons was recommended, but as local conditions favor large capacity at low cost it was suggested that a tank of at least 200,000 gallons be built to furnish additional clear-water storage that could be utilized pending completion of improvements in the filter plant and the construction on the distribution system of a large storage reservoir, which has been projected for some time and for which a suitable site is said to be available.

It is proper, as Alton is growing rapidly, to anticipate soon a maximum daily consumption of 15,000,000 gallons, which represents the approximate maximum filter capacity that can be installed within the present limits of the company's property. Additional reaction chambers, coagulating basins, and filters that will take care of all reasonable future demands could be installed, however, after extending to the harbor line and acquiring land northward.

On April 6 alum was being used instead of lime and iron sulphate, but no material advantage over lime and iron had been found. Potassium alum, which is less efficient than the ordinary commercial filter alum, was, however, being used. The intake had given much trouble due to silt deposited by the river as a result of the construction of wing dams by the Engineer Corps, U. S. A., above the intake. The trouble was overcome by constructing over the intake pipe a wing dam of large broken rock, which caused a strong current to flow past the intake and produced a scouring action that obviated practically all the trouble.

ALTON, Proposed additional sewers.—On request of the Rivers and Lakes Commission the proposed sewerage for the district known as Upper Alton, until recently a separate incorporated community, was studied April 6.

Upper Alton is primarily a residential district, and the population that can ultimately be reached by the proposed sewers will probably not exceed 3,500. The proposed sewers are intended only for domestic wastes. Storm water will be removed in separate conduits, to be built as needed, and will be discharged into adjacent watercourses or ravines, of which there are several in or near Upper Alton. The plans and specifications call for standard construction throughout. All conduits will be of vitrified pipe 8 inches to 16 inches in diameter. Two outlets were originally proposed, one into the valley of Shields Creek and the other into the valley of Wood River, the sewage to be treated by means of septic tanks before discharge into watercourses. Further study, however, showed it to be better to have a single outlet into Mississippi Eiver, even though this involved the construction of long outfall sewers. Accordingly the project presented to the Rivers and Lakes Commission for approval provides for one outlet into Shields Creek just above its entrance into a slough of Mississippi River. The system includes 18.0 miles of vitrified pipe 6 inches to 15 inches, 0.5 mile of 12-inch and 16-inch cast-iron pipe, 144 brick manholes, and 21 brick flush tanks, at an estimated cost of $99,958.

This system involves no special features or peculiarities that warrant special attention on the part of the Rivers and Lakes Commission other than the outfall, which is subject to certain objections. During high water the slough into which Shields Creek empties is flooded and constitutes a side channel of the river. During dry weather it forms an estuary a mile or more long, through which the waters of Shields Creek discharge into the river. Shields Creek has a small watershed and a small dry-weather flow, essentially discharge from springs and condensers at several factories. This dry-weather flow is entirely inadequate properly to dilute the sewage from the new system, and the water near the mouth of the creek and in the slough will doubtless become foul and malodorous. Yet the slough is remote from habitations other than a few squatters' huts and house-boats, and the odor is not likely to give serious offence. The lower end of the slough will not be much fouler than it is now for a large volume of putrescible wastes now enters it from a box-board factory about one mile below the proposed sewer outlet. Though these wastes have been the subject of formal complaint the box-board company has found it advisable to prepare a more satisfactory outlet by digging a channel through the bottom lands opposite the factory to convey the wastes directly to Mississippi River. In view of these considerations it was recommended that the discharge of. sewage from Upper Alton at the bridge of the Chicago, Peoria & St. Louis Eailroad over Shields Creek be permitted as a temporary measure, to be followed at such time as conditions require by an extension.of the outfall to the main channel of Mississippi Eiver about 1,300 feet; it was further recommended that the construction of the outfall sewer be such as to facilitate its future extension.

ALTON, Nuisance complaint.—October 27, at the request of the State Board of Health, a complaint of improper disposal of sewage from Western Military Academy was investigated. This academy, with 225 students, had been polluting a small watercourse, but at the time of inspection the sewage was being satisfactorily treated by a small sewage purification plant consisting of a septic tank, a cinder bed, and means for adding hypochlorite as a sterilizing agent. The effluent at the time of visit was fairly satisfactory, but the unsystematic operation of the plant made it evident that good results could not be expected continually. The plant is entirely temporary as the sewers of the academy will soon be connected to an extension of the city sewers of Alton now being laid. Copies of the full report were sent to the secretary of the State Board of Health and to the president of the Western Military Academy.

AMBOY, Water supply.—(Bull. 11, 29.)

ANNA, Water supply.—(Bull. 9, 15; 11, 30.)

Sewerage.—(Bull. 9, 15; 11, 30.)

ANNA, State Hospital, New water supply.—(Bull. 9, 15; 10, 91.) In accordance with general recommendations made by the State Water Survey November 27, 1911, the Board of Administration engaged Dabney H. Maury, consulting engineer, to design and superintend the construction of a new water supply for Anna State Hospital to be obtained from Kohlers and Wilson creeks about 31/3miles west of the institution.

As the new waterworks neared completion the Survey was requested by the Board of Administration to inspect and test the plant; accordingly visits were made January 15 to 21, and February 4-5. The design of the waterworks was generally satisfactory. It comprised the following structures: (1) a 30,000,000-gallon impounding reservoir with a tributary watershed of one square mile formed in the valley of Kohler Creek by constructing an earth dam with a concrete spillway; (2) an intake into near-by Wilson Creek, which is largely fed by springs; (3) a mechanical filtration plant; (4) a pumping station equipped with 2 electrically driven service pumps of the triplex power type and 2 small low-lift rotary triplex pumps for pumping from Wilson Creek to the filter plant; (5) a pipe line 31/3 miles long from the pumping station to the hospital, 10 inches in diameter between the pumping and the equalizing reservoir and 12 inches in diameter between the reservoir and the hospital; and (6) a 2,000,000-gallon equalizing and storage reservoir. The topography of the site of the impounding reservoir is excellent, and the reservoir is near the Mobile and Ohio R. R. Though the supply obtainable from the reservoir is limited it will probably meet all the needs of the institution in ordinary years. In specially dry years Wilson Creek can make up the deficiency.

The general design of the filter plant is commendable. The arrangement is neat and compact and all important parts are readily accessible. The plant includes auxiliary devices which may insure effective operation, like indicating loss-of head gages, filter-rate controllers. a water-level gage for the clear well, and automatic signal bells on the chemical feeds, which ring when the feed devices are out of order or the chemical solution is exhausted.

The construction work is reasonably good, but all the concrete work is not strictly first class. The concrete in the filter plant is distinctly better than the average and it has been rendered quite acceptable by treatment with water-proofing compounds. The greatest danger to be apprehended is leakage from the coagulating basin into the clear-water reservoir through the dividing wall. At the time of inspection there was but slight seepage. On recommendation of the Survey a laboratory has been installed above the filters. The important considerations based on the two earlier visits are as follows:

(1) Imperfections in the concrete at the spillway of the impounding reservoir and at the equalizing and storage reservoir should be repaired. The wall that separates the coagulating basin from the clear-water reservoir should be carefully and systematically observed for leaks that may permit admixture of raw and filtered water.

(2) Positive provision should be made for preventing the admixture of water from the original sources of supply (the spring and deep wells on the grounds of the hospital) with the new supply by separating the distribution systems for fire protection and for domestic use and permitting only water from the new supply to enter the domestic system.

(3) Provision should be made for correct operation of the waterworks, to which end responsibility should be centralized and complete records should be maintained.

(4) The triplex power pumps should be made to operate with reasonable smoothness and with as little noise as practicable.

(5) Contamination of the equalizing and storage reservoir by careless or malicious persons should be prevented by removing the ladder or better by building a high iron fence around the reservoir at the edge of the embankment.

(6) The waterworks structures and grounds should be beautified as far as practicable by suitable planting.

A third visit was made April 18 to instruct the superintendent of waterworks and to test the filtration plant. The raw water was so good that the purification works had but little to accomplish. Gas formers were present in 10 cc. but absent in 1. cc. portions, the total number of bacteria was less than 300, the color was 20, and the turbidity 5. The treated water was materially better than the raw water; it appeared clear and was in every respect satisfactory. Verbal and written instructions were given to the superintendent for establishment of regular analytical control.

Another visit was made July 21-22 because of complaint of objectionable color, taste, and odors in the new supply. Brownish-black staining of plumbing fixtures and brownish-black deposits in pipes and on concrete walls over which the water flowed indicated the presence of manganese. Manganese to the extent of 5 to 12 parts per million was found in water from the reservoir, but none in water from Wilson Creek. Water freshly drawn from a tap showed little or no color, but that standing in a bottle developed a color of 30 parts in a short time and 75 parts in 36 hours, while a deposit formed in the bottom of the bottle. The presence of manganese, however, did not account for the objectionable tastes and odors. The odor was most pronounced over the filters and suggested decomposing vegetation. The surface of the reservoir was free from visible growths, but large slimy masses of green algae were floating in the coagulating basin of the filter plant. An examination of the algal growth showed *Cyanophyceae* in large numbers.

No definite recommendations for the removal of manganese were made as the problem seemed to involve complexities not covered by experience elsewhere. For the removal of taste and odor due to organisms, treatment with 1.75 pounds of copper sulfate per million gallons of water was recommended.

ANNA, State Hospital, Proposed sewage treatment.—Plans were received August 20 from W. S. Shields Co., Chicago, consulting engineers, for sewage-treatment works to be installed at the Anna State Hospital.

These plans, which embodied 2-story sedimentation tanks in such position as to permit later addition of filters, were reviewed and reported on to the Board of Administration and to the consulting engineers. The Board, was advised that tank treatment alone would not eliminate the nuisance in Cache Creek, though it might improve present conditions by preventing largely the formation of sludge deposits in the bed of the creek; and that the design and construction of secondary treatment devices should be undertaken as soon as funds could be available.

As limited funds were available for sewage treatment, not even sufficient to construct tanks properly, the Board postponed the matter of sewage treatment until it could procure additional appropriations from the Legislature.

AECOLA, Water Supply.—(Bull. 10, 91.)

ARLINGTON HEIGHTS, Water supply.—Visited July 7 and November 12. Arlington Heights is located in the north part of Cook County and has a population of about 2,000.

Waterworks were installed in 1900 primarily for fire protection. The supply was first obtained from a drilled well from which water flowed under natural pressure into a collecting reservoir. When a second well was sunk in 1909 the flow from the first well ceased. The present supply is obtained from the 2 wells, which are respectively, 5 and 10 inches in diameter. The smaller well is 127 feet deep and the larger well is somewhat deeper. Water stands 12 feet below the surface in both wells. The yield of the smaller well is not known but that of the larger well is about 180,000 gallons a day. Protection against contamination is provided by casings driven to rock and sealed to the concrete floor of the pumping station. A 100,000-gallon collecting reservoir adjoining the pumping station is 20 feet deep and triangular with sides 33 feet by 43 feet by 43 feet. It is covered with a concrete slab roof and earth. The pumping equipment comprises a 350,000-gallon deep-well pump, which discharges directly into the distribution system. The high-service pumping equipment comprises 2 compound duplex 430,000-gallon pumps. There are approximately 226 services of which 207 are metered. A 60,000-gallon elevated steel tank is connected to the distribution system and affords a pressure of about 45 pounds per square inch. A local manufacturing company has a 20,000-gallon elevated tank which receives its supply from the city mains. The consumption of water is about 45,000 gallons a day.

The water is of good sanitary quality as drawn from the well and the method of handling precludes contamination. It has a mineral content of 713 parts per million and a total hardness of 340 parts per million.

ARLINGTON HEIGHTS, Sewage treatment—(Bull. 10, 91.) Visited July 7 and November 12 to note the operation of the sewage-treatment plant which has been described. At the time of the earlier visit, owing to a leaky valve, about one-fourth of the sewage from the settling tank was leaking into the by-pass conduit and flowing directly into the stream. At the time of the second visit none of the filter beds were in use. The bottom and banks of the creek below the sewer outlet were covered to a depth of 6 inches with sludge undergoing active decom position. Disagreeable odors prevailed in that vicinity but owing to the remoteness of any buildings no complaints had been made.

AETHUE, Water supply.—(Bull. 10, 94.) The town is growing; several public improvements but no sewerage system has been installed. Construction of waterworks was authorized in 1911, but the works were not accepted as fully completed at the time of visit, March 6, owing to numerous leaks in the distribution system.

The supply is derived from 3 wells in the glacial drift, which discharge under natural pressure into a reinforced concrete collecting reservoir built in the ground over the wells. The water is pumped from the reservoir directly into the distribution system. The wells are about 75 feet deep, at which depth a water-bearing sand is encountered, and they are about 15 feet apart in such relation that lines connecting them form an equilateral triangle. The casings ars 8 inches in diameter to 55 feet and 6 inches in diameter for the remaining depth. No strainers are used and the water enters through the bottoms of the casings. The tops of the casings extend a few inches above the bottom of the collecting reservoir, which is 20 feet in diameter and 25 feet deep. The water ordinarily rises to within 12 feet of the top, a storage of about 30,000 gallons thus being provided.

The pumping machinery, housed in a small neat brick structure, comprises one triplex power plunger pump having a nominal daily capacity of 350,000 gallons. This pump is gear-connected with 20-horsepower gasoline engine. Duplicate pumping machinery can be installed when needed.

The distribution system contains 3.0 miles of 4-inch and 0.4 mile of 6- and 8-inch pipe. A short stretch of 2-inch pipe connects 4-inch dead ends and serves a few houses. A 50,000-gallon steel tank 110 feet high gives when full a static pressure of about 48 pounds throughout the built-up portion of the city, which is quite flat.

The water is of good sanitary quality but is rather highly mineralized. The hardness, consisting mostly of carbonates, is 300 parts per million. The content of iron, **2.2** parts per million, is almost certain to cause complaint.

ASSUMPTION, Water supply.—(Bull. **11,** 31.) Three additional wells had been added to the original group of 6 wells at the time of the visit October 24. The 6 original wells were grouped within a space 25 by 50 feet, but the 3 new wells lie in a southeasterly line and are spaced 100, 150, and 200 feet, respectively, from the original group. The 9 wells have 4-inch casings. Test borings indicate that the water-bearing sand extends at least 200 feet farther southeastward. Large areas of the water-bearing sand, into which the well system may be still further extended, lie north and south. Additional wells are easily and quickly put down by boring with a post auger to the sand and then driving down a casing while removing sand with a bailer. Test borings indicate that the pumping station is practically at the western edge of this sand area.

The pumping equipment, installed since prior visits, consists of a triplex power pump with a nominal daily capacity of 300,000 gallons, belt-connected to a **6-horsepower** gasoline engine.

ASSUMPTION, Sewerage.—(Bull. **11,** 32.)

ASTOEIA, Water supply.—(Bull. **11,** 32.)

ATLANTA, Water supply.—(Bull. **11,** 33.)

AUEOEA, Water supply.—(Bull. 9, 16; **11,** 34.) Aurora was visited June **10, 12-13,** and **16-22** at the request of local authorities in reference to procuring an emergency supply of water to supplement the deficient yield of the deep rock wells.

The most promising source of emergency supply was Esser quarry in the south part of the city. Though the water in this quarry was subject to some pollution it was relatively slight as compared with that of ordinary surface waters; moreover it was quite feasible to divert drainage of an objectionable character.

In accordance with recommendations made by the Survey the quarry was adopted as a temporary supply and the water was pumped into the mains by an electrically driven centrifugal pump. The water was rendered safe to public health by application of hypochlorite under careful analytical control. Recommendations were made that the city at once take steps to procure an abundant supply of water of unquestioned purity; in accordance with this recommendation contracts were awarded for drilling two additional deep rock wells.

AVERYVILLE, Proposed sewerage.—Averyville, which was visited July 1 preliminary to a report on plans for a proposed sewerage system on the separate plan, is located on Illinois Eiver on the north side of Peoria. Its present population is about 3,000. As the town occupies an area overlying gravel from which the water supply of Peoria is obtained the Peoria Water Co. desired to control the design and construction of the sewerage system in order that the source of the water supply of Peoria might receive adequate protection. The sewerage system will be built on standard lines of vitrified pipe with manholes at frequent intervals. The joints will be made of water-tight joint compound and special care will be taken in making them to avoid leakage so far as practicable. The sewers will discharge directly into Illinois River, which has an ample flow at this point to prevent nuisance.

AVISTON, Copper-sulphate treatment of reservoir.—(Bull. 11, 34.)

BARRINGTON, Water supply.—Barrington, visited July 9-10, is a farming and dairy center on the boundary between Cook and Lake counties, about 4 miles east of the McHenry County line. The village drains into a small branch of Fox River that passes through the western part of town. The population is about 1,500.

The waterworks were installed in 1898 by the municipality chiefly for fire protection. After five years' operation a contract was awarded to the local electric lighting company for operation of the pumping station at the rate of 5 cents per 1,000 gallons pumped, and in 1907 the contract was transferred to the Northern Illinois Public Service Co.

The supply is derived from a drilled well 305 feet deep entering rock at 200 feet. It has a 12-inch casing to rock and a diameter of 10 inches in rock. Little could be learned as to the character of the strata but the water probably comes primarily from the rock. The maximum yield is not known, but pumping at the rate of 200,000 gallons a day does not overtax the well. Water is raised by air lift into a circular concrete reservoir having a capacity of 57,500 gallons. From the reservoir it is pumped into the distribution system by an electrically operated triplex power pump having a nominal daily capacity of 220,000 gallons.

The distribution system comprises 7 miles of mains ranging from 4 to 10 inches in diameter, a little more than one-fourth being 4-inch pipe. Installation of 385 services indicates that the supply is generally used. A 95,000-gallon standpipe 50 feet high on an eminence about 80 feet above the general level of the village is connected with the distribution system. The average daily consumption is 162,700 gallons, equivalent to 108 gallons per capita and 423 gallons per service. The water is of excellent quality from a sanitary standpoint and is but moderately mineralized; the total residue is 397 parts per million, and the total hardness is 290 parts per million.

BARRINGTON, Proposed sewerage.—(Bull. 10, 94.)

BARRY, Water supply.—Barry, visited June 12, is a farming community with a population of about 1,700 in the west-central part of Pike County within 10 miles of Mississippi River.

When the waterworks were installed in 1880, chiefly for fire protection, a deep well was drilled near the edge of the city park and a pumping station and an elevated tank were built over it. About 190.9 the steam-driven deep-well pump was replaced by a deep-well power pump and a gasoline engine. The well is 2,510 feet deep, 7 inches in diameter at the top, and 2 inches in diameter at the bottom. No records of the boring could be obtained. Satisfactory water apparently was found at a depth of a few hundred feet but the drilling was continued in search of oil. That the water is derived from several strata is indicated by the fact that the first discharge is palatable, whereas that delivered after the pumps are in full operation is decidedly salty. The total residue of the water is 5,021 parts per million, 3,700 parts of which is salt; the water also contains much magnesium, calcium, and sulphate, and the total hardness is about 1,020 parts per million. The water is thus practically useless except for flushing and extinguishing fires.

The city officials are contemplating the development of two or three springs west of town for general domestic use. The springs can be protected against contamination and the plan is to let 2 springs that have a combined yield of 72,000 gallons a day flow into a reservoir and to pump from the reservoir into the city mains by electrically operated centrifugal pumps, the power to be obtained from the Mississippi River Power Co. If this supply is inadequate the discharge of a third spring somewhat farther away can be included. As the variation in flow from the springs is not known it is proposed to observe the flow during an entire season before development.

The distribution system comprises about 11/3 miles of 4-inch and 6-inch cast-iron pipe. There are 65 service connections, none metered. The elevated steel tank over the pumping station has a capacity of about 54,000 gallons and a total height of 86 feet.

BATAVIA, Water supply.—(Bull. 9, 16.)

BEARDSTOWN, Water supply.—(Bull. 11, 35.)
Pollution of Illinois River by Chicago Drainage Canal.—(Bull. 11, 35.)

BELLEVILLE, Proposed additional sewerage and sewage treatment.—Plans and specifications for an additional sewerage district at Belleville involving a new outlet were received June 20 from the Rivers and Lakes Commission with the request that they be reported on with special reference to the matter of final disposal. Belleville was visited June 29 by a representative of the Survey.

The proposed sewerage system is to serve a narrow stretch on either side of Rock Road, or West Main Street, a thoroughfare between Belleville and East St. Louis. This territory, about 5 miles long, has recently been annexed to Belleville. Part of the sewage will be diverted to existing sewers, but the remainder, that ultimately from about 1,000 persons, will be discharged near the source of a small tributary of Prairie du Pont Creek after having passed through a septic tank. The sewers will be built on the combined plan; the dry-weather flow will be diverted through the tank, but the storm flow will pass directly into the creek. The site of the septic tank is rather remote from habitations, but according to maps the stream flows near several houses a mile below the proposed site. This stream was chosen in preference to another watercourse to the north because the latter about 9½ miles below the contemplated point of discharge passed through a thickly settled portion of Bast St. Louis. This substitution seems unnecessary when it is considered that self-purification of the stream carrying the expected small volume of sewage would overcome all offensiveness within a few miles. The proposed tank is 51 feet long, 18 feet 9 inches wide, and 12 feet 9 inches deep, and it is divided into two chambers. The capacity of each chamber is 44,500 gallons. If the flow of sewage were 100,000 gallons a day, all that need be anticipated for about ten years, the retention period would be about 21 hours with both chambers in service and 10½ hours with one chamber in service.

Eecommendation was made that the method of final disposal of this sewage along Rock Eoad be disapproved, and that the city authorities be informed that continued pollution of the neighboring watercourses by partly treated sewage from existing and proposed new sewers may not continue indefinitely, and that due cognizance be taken of the necessity of complete treatment of the sewage when any modifications or extensions to the sewers of the city are made.

BELLEVILLE, Water supply—(Bull. 11, 36.)

BELLWOOD, Water supply.—Bellwood was visited June 13 to obtain samples of and additional information regarding the recently installed water supply. The supply has been installed and equipped as described (Bull. 11, 37). Analysis of the water collected from the new well in 1914 showed the water to be of good quality from a sanitary point of view, but it has a mineral content of 521 parts per million. The total hardness is 360 parts per million. Iron is present to the extent of 1.0 part per million, an unusual content for deep rock waters in Illinois. So far as could be ascertained, however, this has caused no general complaint.

BELVIDEEE, Water supply.—(Bull. 11, 36.)

BEMENT, Water supply.—(Bull. 10, 95.)

BENLD, Proposed water supply.—Visited May 24 and December 24; conference with the city officials in the office of the engineer of the Survey July 7. Benld is in the drainage basin of Cahokia Creek in the southeast part of Macoupin County. It is a comparatively new town that has grown rapidly because of the development of near-by coal mines. The population in 1914 is estimated at 3,000 and a population of about 5,000 is anticipated within 10 or 20 years.

Deep wells as a source of water supply are doubtless impracticable because of the high mineral content of any water likely to be encountered. Though shallow wells are not promising in the matter of yield yet several shallow dug wells in a ravine north of the village yield approximately 150,000 gallons per 24 hours. This would meet present requirements but would probably not meet reasonable future requirements. At the end of 1914 a dug well was still under observation and test. If dug wells do not yield sufficient water or if the water is too highly mineralized, an impounding reservoir may be constructed on Cahokia Creek or one of its tributaries.

BENTON, Proposed improvement of the public water supply.—(Bull. 9, 16; 10, 95; 11, 38.) Visited December 3. On previous occasions the Survey had recommended improving the Benton public water supply by installing a filter plant. The water company made representations that the size of its business does not warrant the necessary expenditures but indicated its willingness to adopt a makeshift method of improving the quality of the water by utilizing an old borrow pit about 50 feet wide and 2,500 feet long as a sedimentation basin following coagulation of the water and by sterilizing the water before delivery to the consumers. Investigation showed many difficulties in the way of utilizing the borrow pit in this manner; yet the proposition is not absolutely impracticable and would unquestionably be cheaper than immediate installation of a filter. Sketches were furnished by the Survey showing a suitable method for dividing part of the borrow pit about 400 feet long into 2 coagulating basins. Construction has not been begun at the end of 1914.

BENTON, Sewage treatment.—(Bull. 10, 96.) On April 10 the engineer of the Survey attended a conference before the Rivers and Lakes Commission with reference to treatment of the sewage from a portion of Benton. As this local matter could apparently be settled by negotiations between the city and the complainants no action was taken by the Survey or the Commission.

BLOOMINGTON, Proposed increase in water supply.—(Bull. 10, 96.) Visited April 7. Because of deficiency in the water supply of Bloomington early in 1914 the authorities requested advice regarding a proposed method of increasing the supply by diverting surface water and water from farm-tile underdrains into the water-bearing strata from which the wells obtain their yield. The situation was reviewed and various recommendations were made for certain tests, from which it was hoped to learn something regarding the feasibility and cost of such a project. Meanwhile the city had drilled an additional 12-inch well, whose yield was so large that this original idea of replenishing the ground water was abandoned.

BLUE ISLAND, Water supply.—At the request of the mayor the public water supply of Blue Island was inspected June 11 and September 30.

The water supply of Blue Island was originally obtained in 1883 from an open dug well near the summit of the rising ground composed principally of sand and gravel on which Blue Island is built. Operation of a sewerage system a few years later so reduced the level of the ground water that a new supply became necessary, and a dug well in a lower portion of town was utilized pending the drilling of the first of the deep wells in 1894. Another deep well was drilled shortly after and a third in 1909. Water from wells 1 and 2 was at first discharged into 2 connected circular cisterns beneath the floor of the pumping station and then repumped into the mains, but a storage reservoir outside the building has received the discharge of wells 2 and 3 since its construction in 1909. Though the water is very hard it met with general approval until the spring of 1914, when an odor of gas developed in the water from wells 1 and 2 and a film of oil showed on standing. A little later well 3 developed the same trouble to less degree. Though the water is raised by air lift the aeration does not drive off all the gas or remove the taste, and complaints have been numerous and persistent. The 3 wells are about 125 feet apart in the vertices of a triangle. Wells 1 and 2 are cased 10 inches in diameter to rock at 62 feet, and the bore decreases to 6 inches at 1,100 feet, the bottom of the well. The water is derived from St. Peter sandstone at about 910 feet. Well 3, which is 1,659 feet deep, enters the Potsdam sandstone about 184 feet. It is 20 inches in diameter at the top and 6 inches in diameter at the bottom. When it was drilled in 1909 the water rose to within 172 feet of the top, but in June, 1914, the water level was 230 feet from the top, representing a total lowering of 58 feet or nearly 13 feet a year. The present air-lift equipment in the 3 wells is capable of raising 1,000,-000 gallons a day.

No thoroughly satisfactory explanation for the taste and odor of gas could be advanced. A gas plant, which has been in operation several years about 1,000 feet southwest of the waterworks, seems to furnish the only plausible explanation of this contamination. Until a few years ago the gas company obtained its water from a well 287 feet deep whose water developed a decided taste of oil or gas after a short period of use. Another well 2,100 feet deep, drilled about 200 feet away to replace the 287-foot well, also developed a taste and odor of gas in a short time. Weight is given to the belief that the gas plant is the cause of the objectionable tastes and odors by a similar experience at Joliet, where the water from a well entering the St. Peter sandstone was seriously affected by an old gas plant near by. The difficulty has been successfully remedied at Joliet by construction of an aeration and sedimentation basin, comprising a sort of aerator followed by a baffled tank in which the water is further aerated by compressed air. Eecommendation was made to the local authorities at Blue Island to install a plant similar to that at Joliet.

BLUE MOUND, Water supply.—Blue Mound, an agricultural trading center with a population of about 900, was visited June 4. The recent shutting down of a near-by coal mine has materially reduced the population.

The original waterworks, established shortly after 1880, comprised a dug well near the center of the town, a small pump housed at the base of a wooden tower supporting a wooden elevated storage tank, and some wooden mains. The supply was maintained almost exclusively for fire protection. Improvements in the public supply made in 1912 included installation of a new pumping station, an elevated steel tank, and several miles of cast-iron mains. The source of supply is a well about 40 feet deep and 16 feet in diameter, lined with brick and surmounted by the pumping station. The water is derived from an apparently thick stratum of very fine sand encountered at 25 feet. The well was originally 50 feet deep, but it filled so rapidly with the fine sand that it became necessary to sink within the well another curbing of smaller diameter. The depth to which this inner curbing was sunk is unknown, but it is probably greater than the original depth of the well. The water is liable to contamination from near-by privy vaults both east and west, and filth may also find its way through the loosely boarded floor of the pump room over the well. The belief that contamination in this manner has occurred is strengthened by the results of examination of samples collected during the inspection.

The supply is inadequate even for a town so small. As the pumping equip ment, which has a capacity of 100,000 gallons a day, readily exhausts the well the pump can be operated ordinarily for 90-minute periods only morning and evening. During the dry summer of 1913 the city could not use the water supply for domestic purposes, owing to the necessity of conserving for fires the small quantity that could be pumped into the tank. The deep-well power pump, which is driven by a gasoline engine, draws from the well and discharges directly into the mains. The elevated tank, which has a capacity of approximately 40,000 gallons, rests on a steel tower 80 feet high. The pressure in the distribution system ranges from 35 to 43 pounds per square inch, and is relied on for domestic supply and fire fighting.

Private wells are in general use for drinking and culinary supply though there are 45 water takers on the distribution system, representing about 200 water users. The daily consumption is about 12,000 gallons, a little more than 13 gallons per capita. Though the waterworks could be more serviceable if a larger supply were available the local authorities and the general public seem to be giving but little thought to procuring additional supply.

BRACEVILLE, Water supply.—Visited May 21. Braceville, in the south eastern part of Grundy County in the basin of Mazon Creek, has a population of about 500, whereas twenty-five years ago the population was more than 2,000, the marked decrease being traceable to the exhaustion of neighboring coal mines.

The waterworks were installed in 1889 and have always been owned and operated by the municipality. The original supply was obtained from a dug well near the center of town. A deep rock well drilled about 1900 yielded water under sufficient pressure to render pumping unnecessary, but the pressure rapidly decreased. To revive the pressure an attempt was made to drill the hole larger, but it became clogged during drilling and had to be abandoned, and the old dug well was again utilized. The dug well is rectangular, 12 feet by 14 feet to a depth of 18 feet and 6 feet by 6 feet to a depth of 24 feet. Water-bearing sand and gravel was struck below blue clay at about 20 feet. The water rises to within 8 feet of the surface. The walls of the well are 2-inch plank and tight planking covers the top. "Adequate protection, however, is not afforded against surface drainage. The system is now maintained for fire protection only,, and the total pumpage is estimated to be only 850 gallons per 24 hours, much of which is delivered to a watering trough in front of the pumping station. The water is pumped from the well into the distribution system by means of 2 duplex steam pumps, each with a capacity of 420,000 gallons a day. The distribution system comprises about one mile of 3-inch wrought-iron pipe. No domestic service connections are permitted. A wooden tank 12 feet in diameter and 12 feet high about 16 feet above ground, with a capacity of about 10,000 gallons, is connected with the distribution system. When the tank is full it furnishes a pressure of about 7 pounds. The connections to it are so arranged that it can be connected with the suction of the pump and its storage utilized for fire fighting.

BRADLEY, Proposed sewerage.—(Bull. 11, 38.)

BRAIDWOOD, Water supply.—Visited May 19. Braidwood, one of the older coal-mining towns of the State, in the exhausted coal region of southern Will County, is said to have had a population of 9,000 about 1885, but its present population is only 1,500.

The waterworks, installed in 1883, are owned and operated by the municipality. The original supply consisted of 3 driven wells 12 feet deep procuring water from a subsurface layer of sand and gravel. These wells were gradually supplemented until there are now 7 tubular drift wells and one large dug well, which are capable of meeting the small requirements. An 1,800-foot rock well drilled about 1890 (?) yielded water under sufficient pressure to render pumping unnecessary, but the pressure rapidly decreased,' and an effort to revive it by increasing the diameter of the well resulted in clogging the well and necessitated abandoning it.

Analyses indicate that the shallow water is of good quality from a sanitary point of view and is not excessively hard or otherwise objectionable because of its mineral content. The seepage from several near-by privies may sooner or later pollute the water.

The consumption is only 8,000 gallons a day and the consumers number only 35, representing 156 people, or about 8 per cent of the population. The original pumping station was equipped with steam-driven power pumps for the wells and steam-driven direct-acting pumps for pumping from a collecting reservoir into the distribution system. This equipment was abandoned for electrically-driven pumping equipment in a small station under the near-by elevated tank. The power is furnished by the Northern Illinois Public Service Co. at 5 cents per 1,000 gallons pumped, the pumpage being calculated from readings of a meter on the main discharge of the pumping station. Pumping equipment is automatically controlled by the elevation of water in the tank. The wooden elevated tank has a capacity of 34,000 gallons and rests on a steel tower 92 feet high. As the total height is 110 feet and the town site is flat a pressure due to this head is exerted practically throughout the system, which comprises about 21/3 miles of 6-inch and 4-inch cast-iron pipe with leaded joints. No accurate records of the mains are maintained.

BEEESE, Water purification works—(Bull. 9, 16; 11, 39.) When Breese was visited April 8 and December 19 it was found that none of the alterations or modifications recommended by the Survey and relating chiefly to baffling the basins to effect more complete displacement had been made.

Though little purification is effected fairly satisfactory water can be delivered during periods of low turbidity of the raw water. The water delivered to the consumers April 8 was quite muddy; that delivered December 19 was reasonably clear. As no analytical control over the operation is maintained it is impossible definitely to state the quality of the water regularly delivered, but it is safe to assume that the filtered water is not generally so good as that indicated by a single analysis of a sample collected December 19 when the bacteria in both raw and filtered water were reasonably scanty and gas-forming bacteria were absent from the treated water. The tanks for preparation of chemical solutions are incorrectly designed, are wearing out, and must soon be replaced. The installation of adequate chemical-preparation and feed devices, the maintenance of adequate analytical control, and the disinfection of the water by liquid chlorine or calcium hypochlorite before delivery into the mains have been strongly recommended.

BEOOKPOET, Water supply.—(Bull. 11, 40.)

BUSHNELL, Water supply.—Visited May 13. Bushnell, in the northeast part of McDonough County on the divide between Crooked Creek and Spoon River, is an agricultural and manufacturing center with a population of about 2,700.

The waterworks, owned and operated by the city, were installed in 1889. As the first supply, which was obtained from 6 tubular wells entering a sand stratum at about 1.20 feet, was insufficient an open dug well to the same stratum was attempted, but the sides caved so much that the project was abandoned. A deep rock well drilled later to St. Peter sandstone is now the main source, and all the drift wells have been abandoned except one, which is retained for supplying boiler water. The desirability of having duplicate wells and machinery has been impressed on the city authorities' by the occasional necessity of shutting off the supply for the purpose of repairing the deep well or the deep-well pump. The inconvenience is especially pronounced when extensive repairs are made on the deep well, and the city now proposes to drill a second deep well. The present well is 1,352 feet deep and is located in the pumping station in the south part of town. It is 12 inches in diameter at the top and 6 inches in diameter at the bottom. The casing extends to a depth of 900 feet and the pump suction ends at

115 feet. The static level is now 52 feet below the surface and has not appreciably fallen since the well has been used. The drawdown is not known. The water is discharged from the well into 2 circular brick reservoirs, each covered with a conical metal-surfaced roof, and having capacities, respectively, of 63,000 and 43,000 gallons. The most severe draft was during August, 1913, when an average of 140,000 gallons a day was pumped, but the average daily consumption is only 80,000 gallons, equivalent to 30 gallons per capita and 240 gallons per service.

The water is of good quality from a sanitary standpoint, but it is rather highly mineralized. It contains 1,900 parts per million of total solids, about 70 per cent of which consists of sodium salts that impart a distinct taste to the water. As the water causes formation of hard scale in boilers it is generally avoided for boiler use. It has a marked corrosive action on well casing and iron pipe, which has to be renewed every few years. Cast iron, lead, and copper alloys do not seem to be seriously affected. The water from drift wells is said to be excellent for boiler use though no analysis is available.

The deep well and the shallow well used for boiler supply are equipped with steam-head deep-well pumps. The pump in the deep well has a nominal capacity of 260,000 gallons a day, but ordinarily can not produce this yield. Two duplex steam pumps with daily capacities of 500,000 and 750,000 gallons pump from the collecting reservoir into the distribution system. The distribution system, which serves completely the built-up portion of the town, comprises 5 miles of 4-inch to 10-inch cast-iron mains. Very poor records are maintained relative to the distribution system. There are 335 service taps, of which about 33 per cent are metered. About 60 per cent of the population use the water supply for domestic purposes. A new elevated steel tank, with a capacity of 100,000 gallons, is being erected to replace a steel tank that is unsafe.

BUSHNELL, Sewerage.—(Bull. 9, 17.) Visited May 13. Sanitary sewerage only has been built, but it serves nearly all built-up portions of Bushnell. As the incorporated area occupies portions of two drainage basins the system has been divided into two districts of approximately equal size, one discharging east through a 15-inch outfall in the valley of a small tributary of Spoon River and the other discharging west through a 15-inch outfall in the valley of a small tributary of Crooked Creek. At each outlet is a treatment plant. As Crooked Creek is used as a source, of public water supply by Macomb, a few miles below, it is deemed advisable to provide a higher degree of purification at the west than at the east outlet.

The branch into which the east plant discharges has its source on the edge of town, is little more than a small ravine, and flows mostly through open farm land. The concrete tank is of the 2-story type with a crude plank covering. The sedimentation channel along one side at the top is 4 feet wide and has vertical sides to a depth of 4½ feet, below which the sides slope at an angle of 45 degrees to a trapped slot at the bottom. The capacity is about 4,300 gallons, which provides a sedimentation period of 1.4 hours for the sewage of 1,000 persons at 75 gallons per capita per day of sewage. The sludge digestion chamber has a capacity of about 60 cubic yards, which should provide approximately 9 months storage. Suitable piping and valves are provided for withdrawing the sludge by gravity into the neighboring creek. The original plan provided for the discharge of the effluent into an evenly graded circuitous ditch 600 feet long with the expectation that this treatment would produce a degree of retention and aeration that would greatly improve the effluent. The ditch, however, filled with sludge so rapidly that it became necessary to provide the more direct outlet to the neighboring creek that is now used. As the sewage treated in this tank is very weak the effluent is rarely offensive and has not thus far given rise to complaint.

The treatment plant at the west outlet consists of a settling tank similar to the one just described and a so-called trickling filter. The original design included a building over the entire plant, but only the tank has been covered. The filter is enclosed by a brick wall, 20 feet by 30 feet in plan and about 8.5 feet high, on a concrete floor adjoining the settling tank. The floor slopes slightly from the ends toward a central effluent channel covered by a 6-inch half-tile. Tributary to this and at right angles thereto are 4-inch half-tiles laid close together on the floor. The filtering medium is broken drain tile 5 feet deep and ranging from 6 inches in greatest dimension down practically to dust. The distribution system consists of an elaborate arrangement of wooden troughs with lateral troughs 16 inches center to center, along which are ¾-inch holes at 12-inch intervals through which the sewage should flow onto the filter. If the quantity of sewage delivered to this plant were one-half the consumption of water, or 40,000 gallons a day, the detention period in the tank would be 2.6 hours and the rate of application to the filter would be 2,900,000 gallons per acre per day.

Because of rapid clogging the filter is out of service and the distribution troughs have floated from their original positions, the discharge of sewage onto the filter at 3 inlet points near the edge of the bed thus being permitted. A hole has been broken through the brick wall at the filter surface to permit the escape of sewage, and the sewage now flows through the tank, across the top of the filter by numerous passages formed by the troughs, and into the creek. No other manner of operation is possible because neither the filter nor the tanks can be bypassed. Though there was a distinct odor in the vicinity there have been no complaints even from habitations within 500 feet of the plant. During 1913 a farmer owning pasture land just below the outlet into the creek complained that his stock were dying as a result of drinking the polluted water; in consequence of this the city has leased the land immediately bordering the creek one-half mile downstream and have fenced it off to prevent access to the stream.

BYEON, Water supply.—(Bull. 11, 40.)

CAIRO, Proposed improvements in public water supply.—(Bull. 10, 96; 11, 40). Cairo was visited February 4 and March 27 at the request of Mayor W. H. Wood for the purpose of conferring with the city commission and addressing a public meeting on the subject of improving the water supply. As granting a new franchise to the present water company was contemplated the city authorities desired to procure information regarding improvements that are desirable or necessary at the waterworks.

CALUMET EIVEE. Pollution of Grand Calumet Eiver and Calumet Lake. At the request of the Eivers and Lakes Commission the alleged pollution of Calumet Lake and Grand Calumet Eiver between Calumet Lake and Hammond, Indiana, was investigated January 28-31. The complaint was originally made in a report by C. C. McQuirk, deputy game and fish warden, to George Brightman, district game and fish warden, as follows:

> "At your request I went to the Calumet Lake district to investigate the report that there was oil on the water and found report true. The Western Steel Car & Foundry Co. and the Eyan Car Works are located on the river in Hegewich. Both have large paint shops and sewers emptying into the river.

Several people that 1 interviewed told me that the chemical works, glue works and steel company located in Hammond, Gary, and East Chicago, Ind., have large sewers that also empty into the river causing the oil to flow. The Sherwin-Williams Paint Co. who call themselves the largest paint works in the world, located in Kensington, Ill., at 115th St., and Calumet Lake are violating the law by letting the paint and oil flow into the lake. There are several other firms located on the river doing the same thing."

This report was referred by the district game and fish warden to the Rivers and Lakes Commission, which referred the matter to the State Water Survey. The investigation revealed no marked objection by persons living on Calumet Lake and Grand Calumet Eiver on account of pollution. So far as testimony could be obtained there seemed to be no serious injury to fish life in Calumet Lake, though pollution of the stream is inimical to fish life at points along Calumet River, especially near Hammond and West Hammond. Inspection revealed, however, objectionable contamination by sewage, industrial wastes (partly from glue and paint works), and oily discharges from various factories.

It is probable that pollution can be considerably reduced by exercise of reasonable care on the part of various industrial interests bordering the waters in question, and this statement applies with special emphasis to oily wastes. Reducing the pollution to a concentration that will permit the use of Calumet Lake as a fish reserve might, however, entail great difficulties, the extent of which can be ascertained only by detailed inquiry into the various industrial processes conducted along Grand Calumet River and Calumet Lake. As such inquiry does not seem warranted it was recommended that an effort be made to effect improvement of conditions by sending letters of caution to various concerns now contributing to the pollution of the bodies of water under consideration.

CAMBRIDGE, Water supply.—(Bull. 10, 96.)

CAMP POINT, Proposed water supply.—(Bull. 11, 41.)

CANTON, Proposed improved water supply.—(Bull. 11, 41.) On request of Dr. Floyd A. Smith, health officer of Canton, an investigation was made July 1 of suspected pollution of the water supply. The danger seemed to center about a connection between the city mains and the private supply at the plow factory of Parlin & Orendorff Co. The private supply is taken from private wells and Big Creek, which is subject to serious contamination. The factory is the most important industry in the city, employing about 2,000 men in the manufacture of agricultural implements. The situation was fully studied and explicit instructions were given to the local authorities for overcoming any danger through the connection.

The city was again visited August 30 at the request of Dr. Smith to investigate projects for improving the water supply. Three projects were reviewed, (1) an impounding reservoir on Put Creek, (2) an impounding reservoir on Big Creek, and (3) wells in the bottom lands of Illinois River. The Put Creek development might be desirable in the remote future and the well project has many points of advantage, but the most economical and most satisfactory project would be an impounding reservoir on Big Creek. As an exposition of the relative merits of the projects required more thorough investigation and study than the Survey could conduct, it was recommended that a competent consulting engineer be employed by the city to prepare preliminary plans, estimates of cost, and a specific report on the most feasible project.

CANTON, Sewage disposal nuisance.—(Bull. 9, 17.)

CARBONDALE, Water supply.—(Bull. 11, 42.)

CARBON HILL, Water supply.—Visited May 21. Carbon Hill, in the east-central part of Grundy County in the basin of Mazon Eiver, has a population of about 400.

The water supply, installed in 1893, is owned and operated by the village. The water is delivered from a 1,900-foot well 8 inches in diameter. The casing extends into rock at 150 feet. The water rises to 20 feet, and the pump cylinder is set at 60 feet. When the well was drilled it flowed under sufficient artesian pressure to render pumping unnecessary, but this pressure has decreased to such extent that an elevated tank and a pump were installed in 1900 to secure an adequate pressure. In 1908 the tank was replaced by a wooden standpipe, 30 feet high, 15 feet in diameter at the bottom, 12 feet in diameter at the top, and a capacity of 25,000 gallons, and the small rotary pump was replaced by a well pump having a daily capacity of 97,000 gallons.

There are no records maintained relative to consumption of water, but according to the variations of the water level in the standpipe the daily consumption is in the neighborhood of 8,500 gallons, equivalent to 20 gallons per capita. The distribution system consists of 7,200 feet of 3-inch to 6-inch pipe. The number of service connections is unknown; all are connected with yard hydrants and not to interior plumbing. The service pressure is about 13 pounds per square inch.

The water is of good sanitary quality, but it is quite hard and has a mineral content of 1,287 parts per million. The total hardness is 460 parts per million. Iron is present to the extent of 0.8 part per million, but apparently it is not the cause of complaint.

CAELINVILLE, Water purification.—(Bull. 10, 97.) Carlinville was visited July 9, to inspect the plant of the Carlinville Water Co.

Though the plant was maintained in good physical condition the modifications recommended by the Survey in previous reports had not oeen adopted. The community generally depends on private wells for drinking water and does not expect a high degree of purity in the hydrant water. The fortunate lack of epidemics traceable to the public water supply is explainable by the fact that the source receives no continuous pollution. The average daily consumption is about 400,000 and the maximum daily consumption is about 500,000 gallons. This maximum is limited in dry times by the yield at present developed. Alum, the sole chemical used in treating the water, is applied only when the water carries objectionable turbidity, or about half the time. The solution is prepared in a tank 3 feet in diameter and 3½ feet deep. The alum, in a rack near the top of the tank, is sprayed with water at a rate approximately equal to the rate of outflow from the tank. Alum is added from time to time as needed. With such an arrangement it is not practicable in a small plant to prepare a solution of uniform strength. Sedimentation is afforded in a large wooden tank 24 feet in diameter, and 18 feet deep with a capacity of 61,000 gallons. If the daily pumpage were 400,000 gallons this tank would have a retention period of 3.66 hours. As the tank is not ordinarily full the retention period is thus cut down to 2 or 3 hours, and the efficiency of the basin is further reduced by a poor arrangement of baffles. The filter is a wooden tub 14 feet in diameter with 7-foot staves and a nominal capacity of

443,500 gallons per 24 hours. When this filter is out of commission the water is pumped direct to the clear-water basin. A wash-water trough extends around the circumference of the filter with its crest 21 inches above the surface of the sand. The trough is 4½ inches wide and 11 inches deep, a cross-section hardly adequate properly to carry off the wash water. The filtering material is 24 inches of Red Wing sand with an effective size of 0.40 mm. and a uniformity coefficient of 1.36. Beneath this is 12 inches of gravel graded in size from ¼ to ½ inch. The underdrain system is of usual design and has slotted brass strainers. The filter is not equipped with a rate controller or a loss-of-head gage, and it is operated at varying rates depending on the condition of the filter and the consumption of water. Wash water is supplied from the city main and it cannot be furnished at sufficient rate to wash the filter adequately without mechanical agitation, which is not provided. The clear-water reservoir at the time of visit was not adequately protected against surface drainage, but this matter has recently been remedied.

Recommendations were made to the water company relative to (1) improving the method of preparing and applying the chemicals; (2) rendering the filter parts more readily accessible and providing better control over the rate of filtration; (3) improving the method of washing the filter; and (4) procuring a water of assured good sanitary quality by treatment with a sterilizing agent.

CARLYLE, Water supply—(Bull. 9, 17; 11, 43.)

CAELYLE, Sewerage.—Plans and specifications were received April 4 for additional sewerage for Carlyle, and a report thereon was submitted to the Rivers and Lakes Commission. Carlyle, the county seat of Clinton County on Kaskaskia River, has a population of about 2,200. Sanitary sewerage installed in 1910 in the northern section of the community discharges eastward into Kaskaskia River immediately below a much-travelled highway bridge and a short distance below the waterworks intake and dam.

The proposed separate sanitary sewers comprise 5.5 miles of vitrified sewer pipe, and the plans and specifications call for standard construction. Attention was called to certain aspects of the plans and specifications which were not sufficiently rigid. It is proposed to discharge the sewage directly into Kaskaskia River without treatment at a point remote from habitations. Such disposal will doubtless be satisfactory for several years as the minimum stream discharge is about 50 second-feet. The final disposal of sewage is complicated by large quantities of putrescible wastes from a strawboard mill. These waste's have caused considable trouble by creation of a nuisance and destruction of fish; compared with this waste the sewage discharged is almost negligible.

Recommendation was made that the proposed plans and specifications for additional sewerage be approved subject to the condition that the sewage shall be treated in a manner satisfactory to the Rivers and Lakes Commission when treatment is deemed necessary by the Commission.

CARMI, Water supply.—(Bull. 11, 44.)

CARROLLTON, Water supply.—(Bull. 11, 44.)

CARTERVILLE, Proposed water supply.—Carterville was visited March 13-14 at the request of its commer.cial club to offer preliminary advice regarding a proposed public water supply. The projects presented and considered are outlined.

(1) The proposal to obtain water from Herrin is not feasible in view of the present water-supply development and the reasonable future requirements of that city.

(2) The supply of Herrin may possibly be made available by certain improvements and enlargements. First of all, the storage capacity of the impounding reservoir should be increased. It may also be necessary to construct an addititional storage reservoir and to procure additional catchment area by constructing a new dam across the" small stream one mile below the present dam. Utilization of the supply of Herrin should not be undertaken until thorough surveys and studies have been made to assure an average daily yield of at least 1,500,000 gallons, the quantity that will be required by the two communities within 20 years.

(3) Possibilities of procuring an independent supply should be further investigated, especially the abandoned Prosperity Mine and neighboring catchment areas that afford suitable sites for dams and impounding reservoirs. Investigations of the mine should include estimates of the quantity of water that may be continuously drawn from the mine, and if necessary long-continued pumping tests should be conducted.

(4) . No project should be considered that does not provide pure water either in its natural state or after artificial treatment. The present supply of Herrin should not be regarded as acceptable in respect to sanitary purity or visible muddiness.

(5) The-possibilities can best be presented on a comparable basis by securing the services of a consulting engineer well versed in water-supply matters, who should be instructed to make all necessary surveys, to prepare general plans and estimates of cost, and to render a comparative report on possible projects. This information should bring out clearly the quantity and character of water that can be obtained and the structures that will be required for each project.

CARTHAGE, Sewage disposal.—(Bull. 10, 99.)

CASEY," Proposed water supply.—(Bull. 10, 100.)

CEDAR POINT, Water supply—(Bull. 11, 45.)

CENTRALIA, Hypochlorite treatment of the public water supply.—Bull. 10, 102; 11, 45.) A recently installed hypochlorite treatment plant was inspected November 9. General instructions for operations and control of the hypochlorite treatment were given; full instructions could not be given owing to the absence of a control laboratory, which will be available, however, early in 19.15.

CENTEALIA, Sewerage.—(Bull. 10, 102.) At the request of the president of the civic league of Centralia, that city was visited June 15 to investigate final disposal and alleged imperfect construction of sewers then under contract. It was found that the work being done on the Eewers was not up to standard, and recommendations were made that closer inspection be given the work. The present method of final sewage disposal by passage through tanks with a short period of retention is inadequate and the city should look forward to the installation of more complete works. This emphasizes the necessity of maintaining the sewerage system as tight as possible in order that a minimum of sewage may be treated.

CEREO GORDO, Water supply.—Visited June 3. Cerro Gordo, on the watershed divide between Sangamon and Kaskaskia rivers in the southwest part of Piatt County, has a population of about 900.

Waterworks were installed in 1898 by the municipality chiefly for fire protection. The first installation consisting merely of a well near the center of town, a power pump driven by a portable steam engine, and a few distributing pipes. The system was improved in 1909, and it now includes an additional well, two well pumps, a gasoline engine, an elevated tank, and 4 miles of mains. The wells are 150 feet deep and penetrate blue clay until water-bearing gravel is reached near the bottom. Inflammable gas, which still bubbles up through the water, was encountered in drilling the wells, but it imparts no apparent taste or odor to the water. The old well is 6 inches in diameter and is seldom used. The new well is 8 inches in diameter with a 6-inch inner casing and constitutes the main reliance of the waterworks. Both wells are provided with strainers, the length and character of which could not be ascertained. No test has been made of the yield of the wells, but pumping experience would indicate a maximum yield for the larger well of 71 gallons a minute or a little over 100,000 gallons a day. The water level is ordinarily at 75 feet. There are about 100 services, which would indicate that 400 to 500 persons use the supply. A recent estimate of the daily consumption based on the number of hours the pumps are in operation indicates a variation of 13,000 to 45,000 gallons a. day or 15 to 51 gallons per capita per day. All the services are metered. The water is of good quality from a. sanitary point of view, but it is objectionable on account of its high content of iron and hardness, which render the water unsuitable for domestic use. The pumping machinery, which has a daily capacity of about 216,000 gallons, is housed in a neat brick station erected over the wells. The distribution system is 4-inch to 8-inch cast-iron pipe. A 34,000-gallon tank near the station supported on a brick tower which gives the structure a total height of 110 feet is connected with the distribution system.

CHADWICK, Water supply.—(Bull. 11, 46.)

CHARLESTON, Water purification.—(Bull. 10, 103; 11, 46). The operation of the water-purification plant was inspected June 2-3, October 16, and December 21-22.

The purification works were installed in 1912. The raw water is pumped into a mixing chamber, where it is treated with coagulant, from which it flows into an adjoining concrete sedimentation basin. The partly clarified water flows to the filters from the end of the sedimentation basin. There are 2 concrete filters, each with a nominal daily capacity of 500,000 gallons. The purification plant and the pumping station are operated 24 hours a day with 3 shifts. A 200,000-gallon tank 130 feet high was installed in 1914 on the distribution system. After the tank was built the pressure at the pumping station was found insufficient to fill it, and the pressure afforded by the tank also threatened the rising main from the pumping station to the city. To utilize the tank an electrically-driven centrifugal pump has been installed at the base of the tank structure, which sucks from the mains and pumps into the tank at night when the draught is low. This arrangement affords added fire protection to the community but considerably increases the cost of labor and care because the auxiliary pump is so far from the main station.

The plant was found to be untidy and poorly maintained. The windows were broken, the radiators were cracked, and little apparent attention was given to operation. The pumping station and machinery are still in the dilapidated condition described in previous reports. Chemicals are not used when the raw water is fairly clear, and no hypochlorite is added notwithstanding that the plant is equipped for its use. The alum is stored on a portion of the filter-room floor subject to flooding from the inlet compartment of the reaction chamber, which is not provided with an adequate control valve, and much of the chemical is thus dissolved and wasted. The operation of the filters seems to be satisfactory so far as mechanical equipment is concerned. Washing varies from once a day to 5 times a day depending on the turbidity. The pipe gallery criticized in previous reports because of its darkness and poor drainage had not been repaired, but it is understood that improvements in the lighting were about to be made. The water appears to be subject to some contamination due to the leaky condition of an old sedimentation basin which has been used for clear-water storage. This danger occurs only in periods of floods when the ground surrounding the basin are under water. No analytical control of the operation of the plant is maintained. Representations to the local officials failed to interest them in establishing a laboratory. Two sets of samples collected during visits showed reasonably good quality of the filtered water, but at both times the raw water also was of good quality. The actual bacterial removal was not great. The samples of filtered water in all but one 10-cc. portion showed absence of gas formers. These two isolated examinations of shipped samples, however, cannot be taken as correct measures of the performance of the plant.

CHATSWORTH, Water supply.—(Bull. 9, 17.)

CHENOA, Water supply.—(Bull. 9, 17.) Visited May 14. Chenoa, in the northeastern part of McLean County, has a population of about 1,300.

Waterworks were installed in 1895, and the source was a well 183 feet deep, which derived its supply from sand and gravel in the lower layers on the glacial drift. As the yield was inadequate an abandoned coal mine was substituted as a source of supply, but the coal mine caved in so badly in 1897 that it could no longer be utilized. A bored well in the drift, 22 inches in diameter and of unknown depth, was then utilized. Owing to the weakness of the casing, this well caved in after about 3 years' use, and the city derived water from wells belonging to the canning company from 1900 to 1911. In 1911 a deep well was drilled in the northwestern part of the city and a pumping station was erected over it, and since then this has been the public supply. This new well is 2,035 feet deep and obtains water chiefly from sandstone below 1,900 feet. The static level is at 40 feet, and the working level thus far has been lowered below the working barrel of the pump at 165 feet. The water is pumped from the well into a circular reinforced concrete covered reservoir of 100,000 gallons capacity, from which it is pumped into the distribution system by a triplex power pump having a nominal daily capacity of 360,000 gallons. Both pumps are belt-driven by a 20-horsepower gasoline engine. The distribution system comprises 4 miles of 4-inch to 8-inch cast-iron mains, more than half being 4-inch pipe. A 50,000-gallon steel tank, 60 feet high on a brick tower 70 feet high, near the center of town is connected with the distribution system. The total cost of the waterworks to date has been about $35,000, representing a per capita cost of about $27.

The water has shown slight evidence of contamination, which is probably due to surface drainage into the well through defects in the upper part of the casing, though this explanation has not been verified. The mineral content of the water, 1,275 parts per million, is high and the total hardness is about 240 parts per million. The water contains 1.1 parts per million of iron, but thus far this has not given rise to complaint.

CHESTER, Water supply.—(Bull. 0, 18; 11, 47.)

CHICAGO HEIGHTS, Water supply.—(Bull. 11, 47.)
Sewerage.—(Bull. 11, 48.)

CHILLICOTHE, Water supply.—Visited October 9. Chillicothe is on the west bank of Illinois River in the northeast corner of Peoria County. North Chillicothe, a newer town built around the freight yards of the Santa Fe By., joins it on the north, and the two villages are served by the same water supply. The combined population is estimated at 3,000 and growth has been rapid. A sewerage system has not yet become necessary owing to the ease with which liquid wastes are absorbed by the sand and gravel of the alluvium on which the villages stand. Though this easily disposes of the sewage it seriously interferes with the quality of the water supply.

Waterworks were installed in 1891 by a private individual under a 30-year franchise grant. Several wells were drilled on the bank of the river and these, with others that have been added since, constitute the source of supply. In 1910 the ownership was transferred to the Public Service Company of Northern Illinois. This company introduced several changes, chief of which was the substitution of electricity from central generating stations at Streator and Joliet for steam power. During the past summer the company has adopted the policy of installing meters on all services. As the meter rates appeared to result in higher bills to the consumers the matter was placed before the State Public Utilities Commission of Illinois, which ordered a lower schedule. Ten wells about 60 feet deep and 100 feet from Illinois River are in use. They are within a space 10 feet wide and 45 feet long inside the pumping station. Six of the wells are 6 inches and 4 are 4 inches in diameter. Strainers 10 feet long are placed at the bottoms. Water stands ordinarily at 17 feet and fluctuates in a general way with the level of the river. The maximum yield of the wells has not been determined, but they seem to yield readily an ample supply. The water is pumped directly into the distribution system by 2 triplex power pumps having daily capacities of 500,000 and 350,000 gallons. An old duplex steam pump with a nominal daily capacity of 350,000 gallons is kept ready for emergencies. The distribution system comprises 8 miles of cast-iron mains ranging from 12 inches to 4 inches in diameter. About 75 per cent is of 4-inch pipe, a proportion too great to give effective fire protection. A 100,000-gallon tank near the pumping station with a total height of 145 feet is connected with the distribution system. The pumps are regulated by an automatic electric starting and stopping device actuated by the difference in water level in the elevated tank. The limit of fluctuation in level thus regulated is 23 feet. The pressure in the system is 53 to 63 pounds per square inch depending on elevation. The consumption of water is daily observed by readings of a 4-inch meter on the main discharge. The average daily consumption according to these readings is 206,406 gallons, equivalent to 70 gallons per capita and 384 gallons per service. The pumps are run 12 to 18 hours a day.

The method by which the water is delivered into the distribution system prevents any contamination from handling. The general use of cesspools in the villages, however, introduces large quantities of contamination into the gravel deposits from which the water is drawn. Though the purification effected by percolation of the polluting matter through the soil has been sufficient to protect the public water supply up to the present, yet analyses show a marked increase in nitrogen content, particularly in nitrate, which is warning of a dangerous condition.

CHILLICOTHE, Pollution of Illinois River by Chicago Drainage Canal.—(Bull. 9, 19; 11, 50.)

CHRISMAN, Proposed sewerage.—(Bull. 11, 50.)

CLINTON, Contamination of water supply.—Visited August 12. Clogging of the strainer with sand in one of the wells constituting the ordinary source of supply caused the waterworks officials to use some polluted creek water while a new well was being sunk. At the time of inspection the new well had just been placed in service and pumping from the creek had been discontinued. Instructions for disinfecting the creek water with calcium hypochlorite were given to prevent danger from water-borne disease if use of polluted creek water should again become necessary. It was strongly recommended that the ground-water supply be developed to an extent that will eliminate any necessity for ever using the creek water. The new well is 12 inches in diameter and 341 feet deep. A 21-foot strainer, inserted at the bottom, consists of pipe perforated with more than 6,000 ½-inch holes and wrapped with a fine brass screen. It is hoped that this form of strainer will eliminate trouble heretofore encountered from fine sand.

COAL CITY, Water supply.—Visited May 20. Coal City is a mining and manufacturing town with a population of about 2,700.

Waterworks were installed in 1892 by the municipality, and the supply has always been obtained from a drilled well near the center of the city. When tho well was first sunk water flowed under sufficient artesian pressure to make pumping unnecessary, but the pressure rapidly failed until it became necessary in 1894 to install pumps. The city substituted electricity for steam, as motive power in 1910, and a contract was made with the Public Service Company of Northern Illinois to furnish electricity. At the time of visit an additional centrifugal pump for fire purposes was being connected with the well, but it had not been placed in service. The well is 8 inches in diameter and 350 feet deep. The pump suction is an inner 4-inch casing. No record of the well is available, but the water probably comes from St. Peter sandstone. It now rises to 32 feet, and the pumps are set in a pit 30 feet below the surface to avoid using deep-well pumps. According to the record of a meter on the main discharge line from the pumping station the average daily consumption is 220,000 gallons or 82 gallons per capita.

The water is of good quality from a sanitary standpoint, but its mineral content, 1,190 parts per million, is rather high. Its total hardness is about 390 parts per million. The distribution system is one mile of 3-inch galvanized iron pipe. A 115,000-gallon standpipe, 18 feet in diameter and 60 feet high, is connected with the distribution system.

COLFAX, Proposed sewerage.—(Bull. 11, 51.)

COLLINSVILLE, Water supply.—(Bull. 10, 104.)

COLLINSVILLE, Sewage disposal.—(Bull. 10, 104; 11, 51.) Visited June 29 and December 5. Collinsville has 3 sewer outlets, the sewage from which is treated in septic tanks. Sewage from so-called septic tank No. 1 is the cause of much complaint because it flows in. a small stream through pasture land and near habitations, and the city has been obliged to pay damages to riparian owners. More than $2,000 has been expended in extending the outlet, but this has resulted merely in transferring the nuisance to a point farther downstream and does not permanently abate it. Engineering studies preliminary to construction of proper treatment works have been repeatedly recommended by the Survey.

COLLINSVILLE, Typhoid Fever.—Collinsville was visited Nov. 30 to investigate an outbreak of typhoid fever suspected to have been caused by the water supply. It was apparent that the water supply had nothing to do with the outbreak, yet its actual cause was difficult to ascertain in the light of the limited in formation obtainable during the visit. Accordingly the matter was referred to the State Board of Health for further investigation.

COLUMBIA, Proposed water supply.—(Bull. 10, 105; 11, 51.) Columbia was visited October 26 to observe a pumping test on a proposed source of public water supply from an. abandoned coal shaft in the southwest part of town. A test well near the shaft gave an inadequate yield, but the indications of additional water were favorable and the city felt warranted in cleaning out and repairing the old shaft for further tests. These tests indicated a yield at the rate of 60,000 gallons a day, which, combined with the flow of a spring that may be developed later, should meet any probable demands for several years.

COOK, County poor farm, Sewage disposal.—(Bull. 11, 52.)

CREAL SPEINGS, Water supply.—(Bull. 11, 52.)

CEYSTAL LAKE, Water supply.—(Bull. 9, 19; 11, 52.)
Typhoid fever.—(Bull. 9, 19.)

CUBA, Proposed water supply.—Visited March 12 and December 2. Cuba is in the central part of Fulton County in the basin of Spoon River, which enters. Illinois River at Havana. It is a farming and mining community with an estimated population of 2,200.

On June 21, 1913, a bond issue of $12,000 was voted at a popular election for construction of waterworks. During the preliminary investigations the State Water Survey with the assistance of the State Geological Survey furnished information regarding water-bearing strata in the vicinity. On the basis of these data and recommendations of the city's consulting engineers contracts were awarded September 5, 1913, for drilling a deep rock well, which was completed March 10, 1914. The well is in the northwest part of the village anout 1,000 feet north of the public square. It is 1,768 feet deep, 12 inches in diameter to 1,000 feet, and 10 inches in diameter to the bottom. Water is obtained chiefly from St. Peter sandstone between 1,470 and 1,768 feet. The static level is at 103 feet. A pumping test gave a yield of 164 gallons a minute or 236,000 gallons a day with a 39-foot drawdown. The water regained its original level a few minutes after pumping ceased. The pumping station, the elevated tank, and part of the distribution system were completed in 1914. The distribution system when completed will comprise about 6½ miles of 4-inch to 6-inch cast-iron pipe. The brick pumping station, directly over the well and beneath the elevated tank, is 12 feet square and it houses an electrically driven double-acting deep-well pump. A 2-inch meter on the 4-inch main discharge of the pumping station causes serious obstruction to the flow. The elevated tank has a total height of 120 feet and a capacity of about 70,000 gallons.

The water is doubtless of good quality from a sanitary point of view, but the mineral content is 2,400 parts per million. Owing to the unsatisfactory character of the sample a complete mineral analysis was not made.

DANVERS, Public water supply.—Visited July 3. Danvers is in the western part of McLean County and drains into West Fork of Sugar Creek, a tributary of Sangamon Eiver. Its population is about 600.

Waterworks were installed by the municipality in 1892 for fire protection. The original source of supply was a 4-inch well 218 feet deep in the pumping station near the center of the village. The well pump delivered directly into the distribution system, which comprised 1.16 miles of cast-iron pipe, 4 to 8 inches in diameter. A 20,000-gallon elevated steel tank adjoined the pumping station. Another well was drilled in 1904 but it was not plumb. Two more wells, 8 inches in diameter, were sunk in 1907 to 220 feet. A fifth well drilled in 1913 did not yield enough water to make its utilization worth while. The 8-inch well drilled in 1907 now furnishes the entire supply. The water is pumped from the well into the distribution system by a 60,000-gallon steam-head deep-well pump. The. water-bearing strata apparently are sand and gravel in the glacial drift. These materials are prevalent in the vicinity and seem regular in stratification. Similar strata nearer the surface furnish abundant water to shallow wells, which are still extensively used throughout the village.

The public supply is of good quality from a sanitary standpoint, but it contains 1.6 parts per million of iron, which causes turbidity and discoloration, and has a total hardness of 300 parts per million.

No systematic records of water consumption are maintained, but a rough estimate based on the length of time the pumps are in service indicated an average daily consumption of 8,000 gallons, equivalent to 13 gallons per capita or 174 gallons per service.

DANVILLE, Water supply.—(Bull. 0, 19.) Visited June 9-10 and August 21. Danville is the seat of Vermilion County in the east-central part of the State, and it is situated at the junction of North Fork of Vermilion Eiver with the main stream. The city has enjoyed rapid growth, coal-mining and brick-making constituting the principal industries. The population is about 35,000. The city has many municipal improvements, including a sewerage system begun in 1885 and extended much since then.

Waterworks were first installed in 1883 when the city had a population of about 9,000. In that year the city gave the Danville Water Co. the right to construct, maintain, and operate waterworks for a period of 30 years, and fixed hydrant rentals and water rates. After various long-continued lawsuits involving the question of rate-making, a new 30-year franchise was granted August 23, 1907. In 1913 the company was reorganized as the Interstate Water Co.

The original structure at Danville was one brick building, divided into a boiler room and an engine room in the west part of town, on North Fork of Vermilion Eiver, which has always constituted the main source of supply. A standpipe 42 inches in diameter and 210 feet high, was part of the first installation, but this has been abandoned in favor of direct pressure. Early in the experience of the company the water of Vermilion Eiver was found to be very turbid at times; consequently a settling reservoir or pond with a capacity of 6,000,000 gallons was excavated in the bottom lands near the station only a few years after the installation of the plant. The sedimentation thus afforded gave partial relief, but the pond is now used only for storage in case of conflagration. In. 1902 the company installed a mechanical filter plant, greatly extended its mains, replaced the old timber dam with a concrete structure, installed a small hydraulic power plant to furnish part of the power required for pumping, increased the pumping capacity, and made other changes in equipment. Only 4 of the 8 filters were then equipped, but additional filters have been equipped as needed, and the last units were being put into commission in June, 1914. A new high-duty steam pumping engine was installed in 1910. Further improvements were made in 1912, when a building containing a laboratory, office, coal bunkers, and shop, a building containing equipment for treating the water with hypochlorite, and a storage house for chemicals were erected.

The rapid growth of Danville has put the company to some difficulty in keeping pace with increasing consumption. It has been apparent the past few years that the impounding capacity above the dam would soon be inadequate. A temporary solution of the problem was found by placing flashboards on the dam to the maximum height permitted by the banks; meanwhile a search was made for an auxiliary ground-water supply. Six 90-foot wells, which yielded much water, were bored in 1913 just beyond the northeast border of the city, but the water from them contains so much iron and is otherwise so highly mineralized that it is not regarded as acceptable in a community that has become so accustomed to soft clarified surface water. The possibility of installing pumps at the junction of North Fork with the main stream has also been considered, but the expense of this undertaking is regarded as prohibitive. In June the company was striving to meet demands by constructing another impounding reservoir 4 miles upstream from their concrete dam. The first installation will be a low temporary dam, which will be replaced later by a higher dam that will utilize all available storage. All bottom lands for 6 miles above the site have been purchased, and it is believed that this storage will meet the requirements of Danville for many years.

North Fork of Vermilion Eiver above the dam has a drainage basin of 26? square miles. This area is almost entirely farm land and is generally flat, and its soil is of loose absorptive character. The stream itself for several miles above Danville flows in a moderately deep valley bordered by pronounced bluffs. There are two municipalities in the area; Eossville (population, 1,500) is 25 miles by water and Hoopeston, (population 5,000) is 35 miles by water above the dam. Both towns are sewered and discharge their sewage into tributaries of North Fork after it has passed through septic tanks.

The river at the waterworks is subject to wide fluctuations in discharge. In the spring of 1913 during the floods prevalent throughout the Middle West a rainfall of 5½ inches in 3 days caused the water to overflow the surrounding land and threatened the operation of the pumping station and filter plant, but the danger was averted by hasty construction of temporary levees. The flow of the stream during the dry season is small, and for months is less than the consumption of the city. The storage capacity of the impounding reservoir is about 60,000,000 gallons. No data could be obtained on the capacity of the new reservoir. • Unfortunately the dam for it was not completed in time to store run-off from spring rains, and the city was threatened during 1914 with a serious water famine, which was averted only by expensive temporary utilization of 3,000,000 gallons a day of water from the drilled wells in the northeastern part of the city.

The average daily consumption is about 4,000,000 gallons and it is increasing annually at the rate of 250,000 gallons. The consumption in 1913 was 111 gallons per capita per day, 709 gallons per service per day, and 50,400 gallons per mile of mains per day. Though only 23 per cent of the services are metered the meters are on services that use 40 per cent of the supply. The company has many large consumers, including 3 railroads, a national soldiers' home, and a large manufacturing plant.

Except when the water drawn from the river is quite clear it is coagulated with iron sulphate and milk of lime. These chemicals are preferred to alum because they are less expensive and because they seem to remove the color from the water more satisfactorily than alum. This is specially noted because it is unusual. The iron sulphate is used in quantities ranging from 0 to 13 grains per gallon and the lime from 0 to 5 grains per gallon; the average is between 2 and 3 grains of iron sulphate and about one-half as much lime. Rapid fluctuation in the character of the water necessitates close supervision of the application of the chemicals. Turbidity as high as 1,500 parts per million and color as high as 7 50 parts per million have been recorded. A well-equipped laboratory is provided for maintaining analytical control over the operation of the filter plant. After the chemicals have been added the water passes into 2 concrete sedimentation basins, each 35 feet in diameter and 17% feet deep with a capacity of 126,000 gallons; this affords retention about one hour on the basis of the normal capacity of the plant during days of maximum consumption. Experience has shown that this period of sedimentation is too short because it permits not only incomplete sedimentation before the water passes to the filters but also incomplete reaction of the lime with the water, which results in incrustation of pipes in the plant and of the grains of sand in the filters. Before the settled water pasEos to the filters it is treated with an amount of calcium hypochlorite equivalent to 0.4 to 0.5 part per million of available chlorine, doses as great as 0.6 part having been applied only occasionally. A few complaints because of taste of chlorine have resulted, but there Eeems to be no popular prejudice against the water on this account.

Each of the 8 filter units has a daily capacity of 750,000 gallons. They are rectangular, constructed of concrete, and arranged in groups of 4 on either side of a pipe gallery. The rate of filtration is regulated by float controllers. Loss-of-head gages are provided but are not ordinarily used. Air and water are used alternately in washing the filters at the rate of 6 inches vertical rise per minute for water and a pressure of 4 pounds air. The present effective size of the sand is 0.62 mm. and its uniformity coefficient is 1.50. The effective size prior to incrustation with lime was 0.50 mm. and the uniformity coefficient was 1.32. Clear-water storage is afforded by an old 160,000-gallon reservoir, which was formerly an intake well and preliminary sedimentation basin, and by a circular concrete 1,196,000-gallon basin. This total capacity of 1,356,000 gallons is equivalent to 8 hours' storage during an average day and 5 hours' storage on a day of maximum consumption.

The low-lift pumping equipment comprises 2 centrifugal pumps, each with a daily capacity of 6,000,000 gallons, which may be driven by a steam engine or by water power. The service pumps are in 4 units, including 2 cross-compound high-duty pumps with daily capacities of 8,000,000 and 5,000,000 gallons and 2 duplex steam pumps with daily capacities of 3,000,000 and 2,000,000 gallons. Thus the total pumping capacity is 18,000,000 gallons per 24 hours. At the end of 1913 the distribution system comprised 77.28 miles of cast-iron pipe ranging from 4 to 24 inches in diameter, which adequately served the built-up sections of the city, and 5,500 services or 71 per mile of mains. A domestic pressure of 100 pounds per square inch is carried at the pumping station, and the pressure in the main on the higher land covered by the city ranges from 40 to 80 pounds. The domestic pressure in the main business district is about 70 pounds, and it is increased to 85 pounds during fires.

DECATUR, Filtration plant.—(Bull. 10, 106; 11, 53.) The water-purification plant recently installed at Decatur was inspected September 15-16. Various details of operation were discussed with the city authorities and consulting engineers. Since then the plant has been producing filtered water that is highly satisfactory to the consumers, but it has not undergone an official test, nor have all details of operation been adjusted. Steps have been taken, however, to employ a trained assistant to establish a laboratory and to operate the plant under careful laboratory control until all minor adjustments have been made. The plant presents an unusually neat appearance and it is well manned with efficient attendants.

DECATUR, Sewage disposal.—(Bull. 10, 107; 11, 253.) A preliminary report on sewage disposal at Decatur was submitted May 25 by the consulting engineer of the city. The report was based largely on a report by the Survey dated March 24, 1914, and published in full in Bulletin 11. The engineer's report was reviewed and approved. It consisted chiefly of affirmation of the Survey's recommendation and in addition recommended an investigation of the feasibility of developing an impounding reservoir on upper Sangamon River not only to afford additional storage for the water supply of Decatur but also to increase the dry-weather flow of the stream in order to give greater dilution at all times for sewage disposal.

A sewage experiment station was placed in operation on the Broadway outfall sewer early in 1914. The purification included preliminary and final sedimentation and filtration through sprinkling filters. This plant was installed primarily for observing the influence of the wastes from the works of the Staley Manufacturing Co., which shut down during the year; consequently it was deemed inadvisable to continue operation of the sewage experiment station.

DEER CREEK, Water supply.—(Bull. 10, 107; 11, 53.)

DELAND, Proposed water supply.—Visited February 20, March 2, and October 23. Deland, in the northwest part of Piatt County in the basin of Sangamon River, has a population of about 500. A bond issue of $9,000 was voted early in 1914 for construction of waterworks. The burning of one of the important business houses in the village undoubtedly had much influence on the outcome of the vote.

There are no accurate records of well borings in Deland and a few shallow wells in town have limited yields. The village is in a flat area of glacial drift about 160 feet thick. A few small driven wells drawing water from glacial deposits at a depth of 80 feet had never been required to yield more water than that necessary for individual household use. The most favorable indications for a large yield were near an old creamery used as the village hall, where the water in an 80-foot well of small bore rose nearly to the surface; accordingly a contract was awarded for drilling an 8-inch well in that vicinity, and on March 2 the new well was pumped with the working barrel at 70 feet. The water level, which was at 10 feet when the pump was operated, was rapidly drawn down, and the well did not yield continuously more than 15 gallons a minute. As this was insufficient a second test was arranged at the suggestion of the driller after certain modifications in the well had been made. . The well was damaged to such extent in making these modifications that it was abandoned. A second well located by the driller with a divining rod near the first well was drilled to the same depth, but it failed to yield more than the first well. The second well was then continued to 225 feet, the last 65 feet in rock, without finding additional water. Another 8-inch well was drilled about one-fourth mile south of the original well, but it was wrecked at 130 feet in dynamiting a boulder. As the water-bearing stratum encountered in the original well had not been encountered in the third well it was not deemed wise to make a new attempt in the same neighborhood. Accordingly a fourth well was started in October near the site of the first two wells. By drilling this well 12 inches in diameter it is hoped to procure from the 80-foot stratum sufficient water to meet the requirements of the village. This well had not been completed at the end of 1914.

DELAVAN, Water supply.—Visited October 31. Delavan has a population of about 1,200 and numerous municipal improvements have been installed though sanitary sewerage is lacking.

The municipal water supply, which has been in operation since 1887, was recently turned[1] over to the local electric lighting company. The supply is obtained from water-bearing strata in the drift at 140 feet, the two wells being 160 feet deep. The well first put down is 6 inches in diameter, and the other well, 8 inches in diameter, was sunk in 1899. The original pumping equipment consisted of a deep-well pump of the walking-beam type furnished with steam by a double-flue Scotch marine boiler. The well was equipped in 1894 with a steam-head deep-well pump. The original distribution system was wooden pipe, which became unserviceable after about 26 years. Pressure was maintained by a wooden tank on a wooden tower. The wooden tank was replaced in 1902 by a 55,000-gallon steel tank on a steel tower with a total height of 100 feet, and the wooden pipes were replaced by cast-iron pipe in 1912. The wells and the pumping station are in the center of town near the city hall. The wells are 30 feet apart in the pumping station and they appear to be adequately protected against contamination. No records are maintained of the water consumption, but an estimate based on the fluctuation of level in the elevated tank indicates an average daily consumption of 25,000 gallons, equivalent to 21 gallons per capita or 100 gallons per service. This low consumption is undoubtedly explainable by the limited use of indoor plumbing and the absence of sanitary sewerage. The pumping machinery, which pumps directly from the wells into the distribution system, has a daily capacity of 650,000 gallons. The distribution system comprises 4 miles of 4-inch to 12-inch mains. Eecords relating to the distribution system are very imperfect. The total cost of the waterworks to date including improvements is about $27,400, or $23.30 per capita. The improvements cost $16,400, or $13.96 per capita.

The water is of good quality from a sanitary standpoint, and it is fairly low in mineral content. It contains very few bacteria and gas formers are absent. The hardness of the water is 320 parts per million.

DES PLAINES RIVER, Sanitary survey above Riverside.—(Bull. 10, 66; 11, 54.)

DIXON, Water supply.—(Bull. 11, 58.)

DUQUOIN, Water supply.—(Bull. 9, 19; 11, 58.)

DUQTJOIN, Sewage disposal.—In response to a request made by local officials Duquoin was visited June 16 to investigate the alleged inadequacy of the method of sewage disposal. Complaints had been made by riparian owners along the small stream into which the sewage is discharged.

Duquoin has separate sewers, and the sewage is treated in a septic tank 40 feet in diameter and 10 feet deep and divided into 2 chambers. The effluent is piped one-half mile into a small stream northeast of the town. The stream has no flow under ordinary dry-weather conditions, and must be periodically ditched to keep it free from sludge. Several dwellings are within 500 feet of the outlet and the tank, and a public highway passes near the tank. On June 16 the tank was emitting very foul odors and the effluent had a dark unsightly appearance—conditions that undoubtedly justified any complaints that might have been made by property owners downstream. The tank had not been cleaned or given any other attention since it was placed in operation in 1907.

The inadequacy of septic treatment for eliminating the nuisance was indicated and recommendation was made that for immediate relief the contents of the tank be discharged into a suitable excavation and covered liberally with lime. This recommendation was followed and since then the tank has been giving very much better service. A similar difficulty may however be expected to recur any time, when cleaning will again be necessary.

DWIGHT, Water supply.—Visited May 18. Dwight is a farming center with a population of about 2,200. A private asylum for inebriates is located there.

The public water supply is obtained from 3 tubular wells 136 feet deep near the center of the city. The wells penetrate water-bearing sand and gravel at the base of the glacial drift at 108 feet. The works were originally installed in 1891, at which time they comprised one well, a steam pump, and short mains. In 1897 an elevated tank and a gasoline engine, auxiliary to the steam engine, were installed. To meet increased consumption an additional well was drilled in 1906 and another in 1908. By 1909 the steam machinery was practically abandoned and internal-combustion engines were exclusively used, but since 1911 an electric motor driven by power from the local electric lighting company has been used. The water is pumped from the wells into a circular concrete covered collecting reservoir of 50,000 gallons capacity, from which it is pumped into the distribution system by a 390,000-gallon motor-driven triplex power pump. The steam equipment, a gasoline engine, and 2 steam duplex pumps with a combined capacity of 1,000,000 gallons a day are still held in reserve for emergencies. The low-lift pumps for the wells have a combined daily capacity of 790,000 gallons. The daily consumption as measured by a Worthington meter on the main discharge from the pumping station averages 170,000 gallons, or 79 gallons per capita and 352 gallons per service.

The water is of excellent quality from a sanitary point of view, but it is rather highly mineralized, with a total hardness of 460 parts per million and about 0.7 part of iron, which is sufficient to cauEe more or less complaint on the part of the consumers.

The distribution system, which comprises 7 miles. of 4-inch to 8-inch cast-iron pipe with 483 service connections, 197 of which are metered, serves practically the entire built-up portion of the city. Several private wells are, however, still in use for. drinking. The 50,000-gallon elevated tank connected with the distribution system furnishes a pressure of 50 to 60 pounds per square inch in the distribution system throughout the nearly-level town site.

DWIGHT, Sewerage system and sewage treatment.—The combined sewerage system, which comprises somewhat more than 6 miles of 6-inch to 30-inch sewers, practically covers the built-up portion of the town. The large sewers are generally of brick and the small ones of vitrified tile. A crude attempt has been made to treat the sewage by placing at the outlet a cinder filter, which is a cinder bed 125 feet long, 20 feet wide, and 6 inches deep underlaid by a system of 8-inch drain tile. The main sewer discharges directly on this cinder bed and there is no means of regulating the rate of application. The effluent is discharged into a small neighboring creek. If the flow of sewage is equivalent to the consumption of water, 170,000 gallons a day, the filter ordinarily receives sewage at the excessive rate of 3,000,000 gallons per acre per day, and during storms, of course, receives much more. The filter has never operated successfully, even as a strainer. The sewage has eroded a channel directly through the bed of cinders, so that the liquid passes directly into the underdrains. The filtering material is very foul with sludge and stagnant sewage, and the stream below is badly polluted. Objectionable odors are observed in the vicinity, but inasmuch as there are no houses within 500 feet and only a few houses within 1,500 feet little complaint has been made.

EAELVILLE, Water supply.—(Bull. 9, 20.)

EAST DUBUQUE, Water supply.—(Bull. 11, 60.)

EAST DUNDEE, Water supply —(Bull. 9, 20.)

EAST PEOEIA, Proposed water supply.—(Bull. 11, 61.) Plans for a proposed water supply for East Peoria, received May 14, 1914, from the secretary of the commercial club of that city, were reviewed and reported with recommendations.

The proposed source of supply is a series of tubular wells in the drift deposits in the valley of Farm Creek near the junction of this valley with that of Illinois Eiver. The selection of this spot was presumably guided by previous investigations made by the Survey. During these investigations 4 samples of water from wells and springs were analyzed and the best water was that from a large dug well of the Lake Erie & Western R. E. near the chosen site. This well, which is 25 feet in diameter and 20 feet deep, will readily yield 150,000 gallons a day. Similar and also satisfactory water is obtainable from springs emerging from the bluffs in the valley of Illinois Eiver but development of that remote source would be more expensive.

Though the source selected was regarded as acceptable there was pointed out the danger of contamination because of the shallow depth at which water is obtained. To avoid contamination it was recommended that the city acquire sufficient land to prevent the construction of habitations or buildings within 500 feet of the wells. It was further recommended that the city by ordinances require that all privy vaults within 1,000 feet of the wells be so constructed as to prevent any polluting matter from getting on or into the soil, and that within a like distance no pig pens, manure bins, or other accumulations of filth shall be permitted. The plans were otherwise satisfactory and were approved, though recommendation was made that before deciding to use a standpipe the merits of such a structure be compared with those of an elevated tank and a reservoir on one of the near-by hills. It was further recommended that test wells be sunk and adequate pumping tests be conducted before extensive development of the ground water is undertaken.

EAST ST. LOUIS, Water supply.—(Bull. 11, 61.)

EDWAEDSVILLE, Water supply.—Visited Juno 9. Edwardsville, the seat of Madison County, drains into Cahokja Creek, which flows just north and west of the city. The city occupies bluffs overlooking the valley of Mississippi River. The population within the corporation limits is estimated at 5,500, but **1,000 or** more people also live in unincorporated suburbs.

In 1894 Jesse W. Starr attempted to establish waterworks at Edwardsville, but after failing to obtain a sufficient quantity of water from the valley of Cahokia Creek or from low-lying land between Poag and Wanda he was obliged to relinquish his franchise. The Edwardsville Water Works Co., organized in 1898 under a franchise similar to the first, sunk successful wells near Poag. Additional wells were bored as needed, and water is now pumped directly from these wells into the distribution system. The site of the wells is a sparsely populated sandy stretch of Mississippi River bottom land. The wells range in depth from 55 to 80 feet and obtain water from various strata of sand and gravel. There are two 6-inch and two 8-inch tubular wells 55 feet deep and one 9-inch and one 10-inch well 60 feet deep and.two wells lined with porous concrete pipe 28 inches inside diameter 70 to 80 feet in depth. The branch suctions from the pumping station enter each well below the frost line and descend into the water. A ninth well lined with porous concrete pipe to 40 feet, below which a 12-inch casing extends 20 feet, is operated by an air lift, but only when exceptionally large consumption demands it. The water is forced into a separate collecting reservoir, into which a suction line from the service pumps extends. The tubular wells are capped, so that surface contamination is not probable. The cement-lined wells are, however, open at the top, and therefore, subject to contamination by careless or malicious persons. The static level in the wells ordinarily is 22 feet below the surface, but as the pumps are about 7 feet below ground the suction lift is only 15 feet. The main collecting reservoir is an open rectangular concrete structure having a capacity of 450,000 gallons, but it has not been regularly used owing to the large yield of the wells. The water from the well operated by air lift is stored at one end of the reservoir in a small shallow basin formed by a dividing wall 4 or 5 feet high. The service equipment includes 2 duplex pumps, each with a nominal daily capacity of 1,000,000 gallons. The distribution system comprises 15 miles of cast-iron mains ranging from 4 to 12 inches in diameter. There are 750 service connections, which indicates that about 3,500 people use the public supply. An 84,000-gallon tank on a 100-foot brick tower, thus attaining a total height of 136 feet, is connected with the distribution system. Consumption records are not regularly maintained, but the average daily consumption is about 550,000 gallons, equivalent to 100 gallons per capita or 730 gallons per service.

The water is of good quality from a sanitary point of view, and it is only moderately mineralized. The total hardness is **180** parts per million, mostly carbonate hardness. The content of iron (1.8 parts per million) is enough to impart a distinct color to the water, but this is not a subject of popular complaint.

EDWARDSVILLE, Sewage disposal.—At the request of the Rivers and Lakes Commission Edwardsville was visited June 9 and September 11 in reference to objectionable discharge of sewage into Cahokia Creek. This creek, which has a very small dry-weather flow, becomes badly contaminated and gives serious offense to downstream riparian owners. Edwardsville has a population of about 5,500 and has a system of combined sewers divided into 4 districts, each with a separate outlet. The sewage from the district including the business section and adjacent territory passes through a so-called septic tank. The dimensions of this tank are unknown, but it is apparently limited in capacity and produces no improvement in the. sewage. The sewers have been installed from time to time without consideration of ultimate disposal, and moreover there are no maps or records in the city offices on which a design can be based for a comprehensive system of sewers that will utilize so far as practicable the existing sewers.

The city officials were, therefore, advised to engage a competent engineer to design comprehensive sewerage with special reference to inoffensive final disposal of the sewage. This advice has been complied with and surveys were under way at the end of 1914. Eecommendation was made to the Eivers and Lakes Commission that no order against the city be issued at the present time as the local officials apparently desire to remedy existing conditions.

EFFINGHAM, Water supply.—(Bull. 10, 108; 11, 63.)

Disposal of wastes from catsup factory.—(Bull. 9, 20; 10, 108.)

ELDORADO, Proposed water supply and sewerage.—(Bull. 9, 20.)

ELGIN, Water supply—(Bull. 9, 20.)

ELGIN, Proposed sewage treatment.—(Bull. 9, 147.) General plans and a descriptive report of the proposed treatment of sewage at Elgin were received May 18 from the Eivers and Lakes Commission for review and report.

Pollution of Fox River at and below Elgin had already received considerable study by the Survey and reports thereon have been published. The first important studies were made in October, 1911, primarily on behalf of Geneva, which was contemplating the installation of sewerage and was confronted with a threatened suit for injunction unless some provision were made for adequately treating the sewage before its discharge into Fox Eiver. A citizens' committee of Geneva employed the firm of Alvord and Burdick, engineers, to report on the situation, and that firm enlisted the cooperation of the Survey. A sanitary survey of Fox Eiver was made during 1913 by the Survey, which involved stream measurements and the collection of samples at various points. Unfortunately this survey was not made during low water. The results of this study indicate that the low-water flow at Elgin is approximately 90 second-feet; that a nuisance exists below Elgin in times of low water because of discharge of crude sewage into Fox River; that this nuisance has been aggravated by gashouse wastes; and that it continues to be aggravated by extension of the sewerage system of Elgin and the withholding of water behind power dams at Dundee and Carpentersville—a detention which at times reduces the flow in the stream below Elgin to practically nothing.

As the evidence afforded by the studies thus far made were insufficient to permit definite approval or disapproval of the submitted plans, which proposed treatment only by screening and sedimentation, the following recommendations were made:

(1) That the city install an automatic gage to aid in procuring a continuous record of the discharge of Fox Eiver during at least one dry season.

(2) That the city, with the cooperation of the Survey in so far as the means of the latter will permit, conduct a study of the sewage-diluting power of the water of Fox Eiver from above Elgin to below Aurora for the purpose of estimating the burden that each city within this district should bear with reference to maintaining the stream in a cleanly condition.

(3) That the city investigate the feasibility of effecting more dilution by impounding water in the lakes tributary to Fox Biver and report on this feature to the Eivers and Lakes Commission.

(4) That careful measurements of dry-weather flow of sewage from the

various outlets at Elgin be made and reported to the Eivers and Lakes Commission.

ELGIN, State Hospital, Water supply and typhoia fever.—(Bull. 10, 109.)

ELMHURST, Proposed improved water supply.—(Bull. 11, 64.) Elmhurst was visited June 20 to advise the city officials in reference to a proposed improved water supply. It was found, as so often happens, that engineering investigations were lacking; hence it was impossible to conclude competently as to the best plan for the village to adopt.

The present supply is obtained from a large spring in the valley of Salt Creek about 3 miles south of the village, and it is delivered and distributed in small-sized defective wooden mains that permit only very low pressures. The waterworks are owned and operated by a private company. As the service is inadequate the city officials desire improvements, but they are undecided, whether to purchase or utilize any part of the existing system.

It was recommended that the city engage the services of a competent waterworks engineer with instructions to study the situation for the purpose of ascertaining what portions of the existing waterworks might be used and how much the city is warranted in paying therefor.

ELMHURST, Sewerage.—(Bull. 11, 64.)

ELMHURST, Sewage pollution of Salt Creek.—A communication was received September 16 from the Rivers and Lakes Commission, requesting examination of a complaint submitted by Thomas P. Pick, et al., relative to the pollution of Salt Creek, otherwise known as Little Des Plaines River, at and below the sewer outfall of Elmhurst. In compliance with this request Elmhurst was visited September 21-22. Elmhurst is a rapidly growing residential village 14 miles from the center of Chicago with a population of 3,000 to 4,000. The volume of sewage is below normal owing to the small extent to which the public water supply is used. The dry-weather sewage probably does not exceed 170,000 gallons a day.

The basin of Salt Creek above Elmhurst has an area of approximately 50 square miles, which is ordinarily insufficient in Illinois to maintain a continuous flow of water. Because of the presence of springs in the valley of Salt Creek it appears that there is always some flow, even at the driest times. At the time of inspection a low stage was encountered when the flow did not exceed one second-foot, and the flow may be less than that at times. The stream consisted of a series of quiet pools, separated by short stretches of moving water. The sewage of Elmhurst is discharged into one of these pools and it renders the water exceedingly foul and evil-smelling for one-half to one mile downstream Considering the volume of diluting water available further continuance of the nuisance might be expected, but restriction of the nuisance is favored by the pools, which form natural sedimentation basins and permit long periods of detention wherein the sewage undergoes much purification. Yet though the linear extent of the nuisance is reduced by these favorable conditions the intensity of the nuisance below the sewer outfall is correspondingly increased. Foul conditions unquestionably existed in Salt Creek especially in the vicinity of the farm belonging to Mr. Thomas-P. Pick, and he, as well as other property owners, have just cause for complaint.

It was recommended that Elmhurst be required to cease polluting Salt Creek on or before January 1, 1917, to an extent that may in the opinion of the Rivera and Lakes Commission prove objectionable to riparian owners below; and that Elmhurst be advised to engage at once engineers to study the existing sewer age systems and to develop proper plans for collecting the sewage and conveying it to suitable treatment works or otherwise disposing of it in an inoffensive manner; and that these plans be referred to the State Water Survey for review and report prior to the awarding of contracts for any construction. In accordance with these recommendations an order was issued by the Rivers and Lakes Commission on Oct. 14, 1914, commanding that Elmhurst cease polluting Salt Creek on or before July 30, 1916.

ELMWOOD, Water supply.—Visited July 2. Elmwood is a farming community of about 1,400 population 6 miles north of Peoria on an area that is flat yet with good drainage southeast into Kickapoo Creek.

The waterworks were installed by the municipality in 1896 chiefly for fire protection. The source of supply is a well near the center of the city 1,487 feet deep 8 inches in diameter at the top and about 5 inches at the bottom. Little information could be obtained regarding the strata penetrated and their content of water, but the well is supplied chiefly from the St. Peter sandstone. The deep-well steam pump originally used has been replaced by an air lift. The water level is 72 feet below the ground and is apparently influenced but little by normal pumpage. When the well was once pumped continuously for 5 days at the rate of 100 gallons a minute, or 144,000 gallons a day, there were no visible signs of depletion.

The water is excellent from a sanitary standpoint, but it is highly mineralized, the total mineral content being 1,470 parts and the total hardness 365 parts per million. Though the well is in a thickly-settled district it suffers no apparent pollution from near-by sources.

The water is discharged from the well into a 51,000-gallon brick collecting reservoir 30 feet in diameter and 10 feet deep with a substantial roof with well-screened openings. It is pumped from the reservoir into the distribution system by a duplex steam pump having a nominal daily capacity of 200,000 gallons. The distribution system comprises 3 miles of cast-iron pipe 4 to 8 inches in diameter, but mostly 4 inches in diameter. There is no equalizing reservoir. The installation of 214 services indicates that three-fourths of the population uses the public supply. Only 52 per cent of the services are now metered, but the rest are being rapidly metered. The daily consumption according to the pump log averages 48,000 gallons and ranges from 62,200 to 38,300 gallons; these figures are very high, representing respectively 345, 447, and 276 gallons per capita per day. The cost of the waterworks to date is about $30,000 or $21 per capita. During the past fiscal year the income from water rents was $1,800, whereas the cost of operation including a few changes and extensions was $3,000; this excess of operating expenses is due partly to inefficient pumping and partly to low water rates.

EL PASO, Water supply.—(Bull. 10, 109.)

EUREKA, Water supply.—Visited October 30. Eureka, with a population of 1,600, is in the southwest part of Woodford County and drains into Walnut Creek, a tributary of Mackinaw Eiver. It has no adequate sewerage.

The waterworks were installed in 1889, when a 90-foot well was sunk in the northern part of the village into the glacial sands and gravels. The equipment comprised a steam pump, a pumping station, an elevated tank, and a small distribution system. Because of an insufficient supply in 1908 the village bored a new well near the city hall and erected a pumping station over it. A steel pressure storage tank and a collecting reservoir were installed and the old pumping station and well were abandoned. The new well, however, failed to yield an adequate supply and the pumping of 2 new wells close to it so affected its yield that they were abandoned. An abandoned coal mine shaft in the eastern part of the village was adopted as a source of supply in 1913. The shaft had been abandoned at a depth of 90 feet because great quantities of water had been encountered. To render the shaft suitable as a source of water supply it was lined with a 14-inch brick wall, cylindrical in cross-section, 8 feet by 14 feet at the top and 4 feet by 8 feet at the bottom. A small pumping station over the shaft is equipped with an electrically operated centrifugal pump 48 feet below the surface. Though this source seems ample the well near the city hall is kept in regular service, water from both mine and well being pumped into a 21,000-gallon collecting reservoir. It is pumped from this reservoir into the distribution system by a triplex power pump with a nominal daily capacity of 300,000 gallons. A triplex pump over the well and an air compressor are shaft-connected with a 15-horsepower motor and a 20-horsepower gasoline engine, the latter of which is reserved for emergency. The storage tank, 35 feet long and 8 feet in diameter, has a storage of only 2;000 gallons under the conditions of operation. The minimum pressure is. 45 pounds and the maximum 60 pounds per square inch; the pressure is controlled by an automatic starting and stopping device for the motor. The distribution system comprises 1.8 miles of 4-inch and 6-inch cast-iron pipe and 0.6 mile of 2-inch wrought-iron pipe. These mains reach most of the built-up district, but many families prefer to use private wells.

The public supply is of good sanitary quality, but it is objectionable on account of its high mineral content of 761 parts per million, its hardness of 600 parts per million, and the presence of 3.0 parts per million of iron, which causes marked discoloration.

EUBEKA, Disposal of cannery waste.—(p. 235).

EVANSTON, Water supply.—(Bull. 9, 21; 10, 110.)

FA1RBURY, Water supply.—(Bull. 9, 22.) Visited May 15. Fairbury, in the south-central part of Livingston County in the basin of Illinois River, has a population of about 2,500.

An open well 25 feet in diameter and 25 feet deep was dug, a duplex steam pump was installed, a wooden elevated tank and a tower were erected, and about three-fourths mile of 8-inch pipe was laid by the municipality in 1887. In 1892 the dug well was abandoned for a drilled well 2,000 feet deep and a pumping station and a 10,000-gallon collecting reservoir were built. The deep well is on a small plot of ground about two blocks west of the business center. It is cased to 394 feet with 8-inch standard pipe and again from 1,500 to 1,560 feet it is cased with 6-inch casing to shut out salt water. No complete record of the well could be obtained and it is not known from what formation the supply is derived. The static level and the drawdown also are unknown, but the supply seems ample for the pumping equipment that has been installed. An agitation has been started, however, for the installation of a second well to guard against breakdown of the first. The pumping station, built over the well and collecting reservoir, is equipped with a duplex fly-wheel steam service pump with a nominal daily capacity of 720,000 gallons and a simple duplex pump with a daily capacity of 225,000 gallons. The steam-head deep-well pump has a rated daily capacity of 710,000 gallons. An additional circular covered brick collecting reservoir of 63,500 gallons capacity built in 1898 was connected with the old reservoir, so that the two act as a single storage basin. In 1899 the old wooden tank was replaced by a new wooden tank on a brick tower and this in turn was replaced in 1913 by a steel 58,000-gallon tank having a total height of 110 feet.

No regular pumping records are maintained; a rough estimate of the average daily consumption is 400,000 gallons, or 157 gallons per capita and 800 gallons per service. The high consumption may be due to leaks in the mains, a number of which have recently been discovered.

The water is of good quality from a sanitary point of view, and though its total mineral content is 1,272 parts per million it has a total hardness of only 115 parts per million. It has a slight salty taste. The water proves reasonably satisfactory when used in boilers though it has a corrosive action.

The distribution system comprises about 4.7 miles of 4-inch to 8-inch cast-iron mains. A record of 495 service connections indicates that the public supply is in general use. Seventy-five per cent of the services are metered.

FAIRFIELD, Water supply—(Bull. 0, 22; 10, 110.) Visited May 13. The Fairfield Water Co. furnished Fairfield with its water supply from artificial ponds west of the village till late in 1913. The distribution system was limited and of small pipe, and the pressure was only that due to the slightly higher elevation of the reservoir. The city then commenced the installation of its own supply. One well 350 feet deep, 8 inches in diameter to 250 feet and 6 inches in diameter below that depth, was drilled a few feet from the municipal lighting station in the northwest part of the city. The casing extends to rock, which is encountered a few feet below the surface. Water is encountered in sandstones at 90 to 160 feet and at 180 to 240 feet. The water level is at 12 feet, but it is rapidly lowered by pumping. The elevated tank connected with the system was filled from this well, but the hardness of the ground supply as compared with that of the surface supply caused so much complaint that well water is now uEed only in emergencies. The water of this well has not been analyzed, but similar wells in the vicinity yield very hard water of high mineral content. Since this experience leases on the land surrounding the original reservoirs have been secured by the city and the private company has retired from business. The area tributary to the reservoirs is mostly pasture and cultivated fields with very few houses.

The water from the ponds flows by gravity into a 20,000-gallon reservoir at the pumping station, and this reservoir also receives water raised by air lift from the well. The water is pumped from the reservoir by an electrically-driven 2-stage centrifugal pump into the mains against a static head of 115 feet. The daily capacity of the pumps is 575,000 gallons. The distribution system comprises 9 miles of 4-inch to 8-inch cast-iron mains. Too much of the system (83 per cent) is 4-inch pipe. A 60,000-gallon elevated steel tank near the pumping station with a total height of 114 feet is connected with the system. In May there were but 50 services, and the estimated average daily consumption was 25,000 gallons, equivalent to only 10 gallons per capita or 500 gallons per service. The surface supply is very limited and will undoubtedly be inadequate when the public supply becomes more generally used.

No special care is taken to protect the water from contamination and even fishing is permitted. The supply must, therefore, be regarded as subject to dangerous contamination. A single analysis made in the laboratory of the Survey indicated that the water at the time of examination was not objectionably polluted, but such evidence cannot be considered to prove the absence of danger.

The mineral content is very low, and the total hardness is only 31 parts per million.

FAIRFIELD, Proposed sewerage and sewage treatment.—Plans and specifications for proposed sewerage and sewage-treatment works received June 30 from the consulting engineers for Fairfield. These plans were reviewed and a full report thereon was made to the Rivers and Lakes Commission.

Fairfield, the county seat of Wayne County, is situated in the basin of Little Wabash River, about 6 miles west of the main stream. Immediate drainage is afforded by Johnson Creek, which rises in the village. The population is about 2,500. The city is provided with waterworks.[1] The proposed sewerage comprises 8.85 miles of vitrified pipe ranging in diameter from 6 to 14 inches, and it practically covers the built-up portion of the city. The plans and specifications call for standard construction.

It is proposed to treat the sewage before final discharge southeast into Johnson Creek in a 2-chambered septic tank emptying into a small coke strainer. The chambers have capacities of 23,600 and 14,180 gallons, respectively, or a total of 37,780 gallons. The detention periods with a daily flow of 200,000 gallons will be, for the larger compartment 2.8 hours, for the smaller compartment 1.7 hours, and for both in parallel 4.5 hours. This detention period is so short that the tanks can hardly be regarded as other than plain sedimentation tanks. The proposed coke strainer will effect slight straining action at first, but it will soon become clogged and practically useless. The effluent that will reach Johnson Creek will undoubtedly be putrescible and will create foul odors that may be a nuisance to residents 600 to 1,000 feet from the creek. The most that may be expected from the proposed treatment under careful supervision and operation when the sewage reaches normal strength and flow, is the removal of suspended matter that might otherwise clog the channel of the creek and the removal of the grosser and more offensive floating solids.

Recommendation was made to the Elvers and Lakes Commission that the plans for the Eewerage system be approved, but that the plans for treatment of the sewage and final disposal of the effluent be not approved inasmuch as they do not insure a cleanly condition of Johnson Creek. It was further recommended that the local authorities be advised that when pollution of Johnson Creek becomes objectionable in the opinion of the Bivers and Lakes Commission said commission will take such steps as are necessary to cause the city to abate such objectionable conditions.

FARMER CITY, Water supply.—(Bull. 10, 111.)
Sewerage.—(Bull. 10, 111.)

FARMINGTON, Water supply.—Visited March 14. Farmington, in the northeast part of Fulton County on the watershed between Illinois River and Spoon River basins, has a population of about 2,500. The authorities are contemplating the installation of sanitary sewerage and many other improvements.

Waterworks were installed in 1893. Development of springs east of town and wells in the valley of the creek *1½* miles southwest of town were investigated, but both sources were regarded as too remote. A well 1,461 feet deep, which is supposed to terminate in St. Peter sandstone, was drilled. No record of the material penetrated is available. The well is lined with 269 feet of 8-inch and 876 feet of 6-inch casing and the remainder of the bore is uncased 6 inches in

[1]See p. 64.

diameter. When the well was drilled the water stood 78 feet 6 inches below the surface, but it now stands at 135 feet, an annual drop of about 2.8 feet. A test on the well is said to have indicated a daily yield of 250,000 gallons. The pumping equipment has been changed twice since the original installation, first to a different type of deep-well pump and in 1912 to an air lift. A second collecting reservoir was built in 1912. The pumping station was replaced in 1913 by a larger more substantial building. New high-service pumping equipment had been ordered before the inspection in March and was installed a few months later; it includes a centrifugal pump, a triplex power pump, and electric motors for operating them and the air compressor. Steam had been furnished by the local electric light company since the installation of the waterworks, but when this company was absorbed by the Central Illinois Public Service Co. the steam station at Farmington was dismantled and electric motors were installed at the waterworks, this substitution being cheaper in cost and operation than installation and operation of boilers. The water raised from the deep well by air lift is discharged into the collecting reservoirs, which have capacities, respectively, of 24,000 and 133,000 gallons, and it is pumped into the distribution system from the reservoirs by the 225,000-gallon triplex power pump. The 2-stage 1,000,000-gallon ceu trifugal pump is reserved for emergencies. No systematic record of the location of the mains is available. It is understood that the mains are cast-iron and range in diameter from 4 to 8 inches. A 90-foot 53,000-gallon standpipe in dangerous disrepair is connected with the distribution system. Little could be learned regarding the consumption of water, but it probably averages about 30,000 gallons a day, equivalent to 12 gallons per capita and 144 gallons per service.

The supply is of good quality from a sanitary standpoint, but it is high in mineral content, the total solids being 1,600 parts per million. Its total hardness is 340 parts per million, about half of which is sulphate hardness.

FARMINGTON, Proposed sewerage.—Plans for proposed sewerage and sewage purification in Farmington were submitted July 6 by the Rivers and Lakes Commission to the Survey for review and report.

Farmington drains chiefly into Littlers Creek, which flows northwesterly through the southwest part of the city into Spoon Eiver; Littlers Creek has a drainage area above the proposed point of sewage discharge of about 4 square miles. The system proposed for immediate installation comprises only sanitary sewers. It is planned to build storm sewers when paving is installed. The plans indicate a system designed along standard lines, and if they are properly carried out the system should prove satisfactory. All the conduits will be of vitrified sewer pipe 8 to 18 inches in diameter laid with cemented joints. The total length will be 6¼ miles. Manholes will be placed not more than 500 feet apart, and flush manholes will be placed at all dead ends. The system will have one outlet in the southwest part of the city in the valley of Littlers Creek, into which the sewage will be discharged after treatment.

The treatment comprises coarse screening, sedimentation in an Imhoff tank, and intermittent sand filtration. The city has purchased for the plant a tract of land in the valley of Littlers Creek 1½ acres in area remote from habitations though one house is within 1,000 feet of the property line. The creek at this point flows through a rather narrow deep sparsely wooded valley. On the whole the site is favorable but too small.

As a basis for considering the adequacy of the plans a daily flow of sewage of 200,000 gallons, or a population load of 2,000, was assumed to represent the development in the next 10 or 15 years that may reasonably be anticipated. The screen chamber is suitably designed though some modifications have been recommended in the constriction of the screen. The sedimentation tank provides a sedimentation period of about 4 hours and a sludge-storage capacity for about 9 months. Though the capacity of the sedimentation tank is rather large it will probably not prove objectionable inasmuch as the sewage will reach the tank in a fresh condition. The use of two sedimentation compartments, however, with a combined capacity of the one proposed has been suggested as an improvement.

A dosing chamber that follows the sedimentation tank provides for an average detention of about 1½ hours' flow, equivalent to 16 discharges a day or 4 doses a day on each of the 4 filters. The filters have a total area of 0.735 acre, which is not adequate for treating the assumed volume of sewage; the area cannot be depended on to dispose satisfactorily of the sewage from a population of more than 750. Though the desirability of constructing at once an adequate area for treating the sewage of 2,000 people may be questioned the sewage of at least 1,000 should be provided for, and the beds should be so arranged that future additions may be readily made. The proposed depth of filtering material is only 24 inches. A minimum depth of 3 feet should be used. The area of 1,000 square feet proposed for the sludge bed for draining the sludge from the sedimentation tank is ample for the size of the plant. The construction of the sludge bed is similar to that of the sand filters.

The following recommendations were made to the Rivers and Lakes Commission:

(1) That the area of the intermittent sand filters be increased to at least one acre and the beds to be so arranged that future enlargements can be readily made.

(2) That the screen chamber be so modified as to facilitate cleaning of the screen and to permit greater accumulation of solids on the screen than is possible with the design submitted.

(3) That the city authorities be advised to submit to the Survey modified plans for review and also samples of the filtering material for mechanical analysis before the same is placed in the filter beds.

FLOOD BELIEF WORK.—(Bull. 11, 65, 431.)

FLORA, Water supply.—(Bull. 9, 22.) Visited May 12. Flora, in the south-central part of Clay County in the drainage basin of Little Wabash Eiver, has a population of about 2,700. Several municipal improvements, including sanitary sewerage and a public water supply, have been effected in recent years.

The waterworks were installed in 1911 and 1912. Water is forced by air lift from 6 drilled wells into small receiving tanks and then flows by gravity into a covered rectangular reinforced-concrete reservoir with a capacity of 200,000 gallons. It is pumped from the reservoir into the distribution system by a 700,000-gallon 2-stage centrifugal pump driven by a steam turbine. The distribution system comprises 8.65 miles of 4-inch to 8-inch cast-iron mains. There are 278 services, all of which are metered. A 100,000-gallon elevated steel tank 150 feet in total height is connected with the distribution system.

The 6 wells are located in the city streets within 300 feet of the pumping station in a residence district. All are 6 inches in diameter and about 240 feet deep and are cased into the underlying bedrock to 40 to 60 feet. The water-bearing stratum is 110 to 160 feet below ,the surface; according to local statements it is a comparatively soft bluish sandy rock. The additional depth of the wells is necessary to provide suitable submergence for the air pipes. The yields of the wells, individually or collectively, are unknown, but the total is insufficient to meet present maximum demands in summer, which amount to about 150,000 gallons a day. Three of the wells do not yield sufficient water to warrant pumping them. The prospect of procuring additional water by sinking more wells is not favorable as private wells tapping the same water-bearing stratum throughout a wide radius are lowered by pumping the public wells.

The supply is of good quality from a sanitary point of view, but it is rather highly mineralized and rather undesirable for industrial or domestic use. It contains 689 parts per million of mineral matter and has a total hardness of 450 parts per million.

FLOBA, Sewerage.—Flora was visited May 12 to inspect the recently installed sewerage system.

The original installation comprised a main trunk sewer and laterals with a total length of 3.4 miles of standard vitrified sewer pipe ranging in diameter from 10 to 18 inches. Laterals have since been added to this system, but no reliable records of them have been maintained. The sewers, so far as could be learned, are built according to standard practice, and the workmanship is generally satisfactory. The sewage is conveyed to one point on the bank of Seminary Creek, a tributary of Little Wabash River. Before being discharged into the creek the sewage is treated in a septic tank a few hundred feet from the creek and remote from habitations. The installation comprises a combined grit and screen chamber of simple design and a 2-chambered tank, each chamber having a capacity of 50,000 gallons, which will give a detention period of 12 hours if an average daily flow of 200,000 gallons is assumed. This discharge may be reasonably anticipated within 10 years. Inasmuch as the flow of sewage has been small Seminary Creek has not been grossly contaminated, but serious contamination may be anticipated with more extensive use of the system.

FOREST PAEK, Water supply.—(Bull. 10, 112.)

FOREESTON, Water supply.—(Bull. 11, 65.)

FORT SHERIDAN, Water supply and sewerage—(Bull. 9, 23; 10, 112.)

FOX RIVEE WATERSHED—(Bull. 9, 147; 11, 66.)

FREEBURG, Water supply.—(Bull. 11, 66.)

FREEPORT, Water supply.—(Bull. 10, 113.)

FULTON, Water supply.—(Bull. 11, 67.)

Sewerage.—(Bull. 11, 68.)

GALENA, Water supply.—(Bull. 11, 69.) Galena was visited December 15 at the request of the local authorities to advise with reference to the quality of the water incident to proposed renewal of the franchise.

The public water supply of Galena is abundant and of exceptionally good quality. Several minor improvements in the equipment might be effected, most obvious of which are installation of a collecting reservoir at the pumping station and reasonable extension of the mains to cover the settled portion of the city. Danger of contamination of the water in the standpipe by birds can readily be obviated by a suitable cover.

It was recommended that the city should engage expert legal and engineering assistance in considering the renewal of the franchise.

GALENA, Sewage disposal.—The sewerage system of Galena has been built in a haphazard manner, is of unsuitable design and poor construction, and is altogether inadequate. Outlets have been, rendered ineffective by silting up of the river bed. The only adequate sewerage system for Galena is the separate system. All putrescible wastes and cellar drainage should be carried in sanitary sewers; this will involve installation of a small sewage pumping station for low-lying districts. Storm drains may then be laid at much shallower depths than those now prevailing, and this change would give them outlets into Galena River at suitable elevation.

Treatment works will sooner or later be necessary as Galena River does not at all seasons contain sufficient water adequately to dilute the sewage to prevent nuisance; this condition is likely to grow worse.

It was recommended that the village engage the services of a competent engineer to design a comprehensive system of sewers for the entire community.

GALESBURG, Water supply.—(Bull. 9, 23; 10, 114.) Galesburg was visited August 11 and 19, September 1, and October 13 to study possible contamination of and to devise means for improving the public water supply. Several samples were collected and the 6,000,000-gallon collecting reservoir and the site of a suggested impounding reservoir south of Knoxville were examined.

It was locally believed that the 6,000,000-gallon collecting reservoir was subject to contamination, but investigation showed that such contamination is not likely though analyses of water from the reservoir may give unfavorable results because of the entrance of small quantities of surface wash and the occasional presence of heavy organic growths. To prevent contamination by careless or malicious persons, however, it was recommended that the reservoir be better prortected. The most likely way in which contamination may result is through inadequate protection of the water between the wells and the reservoir. This inadequate protection exists at "sand catchers" intended to remove the sand from the water before it reaches the reciprocating pumps.

It was impossible to make formal recommendations regarding an improved water supply because of the inadequacy of available data. Informal communications outlining the relative merits of the several possibilities as revealed by available facts were, however, sent to the local authorities. Three ways of increasing the public water supply have been suggested: (1) increasing the number of drift wells that furnish most of the present supply; (2) increasing the number and size of deep rock wells that are at present an emergency supply; and (3) development of a large impounding reservoir on Haw Creek south of Knoxville.. Nothing but hearsay evidence that an abundant water supply can be obtained from the drift supports the first suggestion. Actual experience indicates that the maximum yield of drift wells has been reached. Costly investigations by means of tost wells would be necessary to determine definitely the feasibility of this project. Deep-rock wells of larger bore than existing wells would probably yield sufficient water, but the water would be more highly mineralized than that obtainable from the other two sources and the cost of pumping would be excessively great. Moreover the continued adequacy of such wells is by no means certain. The Haw Creek project has been fully reported on by competent engineers and combined with the existing supply would seem to meet the requirements of the city. The principal objection to this project is the first cost, about $400,000, but when the cost of operation is considered it appears more economical than deep wells. There is a popular misapprehension in Galesburg that the city must ultimately resort to Mississippi River for water supply, but this project would be excessively costly, and the water would not be so good as that obtainable from impounding reservoirs at less expense.

GALESBURG, Sewage disposal.—(Bull. 9, 23; 10, 114.) A communication was received January 21 from the Eivers and Lakes Commission requesting an investigation of Cedar Creek at and below Galesburg with reference to objectionable pollution. This request was accompanied by a petition signed by occupants of land along Cedar Creek below Galesburg. In compliance with these requests, visits were made to Galesburg March 4, 16-18, and June 29-July 1. The results of the investigation are embodied in a report which is printed in full on page 196.

GALVA, Water supply and sewerage.—(Bull. 10, 115.)

GENESEO, Water supply.—(Bull. 10, 116.)

GENESEO, Pollution of Geneseo Creek by city sewage.—(Bull, 10, 117; 11, 70.) At the request of the Rivers and Lakes Commission Geneseo was visited July 24 to investigate a complaint made by the city against the pollution of Geneseo Creek by the local gas plant for the purpose of simplifying the problem that the city must face in disposing more adequately of its sewage.

Observations during the visit made it apparent that gas-house wastes should not be permitted to enter the sewers because they injure the sewers, are the source of foul odors, and are likely to interfere with biological processes for final treatment of the sewage. Moreover the demand that the gas-house wastes be kept out of the sewers is reasonable because the wastes can be treated at small cost to produce an effluent uninjurious to the sewers or to the processes of purifications. On the other hand, there may be some question as to whether the Eivers and Lakes Commission should take action against the gas company or against the city inasmuch as the gas company uses the sewers under the city's control. Blanket action against the city providing for the elimination of all nuisance from Geneseo Creek would secure the desired results with less difficulty to the Eivers and Lakes Commission if there should not be proper compliance with the order of the commission.

In the light of these considerations it was recommended that the city of Geneseo be ordered to cease pollution of Geneseo Creek in order to eliminate nuisance and to preserve the waters of the creek for cattle watering and any other legitimate uses by riparian owners on or before January 1, 1916. It was further recommended that the city be invited to submit to the State Water Survey for review and report plans for accomplishing the desired result. As the Illinois Northern Utilities Co., owners and operators of the gas works, agreed to treat the gas-house wastes in a manner recommended by the State Water Survey, a request on the part of the city attorney to dismiss the case was allowed on Dec. 1, 1914.

GENEVA, Water supply.—(Bull. 9, 23.)

GENEVA, Sewage treatment.—Plans were received May 14 from the consulting engineers of Geneva for sewage-treatment works, which have since been installed, as required by order of the Bivers and Lakes Commission. Geneva, the county seat of Kane County, is on Fox River between Elgin and Aurora, and it has a population of about 2,500.

As the minimum discharge of Fox Eiver at this point exceeds 100 second-feet, the stream is amply able to dispose of the sewage of Geneva by dilution if the sewage is properly distributed throughout the channel. There are, however, certain objections to disposal by dilution at Geneva; first, the stream is already contaminated by Elgin, 9 miles above, and the water, therefore, will not have the same diluting power at Geneva as it would under normal conditions; secondly, the stream is much used at Geneva for pleasure, and it is lined on either side by residences and summer camps. It is, therefore, highly desirable to keep down pollution as much as possible, to free the stream of unsightly floating matter, and to prevent deposits of sludge. To meet these conditions the engineers have provided for the installation of a 2-story sedimentation tank at the lower end of Harrington Island, which is used as a city park. The tank is somewhat novel in design, and provides in a general way a sedimentation compartment above and a sludge-digestion compartment below. The tank is built in 2 units of equal size with inlets and outlets so arranged that the units may be used independently, in series, or in parallel. The effluent from the tank is distributed by a cast-iron submerged pipe across the main channel of the stream. With an assumed average daily flow of 200,000 gallons of sewage the combined detention period of the sedimentation compartment will be 1.6. hours and the digestion chambers will hold about 9 months' accumulation of sludge. It is proposed to discharge the sludge into the river at high water, which, if properly done, should not prove objectional.

Recommendation was made to the Rivers and Lakes Commission that the plans be approved subject to the condition that when the tanks fail in the opinion of the Rivers and Lakes Commission to produce satisfactory results the city will make modifications or install additional treatment devices satisfactory to said Commission.

GENEVA, Illinois State Training School for Girls. Plans for sewage treatment.—Plans were received July 14 from the consulting engineers for sewage-treatment works at the Illinois State Training School for Girls near Geneva. These plans have been reviewed and report made thereon to the engineers.

The school has about 1,000 inmates and attendants, and it is located on the bank of Fox River. In line with the general policy of the Rivers and Lakes Commission requiring the purification of sewage before its discharge into Fox Eiver the institution has undertaken to install treatment works consisting of 2 double-deck sedimentation tanks preceded by diversion chambers and screens of simple design. One of these tanks will be placed at each of the 2 outlets Of the present sewerage system. One of these outlets discharges into Fox River, and the other into a small watercourse tributary to the river. The diversion chambers are designed to divert the dry-weather flow into the tanks, and they are necessary because the sewers now receive large volumes of storm water. A sewage flow of 80 gallons per capita per day has been assumed in computing the detention period of the tanks. On this basis both tanks would have a sedimentation period of about 2 hours and a storage capacity for sludge of about 9 months. A highly commendable feature about the design of the tanks is an attractive superstructure, which permits ready access to all parts and thereby encourages proper supervision. The plans were approved subject to modification of a few minor details.

GENOA, Water supply.—(Bull. 11, 70.)

GENOA, Proposed sewerage and sewage treatment.—Plans and specifications were received January 6 from the Rivers and Lakes Commission for a sewerage system and sewage-treatment works for Genoa. These plans were reviewed and a report thereon was submitted to the Commission January 19. Inasmuch as the report was not altogether favorable to the plans and specifications an informal conference on February 20 was arranged between the engineer of the Survey and the engineer for Genoa. After this conference several sets of plans were submitted to the Survey, were reviewed, and were informally commented on by letter. A final report on the plans was prepared June 3, which recommended approval of the treatment of sewage in a 2-story sedimentation tank subject to the following conditions:

(1) That is to be understood that the method adopted for treating the sewage will effect only partial purification and that the Rivers and Lakes Commission reserves the right to require additional treatment when in the opinion of said Commission additional treatment is necessary to prevent objectionable conditions in Kishwaukee Eiver.

(2) That the tank be placed at sufficient elevation with respect to the river and the topography of the site for treatment works to secure gravity flow through additional treatment devices to be installed at some future date.

(3) That revised plans for a sludge-drying bed, showing in detail the arrangement of the filtering material, be submitted.

GEORGETOWN, Proposed water supply.—(Bull. 9, 24; 10, 117.)

GEORGETOWN, Proposed sewerage and sewage treatment.—Plans and specifications submitted June 20 for "a proposed system of sewers for Georgetown were reviewed and a report thereon made to the Rivers and Lakes Commission. Georgetown is a growing city with a population of 2,500 in the coal-mining region of southern Vermilion County near Little Vermilion River. The topography within the corporation limits is fiat, but the surrounding country is gently rolling.

The proposed combined system will serve about seven-eighths of the built-up section of the city. The remaining eighth, owing to topographical conditions, cannot be readily connected by gravity to the system, and is, therefore omitted for the present. Sewage from most of the city's sewers will be conveyed eastward in a 54-inch sewer, and the dry-weather flow, will be diverted and carried 2,500 feet farther in an intercepting sewer 15 inches, increasing to 18 inches, in diameter. A small section of the southeast part of the city will have a separate storm-water outlet, from which the dry-weather flow will be diverted and conveyed by means of an 8-inch intercepting sewer into the large intercepting sewer. The volume of sewage to be diverted by the interceptor is equivalent to its capacity or "about **4,000,000** gallons a day.

The dry-weather flow at first will be small because of the absence of a public water supply, but as a water supply will probably be installed before many years provision should be made in any method of treatment that may be proposed for material increase in the dry-weather flow. The population using the sewerage system within the next 10 years will probably be about 2,000 and an ultimate daily flow of about 200,000 gallons of sewage may be assumed. To provide for treatment of this sewage before discharging it into Ellis Creek a septic tank has been built with a capacity of 57,600 gallons, which will give a detention period of 7 hours. It is questionable if the tank will operate satisfactorily because of the large volume of water that will pass through it in times of storm. This water will carry heavy material that will deposit in the tank and rapidly fill it.

There can be but little doubt that additional purification works must be installed when the country about Georgetown becomes more thickly populated. Such works will be costly as the system is designed on the combined instead of the separate plan. Unfortunately the relative merits of the separate and combined systems were not fully investigated before the contracts were awarded. It would not be difficult, however, to convert the system to the separate style if developments should make that change desirable; in that event the existing combined sewers could be utilized as storm-water drains, It was recommended that the proposed sewerage system for Georgetown as shown on plans submitted June 20 be approved subject to the condition **that** when, in the opinion of the Rivers and Lakes Commission, Ellis Creek is becoming unduly polluted the sewage will be purified to relieve such pollution in a manner satisfactory to the Commission.

GIBSON CITY, Water supply.—(Bull. 10, 118.)

GIBSON CITY, Disposal of cannery wastes.—Gibson City was visited February 10, June 26, July 27, and October 9, at the request of the Gibson City Canning Co. for consultation regarding means for inoffensively disposing of wastes from the process of canning beans and corn.

Data relating to processes and the character of the wastes were procured, and a few rough experiments on a small scale were conducted with intermittent sand filters. The results of the experiments were inconclusive, but they indicated that the wastes from the bean-canning process, which appeared to be more objectionable, can be handled at the rate of about 100,000 gallons per acre per day. Full instructions for continuing these experiments were given, but the company felt that the installation of such a plant would be impracticable and abandoned the experiments. The company recently undertook on its own initiative some experiments on the treatment of the wastes by heating and precipitation of the solids with lime. These experiments were likewise inconclusive, but not specially promising. Full instructions for continuing reliable experiments along this line were given, but to date these instructions have not been followed out.

GILMAN, Water supply—(Bull. **11,** 71.)

GIEARD, Proposed water supply.—(Bull. **11,** 71.)

GLENCOE, Water supply and sewerage.—(Bull. 9, 24.)

GLEN ELLYN, Water supply.—Visited August 4. Glen Ellyn is a rapidly growing residential suburb of Chicago about one mile west of Dupage River in the central part of Dupage County with a population of about 1,800, which may increase to 4,000 within 10 or 15 years.

The public water supply was built in 1907 and exists to-day practically as originally installed. It includes one deep well with air lift, a collecting reservoir, one steam service pump, and 17 miles of mains, the great extent of mains being due to large lots. The well, which is close to the business district, is 8 inches in diameter and 310 feet deep. After penetrating **114** feet of glacial drift it enters limestone, in which it obtains a large supply of water. It is said that the well is capable of yielding with the air lift 275 gallons a minute, or nearly 400,000 gallons a day. No indications of depletion have been observed. The water ordinarily stands 43 feet below the surface and recedes 13 feet during operation of the air lift. The water is discharged from the well into a 70,000-gallon collecting reservoir, which is not sufficiently protected against accidental contamination through the dilapidated roof. The water is pumped from the collecting reservoir into the distribution system by a 675,000-gallon compound duplex steam pump. The distribution system is cast-iron pipe ranging from 4 to 8 inches in diameter. Seventy-nine per cent of it is only 4 inches in diameter. The 60,000-gallon elevated tank near the pumping station has a total height of 105 feet, and the average pressure throughout the town with the tank full is 55 pounds per square inch. There are about 500 services and the increase is 50 per annum. All services are metered. The average daily consumption is 84,000 gallons per 24 hours, equivalent to 47½ gallons per capita and **167** gallons per service. The water is of excellent quality from a sanitary point of view, but its mineral content, 462 parts per million, is somewhat high and its total hardness is 280 parts per million. The content of iron, 0.4 parts per million, is not sufficient to cause objectionable discoloration.

GLEN ELLYN, Sewage disposal.—A complaint by James Saunders, M. D., was received July 29 from the Eivers and Lakes Commission relative to inadequate final disposal of sewage in Glen Ellyn, with a request that the Survey investigate the complaint and report on it.

The sewerage system appears to be built partly on the combined and partly on the separate plan, but the volume of storm water entering the sewers is relatively small. The total length of sewers is 19¼ miles, ranging from 8 to 30 inches in diameter. All sewage is carried to one outfall through a 30-inch brick sewer about 4¼ miles southeast of the center of the city on the bank of Dupage Eiver. Dupage River at Glen Ellyn is a very small sluggish watercourse occupying a broad swampy bottom with no well-defined channel. The swampy condition in the bottom was so pronounced in July that the point at which the sewage or sewage effluent is discharged could not be reached. This marshy condition may be regarded as insanitary inasmuch as it fosters the growth of mosquitoes. Conditions could undoubtedly be remedied by dredging a well-defined rectified channel.

Because of inadequate natural dilution sewage-treatment works were built; they comprise a combination screen and grit chamber, 2 sedimentation or septic tanks, a dosing chamber, and 4 so-called trickling filters, and a sludge bed. The nominal capacity for which the plant was designed could not be ascertained, but the present population tributary to the sewerage system is approximately 1,500 and the dry-weather flow is about 75,000 gallons a. day. In view of probable demands within the next 10 years the plant should be capable of treating about 300,000 gallons a day of sewage. The dry-weather flow is diverted into a 12-inch vitrified pipe by means of an 8-inch dam placed within the outfall sewer, but at the time of inspection the 12-inch pipe was either clogged or shut off for no sewage was reaching the plant. That the screen and grit chamber is neglected is proved by the fact that the screen had been removed to avoid the labor of cleaning it. The sedimentation tanks have capacities of 48,690 and 94,990 gallons, respectively, or a total of 143,680 gallons, representing a retention period of 11½ hours with a discharge of 300,000 gallons. On the basis of the present discharge the retention period is 46 hours. The dosing chamber has a capacity of 8,290 gallons and it is automatically discharged on the 4 filter beds in rotation. Much trouble has been encountered, however, in securing regular operation of the automatic dosing apparatus. As the dosing chamber is not covered it is probably damaged by freezing. With the ultimate discharge of 300,000 gallons a day there would be 36 discharges a day or 9 on each bed. At present each dose covers a bed to a depth of 5 inches.

Each of the 4 filters as constructed is 33 feet wide and 80 feet long though the plans call for a length of only 66 feet. The total depth of filtering material is 5.5 feet, consisting of coarse granite ranging from 6-inch cobbles at the bottom to fine screenings 1/25 to 1/8 inch in size at the surface. The beds were evidently intended to operate as percolating or sprinkling filters though retaining the simplicity of intermittent sand filters. The total area is 0.243 acre, which would give a rate of filtration, based on the ultimate discharge of 1,230,000 gallons per acre per day, representing a population load of 16,500 per acre. With the present discharge the rate of filtration would be about 300,000 gallons per acre per day, or a population load of 5,000 per acre. It was learned that the filters clogged so rapidly when they were in use that the sewage, instead of percolating downward, passed through the openings in the dry rubble wells that surround the beds. Briefly, the defects in the sewage-treatment works at Glen Ellyn are not related exclusively to design but rather to operation. The plant has never been intelligently or systematically cared for, and those responsible for its maintenance are apparently ignorant of its mode of operation.

In consideration of the foregoing the following recommendations were made to the Rivers and Lakes Commission:

(1) That better results can be obtained by placing the plant in charge of an intelligent caretaker, who on request may be instructed in his duties by representatives of the State Water Survey.

(2) That in event of further complaint regarding improper disposal of the sewage the Rivers and Lakes Commission may feel justified in demanding more competent operation and such modifications and enlargements in the plant as may be necessary to insure acceptable results.

(3) That a well-defined channel be excavated in the bottom of the east branch of Dupage River for the purpose of eliminating the mosquito-breeding swamps now occupying the valley.

(4) That a municipal ordinance be passed requiring that all cesspool overflows and wastes from plumbing fixtures be discharged into the new sewerage system and that all drains now carrying such wastes to Glen Ellyn Lake or to other watercourses be closed.

GRAFTON, Pollution of Illinois River.—(Bull. 11, 72.)

GRANITE CITY, Water supply.—(Bull. 11, 72.)

GRAND RIDGE, Proposed water supply.—(Bull. 11, 72.)

GRAYSLAKE, Pollution of a watercourse by milk waste and house sewage. Grayslake was visited April 30 and May 4-5 by request of the Rivers and Lakes Commission to investigate pollution of a Email watercourse draining the northern part of the village by small quantities of sewage and large quantities of liquid waste from a milk-condensing plant. The data obtained during these two visits is insufficient for final report on handling the wastes from the milk-condensing plant, but it is proposed to make further studies, especially of treatment of the condensing wastes with the cooperation of the milk-condensing company and the village authorities.

Recommendation was made to the Rivers and Lakes Commission that Grayslake be given until January 1, 1915, to conduct further investigations with the assistance of the State Water Survey into economical and suitable methods for disposing of the sewage of the village and the liquid wastes from the plant of the Wisconsin Condensed Milk Co., and further that on or before January 1, 1915, the village shall present to the Rivers and Lakes Commission complete detailed plans and specifications for treatment works or others means of inoffensively disposing of all putrescible liquid wastes produced within the limits of Grayslake.

The Commission on May 13, 1914, entered an order to stop polluting and defiling the waters of Barron Ditch and Bird or Chittenden Lake by April 1, 1915.

GRAYVILLE, Water supply.—(Bull. 10, 119.)

GREAT LAKES, U. S. Naval Training Station. Water supply.—(Bull, 9, 28; 11, 134.)

GREENUP, Water supply.—(Bull. 10, 119; 11, 74.)

GREENVIEW, Water supply.—(Bull. 11, 75.)

GEEENVILLE, Proposed sewerage.—(Bull. 11, 75.) A conference was held with H. N. Baumberger, city engineer, January 8, and Greenville was visited February 2 to attend a public hearing on the project of constructing sewerage.

As the city is limited in funds practically the entire sum for the proposed improvement, about $35,000, had to be raised by special assessment. It was also desirable to lay sewers throughout the built-up portion of the city in order to procure funds for treatment works. The amount obtainable for purification works could not exceed $5,000.

Treatment of some sort is believed to be necessary because no streams near Greenville are sufficiently large properly to dilute the sewage. The available stream is already grossly contaminated by the Helvetia Condensing Co., whose wastes from the manufacture of condensed milk and cream give rise to very disagreeable odors and unsightly appearance in the stream for a distance of one-half mile below their entrance. No serious objection to this pollution has been raised apparently because the farmers in the vicinity are more or less dependent on the condensing company for a market for milk; very strenuous objection has been made against the proposed use of the stream for conveying the city sewage. In view of these objections the city engineer desired to install intermittent sand filters preceded by tanks. Much larger filter areas and a type of tank different from that in the designs are needed. This enlargement so increased the estimated cost that the proposed outlet was abandoned, and a new outlet at somewhat greater cost to carry the sewage into Shoal Creek was projected. Suggestions were also made regarding the size of sewer pipe and methods of laying it, means for flushing sewers, and suitable spacing of manholes.

Strong opposition to the project developed at the meeting in Greenville February 2. The Survey representative spoke of the sanitary advantages of a general system of sewers, discussed specifically the adequacy of the plans proposed; and explained the functions of the Survey in reference to sewerage projects. The opposition to the project was overruled and at the end of 1914 the sewerage system was under construction.

HAMILTON, Water supply.—(Bull. 10, 120; 11, 76.)

HABMON, Proposed water supply.—(Bull. 10, 121.)

HAEEISBUEG, Proposed water-purification works.—(Bull. 9, 24; 10, 121; 11, 76.) A set of plans and specifications was received July 7 from the State Public Utilities Commission of Illinois for a proposed water-purification works to be installed by the Central Illinois Public Service Co. at Harrisburg in accordance with an order of the Commission requiring installation of water-purification works by December 1, 1914. As the plans were not complete in detail it was impossible to render a final report on them. Several sets of plans of proposed water-purification works at Harrisburg have already been reviewed by the Survey and have been noted in published bulletins.

Water purification at Harrisburg was first brought to the attention of the Survey in October, 1911, when the Peoples Water & Light Co., then owners of the waterworks, and the commercial club of Harrisburg agreed on the Survey to referee water-purification plans proposed by them. Harrisburg was visited October 24-25, 1911, for the purpose of inspecting lo°eal conditions. Late in October, 1911, preliminary plans were submitted on which an informal report was made November **8, 1911.** Harrisburg was again visited November 15, **1911,** to procure additional first-hand information and this visit was followed by a conference with the owners of the water company and their representatives in Chicago November 22. As a result of this conference a revised set of plans was prepared and reported on August 2, 1912. A second conference was held August **16, 1912,** which resulted in the submittal of a second revised set of plans late in August. A lengthy report on this new set of plans was prepared August **31, 1912,** which gave general approval of the proposed plans though it called attention to various details that were considered defective or not properly allowing for future requirements. Construction of the plant was not begun following the submittal of this report as anticipated, because the ownership of the waterworks and its associated utilities, an electric light plant, and an ice plant was transferred from the Peoples Water & Light Co. to the Central Illinois Public Service Co. During 1913 the waterworks company, realizing the tendency to greater pollution of the source of its supply and deferring to various suggestions made locally began a search for a ground-water supply, in which they were assisted by the Survey, but the development of such supply proved wholly impracticable.

The matter of a filter plant was again taken up with the Survey, culminating in a conference in Chicago, December **13, 1913.** It was then believed that the installation would be made without further delay, but new complications were introduced by installation of sewers serving the north portion of Harrisburg with an outlet into a drainage ditch that discharges into Saline Biver above the intake of the waterworks. This sewer was built against advice from the Survey and protest from the water company. The company thereupon decided not to build a water-purification plant until the sewage was properly diverted inasmuch as the company regarded the act of polluting the source of supply as just cause for rescinding a formal promise previously given to install a water-purification plant.

The matter was next brought by the city officials before the State Public Utilities Commission of Illinois and a hearing before that Commission was held in Harrisburg May **13, 1914.** An order was issued requiring the company to install purification works, but the company was informally advised that it might receive redress against the city for polluting the source of supply by appealing to the Bivers and Lakes Commission. In accordance with an informal request by the water company the Survey investigated the pollution of Saline Biver and embodied the result of its investigation with recommendations in a report to the Bivers and Lakes Commission July **2, 1914.** These recommendations included the following:

> "That the city of Harrisburg be required to cease polluting the Middle Branch of Saline Biver above the waterworks intake by January **1, 1915.**
>
> That the attention of the city authorities be called to the desirability of remodelling its entire sewerage system not only for the purpose of protecting the public water supply, but also to provide a better sewerage service and to enable the city to secure an inoffensive final disposal of its Eewage in an effective and economical manner.
>
> That the attention of the city health authorities be called to their duties in protecting the public water supply against undue contamination from improperly constructed privy vaults at Muddy."

Inasmuch as the water company has not yet seen fit to make formal complaint to the Bivers and Lakes Commssion no hearings have been held and the matter has not been actively pressed.

Plans submitted July 7, 1914, called for purification works of more sub stantial construction and better design than those heretofore submitted. The plant is to have a nominal daily capacity of 900,000 gallons and will include chemical-preparation and feed devices for alum, soda, and calcium hypochloritc, a reaction chamber, 2 sedimentation basins, 3 filter units, each with a nominal daily capacity of 300,000 gallons, a clear-water reservoir, auxiliary machinery such as an air blower for agitating the filter sand during washing, and a control laboratory. The chemical-preparation and feed devices will be simple, involving storage tanks and constant-head orifice boxes to insure uniform application of the solutions. The reaction chamber will have a detention period of 30 minutes and will be properly baffled. The coagulation and sedimentation basins, which are somewhat irregular in shape because of the configuration of the property, will have a capacity of 113,000 gallons, allowing 3 hours' sedimentation. The filter units will be of standard design suitably equipped with rate controllers and loss-of-head gages. Filtered water will be stored in a 20,000-gallon clear-water reservoir under the filters, in a remodeled 70,000-gallon collecting reservoir, and in a 47,000-gallon elevated tank on the distribution system, or a total of 137,000 gallons, equivalent to about 3.7 hours' storage of the nominal output of the plant. This clear-water storage is not deemed fully sufficient when the daily consumption equals the full capacity of the filter plant, especially as it is proposed to draw on this storage' for washing the filters. A very commendable feature is the installation of a small laboratory, in which regular analytical control may be maintained over the operation.

In view of the various considerations embodied in the report submitted to the State Public Utilities Commission of Illinois the following recommendations were made:

(1) That detailed plans be submitted to the State Water Survey for review and approval.

(2) That the plant be enlarged whenever neceseary to meet demands beyond the present nominal capacity.

(3) That the plant always be operated by a properly trained man and that the operation of the plant be always under analytical control.

(4) That the clear-water storage capacity be materially increased, that the laboratory be enlarged, that storage space for chemicals be provided and that various other proposed minor alterations be given due consideration.

HARRISBURG, Sewerage.—(Bull. 11, 77.)

HAEVARD, Water supply.—Visited July 7-8. Harvard, in the northwest part of McHenry County near the head of Piscasaw Creek, a tributary of Kishwaukee River, is a growing manufacturing community of about 3,500 population.

Waterworks were installed by the municipality in 1892 chiefly for fire protection. The original supply was a deep rock well, to which one well has since been added. The first well is 1,600 feet deep, 10 inches in diameter at the top and 8 inches in diameter at the bottom, and is cased to rock. Water is derived from the St. Peter sandstone probably near the bottom of the well. The new well is 742 feet deep, 8 inches in diameter at the top and 6 inches in diameter at the bottom, and it probably taps the Niagara limestone. The static level in both wells is about 20 feet below the surface; but pumping sometimes reduces the level below the working barrel of the pumps, which is at 115 feet in the old well and at 95 feet in the new well. How much lower the level could be drawn if the barrels were lowered is unknown. Both wells are pumped by deep-well electrically driven power pumps having daily capacities of 300,000 and 225,000 gallons for the old and the new well, respectively. *The* water is delivered from the deep-well pumps into a 60,000-gallon circular brick collecting reservoir, from which it is pumped into the distribution system by an electrically driven 500,000-gallon triplex power pump and an electrically driven 865,000-gallon 2-stage centrifugal pump. A gasoline engine is also held in reserve for emergencies. The distribution system includes 7.8 miles of 4-inch to 8-inch cast-iron mains, which serve most of the built-up portion. There are 562 services, of which 98 per cent are metered. A 100,000-gallon elevated steel tank 149 feet in height is connected with the distribution system. Recent pumping records indicate a daily consumption of 100,000 gallons, equivalent to 28.5 gallons per capita or 178 gallons per service. The water is of good quality from a sanitary standpoint, and the mineral content, 481 parts, is moderate for a deep-well water though the hardness, 430 parts per million, is rather high.

HARVARD, Sewage disposal.—(Bull. 10, 122.) The sewage-dispoEal plant at Harvard was inspected July 8. It treats the sewage from a separate system of sewers comprising 7.6 miles of pipe 6 inches to 18 inches in diameter.

The septic tank is divided into 2 units each having a capacity of 51,400 gallons. The discharge of sewage was found by measurements to be about 100,000 gallons a day. Thus with one unit of the tank in operation the retention period is 12 hours. The effluent from the tank falls from a broad-crested weir on a series of concrete steps, which form one side of the dosing chamber. The amount of aeration thus obtained is diminished as the level of the liquid rises in the dosing chamber. The dosing chamber has a capacity of 4,600 gallons, and with the measured quantity of 100,000 gallons a day will discharge every 65 minutes. The rate of filtration of the sand beds is 185,000 gallons per acre per day. Fairly satisfactory results were being obtained even with this high rate as one man gives his entire time to the care of the disposal plant. One dose from the dosing tank will cover it to a depth of about 2 inches. A dose is applied to a bed in about 5 minutes and disappears in about 10 minutes. The beds are cleaned once a week by raking the surface to a depth of 1 or 2 inches. The effluent is discharged into a branch of Kishwaukee River and at the time of the inspection it was clear and colorless and much better in appearance than the creek water.

Samples were collected at the influent and effluent ends of the septic tank, at the outlet from the filters, and a few hundred feet downstream from the sewer outlet. Analyses of these samples showed an increase of nitrification by filtration from 0.08 part per million to 7.6 parts per million. Fish were seen at the outfall, and cattle and horses drank freely downstream. People living near by stated, however that the stream becomes at times so foul and obnoxious, that the stock will not drink from it.

HARVEY, Investigation of nuisance.—(Bull. 10, 123.)

HAVANA, Water supply.—Visited November 3. Havana, on the west border of Mason County on the east bank of Illinois River, has a population of about 3,600. Havana is primarily a fishing village, but it also has some large metal-working industries. It has waterworks, sewerage, and well-paved streets.

The waterworks were built in 1889 and except for extensions of mains have not been modified. The supply is obtained from 10 tubular wells, 72 feet deep, penetrating the alluvial sand and gravel of Illinois River valley. The wells are cased 52 feet with 6-inch casing, below which they are equipped with 20-foot Cook strainers. The static level varies with the level of Illinois Eiver about 2,000 feet west of the wells and never drops more than 30 feet below the surface. The wells are all within a radius of 30 feet; 2 are in the pump pit in the pumping station and 8 are in groups of 4 in 2 circular 15-foot pits outside the station. The water is drawn from the wells and is pumped directly into the distribution system.

Analyses show that the water is of excellent quality from a sanitary point of view and only moderately mineralized. The total hardness is 160 parts per million. Unlike many waters from gravel deposits of Illinois Eiver valley the water is free from iron.

No accurate record of pumpage is kept, but the daily consumption is about 400,000 gallons, equivalent to 113 gallons per capita and 580 gallons per service. There are 2 compound duplex 400,000-gallon steam pumps set in a pit 15 feet deep. The distribution system comprises 9 miles of 4-inch to 10-inch east-iron mains. Eighty-seven per cent of the mains are 4 inches in diameter. A 48,000-gallon elevated steel tank on a brick tower near the pumping station is connected with the distribution system. The total height of the tank and tower is 86 feet, and the full tank produces a pressure at the pumps of 61 pounds and an average pressure in the system of 52 pounds per square inch. The cost of construction was about $65,000, or about $18 per capita.

HAVANA, Pollution of Illinois River by Chicago Drainage Canal.—(Bull. 11, 77.)

HENNEPIN, Pollution of Illinois Eiver by Chicago Drainage Canal.—(Bull. 9,24.)

HENRY, Water supply.—Visited October 14. Henry is a fishing village with a population of about 1,800.

Waterworks were installed in 1902 partly by the city and partly by a private company, the title to the works having been transferred to the city after a period of 10 years. Water is obtained from 3 tubular wells 40 feet deep 200 feet from Illinois River. Two are tubular 8 inches in diameter and are equipped with Johnston 8-foot strainers; one is 8 feet in diameter, is lined with brick, and is adequately protected against the entrance of surface drainage. The two tubular wells are in the pumping station and the casings are connected to the pump suctions. The water level in the wells is normally a few feet above that in the river and fluctuates with it from 4 feet to 19 feet below the surface. The maximum rate of pumping does not depress the water level more than one foot.

The quality of the water is very satisfactory from a sanitary standpoint though a privy within 80 feet of one well may sooner or later seriously pollute the water. No other sources of contamination were observed within 200 feet, but disposal of sewage in leaching cesspools is a general practice throughout the village. This method works well because of the porous character of the underlying material, and it apparently has not yet seriously affected the water supply though a steady and marked increase in the content of nitrate, shown by analyses made by the Survey from 1909 to 1914, indicates a growing influence of the prevalent method of sewage disposal. The total hardness of the water is rather high, about 360 parts per million. Otherwise it has no objectionable characteristics and is free from iron and maganese.

Records of pumpage are not regularly maintained. The quantity of electricity used by the pumping equipment indicates a daily consumption of 32,000 gallons, a rather small consumption for a community of this size, representing only 19 gallons per capita and 88 gallons per service. This may be explainable by the fact that many of the services are yard hydrants from which little water is drawn. The pumping station is a neat brick building, which houses the pumping machinery and 2 pressure storage tanks, each 30 feet long and 8 feet in diameter with a total capacity of 13,600 gallons. As much of the space is occupied by air and as large quantities of water cannot be withdrawn from the tanks without seriously reducing the pressure in the mains the usable storage is only about 5,000 gallons. Even so, the pressure in the high parts of town varies from 37 to 62 pounds per square inch. The pumping machinery comprises two 500,000-gallon rotary pumps. One is driven by an electric motor, which is automatically controlled through the pressure in the storage tanks by a device set to operate between 50 and 75 pounds per square inch. The other pump is belt-connected to a gasoline engine, which also drives an air compressor used in maintaining the air pressure in the storage tanks. The mains comprise 3.7 miles of 4-inch to 10-inch cast-iron pipe, chiefly 4-inch, and 2.3 miles of 2-inch wrought-iron pipe. There are 365 services, of which nearly half are yard hydrants. Practically the entire population uses the supply for drinking and general domestic purposes and about one-third of the supply is metered.

HENRY, Pollution of Illinois River.—(Bull. 11, 77.)

HERRIN, Proposed water supply.—(Bull. 10, 125.)
Proposed sewerage.—(Bull. 10, 125.)

HIGH LAKE, Proposed water supply.—(Bull. 9, 24.)

HIGHLAND, Proposed water supply.—(Bull. 10, 126.)

HIGHLAND PARK, Water supply and sewerage.—(Bull. 9, 24; 10, 126.)

HILLSBORO, Proposed new water supply.—(Bull. 10, 127.) Much attention has been given by the Survey to the proposed new water supply for Hillsboro. Hillsboro was visited May 10, June 12, and November 22, 1912, February 7, 1913, May 25-26, October 12, and November 17, 1914, for the purpose of investigating the present and proposed sources of supply and of conferring with local officials. Hillsboro, the county seat of Montgomery County, is situated near Middle Fork of Shoal Creek, a tributary of Kaskaskia River. It is undergoing marked growth because of the recent installation of 2 large smelters employing about 1,500 • men. Its population is about 5,000 and the neighboring towns of Schram City and Taylor Springs make the total population of the district more than 6,000. Great future growth is anticipated, but reliable estimates of it are difficult. A maximum estimate is about 15,000 in 1930 and about 30,000 in 1960. These estimates probably are too high, but the possibility of such increase emphasizes the necessity of adopting a source of water supply that is capable of being developed to meet large increases in population.

Waterworks were first installed in 1887. An earth-bank reservoir 100 feet square impounded the water from a large spring and a small surface area near the center of town. Partial purification was attempted by causing the water to seep through the brick and joints between the brick of a brick wall within this reservoir before it was pumped to the consumers. This source soon became inadequate, but a new supply was not developed till 1904. This consisted of an earth-dam impounding reservoir with a concrete spillway across a small tributary of Shoal Creek near the central part of the city. This source proved inadequate almost from the first, and it is and always has been grossly contaminated by sewage from buildings on the main street. The supply was augmented in 1912 by pumping from Middle Fork of Shoal Creek at North Eoad Bridge, but this supply was soon abandoned. The pumping station which served the original reservoir at the spring and the impounding reservoir was dismantled in February, 1913, and part of the equipment was transferred to the plant of the Southern Illinois Light and Power Co., at the north end of the impounding reservoir. A new centrifugal pump was added, and that company has since been pumping water to the city under contract. The reservoir was exhausted early in 1913, and a 4-inch main was extended in June, 1913, from the lighting company's station to Shoal Creek, and an electrically driven centrifugal pump was installed in a second temporary station on the bank of the creek for the purpose of pumping creek water again. This station has been in almost continual use since its installation because the storage of the reservoir was much depleted by leakage into the outfall sewer of the new sewerage system which passes under a portion of it.

In 1906 a boring for oil was made in the valley of Middle Fork of Shoal Creek just north of Hillsboro, and a large quantity of water under artesian pressure was encountered. Analyses of the water in 1910 showed that it is highly mineralized and salty. Analyses in 1914 showed marked reduction in the mineral content, evidently due to shutting off the flow from the lower and more highly mineralized strata. The water is now of acceptable quality for a public supply, and its hardness is only a little more than 100 parts per million. Though repeatedly proposed as a source of public water supply it was not seriously considered until the emergency of 1913. According to information given by the owners of the well tests made at that time by the owners indicated that the wells were incapable of meeting the entire demands of the city. Nevertheless it was decided by the city in May, 1914, to utilize one of the wells as a temporary source, as it was believed that such use would give a more thorough test of the wells to indicate their suitability as a permanent source. The well, however, proved altogether inadequate from the first and was soon abandoned in favor of Middle Fork of Shoal Creek. As a last hope, however, the city sank an additional well, but this proved to have as small yield as the old wells, not more than 35 gallons a minute. A temporary dam was then thrown across the creek to avoid all possibility of contamination from the sewer outlet, a matter that previously had been overlooked. At the end of 1914 the bulk of the supply was being drawn from Middle Fork of Shoal Creek.

The water supply of Hillsboro has always been recognized as being of poor quality from a sanitary point of view, and has been little used except! for fire protection and flushing. Nevertheless strangers, not knowing the impure quality of the supply, are likely to drink water from handy faucets. The principal cause of local complaint, however, has been the inadequacy of the supply, and this has been the main stimulus toward procuring a new supply.

Since its first negotiations with the city the Survey has recommended as the only rational procedure that the city engage the services of a competent consulting engineer, well-versed in water-supply development, to make a detailed study of the relative merits of the several possibilities for an improvd water supply and comparative analyses with special reference to quantity and quality of water available, cost of development, and cost of maintenance. With such information clearly presented it would be easy for the city to decide definitely what project to adopt. It was exceedingly difficult, however, to have this recommendation carried out and to prevent the local authorities from reaching a decision on the basis of insufficient data. For the purpose of pointing the way the Survey under took to make preliminary investigations with a view to indicating the various possibilities and their relative merits on the basis of the data that could be acquired without making extensive surveys and without drawing up plans to serve as estimates of cost. Care was taken, however, to point out the limitations of such an investigation and to state clearly what further investigations would be necessary before the final decision could be reached.

The possibilities considered by the Survey included (1) an impounding reservoir on Butlers Creek, (2) an impounding reservoir on Millers Branch, (3) an impounding reservoir on Long Branch, and (4) an impounding reservoir on Middle Fork of Shoal Creek. These four streams are the only ones sufficiently near town that have catchment areas capable of furnishing with suitable storage water enough to meet the present and future needs of the city. Well water was eliminated from consideration because there seemed to be ample evidence that sufficient water of satisfactory quality is not obtainable from wells in this vicinity.

Millers Branch was eliminated from detailed consideration because of its remoteness and difficulty of development. The other three streams are usable, and final selection depends on the relative quality of water that can be obtained and the cost of development to meet the requirements of the city. It was not until the middle of 1914 that the city engaged the services of an engineer to report on new water-supply development and his instructions then covered only the study of Butler Creek. These studies show that though sufficient water might be impounded along this stream to meet future requirements the construction of a reservoir would be very costly because a railroad crossing the basin would have to be relocated. Moreover, there would be so much shallow flowage as to threaten Eeriously the quality of the water for domestic use. Though the possibility of utilizing Butler Creek was demonstrated its merits as compared with Middle Fork of Shoal Creek and Long Branch were not discussed. At the earnest recommendation of the Survey an engineer has been employed to pursue further studies to cover the other basins. His studies had not been completed at the end of 1914.

HILLSBORO, Sewage pollution of Middle Fork of Shoal Creek.—A communication was received July 6 from the Rivers and Lakes Commission requesting the Survey to review and report on a complaint made by the American Zinc Co. relative to pollution of Middle Fork of Shoal Creek by sewage from Hillsboro. The American Zinc Co. has a zinc smelter at Taylor Springs, one mile south of Hillsboro and 2 miles downstream from the outlet of Hillsboro sewer. The complaint of this company states that it has installed in accordance with State laws, baths for men who work at the plant and that these baths have been supplied with water from Middle Fork of Shoal Creek, the only readily available source of water. Also that the water of Shoal Creek has been satisfactory for bathing until 1913 when Hillsboro placed in operation a sanitary sewerage system.

The sewerage system of Hillsboro is built on the combined plan and comprises 5.15 miles of 8-inch to 36-inch pipe. The main outfall, which is 36 inches in diameter, discharges into Shoal Creek on the north side of the city. The basin of Shoal Creek above this point is 93 square miles and though the creek seldom goes entirely dry the summer flow is not sufficient adequately to dilute the sewage. While the plans for the sewerage were being prepared the city was requested to submit them to the Survey for review, but this submittal was delayed until all legal arrangements had been perfected for levying special assessments for construction. Though the Survey then called the attention of the local authorities to the probable necessity of treating the sewage and made recommendations for facilitating such treatment by modifying the grade and the location of the outfall sewer it was not possible to carry out that recommendation without repeating the lengthy and intricate legal procedure incident to levying special assessments. With the sewerage system as designed and constructed treatment of the sewage will be expensive.

In view of the foregoing circumstances recommendation was made to the Rivers and Lakes Commission that Hillsboro be required to furnish the American Zine Co. a suitable supply of water for bathing or that the city treat this sewage in a manner that will relieve the water of Middle Fork of Shoal Creek of its present objectionable pollution at the intake of the American Zinc Co. It was pointed out, however, that adoption of the first alternative should not be considered to relieve the city from the necessity of purifying its Eewage when such treatment becomes advisable in the opinion of the Rivers and Lakes Commission. In an effort to meet the order of the Rivers and Lakes Commission based on that recommendation the city first installed a crude plant for coagulating the solids in the sewage by iron sulphate. This causes precipitation of suspended matter in the sewage that settles to the bottom of the creek before it reaches the intake. The presence of several pools along the stream and the small quantity of weak sewage has favored this method of eliminating objectionable conditions, and the results for the time being Eeem to be satisfactory to the American Zinc Co.

HINCKLEY, Water supply—(Bull. 11, 78.)

HINSDALE, Water supply.—(Bull. 11, 78.)

HOMER, Corrosion of boiler.—Homer was visited November 30 to investigate the cause of corrosion of a steam boiler. Mineral analyses of the feed and of water from the boiler did not show the presence of constituents capable of causing corrosion. Inspection of the boiler, however, revealed that the fire tubes are attached to the flue-sheet by means of copper ferrules which set up a galvanic action with the iron of the boiler and thus cause corrosion by electrolysis. Recommendation was made that rolled-zinc plates, each weighing 2 or 3 pounds, be suspended in the boiler beneath the surface of the water in such manner that all parts of the boiler iron are within 6 inches of them. Recommendation was also made that soft iron instead of copper be used for ferrules when tubes are renewed.

HOMEWOOD, Water supply.—Visited March 5. Homewood is a residential district near the south end of Cook County and it has a population of about 800.

Waterworks, owned and operated by the village, were installed in 1911. The source is a drilled well 250 feet deep and 12 inches in diameter at the top and 10 inches in diameter at the bottom. The water rises normally to 16 feet below the top. No test has been made to determine the maximum yield, but the supply has always been adequate for local requirements. The water is pumped from the well directly into the distribution system by an electrically driven 600,000-gallon deep-well pump. The distribution system comprises about 6 miles of 6-inch to 10-inch cast-iron mains. An 80,000-gallon elevated steel tank near the pumping station is connected with the distribution system. When full this tank exerts a pressure of about 45 pounds per square inch throughout most of the distribution system. No regular pumping records are kept, but the consumption is small, possibly not exceeding 40,000 gallons a day. The water supply is of good quality from a sanitary point of view, and it is not excessively mineralized.

HOOPESTON, Sewerage system.—(Bull. 11, 78.)
Water supply.—(Bull. 10, 128.)

IPAVA, Water supply.—Visited November 4. Ipava, in the southern part of Fulton County, has a population of about 600.

Waterworks were installed in 1890 when a well 1,570 feet deep tapping the St. Peter sandstone was drilled near the center of the town. Water was first drawn from the well and forced directly into the mains by a deep-well pump. In 1905 the well was equipped with an air lift, a 13,000-gallon brick collecting reservoir was built, and a centrifugal pump was installed for pumping from the reservoir into the mains. The centrifugal pump was replaced in 1909 by a 145,000-gallon duplex steam pump. The waterworks have always been operated in conjunction with the electric lighting plant, by which steam and power are supplied. As it is now proposed to abandon the local electric lighting plant to purchase electricity by long-distance transmission from the Central Illinois Public Service Co., extensive modifications will be made in the pumping equipment, which will include installation of an electrically driven deep-well power pump and re-setting of the centrifugal pump. There is one mile of cast-iron mains 4 to 6 inches in diameter, and 55 services are in use, none of which is metered. A 26,000-gallon elevated tank 95 feet in total height is connected with the distribution system. The quantity of water pumped cannot be ascertained even approximately, but the yield seems ample for present requirements.

The water is excessively mineralized, its total mineral content being 2,955 parts per million, most of which is alkali, and its hardness is 650 parts per million. It has a taste disagreeable to one unused to it because of its content of salt and hydrogen sulphide, but it is commonly used as drinking water. Its sanitary quality is good.

JACKSONVILLE, Water supply.—(Bull. 10, 129.) Jacksonville was visited August 25, 26, and 27 to investigate the quality of water then being furnished to the city from the Widenham-Daub wells. Jacksonville, in the central part of Morgan County on Mauvaise Terre Creek, a tributary of Illinois River, has a population of about 15,500. Three large State institutions for the insane, deaf and dumb, and blind, and several colleges and academies are situated in Jacksonville.

Jacksonville has had unusual difficulties with its public water supply. The first installation, completed in 1871, utilized as a source an impounding reservoir on a small tributary of Mauvaise Terre Creek south of town. This reservoir, which is still in use, forms the central feature of Nichols Park. The capacity of the reservoir thus formed is about 60,000,000 gallons. It is said to be fed largely by springs in addition to the normal run-off. When the reservoir in 1885 failed to yield sufficient water a 2,200-foot tubular well in the city was equipped and utilized to increase the supply, but it was abandoned in 1895 because of its small yield. A second well, known as the Decker well, drilled in 1888 near the pumping station on the banks of Mauvaise Terre Creek, is 3,110 feet deep and 10 inches in diameter at the top and 4% inches in diameter at the bottom. Another similar well was drilled in 1890 within 200 feet of the Decker well. Late in 1894 or early in 1895 another well known as the American well was sunk several hundred feet from these wells. All 3 wells near the pumping station flowed into a 25,000-

gallon pump pit. The deep-well water was never popular for domestic use because of its high mineral content and strong odor of hydrogen sulphide. The flow from the wells has gradually grown less until only one of them now flows and that has a very small stream. At an unknown date, probably about 1899, the water of Mauvaise Terre Creek was diverted into the pump pit by a small dam near the pumping station. In 1897 or 1898 a project for procuring an adequate supply from an impounding reservoir in the valley of Big Sandy Eiver about 5 miles southwest of Jacksonville was considered, but apparently this project was never thoroughly investigated and was ultimately dropped.

The Jacksonville Water Co. obtained in 1904 a franchise to supply the city with water derived from wells in the alluvial deposits bordering Illinois Eiver near Bluffs, about 20 miles from Jacksonville, and work on that project was commenced in 1905. The installation comprises a group of tubular wells in the alluvium in the valley of Illinois Eiver, a pumping station equipped with two 3,000,000-gallon duplex pumps, necessary boiler equipment, and a rising main 20 inches in diameter and 97,357 feet long leading from the pumping station to Jacksonville. The rising main was constructed of spiral riveted steel pipe, about 1/10 inch in thickness. Part of this pipe was laid through an accumulation of coal-mine wastes, which strongly corroded it. Though the contract provided that the works were to have been placed in operation within 2 years after beginning construction they were actually not placed in operation until 1907 or 1908, and were then unable to deliver the required quantity of water. Failure to deliver the water apparently resulted from improper piping of wells and defective pumping machinery. After 6 months' inadequate service the city gave the water company a definite time in which to deliver the guaranteed quantity of water, namely, 6,000,000 gallons a day, but one difficulty followed another, and the company was never able to comply with the terms of its contract. The principal difficulty resulted from the corrosion of the rising main. The city officials abrogated the contract, and the abrogation was contested in the courts for several years with a final decision in favor of the city.

Meanwhile, the city proceeded in 1910 to develop a group of tubular wells on property about one mile northeast of the center of town and adjacent to Mauvaise Terre Creek. Five wells were sunk, ranging in depth from 58 to 74 feet and penetrating what appear to be alluvial deposits of clay and several thick beds of sand and gravel. This group of wells is known as the Widenham-Daub wells from the owners of the land. Each well was equipped with a deep-well pump which raised the water into a collecting reservoir, from which it was pumped into the distribution system by high-service centrifugal pumps. Much apprehension was felt in reference to the quality of this supply because Mauvaise Terre Creek, which flows past the property on which the wells are located, carries about 70 per cent of the sewage from the city discharged from an outfall in the east part of the city. Furthermore, in times of flood, the land occupied by the wells is entirely covered by the sewage-polluted water.

The present sources of supply comprise Morgan Lake, Mauvaise Terre Creek, the deep well near the pumping station that is still flowing, and the Widenham-Daub wells. During the summer of 1914 water from the Widenham-Daub wells constituted practically the entire supply because Mauvaise Terre Creek and Morgan Lake were so low. Though reliable records of pumping were not regularly maintained the group of wells apparently could yield 1,000,000 gallons a day. Improvements have been made around the Widenham-Daub wells during 1914 by construction of a levee with material excavated from the rectified channel of Mauvaise Terre Creek. This levee is not high enough to protect the wells against the highest floods, but it will protect them against all ordinary floods. The casings of the wells are extended high enough to prevent the entrance of flood water. There are several abandoned wells from which the casings have been withdrawn but which have not been properly plugged to prevent entrance of polluted water into the water-bearing strata.

Several examinations of water from the Widenham-Daub wells indicate that the water is of good quality from a sanitary point of view. It contains some iron but not an objectionable amount and it is moderately hard. The polluted water in Mauvaise Terre Creek is apparently prevented from reaching the water-bearing strata by thick impervious beds of clay.

The principal criticism with reference to the Widenham-Daub wells is the available quantity of water. One million gallons is not sufficient to meet the demands of a city the size of-Jacksonville and there are no data extant, at least in available form, which give any indication as to the possibility of developing still larger quantities of water in the locality of the Widenham-Daub wells. The buildings, houses, and pumping equipment generally are somewhat crudely installed at the Widenham-Daub wells, but this is probably because the supply at the time it was developed was regarded more or less as a temporary installation. and because a large permanent supply from this source was not definitely assured. Water from Morgan Lake and Mauvaise Terre Creek is very unsatisfactory, chiefly because of excessive turbidity. The very dark color of the suspended material adds to the offensive appearance of the water. These waters are also subject to more or less intermittent contamination as the basins are practically unprotected. Neither Mauvaise Terre Creek nor Morgan Lake receives continuous sewage pollution at points above the waterworks intakes, but the creek is used more or less for bathing and the lake for boating and general recreation. The water probably is not ordinarily dangerous, but it may become so intermittently. The deep-well water is satisfactory from a sanitary point of view, but it has highly objectionable mineral characteristics. Sooner or later the city must again face the problem of developing an adequate water supply. As a first step, it would be highly desirable to test in very thorough manner the yield that can be derived from the general locality of the Widenham-Daub wells. If this should fail to meet requirements the city should seek other sources that will yield all the water necessary or that may be supplemented by the present well supply.

JACKSONVILLE, Sanitary inspection of Chautauqua ground.—Jacksonville was visited July 2-3, at the request of a local physician, and a copy of the report was transmitted to the Park Board. Nichols Park, in the southeast part of Jacksonville is used as a Chautauqua ground, and some apprehension was felt as to the sanitation of the grounds especially with reference to privies, water supply, and eating establishments.

The privies on the grounds as at present constructed may become foci of infection for typhoid, dysentery, and any other disease that can be carried by flies or other insects. The danger is especially great during Chautauqua when tent restaurants are on the grounds. Furthermore, the vaults under the privies pollute the soil and this pollution may extend to near-by wells.

To overcome these difficulties at least expense the following recommendations were made:

Vaults under privies should be cleaned and filled and in place of them substantial water-tight receptacles should be placed under the seats in compartments so arranged as to be readily accessible for the removal of receptacles yet so tight that no flies can gain entrance. The seats should be provided with covers that will remain closed except when they are held open during use. Ventilation to the compartments should be afforded by well-screened openings at either end. Further to prevent access of flies to the fecal matter all openings in the entire structure should be well screened, and doors should be provided with springs that will keep them closed. A liberal quantity of powdered slaked lime or dry loamy earth should be used at least once each day to cover the fecal matter. Some of the privies in the park, notably that near the gun club and those near the southeast corner of the park, are so crudely constructed that they should be entirely removed and replaced with more substantial, not to say less repulsive, structures.

All wells in the park are more or less influenced by contamination. Analyses of every water from the wells show the presence of gas formers in 1 cc. and larger portions, and gas formers were found even in 0.1 cc. portions of 3 samples. The total number of bacteria in nearly every sample was higher than should be obtained in good shallow wells and the bacterial count was very high in water from well 7, which is imperfectly protected at the top. It is improbable that the quality of the water in the wells is seriously affected by the privies though this may be possible with wells 2 and 6. The principal contamination results from imperfect protection against surface drainage and the re-entrance of water that has been pumped from the wells. To obviate these dangers the tops of all wells should be constructed in a manner that will adequately protect them against surface contamination and care should be taken to prevent waste water from standing in puddles near the wells.

Proper supervision over restaurants during the Chautauqua is rather difficult. The greatest danger could be overcome by construction of privies along the lines already indicated, as this would prevent in large measure the carrying of specific disease germs by flies from privies to food. As an additional safeguard, the kitchens should be screened, which is perfectly practicable in the manner now used by the United States Army.

A great handicap to cleanliness in the tent restaurants is lack of a good supply of running water. It would not be difficult or expensive to arrange for kitchens a small elevated tank pipe-connected to a hand pump in a near-by well. This would insure more generous use of water for washing dishes.

An increased water supply introduces a new difficulty in the form of increased quantities of dirty sink wastes, which cannot properly be disposed of by throwing them on the ground. Perhaps the most satisfactory arrangement would be a water-tight cistern of proper capacity, which could receive sink wastes through suitable drainpipe connections. When the cistern becomes filled the contents should be pumped out and carried off by a night-soil wagon.

JERSEYVILLE, Water supply.—Visited June 11. Jerseyville, the county seat of Jersey County, has a population of 4,200. The sanitary sewerage with 3 outlets in the northeast, southeast, and southwest portions of the city substantially covers the built-up portion of the city. Nuisance conditions at the two southerly outlets have been the subject of complaint.

The waterworks were installed in 1889. The source of supply then was a well 2,003 feet deep obtaining water principally from the St. Peter sandstone. A shortage in the supply in 1895 necessitated sinking an additional well. The new well is 1,542 feet deep and is of considerably larger bore than the original well, being 12½ inches at the top and 8 inches at the bottom. The static level is at a depth of **117** feet. The water is raised by air lift with a submergence of about 500 feet; no difficulty has thus far been encountered in obtaining an ample supply for the city. The highest rate of pumping has been **148** gallons a minute, equivalent to 213,000 gallons a day. The old well has been abandoned though it could be placed in service again by uncapping the casing and installing a pump.

A 10-year contract, awarded in 1899 to the local electric lighting company for pumping the city's water supply, provided for replacement of the steam-pumping machinery with electric pumping machinery. The contract was not satisfactorily fulfilled with respect to the quantity of water delivered, and it was abrogated some years before the completion of the contract period. The city lengthened the air pipe in the well and installed an additional service pump and since then satisfactory service has been maintained. The water is discharged from the well into a 148,000-gallon covered circular brick collecting reservoir, from which it is pumped into the distribution system by either or both of 2 duplex steam pumps having a combined daily capacity of somewhat more than 1,000,000 gallons.

The quality of the water is highly unsatisfactory on account of its mineral content, which is 3,300 parts per million, 2,400 of which is salt that imparts a distinctly briny taste to the water. The total hardness is 550 parts per million, half of which is sulphate hardness. The public supply is maintained chiefly for fire protection, though it is used to some extent for baths, water-closets, and street sprinkling. It cannot be used for sprinkling lawns.

Water from private wells is extensively used for domestic purposes. Many of these wells are unfortunately located in relation to sources of contamination and are poorly protected against the entrance of surface drainage. An analysis of water from a typical dug well at the Baptist Church indicates contamination.

JOHNSTON CITY, Water supply.—(Bull. **11,** 79.)

JOLIET, Water supply.—(Bull. **11,** 79.)

Illinois State Penitentiary, Water supply.—(Bull. **11,** 81.)

KANKAKEE, Water supply.—(Bull. **11,** 83.)

KEITHSBURG, Water supply.—Keithsburg was visited July 1 in response to a request from the mayor for an investigation of the quality of the water supply. Keithsburg, in the southwest part of Mercer County on Mississippi River, has a population of about 1,500.

The waterworks were installed by the municipality in **1893.** The supply is derived from wells in the alluvium bordering the river. Originally 11 or 12 municipal wells were used, but a few years ago a contract was made with the local electric light and power company to pump the supply from 8 or 9 of the company's wells, which now furnish the main supply, the original city wells and pumping station being held in reserve. All the wells used are tubular and range in depth from 30 to 50 feet and in diameter from 3 inches to 8 inches. Water in the wells is normally about 8 feet below the surface; the static level fluctuates with the water level of the river but not so much. No records of consumption are maintained, but rough estimates indicate that about 60,000 gallons a day is used. The city pumping station has 2 duplex steam pumps each with a daily capacity of about 350,000 gallons; at the electric lighting plant is a 500,000-gallon single duplex steam pump, the total pumping capacity thus being 1,200,000 gallons a day. Water is pumped directly from the wells into the distribution system and the pumps are placed in pits to minimize the suction lift. The distribution system.

comprises about 3 miles of 4-inch to 8-inch cast-iron mains. A 50,000-gallon standpipe 85 feet high and 10 feet in diameter, on ground about 45 feet lower than the highest part of the built-up portion and 5 feet higher than the lowest portion, is connected with the distribution system.

The surroundings of the wells are not altogether satisfactory as there are privy vaults in the vicinity of both groups. Sanitary analyses of the water have thus far indicated safe water, but there are evidences of contamination in the presence of gas formers and large amounts of nitrate. The water has a high mineral content, 1,196 parts per million, and a total hardness of 690 parts, half of which is sulphate hardness.

A copy of the report on the waterworks of Keithsburg was sent to the mayor together with a statement regarding the danger of pollution to which the wells are subject.

KENILWORTH, Water supply and sewerage.—(Bull. 9, 24.)

KEWANEE, Water supply.—(Bull. 10, 130.)

KIEKWOOD, Water supply.—(Bull. 10, 131.)

KJNTOXVILLE, Water supply.—(Bull. 9, 25; 10, 131.) Aeration of the public water supply, recommended by the Survey to remove the high content of iron, was inspected October 8. The discharge line from the deep well had been reconstructed to deliver the water in a solid stream at a height of 2 feet above high water in the collecting reservoir. This did not afford very thorough aeration, but considerable relief was obtained. While this treatment was in use there were almost no complaints due to presence of iron in the water.

In order to make certain recent repairs at the plant it was necessary to change the piping and abandon the aeration, and the result was that consumers again experienced trouble with iron in the water. It was suggested that a more effective device to aerate the water be installed when rearrangements had been made. This could be done by extending the discharge pipe vertically upward from the bottom of the reservoir and allowing the water to discharge at a point near the peak of the conical roof covering the basin. A series of steps below the discharge would further increase the aeration and a few baffles within the reservoir would serve to retain the iron precipitate and prevent it from being drawn into the suction of the high-service pump. The repairs that were being made included replacing valves on pipes connecting the pump with the distribution system and the standpipe, the old valves having been badly corroded. The inside casing of the well has also developed a leak at 91 feet, and inserting a new casing is contemplated. Small leaks have developed in tho bottom of the elevated tank, which has been in service about 20 years, and a new tank will probably be purchased soon. The neighboring towns of Bushnell and Macomb, which have supplies similar in character to that at Knoxville, experienced similar corrosion in their steel tanks after about 20 years' service.

KNOXVILLE, Sewage disposal.—An alleged improper disposal of sewage at Knoxville was investigated October 8 on a complaint referred to the Survey by the State Board of Health. It was found, as frequently happens in small communities with public water supplies without sewerage, that domestic sewage was being discharged through drains ostensibly constructed for the removal of storm water and other surface drainage. The outlet of these drains emptied on the grounds of St. Albans School where a decided nuisance by odor was created. Moreover the outlet is in the drainage area of a valley that will probably be developed as an additional source of water supply for Galesburg. The matter was referred for adjustment to the mayor of Knoxville.

LACON, Water supply.—Visited October 10. Lacon is on the east bank of Illinois River near the center of Marshall County, of which it is the county seat, and its population is approximately 1,500. There is no comprehensive sewerage system, though several drains built from time to time lead to Illinois Eiver down the somewhat steep slopes on which the city is located. The public utilities comprise a privately owned electric light plant and a municipal waterworks, which is furnished with power from the light plant.

The waterworks were installed in 1893 and an old 40-foot dug well about 200 feet from the east bank of Illinois River was utilized. It was improved by sinking in its bottom an 8-inch casing to 60 feet; a new 8-inch well was also sunk to 60 feet a few feet from the original well. The wells seem to intercept ground water flowing toward the river in coarse gravel. This flow must be pronounced for the light company had to extend its boiler-feed intake **400** feet into the river to get beyond the influence of the ground-water affluent. The supply is abundant and the two wells readily meet the present requirements of the city. An additional supply may easily be obtained by sinking additional wells.

There are several possibilities of contamination of the supply from near-by privies and a cesspool. There is also a remote possibility of pollution during a rapid rise of the river, which might cause a back-flow into the ground. This condition, however, has never actually been observed. Overflow of the old well on the pumping-room floor also affords some opportunity for contamination. Though samples collected October 10 showed no dangerous contamination it is conceivable that dangerous contamination may exist under certain conditions of pumping and ground-water flow; therefore, the sources of possible contamination within at least 5 00 feet of the wells should be removed. Prom a physical point of view the water is exceptionally good, being entirely free from turbidity, color, and odor. The mineral content is moderately high, but compares very favorably with that of water from other drift wells in Illinois. The total residue is **434** parts, and the total hardness is 340 parts per million, mostly in the form of carbonate hardness. The supply seems to afford popular satisfaction.

The water is pumped by 2 electrically driven 2-stage centrifugal pumps, each with a nominal daily capacity of 300,000 gallons, against a normal pressure head of 67 pounds and a suction lift of about 15 feet. The pumps are housed in a brick pumping station 16 by 25 feet with its pump floor about 12 feet below the surface. The consumption of water is not recorded, but rough estimates based on fluctuations in the standpipe indicate a daily consumption of about 140,000 gallons, equivalent to 93 gallons per capita. The distribution system comprises about 4.6 miles of 4-inch to 10-inch mains. A 65,000-gallon elevated tank on an elevation east of the city and about one mile from the pumping station is connected with the distribution system. The total height of the tank is 60 feet and it produces a pressure in the mains ranging from 26 to 67 pounds per square inch with the elevation. The estimated cost of the waterworks to date is $30,000. The average cost of operation is about $1,500 per annum and the receipts from the sale of water are about $2,000. The city was being metered, which should tend materially to cut down consumption of water and therefore cost of operation without materially affecting receipts.

LADD, Water supply.—(Bull. **11,** 84.) Ladd was visited November 13 to ascertain if sources of contamination of the water supply noted February 5, **1913,** had been corrected. The lining of the collecting reservoir had been made substantial by constructing a concrete curbing extending 6 inches above and 5 feet below the surface of the ground. The top was covered with a board cover. Though this is a material improvement over previous conditions, it is not adequate to pro; tect the supply against surrounding sources of contamination. Another factor that may at times affect the quality of the water in the city mains is the connection with the private supply of the Illinois Third Vein Coal Co. through a 4-inch Globe valve which is supposed to be opened only in emergency. The danger lies in the valve being accidentally left open or becoming leaky. The water of the coal company's supply is obtained from the bottom of a mine and is salty. Any large inflow into the city mains would be detected by the taste.

LAGKANGE, Sewage treatment plant.—(Bull. 10, 134.)

LA HARPB, Water supply.—La Harpe was visited May 15 in response to a request from the local retail merchants association for advice regarding increase of the water supply. La Harpe, in the northeast corner of Hancock County near the headwaters of Crooked Creek, has a population of about 1,300.

Waterworks were installed in 1894 when the city dug a large well near the center of town and equipped it with a pump to force the water into the distribution system and the elevated tank. Only a limited supply was obtained, and a second and larger well was constructed 10 years later about 400 feet from the first well. The old well is 12 feet in diameter and 47 feet deep and it is lined with brick. There is no record of the formations penetrated, but the water-bearing material is very fine sand locally called quicksand. The water rises only a few feet above the bottom of the well and it is rapidly exhausted by the pumps. The second well has a brick casing 24 feet in diameter and was sunk on a steel shoe to 40 feet. Because of difficulty in sinking the curbing farther an inner curbing 19 feet in diameter was sunk to a total depth of 55 feet in fine sand, which caused great difficulty and prevented reaching greater depth. Water rises to the top of the inner casing and is rapidly exhausted by the pumps. The total storage in the 2 wells is about 32,000 gallons, and this represents the amount that can be pumped at one time. In the means of procuring an increased supply local opinion is divided between sinking deep wells in drift deposits and sinking a deep well into rock. It was on these specific points that the city desired information from the Survey.

After a study of local ground-water conditions it seemed that the possibilities of securing a satisfactory water supply deep in the drift were good. At any rate, this seems the logical first step. An abundant supply is undoubtedly available from deep rock wells, but it is likely to be highly mineralized and undesirable compared with drift water. Abundant water in the drift is usual in central Illinois. It has a total hardness of about 425 parts per million mostly as carbonate. The most serious objection to the drift water is its high content of iron (10 parts per million). To render the water satisfactory would require removal of iron. Such treatment might be combined with softening.

Each well is pumped by a 250,000-gallon triplex power pump driven by a gasoline engine. The engines and pumps are housed in small buildings over the wells. The distribution system comprises about 1% miles of cast-iron mains with leaded joints of which ¼ mile is 6-inch and the remainder 4-inch pipe. The mains serve only about 30 per cent of the population. There are 84 services, all of which are metered. The daily consumption is about 19,000 gallons, or 225 gallons per service. A 3 4,000-gallon elevated wooden tank on a steel tower 60 feet high is connected with the distribution system near the old well.

A copy of the full report with recommendations was sent to the merchants association, the mayor, and the council. Nothing had been done at the end of the year toward following out the recommendations.

LAKE BLUFF, Water supply and sewerage.—(Bull. 9, 25; 10, 135.)

LAKE FOREST, Water supply.—(Bull. 9, 25.) Lake Forest was visited October 6 and November 12, to inspect the recently installed roughing filter and pumping equipment of the Lake Forest Water Co.

The new pumping equipment comprises electrically driven centrifugal pumps, installed to avoid a smoke nuisance in the near-by residential district. The filter is 90 feet by 25 feet, or a little more than 0.05 acre in area; in this bed wooden beams (2-inch by 6-inch dressed material) have been placed on edge at 3/8-inch intervals to form a grid, on which has been placed 12 inches of gravel graded from that coarse enough to be retained by the wooden grid to gravel little coarser than sand. On this gravel has been placed 6 inches of rather coarse bank sand. After a coagulant has been added to the water the mixture is permitted to settle for about 1.75 hours, with a nominal daily consumption of 3,000,000 gallons; it then flows into a 5-foot space underneath the filters, where it is permitted to settle 0.67 hour longer, or a total sedimentation period of 2.42 hours. The water is filtered upward through the bed, and is pumped directly into the distribution system or into a group of pressure filters. The filter is partly cleaned by running water downward through it at a slow rate. It is more thoroughly cleaned by emptying the filter compartment and flushing the space beneath it with a hose. This installation was designed by the company's superintendent and represents not so much an effort to install a perfect type of filter as one that can remove cheaply enough sediment from the water so that it can then be passed through the pressure filters more rapidly and more effectively. It is anticipated, however, that this preliminary filtration alone may be sufficient to produce an acceptable water when the lake water is in its ordinary condition. Main reliance for the sanitary purity of the water at Lake Forest is placed on treatment with hypochlorite.

LAKE FOREST, Sewage disposal.—(Bull. 9, 25; 11, 85.)

LANARK, Water supply.—(Bull. 11, 85.)

LA SALLE, Water supply.—(Bull. 11, 86.)

Investigation of the pollution of two deep wells.—(Bull. 9, 25.)

LAWRENCEVILLE, Water supply.—(Bull. 9, 25; 11, 86.) Lawrenceville was visited April 27, April 30, June 6 and August 19 to inspect the water-purification works, and again November 1-2 to confer with the local woman's club and municipal authorities with reference to improving the character of the public water supply, which is taken from Embarrass River.

It was found in April that the water-purification works were being operated in a more or less slovenly manner apparently because the company expected soon to have a new supply from wells in the low lands near Embarrass River ½ to 1½ miles northeast of the city. The well project had, however, been indefinitely postponed because of controversy between the city and the water company involving a claim for uncharged water rents and because of difficulty in securing land. As the well project, even if assured, would require a year or more to develop special efforts were made to procure efficient operation of the purification works without causing the company to incur any greater expense for modifications than was absolutely essential. Recommendations were made to the water company involving general improvement of the apparatus, methods of applying hypochlorite, renewal of sand in the filters, installation of filter-rate controllers, improvement in the coagulation and the manipulation of the filter valves, maintenance of operating records, and employment of a trained man to operate the filters under analytical control.

The second examination in August revealed that conditions at the purification works were greatly improved. Much of this improvement was effected in June by the employment of a trained filter operator, who had made several improvements previously recommended and was rapidly progressing toward producing a uniformly safe filtrate. Progress had been hindered somewhat because the new employee had been assigned to superintend further investigations for a groundwater supply. Full instructions were given in August for maintenance of a laboratory and for operation of the filter. It was also recommended that a washwater pump or an elevated tank should be installed for washing the filters; that a platform be placed around the filters to facilitate operation; that the low-lift pumps be reduced to half speed during washing of the filters; and that the hypochlorite be purchased in zinc cans and better protected against deterioration. Since that visit the company has regularly submitted to the Survey results of analyses which have shown, except once or twice, a safe water. The turbidity has been high at times, and the content of salt has been at times so great as to cause objectionable tastes. Several analyses made in the laboratory of the Survey of samples collected by citizens from taps on the distribution system have not given so favorable results as those made in the company's laboratory, but this difference may have been partly due to carelessness in the collection of samples and partly due to changes during shipment. With reasonable care the water can be rendered safe with the present equipment. It should also be possible to get the turbidity low enough to render the water acceptable in appearance. The salt cannot be eliminated and is bound to recur on rising floods as long as the oil-well industry continues in the basin above the intake. The purification equipment should be replaced by better designed and more substantially constructed apparatus if Embarrass River is to remain the source of supply.

A few additional recommendations were made November 1-2 especially regarding more perfect application of hypochlorite for sterilization, the enlargement of the capacity for coagulation, maintenance of a more uniform rate of filtration, and increase in the thickness of the sand beds. It is understood that these recommendations have now been complied with. Special attention also was given to the possibility of procuring a supply from wells. The results of inspection seem to warrant further investigation of the practicability of deriving water from wells in the sand and gravel deposits in the bottom land of Wabash Eiver 6½ to 7 miles east of Lawrenceville by sinking several test wells and subjecting them to a thorough and suitable pumping test. There also seemed to be a possibility of procuring a supply from rock wells in the city. Several such wells yield water that would be satisfactory for general domestic use. On the other hand, all the wells concerning which information was available yielded so little water as to render questionable their development for public supply. Further tests are to be made at the local ice plant on wells which are expected to yield with new pumping equipment large quantities of water.

LEAF EIVER, Proposed water supply.—Visited November 12. Leaf River is in the north-central part of Ogle County on Leaf River, a small tributary of Rock River, and it has a population of about 500.

For the past 20 years Leaf River has been afforded limited fire protection along its business street by a water pipe with hydrant connections, into which water could be diverted from the railroad company's water tank. Not more than 20 pounds pressure could be thus obtained and the desire for better fire protection as well as a public supply for domestic uEe has resulted in popular approval of a bond issue for the installation of waterworks. Improvements at present will include erection of an elevated tank and some extension of the mains, and the railroad supply, which is derived from wells in drift, will be temporarily utilized.

The village proposes to develop a supply of its own early in 1915 by sinking one or more wells in the valley of Leaf River in the north part of town. The experience with the railroad well indicates that an abundant supply can be obtained at 70 feet in what appears to be the preglacial valley of Leaf River. If this project should fail an abundant supply can probably be procured from a fine sandstone at 114 feet.

LE CLAIRE, Typhoid fever.—(Bull. 11, 87.)

LELAND, Proposed water supply.—Leland was visited May 20 at the request of local authorities to investigate a possible source of public water supply. Leland is near the northern border of LaSalle County in the drainage basin of Fox River, and it has a population of about 550. Funds for waterworks were appropriated at a recent public election.

Many shallow wells in town obtain a small quantity of water from a stratum of sand at 30 feet. Another water-bearing stratum of very fine sand is encountered at 70 to 80 feet, but it does not readily yield its water. A layer of coarse sand and gravel 10 to 30 feet thick, entered at 100 feet, is said to contain much water and to overlie sandstone which also yields, satisfactory water. The water in a well 157 feet deep entering sandstone at 115 feet stands 15 feet below the surface; the water of this well is of excellent sanitary quality and only moderately mineralized. Plans for the waterworks contemplate sinking a well to rock near the center of the town, erection of a small pumping station over it, installation of an elevated storage tank, and laying mains to cover the built-up portion of the community.

The general scheme was approved, but the local authorities were strongly advised to conduct a pumping test on the well before installing permanent equipment and they were also advised to submit plans and specifications to the Survey for review.

LENA, Water supply.—(Bull. 11, 88.)

LE ROY Water supply.—(Bull, 10, 136.)

LEWISTOWN, Water supply.—Visited March 13. Lewistown, in the southeast part of Fulton County, occupies a site on the highlands bordering Spoon River, and it has a population of about 2,300.

The original supply of the waterworks, which were installed in 1888, was taken from 28 driven wells in the bottom lands of Spoon River 2½ miles southwest of the city after an investigation of existing wells and sinking several test wells in the city. In 1911 the mains were greatly extended, one of the 2 original pumps was replaced by a larger one, and the driven w'ells were abandoned for a large dug well because the screens in the old wells clogged with sand. Steps are being taken to replace the remaining original pump by a larger one, and a second large dug well will probably be constructed.

The dug well is in the broad bottom of Spoon Eiver and penetrates 4 feet of black loam and 21 feet of sand and gravel. Bedrock is 5 feet below the bottom of the well, but it was not possible with the equipment to sink the well to rock. The well is 12 feet in diameter, but the top is constricted like the neck of a jug to a diameter of 3½ feet, is raised 4½ feet above the surface of the ground, and is water-tight to exclude flood waters. Water is pumped from the well directly into the distribution system by 2 compound 500,000-gallon duplex pumps. As the pumping station is 124 feet below the general elevation of the town it is necessary to pump against the high pressure of 102 pounds per square inch. The distribution system comprises 7.2 miles of mains, 5.2 miles within the corporation limits and 2 miles of 8-inch pipe in the rising main from the pumping station. A 35,000-gallon elevated steel tank in the central part of town on a brick tower with a total height of 104 feet is connected with the distribution system. As this storage is inadequate a tank of 80,000 or 100,000 gallons' capacity is being contemplated.

No systematic records of consumption are maintained, but the average daily pumpage is estimated at 75,000 to 140,000 gallons. The water is of excellent quality from a sanitary point of view, and it is but moderately mineralized. The total hardness is 310 parts per million, less than one-third of which is sulphate hardness.

LEXINGTON, Water supply.—Visited May 13. Lexington, in the northeast part of McLean County in the drainage basin of Mackinaw River, has a population of about 1,300.

Municipal waterworks were installed in 1894. The supply was originally obtained from one well, and a second well was added in 1902. The wells are 115 feet deep, 8 inches and 10 inches in diameter, respectively, and are 20 feet apart. The wells are cased to 100 feet, below which are 15-foot Cook strainers. The static level is at 40 feet, and the working barrels of the pumps are placed at 90 feet; the drawdown under pumping is unknown. The wells penetrate clayey glacial drift, but strike coarse water-bearing sand and gravel at 100 feet. The pumping station is a small brick building over the wells. Two deep-well power pumps, with capacities of 278,000 and 165,000 gallons, respectively, driven by a gasoline engine, pump directly from the wells into the distribution system, which comprises about 3.1 miles of 4-inch to 6-inch mains. A 40,000-gallon elevated tank 117 feet in total height is connected with the distribution system. No reliable pumping records are kept, but an estimate based on pump capacities indicates that about 68,500 gallons a day is used, equivalent to 52 gallons per capita and 372 gallons per service. All services are metered.

The water is of very good quality from a sanitary point of view. The total hardness is 300 parts per million, practically all in the form of carbonate. Sufficient iron to cause discoloration and turbidity of water is present, and it is stated that the water corrodes brass and wrought iron.

LIBERTYVILLE, Water supply and sewerage.—(Bull. 10, 137.)

LINCOLN, Water supply.—(Bull. 10, 138; 11, 89.)

LINCOLN, Sewerage.—Lincoln was visited February 11 to address the local woman's club on the necessity of a comprehensive study of the sewerage system for the three-fold purpose of securing better drainage making future provisions for treatment of the sewage to prevent contamination of neighboring streams, and eliminating the danger of pollution of the public water supply by sewage.

LINCOLN, State School and Colony, Water supply.—Lincoln was visited May 12, to obtain data to enable the Survey to advise the authorities of the State school and colony for feeble-minded children regarding means for procuring a water supply and disposing of sewage from the institution and the farm colony connected with it.

Recommendation was made that the water supply at the school be augmented by using the north well, which was abandoned some time ago owing to an unfavorable analysis by the Survey. More recent analyses show that the water is of satisfactory quality, and it is practicable to protect both the well now in use and the north well from further contamination. The greatest danger is from sewers serving near-by buildings. Thus far no indication of such pollution has been found. Each of the 2 wells, 25 feet apart, are 10 feet in diameter and 60 feet deep and obtain water from gravel in the drift. It was recommended that if the north well does not sufficiently augment the supply the authorities consider sinking tubular wells to the same water-bearing stratum far enough apart to prevent them from interfering with one another. The supply at the farm colony is drawn from a well 40 feet deep and 7 feet in diameter. This well apparently just reaches the water-bearing stratum and the condition of the bottom of the well makes it probable that the yield can be materially increased by driving well points in the bottom. This was accordingly recommended.

LINCOLN, State School and Colony, Sewage disposal.—In view of the probable future growth of the farm colony it was recommended that no modifications be made other than those absolutely necessary to eliminate the present cause of complaint. It was suggested that a 10,000-gallon sedimentation tank be constructed at the present outfall and that the effluent from it be conducted through a farm-drain tile to the channel of Salt Creek and discharged at a suitable bulkhead built well into the flowing water and protected so far as practicable against damage by floods. When the material increase in the size of the colony is assured general remodelling of the sewerage system should be considered.

LITCHFIELD, Water supply.—(Bull. 9, 26; 10, 141; 11, 89.)
Typhoid-fever conditions.—(Bull. 11, 90.)

LOCKPOET, Pollution of Illinois Eiver by Chicago Drainage Canal.—(Bull. 9, 26.)

LOSTANT, Water supply.—(Bull. 11, 90.)

LOVINGTON, Water supply.—Visited February 5. Lovington, in the north-central part of Moultrie County at the headwaters of West Okaw Creek, a tributary of Kaskaskia Eiver, is a coal-mining village with a population of about 1,100.

Waterworks, installed in 1891, included a well, an elevated tank, and a pumping station, privately owned until 1909 though the village installed and owns the distribution system. The well proved incapable of meeting increased demands in 1906, and the village drilled 2 additional wells and erected a new elevated tank, and in 1909 purchased the original well, pumping station, and pumping equipment.

All the wells are situated on a lot 50 by 54 feet about two blocks from the business center; only the 2 wells drilled in 1906 are used; they are 147 feet deep and 6 inches in diameter and are in the pumping station 15 feet apart. Though no records of the borings are available the water-bearing stratum is probably glacial sand and gravel. The static level is said to be 40 feet below the surface; the drawdown is not known.

One steam-driven 120,000-gallon and one electrically driven 72,000-gallon deep-well pump discharge into a 47,000-gaIlon circular brick covered collecting reservoir, from which the water is pumped by a 62,000-gallon duplex steam pump. The distribution system includes about 1.7 miles of 4-inch and 6-inch cast-iron pipe. A 36,000-gallon elevated tank near the pumping station having a total height of 114 feet is connected with the distribution system. No records of water consumption are maintained, but estimates indicate that 18,000 to 20,000 gallons a day is pumped, equivalent to 20 gallons per capita and 320 gallons per service.

The water is of good quality from a sanitary standpoint, but is very hard and contains 1.3 parts per million of iron, which causes marked discoloration and turbidity.

McHENRY, Water supply.—(Bull. 9, 27.)

McLEANSBOBO, Water supply.—(Bull. 10, 147.) Visited April 29, October 14, and December 16. The public water supply, which is derived from an impounding reservoir, has been delivered unpurified most of the time since installation. One pressure filter was provided when the reservoir was built in 1911, but this has never been satisfactory for several reasons, chiefly defects in chemical treatment and the remoteness and consequent inconvenience of the plant.

A representative of the filter company visited McLeansboro in February and, after examining the filter, made certain recommendations regarding coagulant feed, which, if carried out, should improve the efficiency. Similar recommendations had previously been made by the Survey, but nothing has been done by the city, and the filter remains out of service.

It was recommended in the last report by the Survey that the filter be removed to the city's electric plant in town where a 360,000-gallon masonry reservoir is now used merely to hold an emergency supply. It would be practicable to convert this reservoir into a coagulating basin and to pump coagulated water from it through filters placed in the power house. The pump at the reservoir could be used for low service to deliver water to the coagulating basin. A pump already installed at the electric plant is capable of supplying the city.

MACKINAW, Water supply.—Visited July 2. Mackinaw, in the east part of Tazewell County one-half mile south of Mackinaw Eiver, has a population of about 800.

Waterworks installed in 1893 by the municipality chiefly for fire protection. The original station was on the public square. The equipment included a 60-foot dug well, a power pump operated by a gasoline engine, an elevated tank, and about 1¼ miles of 4-inch mains. The village operated the waterworks until 1895, when a contract for operation was awarded to Mr. A. T. Judy. In 1897 the contract was transferred to Mr. F. A. Thompson, who erected a new pumping station and a well in a different locality. The well put down at the new site was dug 55 feet deep. The contract was transferred in 1904 to the Mackinaw Electric Light Co., which constructed an electrically operated pumping station near the Vandalia depot in the north part of the village. No important changes have since been made. The source developed by the light company is 2 tubular wells 170 feet deep penetrating water-bearing sandstone. One well is 4 inches in diameter and is equipped with an electrically driven 57,600-gallon deep-well power pump, and the other is 5 inches in diameter and is equipped with an 86,400-gallon pump. The static level is 30 feet below the surface; the drawdown is not known. The combined yield of the 2 wells according to pumping tests when they were drilled was 144,000 gallons a day. The distribution system comprises 1¼ miles of mains, practically all 4-inch cast-iron pipe. Large extensions of the distribution system are planned. There are 150 Eervice connections, few of which are metered. Storage on the distribution system is afforded by a 9,000-gallon pressure tank in the pumping station. No pumping records are maintained, but the daily consumption is 28,000 to 30,000 gallons.

The water has a total hardness. of 465 parts per million, and also contains 1.7 parts per million of iron, which causes objectionable discoloration and turbidity. Though analysis of a sample shows no evidence of pollution the tops of the wells are not adequately protected against the direct entrance of contamination.

MACOMB, Water supply.—(Bull. 9, 26.) Visited May 14, 1914. Macomb, the county seat of McDonough County, is in the basin of Crooked Creek, a tributary of Illinois Eiver. It has a population of about 6,000 and is experiencing a substantial growth. It has extensive manufactories of clay products and the surrounding country has recently experienced an oil boom.

Waterworks were installed in 1894, when a well 1,630 feet deep was drilled, entering St. Peter sandstone at 1,135 feet. The well was near the center of town and was the only source of supply until 1904. The water was very hard and high in sodium salts and, therefore, unsatisfactory. In 1903 the city sunk several drift wells in the southeast part of town and obtained a small quantity of water of much better quality. Pumping stations were maintained for the original well and the new wells until 1911 when Crooked Creek was adopted as a source of supply. This development comprised a small dam, a new pumping station, a filter plant, a rising main to the city, and an elevated tank. The original pumping station was then demolished, but the shallow wells were held in reserve for emergency and it was necessary to resort to these wells during the dry summer of 1913. Since the development of the Crooked Creek supply the mains have been extended until they now reach practically all built-up sections of the town.

Crooked Creek above the intake has a catchment area of 180 square miles occupied principally by rolling prairie land, most of which is under cultivation. The stream varies greatly in discharge and in quality of the water. The water of the creek is clear at low stages, but it becomes excessively turbid at high stages. The dam across the creek was constructed chiefly to protect the intake; the storage above it is about 8,000,000 gallons, or 3 weeks' supply. The purification works, which have a combined daily capacity of 1,000,000 gallons, are built of reinforced concrete throughout and are giving excellent results under intelligent management. Alum, which is used as coagulant, is prepared in concrete mixing and solution tanks and is fed uniformly to the raw water by constant-head orifice boxes. Hypochlorite is used as a sterilizing agent, but it is applied very crudely and is not under analytical control; the hypochlorite application is practically ineffective. The coagulation and sedimentation basin has a capacity of 175,000 gallons affording a detention period of 4.2 hours. There are 2 filters of standard reinforced concrete construction so arranged that additional filters may be added as needed. A filtered-water reservoir of 150,000 gallons capacity. representing about 3.4 hours' supply lies beneath the filters and extends beyond them. This storage is supplemented by the 100,000-gallon elevated tank, making a total filtered-water storage of 6 hours' supply. Water is pumped from Crooked .Creek to the filters by 2 steam-driven 1,500,000-gallon centrifugal pumps. Water is delivered into the mains by 2 compound duplex 1,000,000-

gallon pumps. Water for washing the filters is taken from the discharge of the high-service pumps at a pressure of 110 pounds. Compressed air for agitating the sand is supplied by a blower. The distribution system comprises about 12 miles of 4-ineh to 12-inch cast-iron mains, and 1¼. miles of 12-inch pipe constitutes the rising main from the new pumping station to the city. The elevated tank is connected with the rising main halfway between the pumping station and the center of the city. The tank is 140 feet in total height and affords a pressure within the city varying between 65 and 75 pounds.

Monthly analyses of the filtered water, made in the laboratories at the State normal school at Macomb, indicate that the water is of good quality as delivered to the consumers. A series of analyses made in the laboratories of the Survey in 1911 and 1914 are less favorable, but this may be attributed to changes in the bacteriological samples during shipment.

MACON, County Almshouse, Sewage disposal.—(Bull. 11, 90.)

MANSFIELD, Proposed water supply.—Visited February 23. According to records of existing wells an abundant supply of water can be obtained from a gravel stratum in the glacial drift at a depth of about 200 feet. One well penetrating this stratum used by the Wabash Eailroad yields 100,000 gallons per 24 hours of water of excellent sanitary quality not excessively mineralized. Though the project was an entirely practicable one and the water was much needed by the village for fire protection and domestic use, the project was defeated by popular vote.

MANTENO, Water supply.—Visited March 6. Manteno is in the northern part of Kankakee County on a tributary of Rock Creek, which runs into Kankakee River, and it has a population of about 1,300.

The waterworks, installed in 1897, are owned and operated by the village. The supply has always been obtained from tubular wells entering limestone. The first well, drilled 93 feet deep, is 6 inches in diameter at the top and 3% inches at the bottom. Bedrock is reached at 17 feet. This well alone had supplied the town only a few years when two deeper and larger wells were drilled to meet increasing demand. The first of these is 10 inches in diameter at the top, 8 inches at the bottom, and 310 feet deep, and the static level is 40 feet below the surface. The second well is 10 inches in diameter at the top, 6 inches at the bottom, and 426 feet deep. The static level is also 40 feet below the surface. The necessity of still greater supply became apparent in 1913 and a well 15 feet in diameter and 60 feet deep was sunk into the rock, from which a tunnel was run to the third of the tubular wells, at a depth of 60 feet. The well is lined with concrete to a depth of 20 or 30 feet in the rock, and the top of it is covered by impervious flat concrete. The greater part of the supply is now pumped from the new well and the original well has been abandoned.

The second and third wells are pumped by 175,000-gallon deep-well power pumps, driven by a gasoline engine. The fourth well is pumped by a 2-stage 600,000-gallon centrifugal pump at the bottom of the well driven at the surface through a vertical shaft by a 50-horsepower motor, which is automatically controlled. Estimates based on pumping experience indicate that the combined yield of the wells is about 300,000 gallons a day, and that the average daily consumption is about 40,000 gallons. The fourth well acts in a measure as a storage reservoir with a capacity of 28,000 gallons. The pumps discharge directly into the distribution system. The extent of the distribution system is not accurately known, but it is said that nearly every street in the built-up district of the city is provided with a main. The mains range from 4 inches to 10 inches in diameter. There are 194 services, which indicates that about 70 per cent of the population uses the public supply. Two steel pressure tanks with a combined available storage of about 10,000 gallons are connected with the distribution system at the pumping station.

The water is of good quality from a sanitary point of view, but its mineral content, 614 parts per million, is rather high, and its total hardness is 495 parts per million, of which one-half is sulphate hardness.

MAEENGO, Water supply.—(Bull. 11, 91.)

MARION, Water supply.—(Bull. 10, 142.) Marion was visited July 1 to collect samples of the city water because of complaints of turbidity, color, and stale odor of the supply delivered to consumers.

Results of analyses showed no turbidity or color, but the samples showed some evidence of contamination. It was also found that there is a connection at the pumping station between a 4-inch pipe carrying polluted pond water for street sprinkling and the main discharge carrying well water from the pumping station. This connection is provided with 2 gate valves, one of which was found closed. As the pressure in the 4-inch pipe was less than that in the main discharge there was no likelihood of contamination at the time; on the other hand, it is conceivable that this connection may be carelessly left open and polluted pond water may thus get into the distribution system. Accordingly it was recommended that this connection be cut out altogether, and this recommendation was duly carried out by the water company.

The slight pollution observed in the samples and also observed on samples taken at other times is difficult to explain, but the most probable explanation is that frequent removal of pump rods from the wells for repair and adjustment affords opportunity for some contamination to enter the wells. In view of the difficulty of ascertaining the cause of the pollution and the failure thus far to eliminate it, application of hypochlorite was recommended. This recommendation also has been carried out by the water company.

MAEION, Sewage disposal.—Marion was visited June 17 at the request of the city engineer. Crab Orchard Creek, a small stream south of Marion, receives sewage from the city and is grossly polluted with the result that numerous complaints have been made by riparian owners. The drainage basin above the entrance of the sewage covers only 38 square miles and at times has no natural flow. As complaints had grown very persistent it was felt by the authorities that something should be done at once, even if of temporary nature, until suitable plans could be formulated for complete treatment. Accordingly a settling basin was formed by building 2 dams about 4 feet high across the creek, one immediately above the outlet and one about 75 feet downstream. A ditch around the basin thus formed is expected to carry the normal flow of the creek in ordinary dry periods. It is thought that the sedimentation thus obtained will give some relief during dry periods and that the basin will be thoroughly cleaned by high water.

Plans are now under way for more complete treatment. The works will be designed to dispose of about 200,000 gallons a day of sewage. The daily discharge of sewage, as determined by measurement, is about 100,000 gallons, a rather small quantity for a city of 7,000, but the sewerage system is limited and the public water supply has a maximum daily yield of only about 115,000 gallons. The site chosen for the disposal works is 25 acres bordering Crab Orchard

Creek near the outlet of the sewer. Most of this land is subject to inundation to a depth of 6 feet, but two knolls, now occupied by the city garbage incinerator and a pesthouse, rise a few feet above high water. It is proposed to build the disposal plant principally on these knolls. Pumping the sewage will probably be necessary.

MARISSA, Proposed water supply.—Visited July 30. Marissa, in the southeast corner of St. Clair County in the drainage basin of Kaskaskia River, has a population of. about 2,200.

Installation of a public water supply has been under consideration for several years, but no definite steps have been taken because of difficulty in finding a suitable source of supply. The glacial drift in this vicinity is about 40 feet or less in thickness, consists chiefly of clay, and yields but little water. The only water-bearing stratum of which there is any local knowledge is a thin layer of soft sandstone just below the surface of bedrock, which is penetrated by several wells and 2 coal-mine shafts. The sandstone yields little water and the water contains so much mineral matter that it is undesirable for domestic and industrial use. It was pointed out to the local officials that Red Bud had found a large yield in sandstone at a depth of 169 feet, and it was suggested that Marissa, being only 13 miles farther east, might encounter the same formation by drilling west of the town.

The possibility of procuring an adequate and satisfactory supply of surface water seems but little better than that of procuring a well supply. Yet it may be possible to build a suitable impounding reservoir on Dose Creek, a small stream about one mile from the village. Big Muddy Creek several miles northeast is another possibility, but its development would entail large cost. Kaskaakia River about 9½ miles distant, would likewise be an expensive source. Thorough engineering studies are necessary to determine the best source of supply for the village.

MAROA, Water supply. (Bull. 10, 143.)

MARSEILLES, Pollution of Illinois River by Chicago Drainage Canal.—(Bull. 9, 26.)

MARSHALL, Water supply.—Visited October 28-30. Marshall, the county seat of Clark County, is about 7 miles from Wabash River and it has a population of about 2,600. The city has several municipal improvements, including a combined sewerage system.

Waterworks were installed in 1900. After several test borings in the village a well supply was developed in the bottom lands near Big Creek, 2 miles east of town. The original wells have been abandoned and replaced by new ones, which have been bored from year to year. The pumping equipment has been greatly modified and the pumping station has been enlarged. The boring of an additional well and enlargement of the boiler plant is now under consideration. There are now 5 wells 10 inches in diameter, from which the water is drawn and pumped directly into the distribution system by one 750,000-gallon duplex and one 1,000,000-gallon cross-compound pump. The cross-compound pump is a new installation and the purchase price of it was saved in fuel during 5 years following its installation, the saving having been estimated at $5,000 from the results of seven 8-hour tests on each pump. The extent of the distribution system is not known, but it covers fairly well the built-up community and includes pipes ranging from 8 inches to 1 inch in diameter. The pipes 4 inches and larger in diameter are cast iron. An 80,000-gallon elevated tank connected with the distribution system near the center of town is supported on a steel tower making the entire height of the structure 120 feet. During a typhoid epidemic (see below) a report gained credence that there were dead sparrows in the tank, but an examination showed that this was not so. That birds do occasionally enter tanks and standpipes and die is, however, a well-known fact. There are 325 service connections, representing about 50 per cent of the population. Pump records are not regularly kept, but tests on the new cross-compound pump gave daily consumption figures averaging slightly less than 500,000 gallons and reaching a maximum of 700,000 gallons.

Analyses indicate that the water is of excellent quality from a sanitary standpoint, and that the mineral content is low, the total residue being 274 parts per million and the hardness moderate compared with that of ground waters in Illinois in general.

MAESHAXLL, Typhoid fever.—Marshall was visited October 28-30 to investigate a prevalence of typhoid fever that was locally attributed in part to pollution of the public water supply. The investigation and report were made with all the thoroughness that the circumstances permitted, but in communities where complete and systematic information is not available in reference to communicable diseases it is very difficult to procure all the facts that are necessary in drawing reliable conclusions as to the causes of disease. The weight of evidence, however, indicates that a small dairy was one of the principal causes of the typhoid fever at Marshall. Though this dairy is fairly clean, the milk sold by it could not be regarded as absolutely protected against pollution, as is evidenced by investigations of other milk-borne outbreaks, notably one at Eockford. Only 8 of the 14 cases can be accounted for by milk infection. There are several possibilities to explain the remaining 6, such as contact, fly infection, and drinking from polluted wells, but as so often happens in rural districts and small communities where a variety of factors are active in the spread of disease it is impossible to point to one cause. The water supply is absolutely free from contamination and was not responsible for any of the typhoid cases investigated.

MASCOUTAH, Water supply.—"Visited December 23. Mascoutah occupies flat and poorly-drained territory in the drainage area of Silver Creek in east-central St. Clair County. The population is about 2,000. Coal mining is the principal industry. There are practically no municipal improvements other than sidewalks and an unsatisfactory public water supply. Sewerage is greatly needed to improve sanitary conditions. Private shallow wells are depended on for drinking water and many of them are subject to contamination.

The waterworks, installed in 1905, included a small pumping station, one well 48 feet deep, an elevated tank, and about 5,000 feet of 6-inch mains. The pumping station and the well were placed on a lot south of the built-up section of the city near the electric lighting station, from which steam was obtained for operating the pump. The well yielded an inadequate quantity of water of very unsatisfactory quality because of excessive hardness and high content of iron and was, therefore, soon abandoned in favor of 10 tubular wells 35 to 40 feet deep and obtaining about 72,000 gallons a day of water, softer and with less iron than that from the original well, but still sufficiently unsatisfactory in these respects to discourage its general domestic use. The total hardness of the abandoned supply is 800 parts per million, about one-half of which was sulphate hardness, and the iron content is 9.4 parts per million. The supply now in use has a total hardness of 450 parts per million, less than half of which is sulphate hardness and:

the iron content is about 2 parts per million. Not only is the supply of objectionable mineral character, but it is also subject to serious danger of contamination by general surface drainage and particularly by a privy near one of the wells. The 10 wells now in use are 4 to 6 inches in diameter and are scattered over an area of 4 acres owned by the village. The top of each well is surrounded by a small pit loosely walled up with brick and these pits are covered with loose boards. A 2-inch suction enters the top of each well, which is closed by a loosely fitting iron collar around the suction pipe. During heavy rains these pits are filled with dirty surface drainage, which may readily enter the wells. The water is used for street sprinkling, for flushing closets, and for miscellaneous purposes, but it is stated that it is not used by any persons living in the city for cooking or drinking.

The pumping equipment consists of a duplex steam pump with a nominal daily capacity of 210,000 gallons, which draws directly from the wells and discharges directly into the distribution system. It is set in a pit 8 feet deep. The distribution system comprises about 1.65 miles of 6-inch iron pipe. A 50,000-gallon elevated steel tank with a total height of 125 feet is connected with the distribution system near the center of town. The pressure throughout the system averages about 50 pounds per square inch. No information regarding pumpage could be obtained, but the daily consumption apparently varies from 15,000 to 48,000 gallons.

MASON CITT, Water supply.—Visited November 2. Mason City has a population of about 1,850. The site of the city is very flat and drainage is poor. There is no sewerage.

The public water supply, installed in 1889, is owned and operated by the municipality. Water is obtained from 2 tubular wells about 200 feet deep drawing from extensive sand and gravel deposits in glacial drift. The water-bearing material is entered at 36 feet and continues to the bottom. The wells are 10 inches in diameter at the top and terminate in 6-inch Cook strainers 16 feet long. The static level is 65 feet below the surface. The pump cylinders are set at 85 feet. Steam-head deep-well pumps are used and the water is pumped directly from the wells into the distribution system. No records are maintained of the amount of water consumed, but pumping at maximum capacity, 400,000 gallons a day, seldom lowers the water below the suction limit. Apparently in recognition of the fact that the wells are sometimes now pumped at maximum capacity a third well has been proposed. The average daily consumption may be roughly estimated at 275,000 gallons, equivalent to 150 gallons per capita. This is very large for a town without sewerage, and probably results mostly from waste on the flat-rate connections and partly from almost universal use of the public supply.

The water is of excellent quality from a sanitary point of view and is but moderately mineralized as compared with average ground waters of Illinois. Practically all the hardness is in the form of carbonate and amounts to 270 parts per million. The small content of iron, 0.3 part per million, is sufficient to cause accumulations of iron rust at dead ends, a matter of more or less complaint.

There is 4.76 miles of 4-inch to 8-inch cast-iron pipe and 2.64 miles of 2-inch wrought-iron pipe. There are as many as 22 dead ends, but only 5 of these are on the cast-iron pipes. These dead ends explain in part the prevalence of trouble from iron strains. There are 537 service connections or one for 3.5 inhabitants, which indicates a nearly universal use of the public water supply. Of these connections 37.3 per cent are metered. Pressure is maintained by a 40,000-gallon elevated steel tank with a total height of 110 feet. The tank is 40 feet high and 11 feet in diameter and rests on a brick tower. As the town site is nearly level the static pressure throughout the distribution system varies according to the water level in the elevated tank from 40 pounds to 47 pounds. The waterworks are estimated to have cost the city $30,000, equivalent to $16.30 per capita. The pumping station is in the building with the municipal electric lighting plant and the two utilities are jointly operated.

MATTESON, Proposed water supply.—Visited October 5. Matteson has a population of about 500.

The proposed source of water supply is a 10-inch wall 282 feet deep entering the Niagara limestone. The water rises within 14 feet of the surface and recedes about 8 feet on being pumped at a rate of 200 gallons a minute. The pumping equipment will consist of an electrically driven deep-well pump with its water cylinder set at 96 feet. The distribution system will include about 2.63 miles of 6-inch and 8-inch mains. An elevated tank with a capacity of 100,000 gallons will be erected near the pumping station.

The supply is of good quality from a sanitary point of view, but it has a mineral content of 705 parts per million and a total hardness of 540 parts per million.

MATTESON, Proposed sewerage.—Visited October 5. The citizens of Matteson seem strongly in favor of a combined system of sewers, but local conditions render it doubtful that such a system will be the most satisfactory. The desire of covering a drainage ditch to the north of the village is responsible for the sentiment in favor of a combined system. The improvement of the ditch is, however, a benefit almost unrelated to benefits from sewerage, and these improvements should be made independently. As an elaborate system of storm sewers for Matteson is not needed a separate system would seem more conomical; furthermore the sewage will sooner or later require treatment because of the absence of any perennial streams in the vicinity. A conference was also held with the consulting engineers of the village, but plans embodying the Survey's suggestions had not been received at the end of the year.

MATTOON, Pollution of public water supply by improper disposal of city wastes.—(Bull. 10, 144.) Visited May 27. Garbage and other filthy wastes are dumped promiscuously over part of the area drained by tile that furnishes a portion of the municipal water supply and the water receiving the leachings from the wastes of course is more or less polluted. Though the city supply is intended for industrial use only yet water carried in pipes and accessible at faucets is likely to be drunk by careless or ignorant persons; this practice has resulted in serious typhoid outbreaks in several recorded instances.

Recommendation was made to the local authorities that dumping of refuse on territory drained by tile furnishing any part of the public water supply be prohibited; that the city procure competent engineering advice on suitable methods for collecting and disposing of garbage and other municipal wastes; and that the garbage should be collected separately and buried according to directions which were given in detail until a more satisfactory method can be devised.

MATTOON, Proposed sewerage.—(Bull: 11, 92.)

MAYWOOD, Water supply.—(Bull. 10, 146.)

MELEOSE PARK, Water supply.—(Bull. 10, 148.)

MENAED. Southern Illinois Penitentiary, Water supply.— (Bull. 11, 92.)

MENDOTA, Pollution of Mendota Creek.—In compliance with a request of the Rivers and Lakes Commission dated June 18 the pollution of Mendota Creek at Mendota by gas-house wastes was investigated July 10 and 11.

Mendota Creek is a very small stream which flows southerly through the central part of the city. There is no natural flow during much of the year. Wastes from the local gas works operated by the Public Service Company of Northern Illinois enter the stream and cause a distinct nuisance by bad odor, unsightly oily films, and tarry deposits in the bed of the stream. These conditions injure the value of adjoining property and annoy near-by residents. The nuisance during dry weather persists at least 1,000 feet below the gas house.

The Survey pointed out in its report that methods have been developed whereby gas-house wastes can be properly treated before they are discharged into sewers or into open streams and a method of treatment was tentatively suggested as follows: Application was recommended of 3 pounds of lime and 2 pounds of ferrous sulphate per 1,000 gallons followed by thorough mixture of the wastes with the chemicals for 15 minutes. This is followed by sedimentation for 2 hours and final filtration of the wastes through fine coke 2½ to 3 feet deep at rates of about 1,000,000 gallons per acre per day.

In view of the practicability of eliminating the nuisance it was recommended that the Public Service Company of Northern Illinois be notified to abate the nuisance resulting from pollution of Mendota Creek by wastes from its gas works not later than February 1, 1915. It was also recommended that the company be advised to submit detailed plans to the Survey for approval before any expense is incurred for construction.

MENDOTA, Water supply.—(Bull. 11, 93.)
Sewerage.—(Bull. 11, 94.)

MEREDOSIA, Pollution of Illinois River.—(Bull. 11, 94.)

METROPOLIS, Water supply.—(Bull. 9, 27; 11, 94.)

MILFORD, Water supply.—(Bull. 11, 95.)
Sewerage.—(Bull. 11, 95.)

MILFORD, Alleged nuisance due to wastes from corn-canning factory.—Visited September 26. A communication was received September 24 from the Rivers and Lakes Commission requesting an investigation of an alleged nuisance due to the discharge of organic wastes into Sugar Creek by a corn-canning factory at Milford. The complaint states that the discharge of wastes into Sugar Creek creates foul odors that greatly interfere with the comfort and health of near-by residents and of persons crossing a highway bridge that spans the creek a short distance below the point at which the wastes are discharged.

It was apparent from inspection that the discharge of wastes from the cannery into Sugar Creek does, as alleged, create a very objectionable nuisance, but it cannot be maintained that the nuisance is a cause of disease or that it is detrimental to health except in so far as sensitive persons are nauseated by the odor. The report rendered stated that the Survey is not now prepared to recommend a definite method for the abatement of the nuisance, but that methods similar to those recommended by the Survey and now in successful use at a cannery in Washington can probably be applied at Milford. It was further indicated that the Survey was prepared to assist the canning factory at Milford to the extent of placing at its disposal the results of previous investigations and to the extent of guiding the company in any preliminary experiments that may be deemed advisable.

In view of the foregoing it was recommended that the Milford Canning Co. treat all liquid wastes to prevent nuisance in Sugar Creek during the canning season of 1916' and thereafter.

MINONK, Water supply.—Visited August 8-9. The present population of Minonk is about 2,000. The area within the corporation limits is quite flat, and rather imperfect natural drainage is afforded northeasterly into minor tributaries of Vermilion Eiver.

Waterworks were first installed in 1887. The original system comprised a dug well, a steam-driven pump, a wooden tower and tank, and about 1½ miles of wooden mains. The entire system was practically replaced in 1893 and extended by more substantial construction. A well 1,850 feet deep, deriving water from the Potsdam sandstone, was drilled. The well is 12 inches in diameter at the top and 6 inches in diameter at the bottom, and it is cased to 600 feet. Water is pumped from the new well into the old well, which has been used since 1893 partly as a well and partly as a collecting reservoir. The pumping equipment until 1910 comprised an air lift and a deep-well pump and a duplex steam pump for pumping from the old well into the distribution system, but a favorable contract was then made with the Public Service Company of Northern Illinois for pumping the water by electricity; accordingly the old pumping equipment was replaced by an electrically driven deep-well power pump and a centrifugal service pump, but the steam machinery is still maintained in reserve for emergency, though it is rarely used.

The water is safe from a sanitary point of view, but its mineral content, 2,308 parts per million, is very high, and gives the water a disagreeable salty taste. It has a hardness of only 52 parts per million. The local users, however, have become accustomed to the taste, or at any rate excuse it because of supposed medicinal virtues of the water, of which only a vague description could be obtained.

The consumption averages about 67,500 gallons, equivalent to 32.6 gallons per capita or 150 gallons per service. . The maximum daily consumption is about 105,000 gallons and the minimum daily consumption 45,000 gallons. The consumption is small because most of the services are metered, because many of the houses are not provided with extensive indoor plumbing, and because the water cannot be used for sprinkling lawns and gardens as it is detrimental to vegetation. During summer, even with this moderate consumption, there have been shortages owing to the inadequate capacity of the deep-well pump. The maximum yield of the sources is not known, but it probably does not exceed 150,000 or 200,000 gallons a day. The distribution system comprises approximately 4 miles of 4-inch to 8-inch cast-iron mains, which reach practically the entire built-up section of the city. A 141,000-gallon steel tank 60 feet high and 20 feet in diameter on a brick tower 60 feet high is connected with the distribution system. As the area within the city limits is flat the full tank exerts a pressure of about 45 pounds per square inch throughout the distribution system while there is no unusual draught.

The waterworks originally cost $10,000, and the later additions and replacements aggregate approximately $34,000, which may be taken as the value of the system. This is equivalent to $17 per capita.

MINONK, Nuisance due to improper sewage disposal.—A communication was received July 20 from the Eivers and Lakes Commission requesting investigation of a complaint of alleged improper disposal of sewage at Minonk. This village, in the northeast corner of Woodford County on the divide between the basins of Vermilion and Mackinaw rivers, has a population of about 2,000. The area within the corporation limits is flat, and rather imperfect natural drainage is afforded northeasterly into minor tributaries of Vermilion River. A sewerage system to remove storm water, sanitary wastes and subsurface drainage has been installed in a rather haphazard way by building the sewers of vitrified pipe laid with open joints. The city is divided into two sewer districts, wnich are designated the east and west systems.

The subject of the complaint is the discharge of sewage from the west system, which comprises about 1½ miles of 12-inch to 18-inch trunk sewer with several laterals. The sewage was originally conveyed northward beyond the built-up district and discharged into a small drainage ditch along the tracks of the Illinois Central Eailroad near several houses. Complaints from occupants of these resulted in extension of the outlet one-fourth mile beyond the corporation line, where it was again permitted to discharge into the same ditch. This ditch is intermittent in character and has no dry-weather flow. Just below the outlet part of the sewage with whatever water may be flowing in the ditch is diverted through a drain tile to a coal mine where it is used in boilers. This liquid is not very suitable for use in boilers, but as it is the only available water no complaint has been made by the company. The sewage and water not used by the coal company passes on in a small open ditch for 200 feet, then through a drain tile for about three-quarters of a mile, and into an open ditch passing through the land of Mr. Ben Smith, the principal complainant. The complaint does not relate to nuisance, and in fact there appears to be but little odor or objectionable appearance to the water of the stream when it reaches the complainant's land. The complaint has been made because the land is extensively used for pasturage of milch cattle and other animals, and it is alleged that pollution of the water is injurious to the health of the cattle; that in any event the prejudice against the use of the stream water is so great that the dairy business of the complainant within Minonk has been seriously injured.

In view of these considerations it was recommended that the city of Minonk be required to modify its present practice with reference to sewage disposal so as to abate on or before January 1, 1916, any nuisance or unhealthful conditions to human beings or to cattle that may now exist. It was further recommended that the city of Minonk be advised to have its sewerage conditions studied by a competent engineer with a view to planning for the entire community a comprehensive system of sanitary sewerage that will lend itself to the treatment of sewage in an efficient and economical manner.

MINOOKA, Water supply.—(Bull. 11, 95.)
Sewerage.—(Bull. 11, 96.)

MOLINE, Additional sewerage.— (Bull. 11, 96.)
Sanitary survey of Mississippi River.—(Bull. 9, 27.)

MOMENCE, Water supply.—(Bull. 11, 97.)
Sewerage.—(Bull. 11, 97.)

MONMOUTH, Water supply.—(Bull. 10, 149.)

MONTGOMEEY, Sewage disposal.—Montgomery was visited September 23 at the request of the Rivers and Lakes Commission, which had received a complaint regarding pollution of a small tributary of Fox River that passes through the village. Montgomery has a population of about 400. It appeared on investigation that the complaint grew out of a local dispute regarding assessments for the construction of a sewer to carry the flow in the small stream. As the matter appeared to be of purely local concern no action was recommended to the Rivers and Lakes Commission, but the local authorities were advised as to the correct procedure to procure proper sewerage facilities.

MONTICELLO, Water supply.—(Bull. 1O, 150.) Visited November 16 to confer with local officials relative to proposed improvements in the public water supply. The present pumping equipment is inadequate and the elevated tank is in a dangerous condition owing to corrosion. As pumping records are not maintained it was impossible with the insufficient data available to advise definitely regarding the necessary capacity of pumping equipment and storage facilities. It was advised that the proposed improvements include additions to the pumping equipment and construction of a storage reservoir and erection of an elevated tank. The public supply contains 1.6 parts per million of iron, which is sufficient to impart objectionable discoloration to the water as delivered to the consumers, and it was suggested that the collecting reservoir be so designed that it could ultimately be used as a clear-water basin for an iron-removal plant. The city was advised to obtain the services of a competent consulting engineer in planning and carrying out the proposed improvements.

MORRIS, Water supply.—Visited February 19 and July 2. Morris, the county seat of Grundy County on the north bank of Illinois River, is an industrial town with a population of about 4,600.

Waterworks were installed in 1894 by the city. The Eource of supply during the first 8 years was a drilled well 550 feet deep and 6 inches in diameter, from which water was forced by air lift. A second well 800 feet deep and 10 inches in diameter and a new open air compressor were added in 1902. Both wells derive water from the St. Peter sandstone. The static level in the wells in 1906 was 35 feet and in July, 1913, it was 59 feet below the surface, representing an average fall of 3.3 feet per annum. Steam power was used until 1911, when electrically operated pumping machinery was installed, a deep-well pump was substituted for the air lift in the larger well, and power has since been purchased from the Public Service Company of Northern Illinois. The larger well yields 275,000 gallons a day with the working barrel at 225 feet and the smaller well yields 200,000 gallons a day with the air lift at 200 feet. Neither well is capable of supplying the maximum demands of the city and a third well is being contemplated to prevent shortage if a well is out of commission. The water is discharged from the wells into a 210,000-gallon covered concrete collecting reservoir beneath the city hall and fire station. The water is pumped from the reservoir into the distribution system by 2 single-stage electrically driven centrifugal pumps having capacities, respectively, of 1,500,000 and 350,000 gallons a day. Two 1,000,000-gallon compound duplex steam pumps are maintained in reserve. The small centrifugal pump and the larger well are used for ordinary demands. The distribution system comprises about 9 miles of 4-inch to 12-inch cast-iron pipe. Approximately 900 services, of which 600 are metered, serve about 85 per cent of the population. A standpipe 20 feet in diameter and 125 feet high is connected with the distribution system, but more than 100 feet of the standpipe is seldom utilized. The average daily pumpage for 13 months was 242,000 gallons, equivalent to 53 gallons per capita and 270 gallons per service.

The water is of good sanitary quality and mineral analysis shows but moderate hardness as compared with that of average ground water in Illinois. The total solids amount to 452 parts per million and the total hardness to 285 parts per million.

MOEEIS, Pollution of Illinois Eiver by Chicago Drainage Canal.—(Bull. 9, 27.)

MOEEISON, Water supply.—Visited Aug. 7. Morrison, the seat of Whiteside County, has a population of about 2,500. Several important industries are located at Morrison. A combined sewerage system, which covers most of the built-up section, discharges through 6 outlets into Bock Creek. The discharge of Rock Creek is said to be sufficient always to prevent objectionable nuisance. No complaints have yet been made.

A public water supply was installed soon after 1870. The source was originally an artesian well, the yield of which was increased by a deep-well pump, which drew from the well and discharged directly into the distribution system. This supply proved inadequate in 1881, and during that year a spring issuing from limestone rock in the south part of town and some distance from the artesian well was developed by erecting around it a collecting reservoir with open bottom and building near it a new pumping station, and the original well and pumping station were abandoned. When the spring supply became insufficient a few years later 4 relatively shallow wells deriving water under artesian pressure from limestone at 55 to 80 feet were sunk near Rock Creek about 150 feet from the pumping station. Eock Creek at this point is seriously polluted, but cannot be regarded as a menace to the wells, as the static head in the wells is considerably above the level of the water in the creek. A demand for more water in 1897 was met by sinking a well 1,640 feet deep, 8 inches in diameter at the top and 6 inches in diameter at the bottom. The water entering this well comes chiefly from St. Peter and Potsdam sandstones and it is under sufficient artesian pressure to rise to the surface. It is stated that the boring has filled to within 913 feet of the surface by caving. No information could be obtained regarding the yield of this well. When it became necessary to augment the supply still further in 1912 a well 2,048 feet deep and 12 inches in diameter at the surface and 6 or *6½* inches in diameter at the bottom was drilled within 25 feet of the other deep well. Its natural flow is about 85 gallons a minute, which is piped into the reservoir around the spring. The yield of the well has been greatly increased recently by an air lift, which indicated on test that the well could be continuously pumped at the rate of 685 gallons a minute without being drawn below the practicable limit of this apparatus. Discharge of this water into the collecting reservoir around the spring is an uneconomical arrangement inasmuch as it checks the flow of the spring water and as part of the water pumped might be lost by back flow into the limestone channels from which the spring emerges if the air lift were operated at sufficiently high rate.

Water is pumped into the distribution system by 2 compound duplex steam pumps having daily capacities, respectively, of 1,000,000 and 1,500,000 gallons. The smaller pump draws directly from the collecting reservoir, but the larger pump has suction connections also to the 4 shallow tubular wells and the original deep well, and can draw simultaneously from all three sources. The daily consumption varies widely depending on the extent to which the water is used by the industries. The minimum average daily consumption recorded during any month is 210,000 gallons and the maximum is 625,000 gallons.

The average daily consumption in 1913 was 272,000 gallons, equivalent to 113 gallons per capita and 389 gallons per service.

The supply is adequately protected against possibility of contamination at the pumping station and analyses indicate that it is of good quality. Some of the bacterial results on samples shipped to the laboratory are not entirely favorable, but it is probable that bacterial growth took place during shipment as there are no gas formers. The water has only a moderate mineral content and the hardness is nearly all temporary. The water has no turbidity, color, or odor. Special commendation is due the waterworks authorities for the attractive manner in which the pumping station, pumping-station grounds, and the other properties are maintained.

The distribution system comprises about 9.9 miles of 4-inch to 8-inch cast-iron mains. An additional mile of mains about to be laid will eliminate several dead ends, of which there are now 17. A 342,000-gallon covered steel tank 45 feet high and 36 feet in diameter, on one of the highest elevations near the eity and about one mile from the pumping station, is the equalizing reservoir of the distribution system. The full tank gives a pressure of about 60 pounds at the pumping station and somewhat more than 50 pounds throughout the business district. Certain residence sections at higher elevation secure only low pressure.

MORRISONVILLE, Water supply.—(Bull. 11, 98.)

MOUNDS, Water supply—(Bull. 9, 27; 11, 98.)

MOUNT CARMEL, Water supply.—(Bull. 9, 27.) Mount Carmel was visited April 29, October 14, and December 14-15 to inspect the filter plant. Mount Carmel, on the east border of Wabash County, is the seat of that county and is an industrial center with a rapidly growing population of about 8,000.

Waterworks were installed in 1893 by the Mount Carmel Light and Water Co. under a 40-year franchise. Provisions in the contract for transferring ownership to the city are of such character that a condition of divided authority has caused more or less difficulty between the city and the company. The original supply was obtained from wells in the bottom lands of Wabash River. Good water was found at 160 feet in alluvium, but the yield was insufficient to be economically developed. Large quantities of unusable salt water were found at greater depth. A few years after the introduction of the waterworks the river was adopted as a source of supply, and the unpurified water was pumped into the mains. The distribution system was greatly extended in 1905, and electrically driven pumps were installed in 1906. A mechanical filter plant was installed in 1911 as a result of popular demand for better water free from dangerous pollution and objectionable physical characteristics. In 1913 the waterworks were acquired by the Mount Carmel Public Utility and Service Co., the present owners and operators.

The intake in Wabash River is above local sources of pollution but below the sewers of St. Francisville, 16 miles above Mount Carmel, with a population of 1,500; Vincennes, Indiana, 24 miles above Mount Carmel with a population of 15,000; and Terre Haute, Indiana, 88 miles above Mount Carmel with a population of 65,000. The total area of the drainage basin is 26,300 square miles, and the flow throughout the year is more than ample to meet the requirements of the city. The water drawn from the river is relatively easy to treat by mechanical filtration though some difficulty is caused at times by oil-well wastes that enter the river. The purification works are of modern design and of concrete construction throughout. The nominal daily capacity of the plant is 1,500,000 gallons.

Alum is used as a coagulant and calcium hypochlorite is used as a disinfectant. The alum and hypochlorite were originally prepared in a standard manner in solution tanks and the feed of chemicals was such as to be proportional to the flow of raw water. This was accomplished by a float device which maintained a head over an orifice in a constant-level solution feed-box proportional to the head over an orifice in a chamber receiving raw water. The principles of the device were apparently not understood by the management and the device had fallen into disuse. The chemical at the time of visit (April 29) was not being applied at a uniform rate, and the small size of the solution tank also was causing difficulties. Recommendation was made that this be materially enlarged. This recommendation was not, however, carried out and at the time of the last visit (Dec. 14-15) it was learned that the use of the solution tanks and feeding devices had been discontinued. A long wooden tank had been built with inlet and outlet pipes at opposite ends. Chemicals are dumped into this tank at more or less irregular intervals with a consequence that the strength of solution varies widely and results are now inferior to those formerly obtained.

The sedimentation basin is a rectangular concrete structure with a capacity of about 150,000 gallons, equivalent to 2.4 hours' detention period with the nominal capacity of the plant. This period is short in view of the highly turbid waters that must sometimes be treated. Moreover, a single basin does not give sufficient elasticity in operation.

There are 3 filters, each 12 feet wide, 15 feet long, and 8 feet deep. They are of standard construction and should be capable of giving good results, but sufficient wash water was not being delivered to them at the time of inspection. Recommendation was made that a wash-water storage tank be installed instead of drawing water directly from the mains. In this way or by pumping into the tanks with a separate pump water can be obtained from the mains without reducing the service pressure. The float rate controllers on the filters were out of order and their location in the clear-water basin makes them very inaccessible for repair and adjustment. The filters are provided with loss-of-head gages, but these were out of repair and were not being used. When the increased volume of wash water which should be used is made available it will probably be desirable to add additional overflow troughs to the filters. The clear-water reservoir underneath the filters has a total capacity of 56,000 gallons, which is equivalent to a storage period of 0.9 hour and is inadequate. The original plans provided an additional 180,000-gallon storage, which would have made the total storage 3.8 hours, but this was found impossible because of limited funds.

A laboratory was established at the uptown office of the company when the filter plant was installed. The laboratory soon fell into disuse, but the equipment has recently been turned over to the local high school with the understanding that regular analyses of the water will be made.

The low-lift pumping equipment consists of one 2,000,000-gallon steam-driven centrifugal pump supplemented at times by a motor-driven 2-stage centrifugal pump, which under ordinary circumstances is intended for high service. An additional 1,500,000-gallon low-lift pump for regular service is contemplated. The filtered water is pumped into the mains by a triple-expansion duplex pump with a nominal daily capacity of 1,500,000 gallons. The distribution system comprises about 20 miles of 4-inch to 10-inch cast-iron mains. There are 1,100 service connections, which indicates that about 60 per cent of the population uses the supply. Connected with the distribution system is a standpipe with a capacity of 150,000 gallons, only one-half of which is actually available for storage. Trouble has been encountered on account of dead birds in the standpipe, but during the past year a cover has been put out on the tank. The filter plant was installed for about $10,000 and, excepting the filter equipment, was built entirely by day labor.

As might be anticipated from the foregoing description the water delivered to the city has not always been of satisfactory quality as revealed by analyses made by the Survey. Pull advice has been given to the local authorities for proper operation of the filter plant, and blank forms for maintenance of suitable filter-operation records have been furnished.

MOUNT CARROLL, Water supply—(Bull. 11, 100.)

MOUNT MORRIS, Water supply.—(Bull. 11, 100.)

MOUNT OLIVE, Water supply.—(Bull. 10, 151.)

MOUNT PULASKI, Proposed additional water supply.—(Bull. 11, 101.) As a result of a visit July 31, recommendation was made that the supply be augmented by sinking tubular wells to the same water-bearing stratum penetrated by the existing dug wells, but that these tubular wells be placed sufficiently far apart to prevent interference, such distance to be ascertained by suitable pumping tests. Various suggestions relative to pumping the wells were made.

MOUNT PULASKI, Sewerage.—Visited July 31. There is no public sewerage system, but overflows from cesspools and house drains have been connected with a system of tile laid with open joints and put in originally for drainage. There are 2 outlets to the system, one northward into a branch of Salt Creek, and the other southwestward into a small swamp and pond. The first outlet has never been the cause of complaint, but the other outlet has for a long time been the cause of considerable complaint.

The drain at the second outlet first discharges into a tank said to be about 8 feet in diameter and 8 or 10 feet deep, the overflow from which is carried about 200 feet in a tile pipe to an open ditch, which in turn discharges about 200 feet farther into a small pond formed by a slight depression in the ground. The pond has a water surface of only 2,500 square feet, and it has no outlet to it except at times of heavy rains when it' overflows into a small ditch. The pond and the ditch were very foul. Houses are located only about 400 feet away and the residents have often complained of disagreeable odors. It was proposed at one time that the city and persons owning the farm lands adjoining the pond jointly install a drainage ditch, but no definite plans have yet been made.

MOUNT STERLING, Water supply.—(Bull. 11, 102.)
Proposed sewerage.— (Bull. 11, 101.)

MOUNT VERNON, Water supply.—(Bull. 10, 152; 11, 102.) Visited June 23, October 14, November 1, and December 17-18. The waterworks at Mount Vernon were constructed according to plans described in Bulletin 10. The construction was well carried out, and the plant is under competent management though the operation is not subject to regular analytical control.

One of the most significant things brought out by several visits was the inadequacy of the plant to handle the large quantities of water consumed during summer. The maximum daily consumption in 1914 was 1,800,000 gallons, whereas the nominal daily capacity of the plant is but 1,500,000 gallons. The consumption can probably be handled within the limits of the filtering capacity for several years if all the services are metered. Only 30 per cent of them are now metered.

The rates of filtration in the filters were found to be very unequal in December, ranging from 90,000,000 to 197,000,000 gallons per acre per day. The mechanism of one controller for regulating the rate of filtration outside the apparatus was found to be deranged. As controllers of this type are subject to derangements they should be tested and examined at least once every two months. The loss-of-head gages also were inoperative because of frequent breaking of the cords connecting the indicator with the floats. Substitution of new cords had been unsuccessful because of failure to procure a sufficiently strong cord that would not stretch. The best cord for this purpose is fine insulated brass-wire cord. The distribution of wash water on one filter was uneven; that this apparently was caused by blowing out of the strainers or some injury to them was indicated by the presence of large quantities of sand in the clear well. Recommendation was made that the sand be removed so that the strainers could be examined.

Tastes and odors that apparently were not due to hypochlorite were observed in the supply delivered to consumers. They occurred after a sudden drop in temperature, which might have caused an overturning of the water in the reservoir, which has elsewhere produced objectionable tastes and odors. Contrary to expectations filtration has not prevented accumulations of manganese oxide in the mains, and it would be highly desirable for the company to make further studies in the elimination of this undesirable constituent.

MOWEAQUA, Water supply.—(Bull. 11, 99.)

MUEPHYSBOEO, Water supply.—(Bull. 10, 155; 11, 103.) The water-purification works at Murphysboro were inspected May 25-26 and December 1, 1914, and January 5, 1915. No improvements had been made though a consulting engineer had reported on the requirements of the works and the company had received a proposition from a filter company for carrying out the engineer's recommendations. It was found in January that the filters had not been used at all and that unpurified river water was being supplied to the consumers. Strong representations were made both to the water company and the city officials regarding the danger of the continued use of the present polluted supply.

NAUVOO, Water supply.—(Bull. 10, 157.)

NEW ATHENS Proposed water supply.—(Bull. 10, 158.)

NEW WINDSOE, Typhoid fever.—(Bull. 11, 103.)

Proposed water supply.—(Bull. 11, 104.)

NEWTON, Water supply.—(Bull. 10, 159.)

NOKOMIS, Water supply.—(Bull. 11, 105.)

NOKOMIS, Proposed sewerage and sewage treatment.—Plans and specifications for a proposed sewerage system and sedimentation tank at Nokomis were received April 25 from Dabney H. Maury, consulting engineer employed by the city, and several conferences with the engineers followed.

Nokomis, in the northeast part of Montgomery County in the drainage basin of Shoal Creek, a tributary of Kaskaskia Eiver, has a population of about 1,900, and it is growing rapidly as a result of the development of coal mines in the vicinity. It is anticipated that the population will be 5,000 within 10 years.

The site occupied by the village is flat; general drainage is west and south into small watercourses, which flow into Shoal Creek. These watercourses do not flow during summer and consequently no water for diluting sewage is available. The stream below the village flows through open farm country and there are no houses within one-half mile of it for a great distance downstream. One or two habitations within the corporation limits are, however, not more than one-fourth mile from the proposed point of sewage discharge. There are now about 42 blocks of storm drains with an outlet 30 inches in diameter into one of the small streams. If house sewage is excluded from these drains it is proposed to install a complete system of sanitary sewers with about 3½ French miles of 8-inch to 12-inch vitrified pipe. Specifications call for standard construction throughout with cemented joints.

Realizing that some treatment is necessary the engineers have planned a lateral-flow settling tank on the Emscher design. It is not anticipated that the effluent will be innocuous, but funds are insufficient for installation of a more elaborate plant at present. It is hoped that the tank will adequately safeguard the rights of riparian owners until more complete works may be installed. The belief that the tank effluent will not prove objectionable is strengthened by the fact that the stream is already polluted by creamery wastes that have not roused serious complaints. The tank is well designed; it has a nominal capacity for treating the sewage from a population of 2,000 with an assumed flow of 100 gallons per capita per day, or a total of 200,000 gallons a day. The detention period in the sedimentation chamber with this quantity of sewage will be 3.5 hours. A sludge storage of about 4 months is provided in the digestion chamber. An appropriate sludge bed, which has a superficial area of 600 square feet, has been constructed near the tank.

In view of the foregoing facts recommendation was made to the Rivers and Lakes Commission that the plans and specifications be approved subject to the condition that further treatment will be provided in a manner satisfactory to the commission when it becomes necessary in the opinion of the commission.

NORMAL, Water supply.—(Bull. 10, 159.)

NORTH CHICAGO, Water supply and typhoid fever.—(Bull. 9, 28; 11, 105.) Early in January the Survey was apprised of several cases of typhoid fever in North Chicago and there appeared to be good evidence, according to the local health officer, that the disease was caused by the polluted condition of the public water supply. A representative of the Survey visited North Chicago January 22-26 and procured the cooperation of the city council for installing a hypochlorite plant to disinfect the supply. Such a plant was installed at once under direction of a representative of the Survey and placed in operation, and full instructions for its continued operation were left with the local authorities. The plant was a rather crude temporary one, consisting merely of 2 barrels for preparation and storage of solution and a constant-head orifice-feed box. Unfortunately, the hypochlorite apparatus was rendered inoperative because of repairs in the pumping station after it had been in operation for a few weeks and it was not subsequently placed in service. Numerous communications have been sent to the local authorities urging some treatment of the water supply to render it safe for human consumption, but these communications have met with no response.

NORTH CRYSTAL LAKE, Water supply.—North Crystal Lake, in the southeast part of McHenry County, has a population of about 800.

Waterworks were established in 1898. The installation included a dug well, a pump, a gasoline engine, an elevated tank, and a small distribution system. A deep well was drilled later, the dug well was abandoned and a motor-driven deep-well pump was installed, which now pumps the water into the mains. As North Crystal Lake and Crystal Lake have united, the pumping station at North Crystal Lake is to be operated only in case of fire and the domestic supply for both places will ordinarily be furnished by the plant at Crystal Lake. The well is 285 feet deep, extending 25 feet into limestone, and has 8-inch casing to rock. The static level is 80 feet below the surface and the drawdown is about 3 feet. Water is raised from the well by a 300,000-gallon deep-well pump electrically operated. No record of pumpage is maintained but it may be estimated that the daily consumption is 50,000 to 60,000 gallons, equivalent to 72 to 87 gallons per capita or 315 to 377 gallons per service. All services are metered. The distribution system comprises about 3 miles of mains. A 56,000-gallon wooden tank, 24 feet high and 20 feet in diameter, on a 75-foot brick tower beside the pumping station maintains a pressure of 35 to 40 pounds per square inch in town.

The water is suitable for domestic use from a sanitary point of view though it has a hardness of 265 parts per million and a slight turbidity and color.

OAKLAND, Water supply.—Visited March 5. Oakland, in the northeast corner of Coles County in the basin of Embarrass River, has a population of about 1,100.

Waterworks were installed by the municipality in 1910. Water is obtained from 2 wells within 6 feet of each other near the center of the town. One is 95 feet and the other 110 feet deep, and both have 8-inch casings to a depth of 45 feet. The water-bearing stratum is entered at 75 feet. Water is pumped directly from the wells into the distribution system by 2 electrically driven 90,000-gallon deep-well power pumps. Auxiliary power is afforded by a gasoline engine. The distribution system comprises about .2.65 miles of 4-inch and 6-inch cast-iron pipe. An elevated tank has a total height of 118 feet and a storage capacity of 40,000 gallons. Incomplete records from a meter on the discharge pipe at the pumping station indicate an average daily consumption of 11,600 gallons, equivalent to 10 gallons per capita and 100 gallons per service.

There is every reason to believe that the water is of good quality from a sanitary standpoint though several of the samples analyzed showed evidence of contamination, which was probably due to improper collection of samples. The mineral content is moderate and the hardness is relatively low.

ODELL, Water supply.—Visited May 16. Odell, in the north-central part of Livingston County in the drainage basin of Mazon River, has a population of about 1,000.

Waterworks were installed in 1898, and the supply is obtained from 2 tubular wells within 5 feet of each other near the center of the village; one is 1,360 feet deep, 12 inches in diameter at the top and 8 inches in diameter at the bottom, and is operated by a deep-well pump with its working barrel at 310 feet, the other is 1,298 feet deep, 6 inches in diameter at the top and 4 inches in diameter at the bottom, and is operated by air lift. The casings extend to 1,000 feet, or 832 feet below the surface of bed rock, to prevent caving and to exclude highly mineralized water. The static level is 185 feet below the surface. The water is pumped into a 34,000-gallon covered circular brick reservoir, from which it is pumped into the distribution system by a 432,000-gallon electrically driven triplex power pump. The distribution system has about **2.83** miles of 4-inch to 8-inch cast-iron pipe. A 27,000-gallon elevated wooden tank on a steel tower with a total height of 118 feet is connected with the distribution system. There are 235 service connections, all of which are metered. Pumping records from a meter on the main discharge pipe of the pumping station indicate an average daily pumpage of 25,000 gallons, equivalent to 24 gallons per capita and 106 gallons per service.

Analyses of the water indicate that it is of good quality from a sanitary standpoint. It is, however, highly mineralized containing 2,386 parts per million of total solids and it is salty. The total hardness is 185 parts per million. There is much popular complaint because of a black sediment that appears in the water and continues 5 or 10 minutes after the pumps are started, after which the water is clear. Much of the sediment is removed in a collecting reservoir, but sufficient reaches the taps to cause complaint. This black deposit is largely iron sulphide, whose presence suggests action of hydrogen sulphide in the water on the casing of the well. The content of hydrogen sulphide gradually increased from 3.8 parts per million after 700 gallons had been pumped to 7.1 parts after 14,000 had been pumped. After the water had been pumped from the collecting reservoir into the distribution system its average content of hydrogen sulphide was 1.7 parts per million. The content of hydrogen sulphide at a service tap 300 feet from the tank was 1.1 parts, at 800 feet was 0.9 part, and at 2,500 feet was 1.4 parts per million. These tests show that the greatest loss of hydrogen sulphide occurs between the pump and the elevated tank, which is due to loss by dissipation into the air and loss through oxidation; more efficient aeration of the water would undoubtedly remove all the gas before the water reaches the mains. The hydrogen sulphide, reacting with the iron casing when the pump is not operated, forms a coating of ferrous sulphide. If this remained it would doubtless protect the casing from further action, but, being thin and loose, it is washed off as soon as the pump is operated and exposes fresh surfaces to the action of the hydrogen sulphide during the next rest of the pumps.

Recommendation was made to the water board that devices be placed on the discharge from the wells so that the water may be thoroughly aerated before entering the sedimentation basins in order to prevent hydrogen sulphide from entering the mains. It was also suggested that the first discharge from the low-lift pumps after setting them in motion may advantageously be wasted to prevent the entrance of the black deposits of ferrous sulphide into the reservoir and possibly into the mains.

OLNEY, Water supply.—(Bull. **11, 106.)**

OLNKY, Sewerage and sewage disposal.—Plans were received April **8, 1913,** for proposed sewerage and sewage-treatment works at Olney. These were reviewed and an informal report on them was made to the consulting engineer. The community was visited May 11, to inspect progress of construction.

The purification works comprise 2 double-deck settling tanks, 2 dosing chambers, 8 intermittent sand filters, and a sludge bed. After the sewage has passed through the settling tank it may be delivered on the sand filters or diverted into a small tributary of Fox River. The effluent from the sand filters is collected by a system of underdrains and discharged through 4 outlets into the tributary. As the tributary has no flow during dry weather it cannot assist purification by dilution during such periods. The plant now being installed should be capable of treating the sewage from a population of 5,000 or an average daily flow of 500,000 gallons of sewage; the sedimentation period would be about *13/4* hours, and the digestion chambers for sludge would hold about 100 days' accumulation. The effluent from the tanks flows into dosing chambers, and from the dosing chambers it flows into 2 siphon chambers, each near the center of a group of 4 intermittent sand filters. The combined storage capacity of the 2 dosing chambers and 2 siphon chambers is 14,500 gallons, which on the basis of the assumed sewage flow would produce 34.5 doses a day, or 4.3 doses a bed. The dose would cover the bed to a depth of nearlv 5 inches. The frequency and the depth of dose seem too great. The siphon chambers contain automatic dosing apparatus, which discharges the contents of the chambers on the filters in rotation.

Each of the 8 filter beds has an area of 0.11 acre; thus the total area is 0.88 acre, which gives a population load on the assumed basis of 5,680 persons per acre and a rate of filtration of 568,000 gallons per acre with 8 beds in service. The thickness of the sand, measured to the center of the underdrains, is only 271/2 inches. According to experience elsewhere these rates appear excessive. The sludge bed has an area of 900 square feet or 180 square feet per 1,000 persons tributary to the sewers. This is about half the area ordinarily required. A commendable feature of the plant is the caretaker's house near the works, which will insure continuous attention to the plant. If the plant should become malodorous the caretaker would be the first sufferer. The construction of sewerage and sewage-treatment works was progressing according to plans in May in an apparently satisfactory way. The contract price for the entire project was $84,360.

ONAEGrA, Proposed sewerage.—Visited January 6. Onarga has a population of about 1,300. As the site of the village is flat natural drainage is poor. Much of the land originally was swampy and farming has been rendered practicable only by extensive tile draining. Much inconvenience is suffered during wet seasons because of flooded streets. The health of the inhabitants is also seriously jeopardized by privy vaults, some of which are close to wells and even enter the water-bearing strata from which the wells derive their supplies.

Installation of adequate sewerage is complicated .by the fact that the nearest watercourse into which the sewage may be discharged is Spring Creek 2 miles east, and this stream in very dry weather has no flow. The only existing drainage of the village covers about 300 acres, comprises extensions of farm-tile drainage systems, and is wholly inadequate.

The Survey advised that the most desirable system for Onarga would comprise separate conduits for storm water and domestic sewage, with provision for treating domestic sewage. Such treatment will be necessary sooner or later because there is no available- watercourse with a large perennial flow. This sanitary system should be placed at sufficient depth to drain cellars; it would also be possible to underlay the sanitary sewers by open-jointed underdrains to reduce the general ground-water level. Storm-water conduits, on the other hand, may be laid at depths as shallow as the topography and the penetration of frost permit. It is improbable that an outlet for the sanitary sewers can be obtained $t sufficiently high elevation to avoid pumping to treatment works. Recommendation was made that the city employ competent engineers to make necessary topographical surveys, study various possible arrangements of sewer conduits, ascertain conditions affecting final disposal, and prepare estimates of cost, in order to determine the practicability of the project outlined compared with the financial limitations of the village and to determine its various details.

ONARGA, Water supply.—(Bull. 11, 107.)

OEEGON, Water supply.—(Bull. 11, 107.)

OTTAWA, Water supply.—(Bull. 9, 28.)

PALATINE, Water supply.—Visited July 11. Palatine, in the northwest part of Cook County about 25 miles from Chicago, is in the drainage basin of Des Plaines River at the head of Salt Creek, and it has a population of about 1,200. The local topography is flat and drainage is poor.

Waterworks were installed by the municipality in 1898 chiefly for fire protection, and few changes have been made other than those necessary to meet ordinary growth. The supply is obtained from 3 drilled wells near the south edge of town on a lot about 0.6 acre in area. The first well, drilled in 1891, is 168 feet deep and 2 inches in diameter. The water then rose 31 feet above the surface, but it now rises just to the surface and will flow into the reservoir at about 36,000 gallons a day. While the other wells are being pumped the level falls to 19 feet below the surface. The second well, drilled in 1904, is 6 inches in diameter and 168 feet deep and is pumped with an air lift, whose pipe ends 63 feet below the surface. The third well, sunk in 1911, is 10 inches in diameter and 168 feet deep, and it is pumped by direct suction with a centrifugal pump. These wells penetrate 152 feet of drift, after which they probably enter limestone, from which the water is derived. Very little definite information could be obtained. The wells yield about 100,000 gallons a day, which is derived from the individual wells at rates ranging from 36,000 to 145,000 gallons a day. This pumping has not visibly diminished the available supply. Water is pumped from the wells into 2 masonry collecting reservoirs with capacities, respectively, of 38,000 and 64,000 gallons. The pumping equipment comprises 2 duplex 500,000-gallon pumps and one 2-stage electrically driven centrifugal pump. The steam pumps are used only for emergency, the centrifugal pump being used for ordinary service. The distribution system comprises about 4½ miles of 4-inch to 8-inch cast-iron pipe, 79 per cent of which is 4-inch pipe. A 76,500-gallon standpipe, which furnishes a pressure of 60 pounds, is connected with the distribution system.

The water is of good quality from a sanitary standpoint, but it is rather highly mineralized having a total hardness of 385 parts per million of which more than half is sulphate hardness.

PALATINE, Sewage treatment.—(Bull. 10, 161.) Palatine was visited November 12 to inspect recently completed sewage-treatment works built as the result of an injunction suit by farmers owning property downstream. These works, which receive the intercepted dry-weather flow of a combined system of sewers, comprise a screen chamber, a grit chamber, a sedimentation tank, and 2 sludge beds. Salt Creek is about to be dredged and straightened below the point of sewer discharge.

The double-deck sedimentation tank is of sufficient size to permit a detention period of 2½ hours in the sedimentation compartment if 800 persons tributary to the sewers produce 75 gallons per capita per day of sewage. This seems a reasonable estimate for the community. The sludge compartment will hold 6 months' accumulation of sludge. Other features of the installation are satisfactorily designed. The discharge of Salt Creek at the point of entry of the effluent is so small that the liquid below the outlet will unquestionably be putrescible, but the removal of suspended matter and the better flow of the stream due to dredging will materially alleviate present conditions.

The local officials have little understanding of the operation of the plant; though the tanks and appurtenances had just been completed the sewage was not flowing through them properly and no steps had been taken by those responsible to remedy matters.

PANA, Water supply—(Bull. 9, 29; 10, 161.)

PANA, Sewage disposal.—In response to a complaint received July 6 and a request by the Rivers and Lakes Commission an investigation was made July 16 of the final disposal of sewage from Pana, which is alleged to pollute a small stream, causing foul odors along its course and also rendering it unfit for watering cattle, for which purpose it had previously been extensively used.

There can be no doubt as to the existence of objectionable conditions below the sewer outlet. For a distance the stream is grossly polluted, evil smelling, and totally unfit for watering cattle. During extremely dry weather, when there is no natural flow in the stream, sewage soaks into the bed and disappears within 2 miles. There also takes place a considerable degree of; self-purification within this distance, so that there is but little odor and the water may be considered reasonably satisfactory for cattle at the end of 2 miles. Worse conditions may be anticipated in future years with more extensive sewerage and more extensive use of existing sewers in Pana. The number of persons now using the sewers probably does not exceed 1,500, and the sewage flow is not more than 150,000 gallons a day. A complete system for a city the size of Pana (population 6,000) would have an average daily flow of 500,000 gallons.

In view of the foregoing circumstances, a recommendation was made to the Eivers and Lakes Commission that the city be required to establish an inoffensive disposal of the sewage in a manner satisfactory to the commission on or before June 1, 1916. In accordance with this recommendation, the commission issued an order effective July 1, 1916, commanding the city to abate the nuisance with the above recommendation. It is understood that the city was negotiating at the end of the year for the employment of an engineer but that no other active steps had been taken.

PANA, Typhoid-fever epidemic.—Pana was visited October 6 to investigate a small outbreak of typhoid fever. There were but five cases. One occurred in early spring and could not be connected with the others, which occurred in late summer. One of these cases may have been infected by a carrier in the same household, who had had typhoid fever the previous year. Another case apparently was imported from St. Louis. Another may or may not have been imported and it was impossible to locate the cause. The local health official suspected several wells as having been responsible for one case, but the epidemiological evidence did not support this view. The wells, however, were unquestionably subject to contamination as proved by analyses that were subsequently made to support the conclusions drawn from inspection of the wells.

PARIS, Water supply.—(Bull. 10, 164.)

PAXTON, Water supply.—(Bull. 10, 165.)

PEARL, Water supply.—Visited November 14. Pearl is one-half mile from the west bank of Illinois River in the southeast part of Pike County, and it population is about 900. A bond issue for waterworks was defeated by **popular vote** in 1913, but because of a desire on the part of the more progressive element for waterworks a public-spirited individual on whose land a large spring is situated undertook to finance the installation and operation of waterworks as a private enterprise. The system, recently completed, is intended primarily for domestic needs, and practically no fire protection is afforded.

Water derived from the large spring is lifted by a hydraulic ram to a reservoir on a near-by hill, from which it flows by gravity through small pipes to the consumers. The spring is about three-fourths of a mile south from the center of the city, and it emerges from a large cavity in the limestone that forms the steep hillsides bordering the valley of the Illinois. Weir measurements show a yield of 50 gallons a minute or 72,000 gallons a day. According to the oldest inhabitants the spring has had a uniform flow unaffected either in quantity or quality by changes in season or rainfall. The spring is at present unprotected either from persons or creeping animals and recommendation was made that the cavity be so enclosed as to prevent any possiblity of contamination. The hydraulic ram is capable of pumping 14,400 gallons a day under the conditions of installation, and it is doubtful that this will meet requirements. Already there are 55 subscribers, each representing 3 or more persons, and it is anticipated that the number will be increase before long to 100. This would be equivalent to **144** gallons per service, which is considerably less than the average consumption per service in towns of similar size. During warm weather there will be a tendency to use large quantities for sprinkling lawns and the supply is likely to be exhausted. If the hydraulic ram were supplanted by a pump the entire 72,000 gallons would be available. The proposed reservoir has a capacity of 28,500 gallons; and will be built partly in excavation and partly in embankment and covered by a timber roof. It is at an elevation of 100 feet above the settled section of the town. The distribution system comprises 1½ miles of wrought-iron pipe, about one-half of which is 3 inches and the other half 2 inches in diameter.

The principle criticism of this distribution system, aside from the fact that it does not furnish material fire protection, is that the friction losses will be so great at times of maximum consumption that it will not be possible to draw water from the faucets in parts of town remote from the reservoir. Accumulations of air in the mains, for which no release has been provided, are also likely to occur. An analysis of the water is not altogether favorable, but this is unquestionably due to careless collections. There is reason to believe that the supply can be so protected as to be of excellent sanitary quality. It is not highly mineralized and is apparently very soft.

PEARL, Pollution of Illinois River.—(Bull. 11, 108.)

PECATONICA, Water supply.—(Bull. 11, 108.)

PEKIN, Water supply.—(Bull. 10, 166.)
Pollution of Illinois Eiver by Chicago Drainage Canal.—(Bull. 11, 108.)

PEORIA, Water supply.—(Bull. 9, 29; 11, 109.)

PEORIA HEIGHTS, Water supply.—(Bull. 9, 29; 11, 109.)

PEOTONE, Water supply.—(Bull. 11, 109.)

PERU, Water supply.—(Bull. 11, 109.)

PETERSBURG, Water supply.—(Bull. 10, 167.)

PINCKNEYVILLB, Water supply.—(Bull. 11, 110.)

PIPER CITY, Water supply.—(Bull. 11, 111.) Piper City was visited June 8 to inspect the recently completed public water supply. Piper City, in the north, part of Ford County in the basin of Vermilion Eiver, has a population of about 700.

The installation of a water supply was begun in 1913 and completed early in 1914. The original intention was to obtain water from a stratum of gravel at 170 feet, but the yield of a 6-inch well drilled to this stratum was inadequate. The casing was then pulled until its bottom was at 70 feet, where another water-bearing stratum was penetrated. Two additional wells were sunk to the upper stratum, and a good yield was obtained by pumping these wells. Water is also available from sand and gravel at 25 feet, but this was cased out because of fear of surface contamination. Two of the wells are' 8 inches and one is 6 inches in diameter, and all are located within a radius of about 30 feet. One well is equipped with a Cook strainer 12 feet long, and those on the other two are 8 feet long. The wells are connected through 4-inch pipes to the suction of the pump inside the pumping station, and the water is pumped directly from the wells into the distribution system by a 200,000-gallon triplex power pump driven by a gasoline engine. The distribution system comprises 4.4 miles of 4-inch to 8-inch cast-iron pipe. A 50,000-gallon elevated steel tank 12 7 feet in total height is connected with the distribution system. The consumption was very small in June as few service connections had been made.

From a sanitary point of view the water is of very good quality, and it is protected from contamination after it is drawn from the wells. It is moderately hard, but nearly all of the hardness is in the form of carbonates.

PITTSFIELD, Water supply.—(Bull. 11, 111.)

PLAINFIELD, Water supply.—(Bull. 11, 112.)

PLAINFIELD, Sewage disposal.—A request was received March 12 from the Eivers and Lakes Commission for an investigation of a recently installed sewerage system at Plainfield with special reference to final disposal. As this matter had already been investigated by the Survey an additional visit was unnecessary. The investigation showed that the final disposal of sewage in Dupage Eiver at Plainfield is not now creating objectionable conditions, but the stream flow at times may become so low that the water may become visibly polluted and sludge banks may form.

Recommendation was made that the village of Plainfield be required on or before June 1, 1916, to have in operation a tank for removing suspended solids.

PLANO, Sewerage and sewage disposal.—Visited November 12. Piano, in the northwest part of Kendall County on Big Rock Creek, a tributary of Fox Eiver, has a population of about 1,600. It has had a public water supply since 1891. The water is obtained from a well near Big Eock Creek, and the pumpage is about 120,000 gallons a day.

A sewerage system and sewage tank have just been completed. The contract was awarded February 10, 1914, to E. E. Harding & Co., of Eacine, Wisconsin, for $34,560. The system is designed on the separate plan. It completely covers the city, but all the mains have not yet been installed. The specifications called for best-quality fire-glazed pipe, the joints to be calked with oakum and filled with cement. The designs for sewage-treatment works comprised a so-called septic tank and sprinkling filters. Only the tank has been installed. The tank is south of the city on the bank of Big Bock Creek about 20 feet from the road between Piano and Yorkville. The west bank of the stream at this point is said to be just slightly above high water for a distance back of about 25 feet and then the bank rises steeply 6 or 8 feet. The soil is sand and gravel. The tank is at the top of this embankment and sprinkling filters, if installed later, are to be placed, according to the plans, on the lower terrace. The tank is built in excavation and the top has been covered. The tank is divided into 2 units, each 60 feet by 9½ feet in plan and 43/4 feet and 7½ feet deep, respectively, at the inlet and outlet ends. The capacity of each unit is thus 25,600 gallons. If a sewage of 100 gallons per capita from 75 per cent of the population is received the tank will afford a detention period of 5 hours with one unit or 10 hours with both units in operation. Narrow inlet and outlet chambers are provided at the end of the tank and hanging baffles extending 6 inches below the flow line are placed 10 inches from each end. There are 4 manholes in the top, one at each end of each unit. The effluent is discharged on the ground 40 feet or more from the creek. On November 12 the 8-inch outlet was flowing less than one inch deep and the discharge was clear and colorless, but there was a noticeable odor at the outlet. There are yet only 30 connections to the sewer system, which has been in use about 3 months. The creek near the outlet is about 40 feet wide and has a fair current. The water is very clear and the small amount of sewage entering November 12 did not alter its appearance. The area of the basin of the creek above the outlet is i00 square miles, and the creek discharges into Fox Eiver 1½ miles below the outlet. Big Eock Creek was said to be at comparatively low stage November 12. It never goes dry. During high water the low land on the side opposite the sewage tank is flooded.

An objectionable feature about the location of the sewage-treatment works is the proximity of a much-travelled highway. A better location might possibly have been reached by carrying the main outlet sewer down a ravine or depression running southeast from Hale Street and thus placing the sewage-disposal works 600 or 700 feet upstream from the present location. An available fall of 30 feet or more between the creek and the uptown end of the main sewer makes possible the installation of any sort of treatment device without pumping the sewage.

PLANO, Water supply.—(Bull. 9, 29.)

PLEASANT HILL, Typhoid fever.—(Bull. 11, 113.)

POLO, Water supply.—(Bull. 11, 113.)

PONTIAC, Water supply.—(Bull. 9, 30; 11, 113.)

PONTIAC, Sewage disposal.—A communication was received September 4 from the Eivers and Lakes Commission transmitting a complaint of stream pollution to the commission by an attorney representing numerous farmers along Vermilion Eiver below Pontiac, with the request that the complaint be investigated. A representative of the Survey accordingly visited Pontiac September 10-11 and made a careful inspection of Vermilion Eiver for 6 miles below the outlet of the Pontiac sewer.

The investigation showed that impounding the water of Vermilion Eiver at Pontiac for public supply causes the stream to be dry frequently during the summer near the outlets of the sewers. The result is a gross nuisance, which gives offense by odors and unsightly conditions for about 3½ miles downstream. The condition of the stream varies greatly with rainfall, which decreases the nuisance by increasing the volume of diluting water and by scouring out the bed of the river. The latter effect was observed September 4. The discharge of the stream was then practically negligible after a period of recent flood; the sewage was generally fresh and but little sludge had accumulated to putrefy. Nevertheless when the bed of the stream was probed it showed the effects of previous accumulations of sludge and previous foul conditions for fully 3½ miles below the outlets.

Treatment of the wastes at Pontiac has been complicated by using as combined sewers what were originally intended for sanitary sewers. This has greatly increased the volume of sewage especially during storms, when the sewers • are taxed to their full capacity. When sanitary sewers were needed recently for certain sections of the north side it was necessary to construct a new outfall sewer to carry the additional flow of wastes. A much better procedure with reference to meeting any requirement for proper treatment of sewage before final discharge into Vermilion River would have been to disconnect catch-basins and storm-water inlets from the sewers and to connect them with storm drains discharging into the river or any other convenient watercourse at the nearest point below the waterworks intake. This would have made it possible to concentrate the sanitary sewage for treatment at minimum expense unencumbered with large quantities of storm water. As the new outfall sewer has been built, however, it is difficult to say what is the most economical method of meeting the situation with reference to final disposal, and, therefore, the city should undertake studies to ascertain what modifications in the existing sewerage system, if any, are required and what methods of treatment should be utilized to prevent at minimum expense the offensive conditions now existing in Vermilion Eiver.

It was recommended that the city of Pontiac, on or before June 1, 1917, be required to dispose of sewage from the city in such manner as to prevent bad odor and unsightly appearance of water in Vermilion River. It was also recommended that the city be advised to confer with and submit plans to the State Water Survey for review before taking steps to obtain the necessary funds to comply with the requirements of the commission.

POETLAND, Proposed water supply.—(Bull. 11, 115.)

PEINCETON, Water supply.—Visited October 12. Princeton, the seat of Bureau County, has a population of about 4,200. It has several municipal improvements, including waterworks and a complete system of sanitary sewers.

Waterworks were installed in 1886. The supply was originally taken from a rock well 2,550 feet deep, which was supplemented a few years later by another well 2,092 feet deep. It became necessary because of corrosion of casings to reduce the diameter of the wells by inserting smaller casings, and those now in the wells are, respectively, 6 and 4 inches in diameter. Each well is served by a compressor delivering air at a pressure of 140 pounds per square inch. As the cost of raising water from these wells by air lift is excessive a 20-inch tubular well, 245 feet deep, deriving its supply from a 70-foot sand at the base of the glacial drift, was drilled in 1912. The water is raised from the new well by a 720,000-gallon double-acting deep-well power pump. The air lifts in the deep wells can give a combined yield of 300 gallons a minute, equivalent to 432,000 gallons a day, and the new well, under a continuous'pumping test of one week's duration, yielded 600 gallons a minute or 865,000 gallons a day with a drawdown of only 5 feet. The total available supply from the 3 wells is, therefore, at least 1,297,000 gallons a day. The water from the 3 wells is discharged into a 128,000-gallon masonry collecting reservoir, from which it is pumped into the distribution system by one 1,000,000-gallon compound duplex pump and one 500,000-gallon simplex single-acting tandem compound pump, which operate ordinarily against a pressure of 65 pounds per square inch. The pumping plant is combined with an, electric power plant in a brick building on the main street. Though no systematic record of pumpage is kept the daily consumption may be estimated at about 350,000 gallons and the maximum consumption at 450,000 gallons. The distribution system comprises approximately 16 miles of 4-inch to 8-inch pipe. A small portion that is wrought iron will soon be replaced by cast iron. There are approximately 1,300 service connections, all of which are metered. A 55,000-gallon elevated steel tank with a total height of 128 feet, which affords when full a pressure of 55 pounds at its base and 70 pounds in the lower part of the city, is connected with the distribution system.

Analyses of the water indicate that it is of good quality from a sanitary point of view, and inspection indicates no likelihood of contamination. The water is moderately hard, compared with other ground waters of Illinois, and that from the deep wells is slightly harder than that from the new well. The water from the well in the drift contains a little iron, which does not give rise to much complaint. The water seems to meet with general approval for ordinary domestic use though rain water is preferred by many for laundry use.

PRINCETON, Sewage disposal.—The sewerage system of Princeton was built about 14 years ago, and it covers including recent extensions, practically the entire built-up section of the city. The original installation included a septic tank, and it has been enlarged to include a small trickling filter because of complaints that began to develop about 3 years ago. The system now comprises about 15 miles of 8-inch to 18-inch vitrified pipe laid with cemented joints. Thirty automatic flush tanks are placed at dead ends. The outfall sewer follows the bottom of a shallow valley in the north part of town westward about one mile to the disposal plant. The sewers are used exclusively for domestic waste, storm water being removed by short conduits discharging into the nearest watercourses. The disposal plant is on a 30-acre tract of city land in a deep ravine. It includes the original septic tank, now used for sedimentation, a dosing chamber, and a trickling filter. The effluent is discharged into a small stream whose drainage above this point is only a few hundred acres. This stream enters Big Bureau Creek, a tributary of Illinois River.

The flow of sewage is assumed to be the average daily consumption of water, or 350,000 gallons. As the sedimentation tank has a capacity of about 100,000 gallons it affords a detention period of somewhat less than 7 hours on the basis of the assumed flow. The tank is divided into 4 sections in order that the detention period may be modified. The contents of the dosing chamber, whose capacity is 500 gallons, are discharged by 2 alternating automatic siphons on the trickling filter. The filter is built in a concrete basin about 45 feet square and 8 feet deep; as it thus has an area of only 0.046 acre the rate of application, on the basis of the assumed flow, would reach the very excessive figure of 7,500,000 gallons per acre per day. The sewage is distributed over the filter by an elaborate system of wooden troughs. The plant is given reasonably good attention and the distribution system operates in a fairly satisfactory manner. The effluent is putrescible, but it represents a material improvement in the crude sewage. The stream below is visibly polluted, but no complaints of nuisance have been reported.

PEINCEVILLE, Proposed water supply.—(Bull. 11, 116.) Princeville, in the north-central part of Peoria County, was visited April 9 to advise the local authorities in reference to a difficulty encountered in drilling a well. The complete disappearance of the drillings from 1,365 to 1,435 feet left the driller in doubt as to what formation had been penetrated, and he ceased drilling because of possibility that the unknown strata included the St. Peter sandstone, from which it is intended to derive the supply and because of fear that further drilling would tap salt water. As the St. Peter sandstone is not entered less than 1,500 feet below the surface at Wyoming, 10 miles north, and not less than 1,400 feet below the surface at Toulon, 4 miles west of Wyoming, it appeared highly probable that the drillings were lost in cavernous limestone; this conclusion is supported by the improbability of the presence of large cavities in sandstone. Drilling was then continued. The waterworks had not been completed at the end of 1914.

QUINCY, Water supply.—(Bull. 9, 30; 11, 116.) Quincy was visited June 25 to discuss with the city council and the trustees of the water company the relative merits of several projects for a new intake.

The water company, because of the inadequacy of the old intake, its bad state of repair, and the entrance of gross pollution from near-by sewers, had decided to build a cast-iron intake across the mouth of Quincy Bay to the edge of the channel of Mississippi River. The city council, however, favored extending an intake from the end of Tow Head Island, a point of land between Quincy Bay and the main stream, and constructing a station on Tow Head Island to pump the water to the recently constructed purification works on the mainland because it would enable the company to draw the best water from the main channel, would eliminate the present danger of gross contamination from near-by sewers by breakage of intake pipes, and would be a nucleus for the development of a park and a bathing beach on Tow Head Island. Closer examination indicated, however, that, though some of these benefits would result, certain objections to the project render it impracticable. To build an intake, necessary mains, and a stable structure for a pumping station on Tow Head Island would cost at least $70,000, compared with only $25,000 for cast-iron pipe and intake extending out from the present pumping station. Furthermore, a pumping station on Tow Head Island would be difficult of access, and would have to depend on electric power, and could not deliver raw water to the purification works if the force mains under Quincy Bay should break. Such a breakdown, which is always possible during floods, would deprive the city of water except what might be taken with an emergency inlet near the mouths of sewers. Though the proposed construction at Tow Head Island might favor the development of a park it would render a bathing beach impracticable because the beach would necessarily be above the intake and would, therefore, add materially to the pollution of the river at that point. The construction of a tunnel intake provided suitable material could be found in which to drive a tunnel was suggested as a third possibility, for such an intake would be free from the objections advanced against the other two projects. A tunnel would cost about $40,000. The principal objection to it was the length of time required to construct it, for the danger of contamination to the intake constituted an emergency that had to be dealt with at once. The Survey, therefore, felt warranted in recommending the construction of the intake of cast-iron pipe advocated by the water company.

EANKIN, Proposed sewerage.—(Bull. 11, 117.) Plans and specifications for the proposed sewerage system at Rankin were received March 16 from the Eivers and Lakes Commission. Bankin was visited October 29 at the request of local authorities, and a preliminary report on the necessity of treatment of the sewage was prepared December 17, 1913. A conference with the city officials and interested taxpayers was held in January in the office of the Survey, and on April 1 with the engineer employed by the village. Rankin has a population of about 900. No municipal improvements have been made and sanitary conditions are generally bad.

The sewerage system is designed on the combined plan and will comprise about 3.8 miles of 8-inch to 24-inch pipe. The point of outfall into a small stream east of town is remote from habitations. A 25,000-gallon septic tank is proposed for treatment of dry-weather flow.

The combined system planned was not the best design for the village because the conduits are not sufficiently large to carry off heavy rainfall, because storm water mixed with domestic sewage will probably get into cellars, and because the combined system does not lend itself well to purification of sewage. The local authorities, however, were disinclined to modifications that would increase the cost of first installation. Moreover, preliminary arrangements for the awarding of contracts had been perfected and changes would probably have defeated the whole project.

It was recommended that the proposed sewerage system and treatment tank for Eankin be approved on condition that when, in the opinion of the Eivers and Lakes Commission, further treatment is necessary to prevent undue contamination of neighboring watercourses treatment works will be installed and operated in a manner to be approved by said commission. The action recommended was taken April 10 by the Eivers and Lakes Commission.

EANTOUL, Water supply.—(Bull. 10, 168.)

RED BUD, Proposed water supply.—Visited May 20 and December 1. Bed Bud, in the northwest part of Eandolph County 5 miles west of Kaskaskia River, has a population of about 1,300.

The most practicable source of water supply is the Chester sandstone at 190 to 250 feet below the surface. The water is of excellent quality from a sanitary point of view; the mineral content of one water from a well entering this sandstone is 332 parts and the hardness is 179 parts per million. The quantity of water obtainable is somewhat small. Tests made later indicated a daily yield of at least 70,000 gallons. A 10-inch well 294 feet deep had been drilled between May 20 and December 1 that terminated in a 54-foot bed of Chester sandstone. The static level is 58 feet below the surface. The new well will be equipped with an electrically driven deep-well pump. The distribution system will comprise 3.93 miles of 4-inch to 8-inch mains. A 75,000-gallon steel tank on a 120-foot tower will be erected.

. EEDDICK, Proposed water supply.—(Bull. 11, 117.)

RIVER FOREST, Water supply—(Bull. 10, 169.)

EIVERSIDE, Water supply.—(Bull. 11, 118.)

ROANOKE, Proposed water supply.—(Bull. 11, 119.)

EOBINSON, Water supply.—(Bull. 9, 30.) Visited March 4. Robinson, the county seat of Crawford County, has a population of about 5,000.

Waterworks were installed in 1896 when a supply was obtained from drilled wells 80 to 90 feet deep near the center of the city. The plant was sold later to the National Power Light and Heat Co., which was unable to operate successfully because of insufficient supply. After the plant went into a receiver's hands in 1909 a dug well was sunk 6 miles east of Robinson in the sand and gravel of a terrace of Wabash River. This water was delivered in 1910. The plant eventually was transferred to the Central Illinois Public Service Co. The well is 24 feet in diameter and 28 feet deep. It is walled with brick and is covered by a suitable reinforced-concrete roof. A pumping station near the well with a depressed pumping pit contains 2 duplex pumps having capacities of 254,000 and 176,000 gallons a day. The water is pumped directly from the wells to the city through an 8-inch main. The distribution system in the city comprises 5.38 miles of 4-inch to 8-inch cast-iron pipe and 0.77 mile of 2-inch wrought-iron pipe. The 8-inch rising main is too small. A 75,000-gallon elevated tank 90 feet in total height is connected with the distribution system. Regular records of pumpage are not kept, but the average daily consumption is about 254,000 gallons, equivalent to 65 gallons per capita and 450 gallons per service. The water is of excellent quality from a sanitary point of view and is also unusually low in mineral content. The total hardness is about 180 parts per million.

ROCHELLE, Water supply.—(Bull. 11, 120.)
Sewerage.—(Bull. 11, 120.)

ROCKFORD, Water supply.—(Bull. 10, 170.)

ROCK ISLAND, Water supply and typhoid fever.—(Bull. 9, 30.)

ROCK ISLAND, Pollution of Mississippi River between Rock Island Arsenal and Moline and Rock Island.—A communication was submitted June 23, to the Survey by the Rivers and Lakes Commission transmitting a complaint by the Fish and Game Commission regarding the pollution of the channel of Mississippi River lying between Rock Island Arsenal and the cities of Moline and Rock Island. The locality was visited on July 21-23, 1914, for the purpose of making an investigation. As this investigation may be of general interest and relates to a form of pollution, namely, gas wastes, that in some respects is more injurious than pollution by domestic sewage, the results are summarized at considerable length on page 225.

ROCK ISLAND, Arsenal, Water supply.—(Bull. 11, 120.)

ROODHOUSE, Water supply.—(Bull. 11, 121.)

ROSSVILLE, Water supply.—(Bull. 10, 172.)

RUSHVILLE, Water supply.—(Bull. 9, 30.) Visited December 3-4. Rushville, the county seat, is in the southeast part of Schuyler County and drains into Crane Creek, a small tributary of Illinois River about one mile east of town. Its population is about 2,500.

Waterworks were first established in 1892 with a deep rock well near the public square as the source. As this supply was highly mineralized and soon became inadequate an additional supply was procured by impounding the run-off from a small area northeast of town. When that supply became inadequate a second deep well was drilled at the pumping station used for pumping the impounded surface water. This well yielded little more water than the original well and again the supply became inadequate. A large well was then dug in 1911 in the valley of McElho Branch, a small tributary of Crane Creek, about

6 miles south of town. Preliminary tests indicated a yield of 15 0 gallons a minute, but the yield now is only a little more than 50 gallons a minute or 72,-000 gallons a day, which is inadequate. The leakage from the wooden-stave pipe leading to town also is so great that even after costly repairs it is impossible to deliver water into the mains under adequate pressure. The city has augmented this supply by extending a drain tile from the well into McBlho Branch, which is too polluted to be a satisfactory source. If the wooden-stave pipe to town can be properly repaired it may be feasible to sink additional wells in the valley of McElho Branch or to filter and disinfect the water of the branch. Either development, and particularly the latter, would involve large expenditure. It is now necessary to use the deep-well water and the impounded supply northeast of town.

Inspection shows that the impounding water is subject to contamination, and it also frequently contains a luxuriant growth of organisms that impart a disagreeable taste and odor. Fortunately this water is seldom admitted to the mains. A deep-well water, though it is of good sanitary quality, is exceedingly objectionable on account of its mineral content of more than 4,000 parts per million, which renders the water unpalatable. The water from the well near McElho Branch is satisfactory from sanitary and mineral points of view, though it is rather hard. Its content of iron is not sufficient to render it objectionable. The water direct from McElho Branch, which is fed largely by springs, differs but little from that obtained from the well in dry weather, but it is subject to contamination that renders it unfit for use without purification.

An estimate based on variations of level in the standpipe indicates that the average daily consumption is about 17,000 gallons, equivalent to 150 gallons per service and 7 gallons per capita. The pumping station in the northeast part of town is rather dilapidated, little attention being given to it because it will probably be abandoned. It houses one deep-well steam-head pump of unknown capacity, one 200,000-gallon duplex steam pump, which is reserved for emergencies, and one 400,000-gallon duplex steam service pump. The service pump draws from a circular brick collecting reservoir which may receive water from the impounding reservoir or from the well, and discharges into the distribution system under a pressure about 45 pounds with standpipe full. The pumping station in the valley of McElho Branch contains two 3-stage 360,000-gallon centrifugal pumps, which draw from the dug well and discharge into the wooden-stave pipe. Power is furnished to one of the pumps by a 30-horsepower electric motor and to the other by a 45-horsepower vertical 3-cylinder oil engine. It has been far more economical to use the pump connected with the engine than that connected with the motor. A single-stage turbine pump direct-connected to a 20-horsepower electric motor near the standpipe has a capacity of 450 gallons a minute or 650,000 gallons a day against a head of about 45 pounds. This pump utilizes the full storage of the standpipe in case of fire. The distribution system comprises about 4.7 miles of 4-inch to 10-inch cast-iron pipe, and more than 5 miles of 10-inch wooden-stave pipe constituting the rising main from MeElho Branch. The standpipe, 14 feet in diameter and 100 feet high with a total capacity of 115,000 gallons, is located near the center of town.

ST. ANNE, Proposed sewerage.—(Bull. 11, 122.)

ST. CHAELES, Water supply.—(Bull. 9, 30.) Visited August 6. St. Charles is a growing manufacturing town on Fox Eiver in the northern part of the State with a population of about 5,000.

The city has had since 1907 a public water supply, which is operated in conjunction with the municipal electric lighting plant. The supply was originally obtained from an 8-inch well 350 feet deep drilled into rock. No record of the formations penetrated is available but it is understood that the supply comes entirely from limestone. The well can yield about 170,000 gallons a day. The static level is within 6 or 8 feet of the surface, and the drawdown at the rate of pumpage indicated is to about 60 feet, which is the level at which the working barrel of the pump is placed.

This supply became inadequate in a few years and another well was sunk about one-fourth of a mile from the first. The new well is 850 feet deep and 10 inches in diameter. Water rises to within 40 feet of the surface and the pump cylinder is set at 125 feet. While the well is pumped to its maximum capacity of approximately 150,000 gallons a day the water is drawn down nearly to the cylinder. The water from the new well is pumped directly into the distribution system. The water from the first well is pumped into a 50,000-gallon rectangular concrete collecting reservoir covered with a concrete-slab roof, from which it is pumped into the distribution system by a 1,500,000-gallon duplex steam pump, the sole reliance in case of fire. The direct connection with Fox Eiver for use in emergency should be regarded as decidedly dangerous because the valve controlling the intake may become defective or may be carelessly left open. The direct intake certainly should be abandoned and the necessary emergency supply should be obtained by sinking additional wells. No pumping records are maintained, but the average daily consumption may be estimated as about 250,000 gallons and the maximum as about 300,000 gallons. The distribution system comprises about 11% miles of 4-inch to 10-inch cast-iron pipe with leaded joints. They are approximately 400 connections, all of which are metered. A 100,000-gallon elevated steel tank over the new well and the pumping station, affording a pressure of 35 to 75 pounds per square inch, is connected with the distribution system. The tank is usually shut off in case of fire so that the higher pressure of the pumps can be applied.

The supply is of good quality from a sanitary point of view and is not excessively mineralized. The water from the old well has a total mineral content of 594 parts per million and a total hardness of approximately 400 parts, and that from the new well a total mineral content of 401 parts per million and a total hardness of 290 parts. The content of iron of water from the old well is 0.8 part and that of water from the new well is 0.4 part per million. The mixture of the two waters seems to give general satisfaction though the iron imparts a slight turbidity seldom amounting to more than 15 parts per million except at dead ends. All dead ends supply flush tanks on sewers, which keeps the water in these sections relatively fresh.

ST. ELMO, Water supply.—(Bull. 10, 174.)

SALEM, Water supply.—(Bull. 11, 123.)
Sewerage.—(Bull. 11, 123.)

SANDWICH, Water supply.—(Bull. 9, 30.) Visited November 12. The steam pumping equipment was replaced in May by 2 electrically driven centrifugal pumps having daily capacities, respectively, of 450,000 and 1,000,000 gallons. The current is obtained from the Public Service Company of Northern

Illinois. The steam duplex pump and boiler plant are, however, retained in working order for use in emergency.

SANGAMON, County poor farm, Proposed sewage treatment.—(Bull. 11, 12 3.)

SAN JOSE, Water supply.—Visited October 31. San Jose, in the east part of Mason County in the basin of Salt Creek, occupies flat and poorly drained territory. Its population is about 450.

The public water supply, installed about 1885, is obtained from one well about 105 feet deep in glacial drift. The water comes from sand and gravel extending from a depth of 85 feet to the bottom of the well. The water is raised by a deep-well power pump with its water cylinder 85 feet below the surface. The static level is within 80 feet of the surface, and the water has never been lowered below the cylinder by pumping at the full capacity of the pump, which is about 45,000 gallons a day.

Water is pumped from the well into the distribution system and a pressure storage tank under a head of 90 to 115 feet. The distribution system comprises about 2,700 feet of 1¼-inch pipe, which supplies 14 house services, and three 4,250-gallon cisterns, each of which is equipped with a hand pump. Though the cisterns are rather crudely constructed, being merely plastered on the inside, they appear to be adequately protected against the direct entrance of surface contamination. They also serve as reservoirs in case of fire. Additional fire protection is furnished by 50 feet of 6-inch pipe from the pressure tank to a hydrant in the main street near the principal business houses. The pressure tank is 9 feet in diameter and 38 feet long with an average storage capacity of 5,400 gallons. A 45,000-gallon power pump, which is maintained in reserve for fire protection, draws from the cistern near the pumping station and discharges into the distribution system.

The water supply seems safe from a sanitary standpoint, but it has a total hardness of 420 parts per million and a mineral content of 517 parts and would be corrosive in boilers. It meets with general satisfaction.

SAVANNA, Water supply.—(Bull. 11, 12 4.)

SEARS, Proposed water supply.—Sears was visited July 22 by request of the local authorities to investigate a proposed source of water supply. Sears is a village of about 300 population on Bock River just south of Bock Island.

There are many shallow wells in the community, but all have small yields. An adequate supply can probably be obtained from ground-water sources only by a well drilled into rock. The rock water, as indicated by several existing private wells, is likely to be rather highly mineralized. As a result of the examination, the village authorities were advised of the possibility of procuring water from deep rock wells but were warned that the water would be rather highly mineralized.

SHAWNEETOWN, Flood conditions on Ohio Biver.—(Bull. 11, 124.)

SHEFFIELD, Water supply:—Visited October 13. Sheffield, in the drainage basin of Green Biver in the west part of Bureau County, has a population of about 1,000.

Waterworks were installed over 20 years ago by the village. The supply was first obtained from a dug well 9 feet in diameter and 46 feet deep near the center of town. A second well was dug 10 feet in diameter and 50 feet deep about 1902 when an increased supply became necessary. The 2 wells are connected at the bottom of the shallow well by a 2-inch pipe, and water ia pumped only from the deeper well. Steam pumping machinery was used until recently, but electrically driven machinery receiving power from the Consolidated Light and Power Co. has been installed. A pump with a nominal daily capacity of about 250,000 gallons, which actually delivers not much more than 110,000 gallons, pumps the water from the wells into the distribution system. This system comprises about 2¼ miles of 4-inch to 6-inch pipe. Additions to the system are contemplated. There are 160 services, 60 per cent of which are metered. An 80,000-gallon elevated steel tank near the pumping station on a tower which gives it a total height of about 160 feet is connected with the system. This tank replaced a 70-foot wooden tank 3 years ago. During 1912 there was registered by a 6-inch meter at the pumping station a daily consumption of 12,500 gallons, equivalent to 12.5 gallons per capita and 82 gallons per service. The small size of these figures and their disaccord with estimates based on operation indicate that the meter is under-registering.

The water is of good quality from a sanitary standpoint and meets with general approval. It has a total mineral content of 507 parts and a total hardness of 440 parts per million.

SHELBYVILLE, Water supply —(Bull. 11, 125.)

SHELDON, Water supply.—(Bull. 11, 125.)

SILVIS, Water supply.—(Bull. 10, 173.)

SPAETA, Proposed water supply.—"Visited February 16 and September 10. It has been proposed to obtain a water supply from an impounding reservoir about one mile south of the city. The proposed development will furnish sufficient water of good quality from a sanitary and physical point of view to meet the probable future growth that may take place within 30 to 50 years. It includes an impounding reservoir, a mechanical filtration plant, a system of mains, and an elevated storage tank, though detailed plans for the entire project had not been developed construction work on the dam for the impounding reservoir was begun in order to catch, if possible, the spring run-off of 1915.

SPAETA, Typhoid fever.—Sparta was visited December 23-24 by a representative of the Survey, working in cooperation with the State Board of Health, to investigate an outbreak of typhoid fever involving 28 cases in 3 months. The full report is published on page 229.

SPEINGFIELD, Sanitary condition of State fair grounds.—Visited August 20-21. The most important disclosure of the inspection was the polluted condition of the wells on the fair grounds, which are extensively used as sources of drinking water. The analyses show.that not one of the wells was entirely free from the influence of contamination and that some of them were dangerously polluted. The water from them undoubtedly became worse during the fair, which opened September 16, because of the large number of visitors who would contribute greatly to the sources of contamination.

Special attention was directed to the well at the poultry building, the well at the exposition building, and the well near the grand stand. The first two wells are not more than 5 or 10 feet from sewer lines and the last well is within 40 feet of several sewers from the toilets under the grand stand. Little could be learned of the construction of the sewers, but it is understood that many have been laid with open joints so that there may be an abundant opportunity for leakage of their contents into the soil. Six of the 7 wells on the ground are subject to contamination at the top through coverings that are not water-tight. The exception is the well near the grand stand, which is near several sewers. Apparently only the well at the custodian's house and that at the machinery building can be readily protected against contamination. There may, however, be unknown sources of danger near those wells in the form of drain tiles and sewers.

All the other wells should be closed at once and preferably filled so that water cannot by any chance be drawn from them. This will not be in any way a hardship because the public water supply of Springfield, which is now of high quality from a sanitary standpoint, is available throughout the grounds. The entire supply is obtained from wells, the water from which is known to be of excellent quality through monthly analyses made in the laboratory of the Survey. There is a remote possibility that the city may be obliged temporarily to use water directly from Sangamon Eiver because of excessive demand or breakdown of machinery, but the development of wells and safeguards against breakdown have progressed so far that the use of river water is very doubtful. The toilets throughout the fair grounds are generally satisfactorily arranged and apparently well kept, except those under the grand stand, which are used by the most people. These toilets should be given more light and air and should be kept cleaner. Several badly constructed privies in certain parts of the grounds should be replaced by more substantial and more sanitary structures.

At the time of inspection there were no evidences of unsatisfactory disposal of the garbage, refuse, and manure. The dump near the grounds, 'which has received the refuse of previous years, was in good condition and gave every evidence of having been properly maintained. According to the custodian the principal difficulty lies in removing the garbage, refuse, and manure as rapidly as they are produced. The/only remedy is the purchase of more teams and the employment of more laborers. The receptacles now available for garbage should prevent nuisance at the point of production, and apparently little difficulty is experienced in inducing concessionaires to place all wastes in the receptacles and to keep the receptacles covered.

It would be advantageous to keep the three forms of waste separate for final disposal. The rubbish, which is chiefly waste paper, may readily be burned on the dump in a stove improvised from an old boiler or tank. The garbage, which is the most objectionable because of its disagreeable odor and the rapidity with which it breeds flies, should be buried. As the manure has a market value it could be sold or used on the grounds if it were properly composted. It would, therefore, seem a wise investment to build manure pits of such design as rigidly to exclude flies. The authorities were advised that it would be impracticable to complete suitably designed pits for use during the fair of 1914; therefore, as a temporary expedient, the manure might be buried with the garbage.

It is very difficult, as pointed out by the State Board of Health, to maintain sanitary conditions and cleanliness without systematic and continuous inspection because of the temporary character of many of the kitchens and dining rooms on the grounds and because of the presence of a large number of people with basket luncheons. It was recommended that one or more sanitary policemen be employed to patrol constantly the grounds to provide this inspection.

SPRINGFIELD, Water supply.—(Bull. 9, 31; 11, 126.)

SPRING VALLEY, Water supply.—(Bull. 11, 126.)
Pollution of Illinois River.—(Bull. **11,** 126.)

STAUNTON, Proposed sewerage and sewage disposal.—Staunton was visited June 8 at the request of the consulting engineer for the city to inspect conditions in relation to proposed sewerage and sewage disposal. Several sets of plans were subsequently reviewed and a formal report on them was made October 21.

Staunton, in the southeast part of Macoupin County in the drainage basin of Cahokia Creek, is a rapidly growing coal-mining center with a population of about 6,000. Bad sanitary conditions because of the discharge of domestic sewage into a small watercourse passing through the city and lack of sewerage facilities in parts of town remote from the watercourse stimulated a desire for complete sanitary sewerage. As there is no large stream near by it became necessary to purify the sewage. The system is designed on the separate plan, which is the most suitable with reference to final disposal and the most economical inasmuch as storm water drains already exist and additional drains are not immediately needed. There are in all about 9.1 miles of 8-inch to 18-inch sewers of vitrified pipe to be laid with cemented joints. The total estimated cost of the sewerage system proper is $52,435.

The sewage-treatment works are to be located somewhat remote from habitations in the valley of the small branch that passes through the village. The plant is designed to treat the sewage from a population of. about 4,000, which is estimated to be the number that will use the system within 10 or 15 years, and the probable daily discharge of sewage flow from that number will be about 400,000 gallons. The plant comprises 2 plain sedimentation tanks, one dosing chamber, 4 contact beds, and a sludge area. The combined capacity of the reinforced-concrete sedimentation tanks is 130,000 gallons, which represents an average detention period of 7.8 hours. The larger tank has *ai* detention period alone of 5.2 hours and the smaller of 2.6 hours. It is hoped by frequent cleaning to secure sedimentation without anaerobic decomposition and without difficulty through ebullition of sludge. A roughing filter with a coke strainer, which is expected to remove the coarser suspended matter and prevent clogging of the contact beds, is placed at the outlet of each tank. The coke filters will, however, probably clog so rapidly as to be of little value. The dosing chamber is an open semicircular structure of reinforced concrete with a capacity of 72,300 gallons, which provides 5.5 doses a day. The 4 contact beds have a total area of 0.496 acre and an effective depth of 5.5 feet, equivalent to a total content of 2.73 acre-feet, which is insufficient for a population of 3,500. The distribution system is so arranged that sewage will not appear on the surface of the contact material, which is broken stone. Sludge from the tanks will be discharged on an area surrounded by low dikes, and it will be sun-dried or diverted into the stream during high water. Probably special sludge beds will later be constructed. The total cost of the sewage-treatment works is estimated at $38,600, thus making the total cost of the entire improvement $91,035.

STAUNTON, Water supply.—(Bull. 10, **174.)**

STEGER, Water supply.—Visited March 4. Steger, on the boundary between Cook and Will counties, has a population of about 2,500.

The waterworks, owned and operated by the city, were Installed in 1910. The source of supply is a well 12 inches in diameter and 318 feet deep, in which rock was entered at 94 feet. The well is cased to 147 feet. The static level is 75 feet below the top, and the working barrel of the pump is set at 147 feet. No tests of the yield of the well have been made, but there is apparently abundant water to meet the requirements of the village. The maximum rate of pumping is 300 gallons a minute or 430,000 gallons a day. An emergency supply is available from 2 similar wells at the factory of the Steger Piano Co. These 2 wells are pumped by deep-well pumps, which discharge intd a concrete reservoir having a capacity of 500,000 gallons. Water is pumped from the city well by a 575,000-gallon electrically driven deep-well pump, which delivers from the well into the distribution system. The distribution system comprises about 4½ miles of 4-inch to 8-inch cast-iron mains. There are 200 service connections, all of which are metered, which indicates that about 40 per cent of the population uses the public supply. A 100,000-gallon elevated steel tank near the pumping station with a total height of 119 feet is connected with the distribution system. Pumpage is not recorded, but the average daily consumption may be estimated at 35,000 gallons, equivalent to 14 gallons per capita and 175 gallons per service.

The water is of excellent quality from a sanitary standpoint, but the mineral content is 443 parts per million, and the content of iron, 1.0 part per million, is sufficient to cause some discoloration of the water and staining of plumbing fixtures.

STEELING, Water supply.—(Bull. 11, 127.)

STOCKTON, Water supply.—(Bull. 11, 127.)
Sewerage.—(Bull. 11, 128.)

STONINGTON, Water supply.—(Bull. 11, 128.)

STEAWN, Typhoid fever—(Bull. 11, 130.)

STEEATOE, Water supply.—(Bull. 9, 31; 11, 128.)

STRONGHUBST, Proposed water supply.—Stronghurst was visited October 8 in reference to proposed installation of a water supply immediately prior to an election on the issuance of bonds and at the request of the local authorities. A brief report, outlining the possibilities of procuring a water supply and presenting arguments in favor of it, was submitted for the information of the public by the Survey's representative before leaving town;

Stronghurst, in the south part of Henderson County about 10 miles from Mississippi Eiver, has a population of about 800. About 1885 the city in cooperation with a private company drilled a well to a total depth of 1,600 feet, and a large volume of water was encountered. The "choice of a supply at present seems to lie between a deep well and some springs less than a mile from the village. As the existing well was not acceptable as a source of supply because of local controversy a contract was later awarded for drilling a new well. Both the springs and the wells yield water of good sanitary quality, but the spring water contains less than one-fourth as much mineral matter and hardening constituents as the well water. Considerations of cost and difficulty in securing a clear title to the water rights of the springs decided the local authorities in favor of a deep-well supply.

SULLIVAN, Water supply.—(Bull. 11, 130.)

SYCAMOEE, Water supply.—(Bull. 11, 131.)

TAYLOEVILLE, Water supply.—(Bull. 11, 132.)

TINLEY PARK, Water supply.—At the request of Mr. Francis A. Harper, president of Tinley Park, the village was furnished by the Survey with available information regarding the occurrence and composition of deep ground waters that might be considered as sources of public supply. Tinley Park is in the southwest part of Cook County a few miles beyond the boundary of Chicago and its population is about 300.

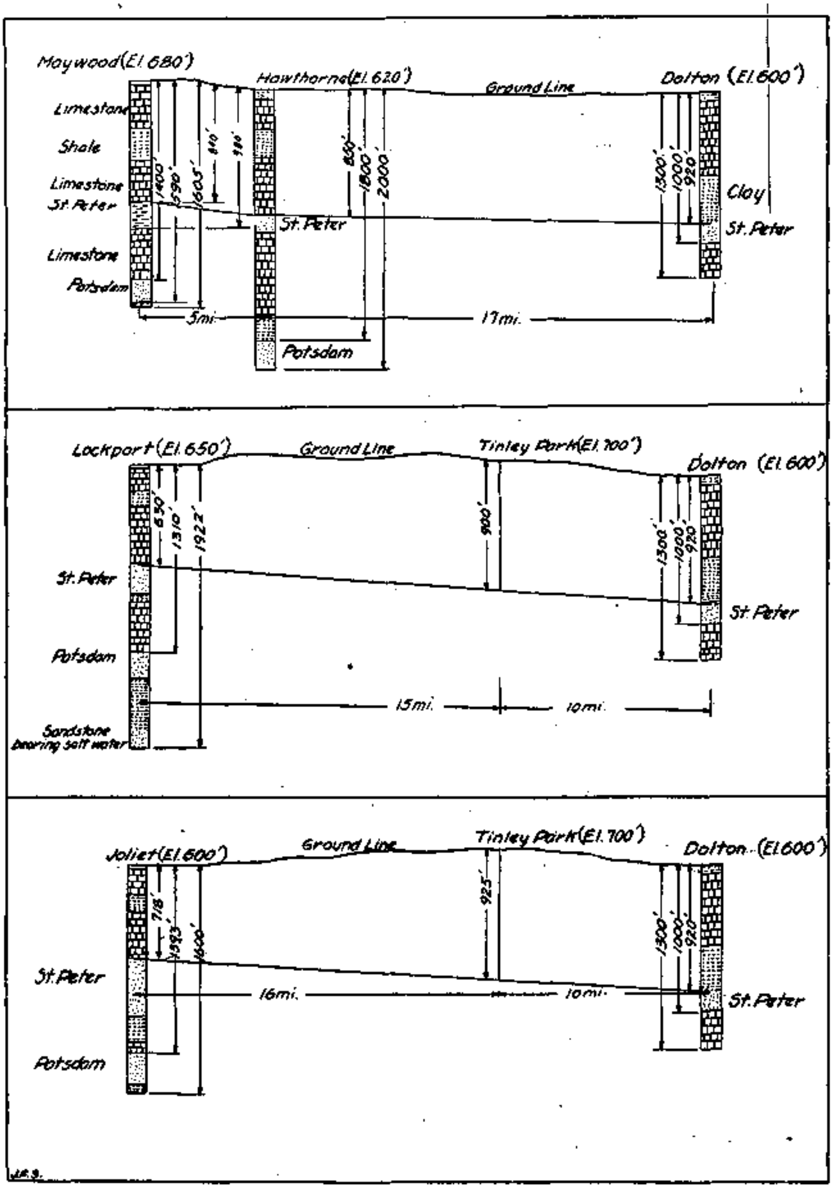


Figure 1.—Sections of deep wells in the vicinity of Tinley Park.

A study of available records of wells in the vicinity was made and a sketch (Fig. 1) showing their depths and relations was prepared. The relative position of these sections is shown in figure 2. The sections in figure 1 indicate that the St. Peter sandstone would probably be entered at Tinley Park at a depth of 900 to 1,000 feet. The meager information concerning the probable depth of the Potsdam sandstone indicates that it would probably be reached within 1,800 feet. The accompanying table gives analyses of water from 9 wells. Only the well at Joliet and the well of the Sears-Eoebuck Co. reach the Potsdam sandstone. After the well of the Chicago, Milwaukee & St. Paul Eailway Co. at Bensenville had been cased to 1,236 feet to shut out surface water and water from the St. Peter sandstone, a supply of 170 gallons a minute, very satisfactory for use in locomotives, was obtained. The Chicago & Northwestern Eailway Co. obtained satisfactory boiler water from an 1,850-foot well at Orchard Place.

Great care must be taken in drilling wells in the vicinity of Tinley Park not to drill too deep into the Potsdam sandstone and thus strike salt water. This happened with one of the wells at Bensenville. The well of the Sears-Eoebuck Co. at Homan Avenue and Harvard Street, Chicago, was drilled too deep,

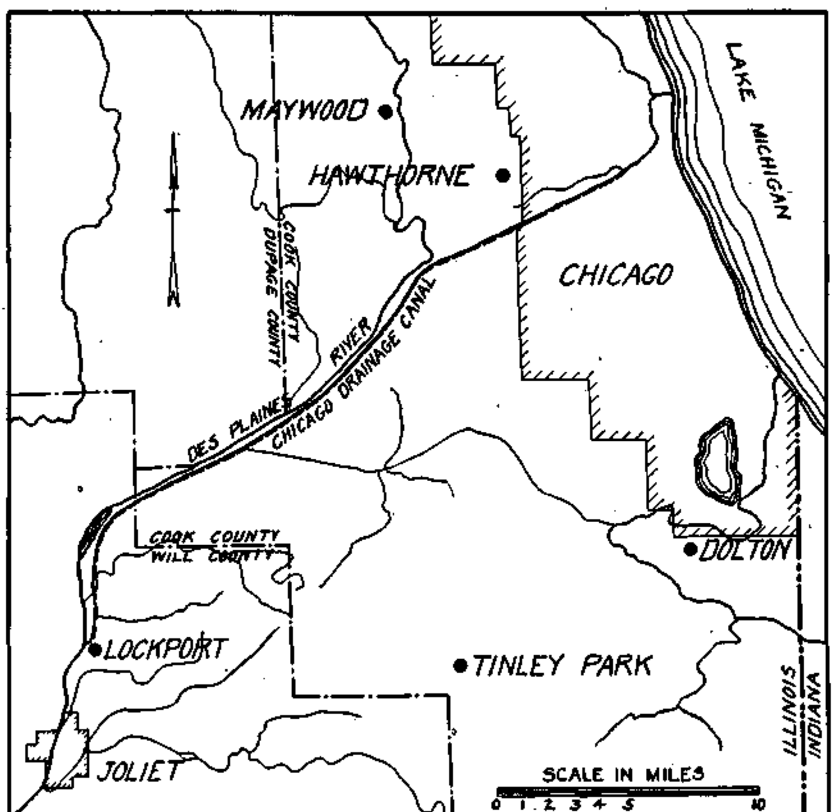


Figure 2.—Map showing location of municipalities in the vicinity of Tinley Park having deep wells.

TABLE 7.—MINERAL ANALYSES OF WATER FROM DEEP WELLS NEAR TINLEY PARK.

Number	1.	2.	3.	4.	5.	6.	7.	8.	9.
IONS IN PARTS PER MILLION									
Potassium (K)	22	24	4.7	7.1	34	12	11	.....	} 149
Sodium (Na)	46	80	32	159	138	22	83	.....	
Ammonium (NH_4)	.5	.....	.6	.....	.....	.....	2.0	.....	.....
Magnesium (Mg)	41	39	66	82	48	61	9.9	84	20
Calcium (Ca)	92	102	79	114	173	109	69	.....	69
Iron (Fe)	.5	.....	3.6	.1	.2	.7	.....	.....	.....
Alumina (Al_2O_3)	.....	.....	5.9	4.2	3.0	8.8	.....	.....	.....
Silica (SiO_2)	13	14	22	7.0	8.8	12	.....	.....	.....
Nitrate (NO_3)	.....	2.4	.....	.....	3.3	1.2	2.2	.....	.....
Chloride (Cl)	29	84	32	134	136	10	36	530	111
Sulphate (SO_4)	210	240	245	385	493	168	89	423	152
Carbonate (CO_3)	.....	.....	43	.....	.....	.....	.....	176	134

HYPOTHETICAL COMBINATIONS

	1. Parts per million	1. Grains per U.S.gal.	2. Parts per million	2. Grains per U.S.gal.	3. Parts per million	3. Grains per U.S.gal.	4. Parts per million	4. Grains per U.S.gal.	5. Parts per million	5. Grains per U.S.gal.	6. Parts per million	6. Grains per U.S.gal.	7. Parts per million	7. Grains per U.S.gal.	8. Parts per million	8. Grains per U.S.gal.	9. Parts per million	9. Grains per U.S.gal.
Potassium nitrate	.....	.....	1.0	.06	.....	.....	.....	.....	5.4	.31	2.0	.12	3.5	.20	.....	.....	.....	.....
Potassium chloride	415	2.42	44	2.57	8.9	.51	14	.79	62	3.59	21	1.24	19	1.09	.....	.....	.....	.....
Sodium chloride	15	.89	103	6.01	46	2.68	211	12.28	176	10.28	.....	.....	45	2.59	875	51.02	183	10.72
Sodium sulphate	122	7.13	121	7.66	43	2.49	233	13.60	212	12.38	69	4.05	131	7.66	558	32.54	224	13.11
Sodium carbonate	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	53	3.10	.....	.....	12	.68
Ammonium sulphate	1.8	.10	.....	.....	2.2	.12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ammonium carbonate	.....	.....	.....	.....	2.2	.12	.....	.....	.....	.....	.....	.....	5.3	.30	.....	.....	.....	.....
Magnesium sulphate	158	9.24	182	10.63	269	15.68	159	9.26	240	13.98	152	8.86	.....	.....	58	3.36	.....	.....
Magnesium carbonate	30	1.74	9.7	.56	40	2.32	.....	.....	.....	.....	105	6.14	34	1.99	80	1.75	68	3.98
Calcium sulphate	.....	.....	.....	.....	.....	.....	44	2.55	225	13.13	.....	.....	.....	.....	.....	.....	.....	.....
Calcium carbonate	230	13.41	257	14.98	197	11.50	252	14.68	268	15.60	272	15.85	172	10.01	250	14.58	148	8.64
Ferrous carbonate	1.0	.01	.....	.....	7.6	.44	.2	.01	.....	.....	1.5	.08	.....	.....	.....	.....	.....	.....
Alumina	3.3	.19	} 2.5	.....	5.9	.34	4.2	.24	3.0	.17	8.8	.51	25	1.47	.....	.....	.....	.....
Ferric oxide	.....	.....		.14	.....	.....	.....	.....	.2	.01	.....	.....	.....	.....	.....	.....	.....	.....
Silica	13	.73	14	.84	22	1.28	7.0	.41	8.8	.51	12	.70	9.0	.52	.....	.....	.....	.....
Bases	5.0	.29	.....	.....	1.6	.09	2.2	.12	4.8	.28	1.4	.08	.....	.....	.....	.....	.....	.....
Total	621	36.15	735	42.85	643	37.45	925	53.94	1,204	70.24	645	37.63	497	28.93	1,770	103.25	635	37.13

1. Well 1,600 feet deep at Maywood, Cook County. Sample collected February 3, 1911. Laboratory No. 21,793. Analysis by State Water Survey.

2. Well 1,570 feet deep at Berwyn, Cook County. Sample collected June 27, 1904. Laboratory No. 12,159. Analysis by State Water Survey.

3. Well 2,000 feet deep at Eiverside, Cook County. Sample collected Sept. 13, 1912. Laboratory No. 26,086. Analysis by State Water Survey.

4. Well 1,400 feet deep at Morgan Park, Cook County. Sample collected Sept. 8, 1910. Laboratory No. 21,481. Analysis by State Water Survey.

5. Well 1,670 feet deep at Harvey, Cook County. Sample collected Sept. 15, 1908. Laboratory No. 18,165. Analysis by State Water Survey.

6. Well 200-250 feet deep at Chicago Heights, Cook County. Sample collected Sept. 27, 1909. Laboratory No. 19,908. Analysis by State Water Survey.

7. Well 1,565 feet deep at Joliet, Will County. Sample collected May 15, 1913. Laboratory No. 25,278. Analysis by State Water Survey.

8. Well 1,960 feet deep of the Sears-Eoebuck Co., Homan Avenue and Harvard Street, Chicago. Sample collected Feb. 6, 1912. Laboratory No. 22,966. Analysis by State Water Survey.

9. Well more than 1,236 feet deep of Chicago, Milwaukee, and St. Paul Railway, at Bensenville, Dupage County. Sample collected Oct. 30, 1913. Analysis by C. M. & St. P. Ey.

and analyses of samples taken at intervals showed an increase in mineral content; it was necessary to fill the bottom of the well with concrete to shut out the salt water. .

Though it could not be guaranteed from consideration of the available data that suitable water would be obtained at a depth of 1,800 feet, it was recommended that the village drill a well to the Potsdam sandstone, at 1,500 to 1,800 feet. It was also stated that a satisfactory supply could probably be obtained from the St. Peter sandstone at 900 to 1,000 feet. After having received this report the village drilled a well into the St. Peter sandstone to a depth of 915 feet and obtained a flow of 250 gallons a minute of water very satisfactory for domestic and commercial use.

TISKILWA, Water supply.—(Bull. 9, 31; 10, 175.)

TOLONO, Water supply.—"Visited February 3. Tolono, in the southwest part of Champaign County in the drainage basin of Embarrass Eiver, has a population of about 800.

The waterworks were installed in 1895, during which year 2 wells were sunk in the drift. One of them filled with gas about 2 years later and was abandoned. A third well was drilled in 1901 and this with one of the original wells is now the source of supply. The wells are in the northeast part of town and are 146 feet deep. One is cased with 8-inch pipe to 138 feet and the other with 6-inch pipe to 129 feet, and both are equipped with Cook strainers. The chief material penetrated is clay, underlain by layers of sand from 129 feet to 165 feet. The static level is 40 feet below the surface. The effect of pumping on the water level is not known, but past experience indicates sufficient water. Water is pumped from the wells into the distribution system by 2 steam-head deep-well pumps having nominal daily capacities, respectively, of 425,000 and 233,000 gallons. The actual working rate is somewhat less than one-half those given. The distribution system comprises about 4¾ miles of pipe; it is stated that only

300 feet of this is 4-inch pipe and that the remainder is 8-inch pipe. There are **116** service connections, all but 4 of which are metered. A 69,000-gallon elevated wooden tank with a total height of 109 feet is connected with the distribution system. The daily consumption is roughly estimated at 50,000 gallons.

The water is of good quality from a sanitary standpoint, but it contains 639 parts per million of total solids and has a hardness of 370 parts per million.

TOLUCA, Water supply.—(Bull. **11,** 132.)

TOULON, Water supply.—(Bull. **11,** 133.)

TOULON, Sewage-treatment plant.—Plans for proposed sewers and sewage-treatment works for Toulon were submitted May 20 by the consulting engineer of the village to the Survey for review. Informal comments and criticisms of these plans were offered. Revised plans had not been received at 'the end of **1914.**

TEEMONT, Water supply.—Visited July 1. Tremont, in the central part of Tazewell County, has a population of about 800.

Waterworks were installed in 1911 chiefly for fire protection. An attempt to procure water from a well near the town hall failed after a depth of 150 feet had been reached. After a favorable yield had been obtained by. a 2-inch tubular well in the eastern part of town a second well was drilled there, and a pumping station was erected beside it. The well is 132 feet deep and 8 inches in diameter. The water is derived from a stratum 4 feet thick, the exact nature and depth of which were not ascertained. The equipment comprises one deep-well power pump driven by a 12-horsepower gasoline engine, a distribution system, and a 40,000-gallon steel elevated tank. About half the population uses the water supply, and the daily consumption varies from 15,000 to 20,000 gallons.

The water is of good quality from a sanitary point of view, but it is moderately hard (total hardness 288 parts per million). Iron is present in sufficient quantity (2.6 parts per million) to cause marked staining and discoloration.

TRENTON, Water supply.—Visited April 7. Trenton, near the west border of Clinton County in the drainage basin of Kaskaskia River, has a population of about 1,700.

Waterworks were installed in 1909 chiefly for fire protection, and they are operated in conjunction with an electric-lighting plant. An existing drilled well, which was utilized as part of the supply, is now used exclusively to furnish boiler feed. Three additional wells drilled in 1909, 234 to 237 feet deep, encounter porous white sandstone at about 100 feet. The water level is readily lowered by pumping and the wells can be pumped practically dry. The test yields for the 4 wells, which are, respectively, 8, 10, 12, and 13 gallons a minute, are reduced materially when more than one well is being pumped. The well of smallest yield has been abandoned. During the first two years wells 2, 3, and 4 were equipped with air lift, but the depth of the wells was not sufficient to give adequate submergence for the air lift and the air lifts were replaced by deep-well pumps. The pumping machinery comprises one steam-head well pump on the original well and 2 electrically driven deep-well power pumps on 2 of the newer wells. The water from the 2 newer wells is pumped into an open rectangular concrete collecting reservoir with a capacity of 450,000 gallons. The water.is pumped from the reservoir into the distribution system by 2 duplex steam pumps having daily capacities of 750,000 and 210,000 gallons. The distribution system comprises about 2¼ miles of 4-inch to 8-inch cast-iron mains. Connection with 42 services indicates that only one-tenth of the inhabitants use the public supply. The original plans call for an elevated tank near the pumping station, but this has never been built and direct pressure is maintained. Pumpage is not recorded but rough estimates indicate an average daily consumption of 2,700 gallons, equivalent to 64 gallons per service and 16 gallons per capita with 4 persons per connection.

The water is of good quality from a sanitary point of view, but it contains 964 parts per million of total solids, mostly alkali, though the total hardness is only 62 parts per million.

TUSCOLA, Water supply.—Visited February 4. Tuscola, in the northwest part of Douglas County, of which it is the seat, has a population of about **2,500.**

Tuscola established a public water supply at a cost of. $l5,000 in 1898. A well was first drilled to a depth of 3,017 feet in an attempt to procure water from the Potsdam sandstone. The water encountered was very salty and highly impregnated with hydrogen sulphide, and it was, therefore, never extensively used for domestic purposes. In 1899 the city sold the well and the land on which it is situated to an individual for the nominal sum of $1.00 with the understanding that he would establish and maintain a public water supply to the best of his ability. The deep well was the source until 1904, when a surface supply was developed on a small creek west of town. In 1912 the Central Illinois Public Service Co. purchased the plant and drilled 2 wells, respectively, 850 and 230 feet deep, but the yield of both was so small that they were soon abandoned. Little could bo learned regarding the deep wells. The yield of the the first well is about 50 gallons a minute. The yield of the 850-foot well is only 10 gallons a minute. The present supply is obtained chiefly from the creek and is supplemented when necessary by water from the original deep well. The creek is little more than a drainage ditch with a catchment area of only 3 or 4 square miles of flat farm land, and it has no flow during the greater part of the summer. So far as known the stream receives no direct sewage contamination, but it is subject to more or less intermittent contamination incident to farming operations. An attempt is made to clarify the water from the creek by using a tile drain 300 feet long laid with open joints 2 feet down in the bed of the stream, which discharges into an old dug well used as a pump-suction pit. Water is pumped from tho old dug well and from the deep rock well into 2 open collecting reservoirs having capacities, respectively, of 120,000 and 45,000 gallons, so connected that they are essentially one. The creek water and the deep-well water can, however, be separately pumped into the mains and the creek water when available is used instead of that from the deep well. A deep-well steam pump is set in the deep rock well with its working barrel of 3 25 feet. Water is pumped from the collecting reservoirs into tho distribution system by 2 compound duplex 300,000-gallon steam pumps. The distribution system comprises about 10 miles of 4-inch to 6-inch cast-iron mains. There are 144 service connections, of which 140 are metered. These figures indicate that about one-fourth of the inhabitants use the public supply. Nothing definite could be learned regarding the consumption of water, but it seems to **vary** with the quantity available. The quality of water is not good from a sanitary or a mineral point of view. The water from the creek can be rendered satisfactory by treatment, but an expensive filter plant is not warranted because of its limited quantity.

Eeeommendation was made that the supply be treated with calcium hypochlorite to avoid danger from disease, and this recommendation has been observed since August, 1914.

TUSCOLA, Proposed sewerage.—Plans and specifications were received June 20 from the Eivers and Lakes Commission for a proposed sewer at Tuseola, and conditions at Tuscola were investigated June 23 by a representative of the Survey.

The proposed sewer extends north and south the full length of Center Street, one of the main streets of the community. It is to be laid with bell and spigot pipe. The plans call for only 2 manholes in a distance of more than a mile. The sewer is intended like others in the community, to carry both storm water and sanitary sewage. Ordinances, however, do not permit the direct discharge of sanitary sewage into the sewers; cesspools and small tanks on house connections are, therefore, in common use. It is planned to discharge the sewage into Dredge Ditch No. 1, which now receives the discharge of other sewers of the community; this is a small wet-weather stream with a catchment area of about 8 square miles, which ultimately finds its way into Scattering Fork, a small tributary of Embarrass Eiver. The ditch is now visibly polluted by the small flow of sewage from Tuscola, but no complaints have yet been made. With increase in sewage the ditch will probably become a public nuisance.

The proposed sewer is very crude and it is not a substantial and permanent improvement. The proposed construction is all the more objectionable because the limited quantity and poor quality of the public water supply have resulted in the use of many shallow private wells that may be contaminated by seepage through the open joints of the sewers. The proposed sewers as well as those now existing are too small to carry off storm water as rapidly as it falls during heavy storms. This causes occasional surcharging of the sewers and consequent backing up into cellars of mixed storm water and domestic sewage. As the proposed system was already under construction when the matter came to the attention of the Survey it was impossible to make any important modifications. The local authorities were advised that before any additional sewerage is planned thorough engineering studies should be made of the practicability of constructing a system of sanitary sewers and storm drains that would serve all needs of the community and provide for conveying the sanitary sewage to a point where it may ultimately be economically and satisfactorily disposed of by treatment or otherwise.

It was recommended to the Eivers and Lakes Commission that the proposed additional sewer be approved only as a stormwater drain. It was also recommended that the local authorities be notified that, when in the opinion of the Eivers and Lakes Commission Dredge Ditch No. 1 becomes objectionably polluted the commission will require the treatment of all sewage from Tuscola for the purpose of abating such pollution.

UTICA, Water supply.—(Bull. 11, 134.)

VILLA GROVE, Proposed water supply.—Villa Grove was visited December 5 at the request of the consulting engineer for the village to make a preliminary investigation of a proposed public water supply. Villa Grove, in the north part of Douglas County in the drainage basin of Embarrass Eiver, has a population of about 2,000.

The drift in this locality is 200 or more feet thick, and consists principally of bluish clay with fine sand at the bottom overlying blue shale. Thin layers of coarse sand containing water occur at 35 to 40 feet and at 80 to 90 feet, and these strata are penetrated by many private wells. The yield of water from them is, however, too small for a public supply though it is enough, for private household use. The probability of procuring an adequate supply from the drift is, therefore, doubtful. Farm wells around Villa Grove and wells in neighboring towns that penetrate rock encounter water at 500 to 600 feet, but the quantity available at this depth is uncertain. A test well had been sunk prior to the visit to a depth of 250 feet or through the drift without developing any considerable quantity of water, and a contract for an additional depth of 100 feet had been awarded. The well will probably be drilled still deeper if an adequate supply is not found within 350 feet.

VIRDEN, Proposed water supply.—(Bull. 11, 135.)

WARREN, Water supply.—(Bull. 11, 136.)

WARSAW, Water supply.—(Bull. 10, 176.)
Filter plant.—(Bull. 11, 136.)
Sewerage.—(Bull. 10, 177.)

WATERLOO, Water supply.—(Bull. 10, 178.)

WATSEKA, Water supply.—(Bull. 10, 179.)

WATSEKA, Iroquois County poor farm, Sewage disposal.—The Iroquois County poor farm was visited September 27 in response to a request for advice regarding a proper disposal of sewage. The institution is about 2½ miles southeast of the center of Watseka and consists of 2 large buildings, in which the inmates are housed, besides several small buildings and stables. The number of inmates varies from 50 to 60.

A water-carriage system of sewers is provided for only one of the dormitories, in which the toilets are used by 20 to 25 people. This system also carries the sink wastes, laundry water, and roof drainage. The sewage is discharged into a small ditch having a drainage area of only a few hundred acres and having ordinarily no flow during summer. The volume of sewage is small, the point of discharge is remote from habitations, and the stream is not depended on for watering cattle though they have access to it.

In view of these conditions it was not deemed worth while to treat the sewage at present and recommendation was, therefore, made that the ditch be fenced to prevent access by cattle.

WAUKEGAN, Water supply,—(Bull. 9, 31; 11, 137.)

WEST CHICAGO, Water supply.—Visited November 12. West Chicago is located in the west-central part of Dupage County on West Branch of Dupage River about 12 miles below its source. It is a rapidly growing place with a population of about 2,500. It lacks municipal improvements especially a sewerage system.

The waterworks were installed by the municipality in 1896. The original installation included a deep well, a deep-well pump, a service pump, and an elevated tank. A second well was drilled in 1908 and equipped with a deep-well pump on account of the increased demand, and a second service pump was installed in 1911. There have been no other changes in the waterworks except normal extension of the mains. The wells are located near the center of the town and are, respectively, 775 and 322 feet deep, and are cased with 10-inch pipe to rock, encountered at 90 feet, below which they are 8 inches in diameter. The water-bearing stratum of the shallower well is dolomitie limestone at an unrecorded depth. The static level is within 50 feet of the surface. The working barrels of the pumps are set at 90 feet and at this depth are apparently capable of continuous operation at their full capacity. The 300,000-gallon deep-well pumps discharge into a 72,000-gallon circular collecting reservoir, with cement-plaster and brick walls, covered by a conical wooden roof. The water is pumped from the reservoir into the distribution system by 2 duplex pumps with nominal daily capacities, respectively, of about 500,000 and 900,000 gallons. The standpipe 115 feet high near the pumping station has a base 12 feet high, is 16 feet in diameter, has a total capacity of 170,000 gallons, and produces a pressure in the system of 60 to 60 pounds per square inch. The distribution system comprises about 18 miles of 4-inch to 8-inch cast-iron pipe, which covers practically all the built-up section of the city. The estimated total cost of the waterworks is $50,000.

The water is of highly satisfactory quality from a sanitary point of view. The total hardness is 320 parts per million, and the content of iron is 0.8 part per million. Notwithstanding these somewhat objectionable characteristics the water meets with popular satisfaction.

WEST DUNDEE, Water supply.—(Bull. 9, 32.)

WEST FRANKFORT, Proposed water supply.—(Bull. **11,** 137.) Visited March 26 and May 14-15. It appeared from these inspections that a well supply is inadvisable and that the city may resort to storing water in an impounding reservoir, for which several site3 seem acceptable. The most favorable one appeared to be a ravine about one mile north of town having a potential capacity of at least 72,000,000 gallons. Additional surveys were recommended to ascertain more fully the availability of the site.

WEST HAMMOND, Water supply.—Visited June 12. West Hammond is in the south part of Cook County adjoining Hammond, Indiana, just south of the boundary of Chicago. The population is growing rapidly and it is now about 6,000. The city has several improvements, including 10 miles of brick and macadam pavement and a sewerage system. The sewage is discharged, after being pumped northward, into already polluted Grand Calumet River.

The waterworks were installed in 1892 or 1893 and consist merely of a system of mains connected with the water-supply system of Hammond, Indiana. The supply of Hammond is obtained from Lake Michigan through a 42-inch intake about one mile long. The intake proper consists of a cylindrical screen 102 feet long and 44 inches in diameter composed of ¼-inch rods woven into a mesh with ½-inch square openings. This is parallel to the intake and connected with it by 18 short 20-inch connecting pipes. The water at the intake is subject to more or less pollution from sewage discharged near shore, and analysis frequently shows the presence of gas formers and a large number of bacteria. The intake pipe discharges into 4 intake wells, and the water is pumped from them into the distribution system by pumping machinery having an aggregate daily eapacity of 28,000,000 gallons. As the pumping station is somewhat more than 6 miles from the business centers of the two cities there has been opportunity **for** much frictional loss in the pipe lines; this has recently been remedied to great extent by the installation of an additional 36-inch rising main, which, with the existing 16-inch and 24-inch rising mains, should reduce the frictional losses from about 28 to about 4 pounds per square inch.

The distribution system of West Hammond has 4 connections with the distribution system of Hammond, each of which is provided with a meter, by means of which the consumption of water is ascertained. The system is mostly 4-inch cast-iron pipe though there is considerable 2-inch pipe. The arrangement of the system is poor and the pressure at service connections is always very low. The daily consumption of water is approximately 600,000 gallons but it varies greatly. This is excessive, amounting to considerably more than 100 gallons per capita, and it is proposed to effect a reduction in it by universal metering. An ordinance passed early in 1914 provides for complete metering of the system by September 1. The meters are to be paid for by the consumers. The financial management of the waterworks seems inefficient inasmuch as the amount paid to Hammond for water is greatly in excess of the amount received in water rates, to which must be added the cost of extensions and repairs, reading meters, making collections, and other operating charges. The maintenance of the waterworks seems to be a serious burden on the general funds of the city.

WHEATON, Sewage purification.—(Bull. 10, 180.)

WHITEHALL, Water supply.—(Bull. 11, 138.)
Sewerage.—(Bull. 11, 139.)

WILMETTE, Water supply and sewerage.—(Bull. 0, 31.)

WINCHESTER, Proposed water supply.—(Bull. 11, 139.) Winchester was visited May 25 to obtain information regarding a test well drilled in connection with a proposed public water supply.

The well under test on the Perkins farm was bored 28 feet deep and cased with pipe, which passed through about 10 feet of surface soil and clay, below which was sand and gravel with particles having a maximum diameter of 2 inches. The water stood within 10 feet of the surface. The well was 12 inches in diameter and was provided with an 8-inch Johnston strainer. The water in an observation well about 19 feet deep, which was dug more than 200 feet northwest of this well, stood 8 feet 11 inches below the surface. The pumping test of the test well was continued 55 hours at the rate of 55 gallons a minute; it lowered the water in the test well nearly to the bottom and reduced the water level in the observation well 3 inches. It seemed to indicate that each of a group of wells could yield 50 gallons a minute.

The water from the test well contains 15 parts per million of iron and derelops marked color and turbidity on exposure to the air. Because of the large iron content and the making of a favorable contract for drilling wells on the Grout farm this source of supply was abandoned.

WINNETKA, Water supply.—(Bull. 11, 140.)

WITT, Proposed water supply.—(Bull. 10, 184; 11, 140.)

WOODSTOCK, Water supply.—(Bull. 9, 32.) Visited July 9-10. Woodstock, the county seat of McHenry County, located on the watershed between the basins of Pox and Eock rivers, is a rapidly growing industrial community with a population of about 4,500.

Waterworks were installed in 1894 by the municipality chiefly for fire protection. One well originally was the source, but a second well was soon drilled near the first, and a third well was drilled in 1906 or 1907. When the supply again became inadequate in 1912 two additional wells were drilled in a distant part of the city and a pumping station was erected near them. The main pumping station is located near the center of the city. The wells at the main pumping station are about 2,000 feet deep, and derive water from the Potsdam sandstone, their total yield being about 500,000 gallons a day. One of the wells is operated by a 225,000-gallon electrically driven deep-well power pump and the other two are operated by air lift. The water is discharged into two 100,000-gallons reservoirs, one circular and constructed of brick and the other rectangular and constructed of concrete. The water is pumped into the distribution system by 2 duplex steam pumps having daily capacities, respectively, of 1,500,000 and 750,000 gallons. The 2 wells at the new pumping station are 85 feet deep and 10 inches in diameter and they obtain water from gravel and sand in the drift through 18-foot Cook strainers. They have a combined daily yield of about 500,000 gallons. Water is pumped from the wells into the distribution by two 280,000-gallon electrically driven deep-well pumps. The power is obtained from the main pumping station. An emergency supply is available from the typewriter factory, at which there are 2 deep rock wells having a combined daily yield of about 400,000 gallons. A connection between the city mains and the factory mains has a check valve opening toward the factory; the factory supply can be made available for city use only by connecting hydrants on the two systems with lines of hose. The average daily consumption may be estimated at 475,000 gallons, equivalent to 110 gallons per capita. The distribution system comprises about 17 miles of mains and the existence of about 1,000 service connections indicates that the supply is in general use. A 120,000-gallon standpipe, 80 feet high and 16 feet in diameter, is connected with the distribution system.

The water is of good quality from a sanitary standpoint and is not excessively mineralized. The total residues of waters from the 3 wells at the main station range from 323 to 359 parts per million. The water from drift well No. 2 at the new station has a mineral content of 408 parts per million and a total hardness of 362 parts per million. The hardness is practically all in the form of carbonates. The water from the drift wells contains 2.6 parts per million of iron, which produces an objectionable color and sediment in the water.

WYOMING, Water supply.—Visited December 1. Wyoming, in the south-central part of Stark County about one mile east of Spoon River, has a population of about 1,700.

Waterworks were installed in 1902. The source is a drilled well 1,557 feet deep obtaining a large quantity of water from the St. Peter sandstone, which was entered at 1,500 feet. Practically 1,200 feet of the well is cased to exclude water of poor quality. A pumping test when the well was completed indicated a yield of 200 gallons a minute, or 288,000 gallons a day, with only Blight lowering of the static level, which normally stands at 85 feet. The waters was originally raised by an air lift, but this was abandoned for a 288,000-gallon double-acting deep-well power pump, which discharges into an 85,000-gallon covered circular brick collecting reservoir. The water is pumped from the reservoir into the distribution system by a 360,000-gallon triplex power pump. Both the deep-well pump and the triplex service pump are driven by a 45-horsepower gasoline engine. The distribution system comprises about 5 miles of 4-inch to 8-inch cast-iron mains. As there are about 300 services it seems that the supply is generally used. A 34,000-gallon elevated tank near the pumping station, with a total height of 100 feet, is connected with the distribution system. No regular pumping records are maintained, but the daily consumption is probably 45,000 to 55,000 gallons, equivalent to 26 gallons to 32 gallons per capita or 150 to 180 gallons per service.

The water is of satisfactory quality from a sanitary point of view, contains only a trace of iron, and has a hardness of only 180 parts per million. The mineral content, 1,037 parts per million, is high, but it would not interfere with general use of the water.

YOEKVILLE, Proposed sewerage.—(Bull. **11, 141.)**

ZION CITY, Water supply and sewage conditions.—(Bull. 9, 32.)

BUREAUS OF WATER SUPPLIES [1]

By Edward Bartow.

The United States government and the State governments should maintain special bureaus for the investigation and control of water supplies; The United States government bureau must of course control the purity of water in interstate streams and the quality of water furnished by common carriers in interstate traffic. The State bureaus must control the purity of water in streams and ponds within the respective States and must control the quality of water furnished by the various municipalities and even must control private supplies of the citizens in the State. The bureaus must have more than mere routine control laboratories. They must be ready with staff and equipment to make investigations of methods of analysis, to determine standards of purity, or to make any other investigations on which the routine tests may be based or by which results of analyses may be interpreted.

The development of water-supply control has been comparatively slow for it has been the custom, apparently for administrative reasons, to place the control of water supplies in a bureau or department having other duties. It has been very natural to place the control of water supplies in the health department; for no one cares to deny that the health of the water consumer is of the greatest importance and therefore that the control of the purity of water used for drinking purposes is the most important duty of a water bureau. In practically all of the States, therefore, where any control of the water supplies is attempted, it is done by a bureau or department that is a division of the board of health. Among the many duties that must be performed by a board of health the work of the water bureau or division is very often considered of minor importance. If no specific appropriation is made by the Legislature and if those in charge of the general bureau have insufficient funds to perform all of their duties the work of the water laboratory is usually neglected.

We wish to emphasize our belief that the Federal and State

[1] Address of chairman, laboratory section, American Public Health Association, Jacksonville, Florida, December, 1914; pub. in Am. J. Pub. Health, 6, 871-4 (1915).

water bureaus must be given more liberal support and especially more extensive powers than is the custom. The powers must be broad enough to include the duties of two extremes of routine laboratory, work—at one extreme, the duties of a laboratory which, being under the control of a health officer, is merely an adjunct to the health department or performs routine work to determine the quality of drinking water and at the other extreme, the duties of a railroad laboratory, which, being under the control of an engineer, is used only to save money by obtaining a satisfactory boiler water and often neglects the quality of water furnished to passengers for drinking; Further the laboratory or. bureau must be given freedom to make any scientific investigatiohs that have connection with water problems. It must have freedom to investigate or develop new methods of analysis, new methods of water purification, and new methods for the purification of sewage or trade wastes, whenever and wherever these may be proposed. Health, comfort, and convenience is dependent on the quality of water, and the bureau must be prepared to deal with hygienic, aesthetic, and economic water problems.

The bureau for the investigation and control of water supplies should include divisions of chemistry, biology, bacteriology, statistics, and engineering. The bureau may be in charge of a physician, a chemist, a biologist, a bacteriologist, a statistician, or an engineer, but in any case a man should be chosen who will be broad minded enough to understand the necessity for the investigation of all water problems.

A review of the progress of water-supply control for the past thirty years shows that the most marked progress has been accomplished through the efforts of bureaus which have been almost if not quite independent. The State of Massachusetts, for example, made a specific appropriation for the control of the water supplies of Massachusetts and the work of this laboratory has been epoch making. The city of New York has apparently given the directors of Mount Prospect laboratory a free hand as publications from this laboratory have helped greatly to advance the science of water supply. Special studies at Columbus, Ohio, and at the experiment station of the Sanitary District of Chicago are noteworthy. Large cities like Cincinnati and Louisville have conducted special investigations in connection with the establishment of purification plants. These investigations have been important factors in extending our knowledge of water supplies and water treatment. The continuation of the laboratories in these cities under the direction of specialists after the completion of the purification plants has also been an important factor in extending our knowledge of routine control of water purification.

It is a bad plan to assign the examination of the quality of water to one department and the furnishing of a sufficient quantity of water to another. We have heard of cities where it is the duty of the engineering department to furnish the water and the duty of the health department to determine its quality. The engineering department considers the necessity of obtaining a sufficient supply and deems it an interference when the analyses by the health department show that the water supply is of impure quality. The health department, if it considers only results obtained in routine examinations, condemns the water and is unable to offer a remedy that will assist the engineering department to obtain pure water. Without cooperation, under such conditions the water remains impure indefinitely, perhaps until a serious epidemic arouses the citizens and compels the authorities to purify the water. It is surely desirable to have a bureau or department of water supplies whose sole business it shall be to furnish an abundant supply of pure water.

The larger cities can of course easily maintain a special bureau of water supply: It is, however, practically impossible for smaller towns, individually, to defray the necessary expenses of an efficient water-supply bureau. Several small cities may unite to maintain a bureau of water supplies or each State may maintain a bureau. This community or State bureau should have the cooperation ,of every municipality within its area. Some of the duties of the State bureau are specific and necessary. It must collect accurate statistics concerning the quantity and quality of the water supplied to all the citizens of the State in order that corrective measures may be applied where necessary. It should have the power to compel cities to employ competent engineering assistance properly to plan new water supplies. Each city should make the necessary routine chemical and bacteriological tests to control the quality of water, and each city having a purification plant should carry on simple daily control tests in order that the water supply may be ever pure. The State laboratory should know that these tests are properly carried out either under its own direction or under the direction of competent consulting sanitarians.

Owing to the fact that the economic features of any problem appeal to the general public, the State bureau should take control not only of the quality of the water from the hygienic standpoint but also from the economic standpoint. Experiments that will be of general interest should be carried on to determine the best methods of softening water, the best methods of preventing scaling, corrosion, and foaming in boilers, the best methods of treating water for special manufacturing uses, and the best methods of treating and utilizing trade wastes. While such experiments are not directly the function of a health department, whenever the water bureau is in the department of health, executive health officers should encourage their solution. The solution of economic problems will also render it more easy to obtain funds for the solution of the hygienic problems.

State bureaus have necessarily a limited influence. There should be a permanent national bureau of water supplies which can cooperate with all the State bureaus. As the State bureau should be a clearing house for community bureaus, the Federal bureau should serve as a clearing house for cooperative work to be carried on by the various State bureaus. It may be claimed that the general government can deal only with interstate problems. The interstate problems are very important and will become more so as the population of the country becomes greater. The investigations of the condition of Potomac and Ohio rivers carried on under the direction of the Hygienic Laboratory of the United States Public Health Service are examples of what can be done. Let us hope that the laboratory established at Cincinnati may be continued after the present investigation of Ohio River is completed in order that a record may be kept from year to year of the condition of the river.

The Federal bureau should maintain an experimental laboratory in which studies could be made of problems which are of interest to two or more States. In order properly to enforce the rulings of the Treasury Department in regard to standards of water for interstate carriers, the Hygienic Laboratory or a Federal bureau should have examinations made by its own agents throughout the whole country. The Federal government should maintain a central laboratory and division laboratories, similar to those maintained by the Department of Agriculture for the enforcement of the pure food laws—the central laboratory in Washington and branch laboratories throughout the country. As a beginning the laboratory fitted up at Cincinnati, Ohio, for the study of the conditions of Ohio River can be made a permanent division laboratory, and similar laboratories can be installed wherever necessary to obtain promptly and efficiently the requisite knowledge of the condition of water served on interstate carriers and to enforce the regulations made by the department.

Such an arrangement should be welcomed by the various State organizations.

Cooperation of the Federal bureaus with the State organizations and both with city or community organizations will bring about more efficient control of the purity of all our water supplies, and as a natural consequence the comfort and health of all our citizens will be improved.

POSSIBLE FUNCTIONS OF MUNICIPAL LABORATORIES [1]

By Edward Bartow.

During the past five or six years the State Water Survey has advocated the establishment of control laboratories for water supplies especially where surface waters are used. The success of the laboratories already established proves their desirability. Their success also indicates that it would be practicable to extend the work to cover all analyses that may be useful to a municipality.

A brief review of the water-control laboratories will tend to show the means by which the more general municipal laboratories may be established. It is not a difficult matter to persuade the authorities of large cities having large waterworks plants to install laboratories. Chicago has had a laboratory for years. It is a more difficult proposition to persuade moderate-sized and small cities that they can afford what seems to them to be luxuries. In reality water-control laboratories are necessities and the day is not far distant when they will be so considered.

The large city installs a laboratory for water control with a special room for the bacteriological examination, another room for the chemical examination, and possibly a third for the examination of the mineral content when such analyses can be shown to be advantageous. Each room may have a special chemist or bacteriologist in charge. The small city hesitates to install a laboratory because of the large expense to which the large city has gone. For the small city such an elaborate equipment is unnecessary, and it has been the policy of the State Water Survey to advocate an installation to fit the needs of each plant. An illustration of this is a little laboratory established at the pumping station of the Champaign & Urbana Water Co.

The water is taken from wells 160 feet deep, and as its sanitary quality is excellent, frequent bacteriological tests are unnecessary. The water, however, contains iron and an iron-removal plant has been constructed, over which it is necessary to exercise continuous control. The laboratory established contains a few collecting bot-

[1]Read before Illinois State Medical Society, Decatur, May 20, 1914; published in Illinois Med. J., December, 1914.

tles, four or five bottles of reagents, a burette, pipettes, and a few flasks. The whole outfit probably did not cost more than $20 and the tests are made by the engineer in charge of the filter plant.

More tests are, however, necessary at filter plants where the raw water is not hygienically pure. In such plants the Survey ordinarily advocates tests for turbidity, color, odor, alkalinity, number of bacteria, and presence of gas-forming bacteria. A list of apparatus needed for such a laboratory has been published,[1] and drawings showing arrangement of the equipment and a simple labora-

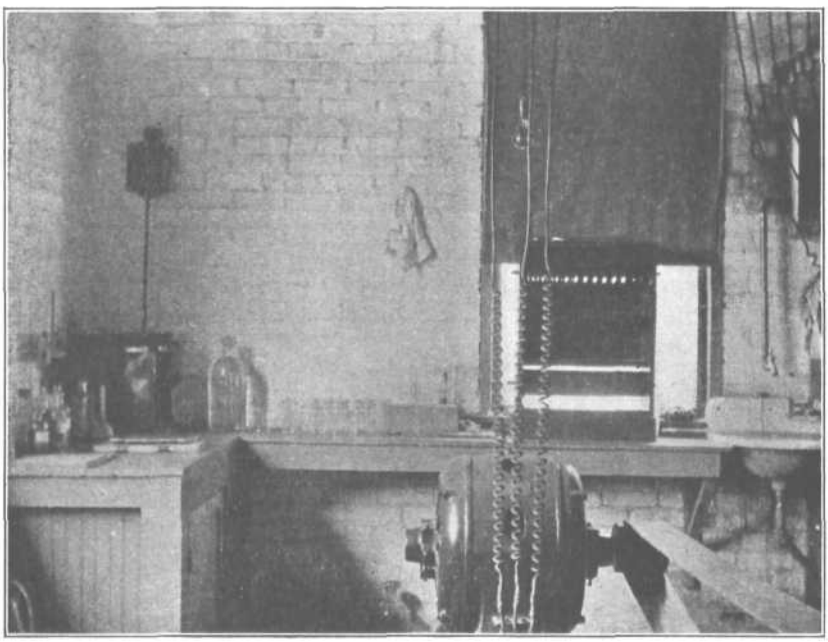


Figure 3.—Control laboratory at waterworks, Champaign & Urbana Water Co., Urbana.

tory table have been prepared. This outfit modified to suit the conditions has been adopted by several waterworks. One of the more recent installations is at Cairo, where regular tests are made.

The laboratory is not all that is necessary. There must be a man to make the tests. At some plants a trained man devotes his whole time to the care of the filters and the analytical work. As this often is considered too great expense the superintendent or engineer of some plants makes the necessary tests. For a small plant an hour a day will be all the time needed. In other places a mod-

[1]Illinois Univ. Bull., Water Survey Series 8, 136-9 (1911).

erate compensation has been paid to professors in educational institutions for making the necessary daily control tests.

The success of the water-control laboratory indicates that similar chemical control can be extended to other municipal departments. Where all the time of one man is not taken entirely by water analysis he can profitably make analyses for the health department, the department of streets, police department, and other departments. At Moline, for example, the city chemist is making analyses of the water before and after fitration, making tests for diphtheria, typhoid, and

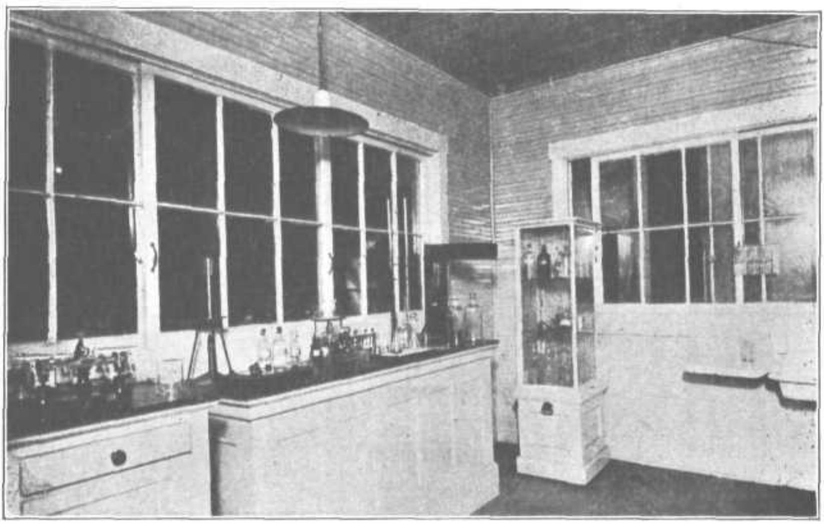


Figure 4.—Control laboratory at waterworks, Cairo Water Co., Cairo.

other organisms for the health department, testing samples of milk, testing limestone, cement, and asphalt used on the streets, making analyses of alcoholic liquors for the police department, testing coal for the power plant, and is otherwise making himself generally useful as the occasion arises.

All cities in the State of approximately the size of Moline can have such a laboratory with a competent man in charge. It is understood that Aurora has already made provision for a laboratory. The argument might be advanced that the smaller towns could not afford to employ a chemist. It is our opinion that they can not afford not to employ one. Sometimes several towns located near each other might unite and support a laboratory, possibly as a county laboratory supported by all the cities and villages in the county. Arrangements have already been made to have the cities of La Salle, Peru, and Oglesby under the control of a competent man, and Dr. *G.* F. Ruediger, formerly of the State Board of Health of North Dakota, has been engaged as sanitary expert.

From the standpoint of the health department all the minor laboratories in the State might be under general advisory control of a central laboratory. Check analyses could be made and general supervision could be exercised. -The State Water Survey already exercises supervisory control over the waterworks laboratories.

The laboratory of applied chemistry at the University of Illinois is testing the coal supplied to the State institutions under the State Board of Administration. A central authority might also be established for the control of analyses of milk, food, and other products. It is certain that an arrangement of this kind will promote economy, efficiency, and health.

APPLICATIONS OF WATER ANALYSIS [1]

By Edward Bartow.

The practical side of any subject appeals to the majority of people so that the question most frequently in the minds of those who are informed that water analyses are being made is, "What is the use of water analysis?" A brief answer to the question would be that a water analysis is made for the purpose of safeguarding health or of saving money. Often the first of these reasons is explained in terms of the second for it is often necessary to appeal to the pockets of the voter in order to obtain sufficient means for safeguarding the health of a community. Because of the two points above mentioned, water analysis naturally divides itself into sanitary water analysis and what may be called commercial water analysis. The members of the laboratory section of the American Public Health Association are familiar with the applications and advantages of a sanitary water analysis. They are also familiar with the analytical data of the so-called mineral waters and with their therapeutic uses. Possibly many of them have not thought of the commercial applications or of the related analytical work which a water analyst may be called upon to perform. A brief statement concerning some of the other work that may be done by the water analyst should be of interest.

The Illinois State Water Survey is authorized by law to make any investigations that will enable the citizens of the State to obtain and maintain an abundant supply of water for domestic or manufacturing uses. It is not under the control of a board of health and is, therefore, called upon to perform analytical work not only to safeguard the health but also to make the so-called commercial analyses.

It is the purpose of the Survey in its sanitary water analysis to make analyses that will enable the citizens of the State to *obtain* and *maintain* both public and private water supplies in a state of purity. While analysis may be made of a water supposed to have caused typhoid fever or other water-borne diseases, the Survey recommends that other possible causes be investigated before the water analysis

[1]Address of acting chairman, laboratory section, Am. Pub. Health Assoc, Colorado Springs, Colo., September, 1913; pub. in Am. J. Pub. Health, 4, 633-7, (1914).

is made. Chemical, bacteriological, and microscopical examinations are made according to regular approved methods, which it seems hardly worth while at this time to discuss in detail.

It is especially the applications of water analysis not directly related to the public health that will be described.

The analyst is often called upon to assist municipal authorities in their choice of a water for their supply. Two or more sources of supply may be available, all of which are either pure or can be readily purified to meet sanitary conditions; then there arises a necessity for the determination of the mineral content. The experience of the city of Belleville, Illinois, is an example of what happens. For years it had used water from deep wells which was soft, though containing a considerable quantity of sodium salts. The supply being inadequate, it was necessary to increase the supply. This was done by drilling wells in the alluvial drift along Mississippi River. The water obtained was much harder and was regarded by the housewives with much disapproval. The character of the mineral content has made it advisable to substitute the softer water of Mississippi River.

The analyst is asked to determine the cause and suggest a remedy for corrosion in boilers and on the outside of water mains. An analysis of the mineral content will usually explain the cause of the corrosion in boilers, and the proper amount of lime or soda ash to neutralize the corrosive ingredients can be readily calculated. A water main near the spoil bank of a coal mine was badly corroded on the outside due to the presence of iron sulphate formed by the oxidation of iron pyrite in the waste from the mine. A protective coating or suitable drainage is a remedy.

The analyst is asked to determine the cause and suggest a remedy for foaming in boilers. This trouble is usually found to be due to an excessive amount of sodium salts. The simplest remedy is either the careful blowing down of the boilers to prevent concentration or modification of the boilers to give ample steam space above the water line.

A common complaint that reaches the analyst is that waters will form a scale in boilers or in hot-water systems or even in the mains. The scale in boilers is due chiefly to the presence of calcium and magnesium, which usually form a soft scale if carbonate is predominant and a hard scale if sulphate is predominant. The best remedy for this difficulty is the construction of a softening plant to remove the calcium and magnesium before the water enters the boilers. When this is not practicable the use of the proper amount of a boiler compound may be recommended.

Scaling in the steam pipes of heating systems has been found to be due to ammonium carbonate. Some waters in Illinois contain large quantities of ammonia and carbonate. These at the high tem, perature of the boiler are dissociated. In the cooler parts of the system they are reunited and cases have been reported where the pipes have been entirely clogged by crystalline ammonium carbonate.

The scaling in water mains may be due to incomplete reaction in treatment of water with lime. The Survey has had brought to its notice a case where a 20-inch pipe has been reduced to a diameter of 8 inches because of this incrustation. It was suggested that the incrustation could be dissolved in acid but the amount of acid required (84 tons) and the difficulties of application rendered this scheme inadvisable. The scale was removed much more economically by taking up portions of the pipe and chipping out the incrustation. To prevent scaling of this kind there should be arrangements for complete reaction of the lime in suitable mixing chambers and large settling basins before the water enters the mains.

Even in Illinois the analyst is sometimes called upon to give an opinion concerning the value of water for use in irrigation. Many available waters, especially those from deep wells, contain sufficient mineral matter to make them unsuitable for irrigation. Complaints have come from florists and gardeners. With proper drainage some highly mineralized waters may be used, but it is the duty of the analyst to determine the conditions under which the water may be used.

One of the most important problems which the analyst is called upon to consider is the removal of iron. An experimental plant was constructed and operated for several months at the University of Illinois. With the water study it was found that simple aeration and filtration would be satisfactory. However, after a plant was constructed and operated continuously it was found that the sand bed clogged very rapidly because an enormous growth of crenothrix throughout the sand bed made it impossible to wash the filter satisfactorily. The use of hypochlorite has been effective in killing the crenothrix so that the filters can be satisfactorily washed. A reduction of the iron from 2 parts per million to less than 0.05 part per million has been effected.

Specimens of service pipes almost entirely clogged with a black powder have been brought to the analyst for examination. These powders have contained considerable proportions of manganese. Examination of the water from the sources from which the supply was obtained has showed small quantities of manganese in the original water. The recommendation in one place where the source of supply was a reservoir fed by springs was the construction of a filter and a softening plant. The recommendation in another place where the amount of manganese in the water ranged from 0.01 to 1.2 parts per million in six wells, was the use, as far as possible, of the water containing the smaller quantities of manganese.

In addition to the work done for the State Board of Health, the Illinois State Water Survey has cooperated with other State departments, for example, with the State Laboratory of Natural History, the State Geological Survey, and the Eivers and Lakes Commission.

Examination of Chicago Drainage Canal and Illinois Eiver to determine their condition as affected by Chicago sewage and to determine the probable effect on fish life was made in cooperation with the State Laboratory of Natural History. The condition of the river as indicated by the small amounts of dissolved oxygen confirmed the observations of the State Laboratory of Natural History that sewage organisms were present in abundance in the upper readies of the river but gradually died out farther down. Fresh-water organisms, both animals and plants, were entirely absent in the upper reaches of the river and began to appear farther down where self purification had taken place. Gases rising from the river were found to resemble in composition the gases from septic tanks and to differ widely from the gases from unpolluted swamps. The sludge in the river bottom shows interesting variations in its content of fat and nitrogenous organic matter.

A study of the relation of the composition of water to the strata has been carried on with the State Geological Survey. Wells in the northern part of the State and entering certain strata furnish water suitable for domestic use. Waters from deep wells to the southward, in strata corresponding to wells farther north, are so highly mineralized that it is impossible to use them for domestic supplies. By analyses of water from different strata the analyst can advise the driller as to the proper arrangement of casing, and he can prophesy from records the composition of water to be expected in new wells.

The Rivers and Lakes Commission of Illinois has power to hear complaints concerning nuisances caused by waste matters emptied into the streams and lakes of the State. Analyses of the water and sanitary surveys of the rivers of the State made by the State Water Survey are used by the Rivers and Lakes Commission.

The State Food Commission has taken up the study of bottled waters.

From time to time various processes of water or sewage treatment are suggested. The examination of such processes by disinterested parties is valuable. Some of these processes have been tested in the laboratories of the Water Survey or have been examined in the field.

We have not yet been able to install an experimental plant for the treatment of sewage, but tests have been made on the local plants at Champaign and Urbana. The plant for the electrolytic treatment of sewage of Oklahoma City was visited by a representative of the Survey with the result that more successful operation must be shown before the Survey will approve the construction of similar plants in Illinois.

An apparatus for sterilization of water by ultraviolet rays is installed in the laboratory and has been used successfully. Water softening with.lime and soda has been carried out on a small scale. A slow sand filter and a rapid mechanical filter are installed in the hydraulics laboratory of the University and are available for special tests or for the use of students. A permutit water-softening apparatus has been purchased and given a thorough test in the laboratory of the Water Survey.

An article on the applications of water analysis would hardly be complete without a brief statement of some of the related work which can be done by an analyst in charge of a waterworks laboratory. At a filter plant he may make analyses of sand to determine its availability for use in filters. From sand analyses the builders of filter plants have been assured that less expensive local sand could be substituted for special sand which must be shipped from a distance.

Practically all waterworks must use coal as a source of power. Analyses of the coal and purchase of it on specifications will result in reduced operating expenses since the dealers may be checked in accordance therewith.

Some water analysts have effected savings by making analyses of oils, others by analyses of the mineral content of the water and the mixing of suitable compounds to soften the water used in the boilers. In filter plants and water-softening plants analyses of the alum, lime, soda, and bleaching powder used enable the operator to obtain a better control of and to increase the efficiency of the plant.

If any conclusions can be drawn from the examples of work of a water analyst enumerated in this paper, the most important are that water analysis has wide applications and that the analyst should have a broad and thorough training in order that he may be competent to study and solve many varied problems.

SOME EUROPEAN WATER-PURIFICATION AND SEWAGE-DISPOSAL PLANTS [1]

By Edward Bartow.

During a trip to Europe in the summer of 1914 some of the results of European practice in water purification, sewage disposal, and laboratory control were observed. No special outline was made for the trip beyond a plan to visit certain prominent men who would know the latest developments along the lines to be investigated. No definite schedule was made as it was planned to visit places off the regular line if visits to them were recommended. After August first, nearly three weeks of a gradually developed schedule had to be abandoned owing to the war. It was impossible to visit the fish ponds used for sewage disposal at Strassburg, to see the water purification by means of ultraviolet rays at Luneville, or to observe special methods of sewage disposal at Frankfort, Cologne, the Essen district, or Ghent. No attempt was made to see any plants in the neighborhood of Paris. In London all permits to visit the reservoirs of the water department had been withdrawn and armed guards watched the reservoirs day and night.

As many of the European water-purification plants and sewage-disposal works have been described by others, only what seems unique will be described here. Owing to the fact that water purification and sewage disposal are so closely related the descriptions are arranged in the order in which the places were visited.

The water supply of Hamburg is taken partly from Elbe River and partly from wells. The waterworks are located on the river above the city but as the Elbe is a tidal stream the sewage-polluted waters of the river at times reach the intake. It is customary, therefore, to pump water into the large settling basins only during ebb tide. Altona, which adjoins Hamburg down the river, obtains its water supply from a point below the sewers of both cities. Reversing the practice of Hamburg, Altona pumps water into its purification works only during flood tide. Elbe River through Hamburg and Altona is, therefore, like a large tank disposing of the sewage which

[1] Read before a special meeting of the Illinois Water-Supply Association, November 11, 1914; pub. in J. Am. W. W. Assoc, 2, 13-24 (1915).

flows into it. The only treatment the sewage of Hamburg receives is screening through revolving screens composed of aluminum bars about one foot long placed a little less than one-half inch apart. The average discharge of the river is 425 second-feet. The dry-weather flow of sewage is 100 to 140 second-feet and the wet-weather flow is 700 second-feet so that there is ample dilution to prevent niusance and to allow the water to be satisfactorily purified for drinking. At the water-purification plant alum is used as a coagulant prior to sedimentation. It is thought that Hamburg has the only purification

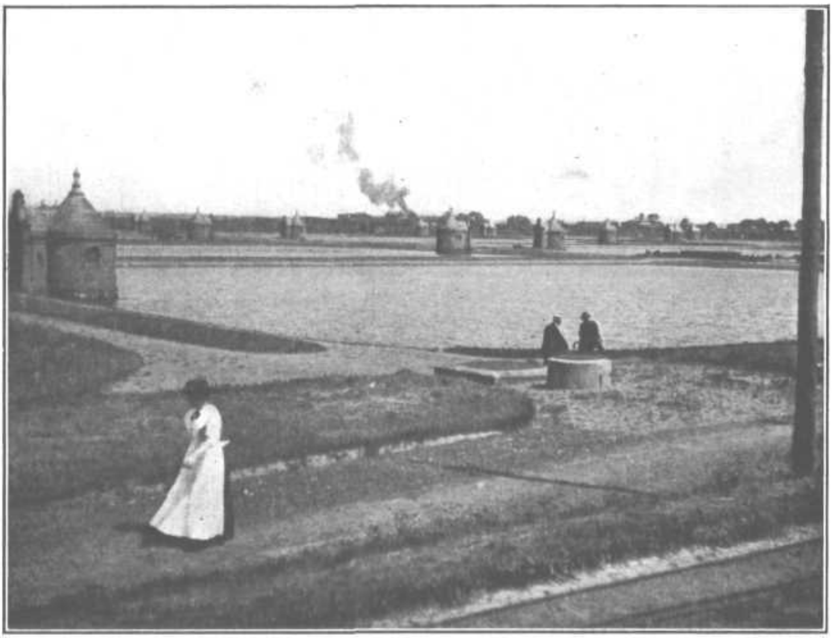


Figure 5.—Slow sand filters, Hamburg, Germany.

plant on the continent where the use of a coagulant is allowed. The water after passing through large sedimentation basins is filtered through uncovered slow sand filters (Fig. 5), which in winter are covered with ice. As there is objection to the use of water from the river the department is endeavoring to develop a ground-water supply. A number of wells have been sunk and considerable water obtained ; but the authorities are handicapped by the fact that there is not sufficient area in Hamburg for proper development of ground waters. Hamburg is unable to extend its well system into Prussia and for the disposal of its sewage has purchased from Prussia an island in the lower Elbe. The situation is similar to one in this country where Greater New York can not go outside of the State of New York to Connecticut or New Jersey for its water supply. The ground water obtained by Hamburg contains so much iron that iron-removal plants have been constructed.

Though the sewage from the city of Hamburg itself is easily disposed of by the dilution method several of the smaller cities under the direction of the Hamburg authorities are located so far

Figure 6.—Fish pond and laboratory of the sewage-disposal works, Bergedorf, Germany. Photograph by Dr. Keim.

from the river that another method of purification is necessary. At Bergedorf, a city of 15,000 inhabitants about ten miles from Hamburg, no water is available for sewage dilution, and purification is accomplished by Imhoff tanks and sprinkling filters followed by fish ponds.[1] This is a modification of a system of purification introduced at Strassburg under the direction of Professor Hofer of Munich,[2] where satisfactory results with a dilution of 2 to 3 parts of pure water are claimed. At Bergedorf with no dilution it has been possible to purify satisfactorily the effluent from the sprinkling filters. The purification is accomplished with the assistance of water plants (Fig. 6) which apparently remove the toxic properties of

[1]K. Allen, Municipal Engineering, 47, 197-201.
[2]Hofer, Fischerei Zeitung, 16, 148.

sewage and make the water suitable for fish culture. Fish placed in the ponds in spring grow rapidly during summer. The flesh is good, especially if the fish are transferred to pure water one or two weeks before they are eaten.

The laboratory for water hygiene at Bcrlin-Dahlem was of special interest. The royal research and testing station for water and sewage purification was established in 1901. The growth of the or-organization has been changed to "Landesanstalt fur Wasser-hy-

Figure 7.—Laboratory for water hygiene, Berlin-Dahlem, Germany.

was constructed at the end of 12 years. (Fig. 7). The name of the organization has been changed to "Landesanstalt fur Wasser-hygiene."[3] This laboratory has control of the water supplies and sewage disposal in the province of Prussia. It also does commercial work for other German provinces and for foreign countries. Work of investigation is often done in cooperation with officers in cities and villages, and joint articles arc frequently published by members of the staff and by city officials. At present the staff numbers 40. The scientific publications from the laboratory are of great value; the library in the new building will accommodate 30,000 volumes. In July, 1914, 101 journals were regularly received. An attempt was being made to have available for the use of the laboratory staff all literature in

[3]Mitteilungen aus der Koniglichen Landesanstalt fur Wasser-hygiene, 17.

all languages concerning water. Instruction is given to waterworks men in methods of water supply and sewage disposal during April and October. Regular lectures are given and the men are taken on trips to interesting plants in the neighborhood of Berlin. Professor Dr. Thum of the laboratory very kindly outlined several trips which were most advantageous to me during the limited time at my disposal.

The water supply of Berlin is obtained partly from lakes and partly from wells. In Berlin as in Hamburg there is a prejudice

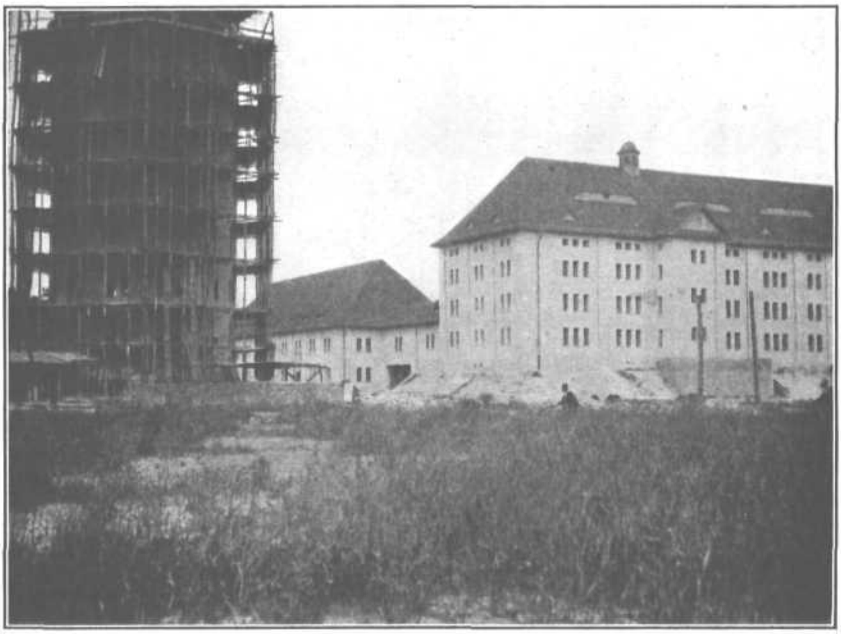


Figure 8.—Iron-removal plant, Berlin waterworks, Wühlheide, Germany,

against water from surface sources and the authorities arc endeavoring to replace the lake supplies by ground-water supplies. At Mugglesee about one-third of the slow sand filters originally used to filter lake water have been given over to the removal of iron from groundwater supplies obtained from wells near the lake. The water is pumped from the wells to elevated distributors from which it trickles over many series of wooden gratings, during which process the iron becomes completely oxidized.

A new plant at Wiihlheide obtains ground water from 80 driven wells. It had been in operation only five days at the time of my visit.

The water from the wells is pumped to the upper part of a high building (Fig. 8) and is sprayed through special nozzles over beds of coarse gravel. After the water has thus been thoroughly aerated and the iron oxidized it is passed through pressure filters. (Fig. 9). The plant had been in operation only a few days, but the results of the experiments on which the designs of the plant were based indicate that good results in iron removal will be obtained.

The Prussian authorities are very particular to protect the streams from pollution by sewage. This is especially necessary because of the small flow and the sluggish character of the streams. Berlin -proper owns 43,000 acres of irrigation fields to 21,000 acres of which sewage is pumped. The sewage from twelve districts of Berlin is pumped to various sewage fields. The fields at Gross Beeren are the largest and are typical of all the fields. The sewage passes through a pressure pipe line. An indicator tower shows the rate of flow. The heavy material is removed in open tanks, from which the effluent flows by gravity through open channels to the fields. The land is rented to peasants, who are willing to pay twice as much for land inside these irrigation fields as for land outside. Several crops are harvested each year on some of the fields. The vegetables raised were especially noteworthy, most of the vegetables used in Berlin being obtained from the sewage farms. One other noteworthy crop, Italian rye grass, may be harvested six times during the season. It grows to the height of 40 inches in a month. It is rumored that Berlin is giving up sewage irrigation, but Berlin proper is not doing so. The suburbs have, however, found it necessary to adopt biological processes of purification because of lack of suitable land for irrigation fields.

Tanks or sprinkling filters are in use at Wilmersdorf, one of the larger suburbs, and in other parts of greater Berlin.

Attention has been especially called to the Eeinsch screens[1] used at Eberswalde. These are revolving screens having numerous holes about 1-16 inch by ½ inch. The screens are cleaned by revolving brushes. The sludge is sold to farmers, who allow it to ripen for use as fertilizer. Very complete purification is obtained at Eberswalde. The sewage after screening is passed into septic tanks and through sprinkling filters with a unique system of distribution. (Fig. 10). The sewage passes along the side of filter beds to a trough, from which it is siphoned into a travelling cylindrical distributor containing numerous buckets. When these buckets are full the weight of the

[1]Engineering and Contracting, 42, 273-6.

contents causes the traveller to move. A check at the end of the bed reverses the flow and the direction of the traveller. The sewage then passes through contact beds, the effluent from which is discharged into a canal.

At Copenick, another Berlin suburb, the sewage is mixed with finely ground lignite or brown coal and a small amount of alum to serve as a coagulant. Complete mixing is obtained by means of perforated baffles, (Fig. 11), which are more efficient than solid baffles. The mixture of sewage and lignite passes to large sedimentation

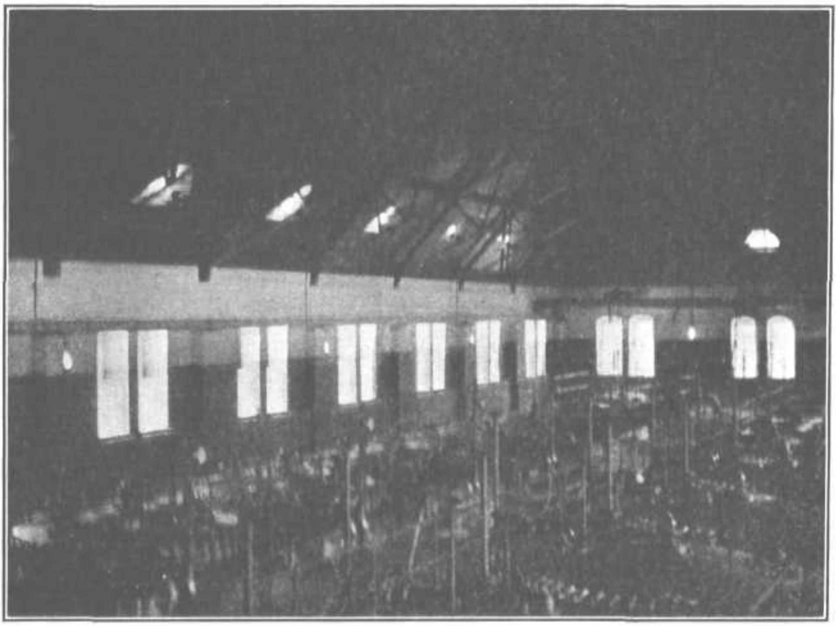


Figure 9.—Pressure filters of iron-removal plant, Berlin waterworks, Wiihelheidc, Germany.

basins. Much of the suspended matter settles near the inlet. Very little baffling is needed and an effluent satisfactory to the government authorities is obtained. Three sedimentation basins are provided. While one is in use as a sedimentation basin, the sludge is being dried in the second, and the dried sludge is being removed from the third. The dried sludge is burned for fuel; it is used pure under the low-pressure boilers and is mixed with one or two parts of coal under the high-pressure boilers which supply power to the electric light plant of the city. It is stated that more satisfactory drying of the sludge takes place when it is piled to a height of several feet than when it is spread out in a thin sheet, probably because of the pressure exerted on the lower porous layers.

The water supply of Dresden is obtained from wells, and serious difficulties have been experienced because of its content of manganese. Service pipes become filled with a black precipitate and the water can not always be used in laundries. Two manganese-removal plants are in operation. One consists of gravity filters built in the original reservoir. The water passes through coarse sand on which manganese-removing algae have developed. These filters are washed by reversing the current and are probably the nearest approach to the mechanical gravity filters used in the United States. The second plant consists of pressure filters. Half of them are filled with manganese permutit and half with gravel on which a manganese-removing organism has been allowed to develop. Both processes are satisfactory, but owing to the economy of the sand and the manganese-removing organism this process seems better than the manganese permutit. A satisfactory account of the experiments performed at Dresden is given by Tillmans.[1]

Reinsch screens have been recently adopted at Dresden for sewage treatment.[2] The dry-weather flow is taken care of by one screen. The storm water sometimes requires four to be put into operation. Without further treatment the sewage is allowed to flow into the Elbe. There is sufficient diluting water to render the sewage innocuous.

Photographs of a sewage-disposal plant at Coethen could not be obtained for the plant was visited during a heavy rainstorm when photography was out of the question. This plant has been designed by Baumeister Benzel with Dr. Dunbar of the Hamburg Hygienic Laboratory as consultant. Ninety-two per cent of the suspended matter is removed by settling, and the sludge is withdrawn before it has time to putrefy. In the bottom of the settling tank are 16 transverse divisions with sloping sides that terminate below in troughs into which the sediment settles. When the sediment is to be removed a sliding door separates the trough from the upper part of the tank. The opening of a gate on the side of the tank allows the greater part of the sludge to flow out, and the balance is scraped out with a hoe. The gate is closed, the trough is filled with water, and the sliding door is opened without any disturbance of the supernatant liquid. The effluent from the tank flows into sprinkling filters which are well

[1]Journal fur Gasbeleuchtung und Wasserversorgung, 57, 713-24.
[2]Datesman, G. E., J. Am. W. W. Assoc, 1, 359-83 (1914).

constructed with an outside concrete retaining wall of special design. In the center is a specially designed piece of concrete so arranged that the underdrains can be flushed out with a hose whenever desired. Growths of green algae in the effluent drains indicate very satisfactory purification. As the plant is new, takes care of both sanitary sewage and storm water, and comparatively few sanitary connections have been made, it should receive a more extended trial before the design is unreservedly recommended.

At Magdeburg the Puech-Chabal filters of the Madgeburg water system were visited. Madgeburg has the only large plant of this

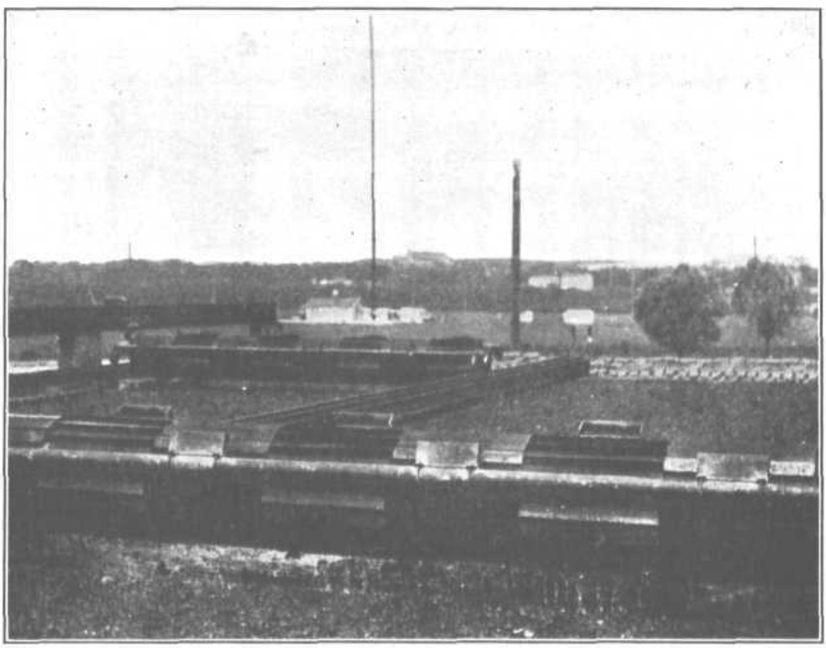


Figure 10.—Sewage distributors of sprinkling filters, Eberswalde, Germany.

kind. The authorities are apparently satisfied with it for they are doubling its size. At Madgeburg they use not only the prefilters but also the so-called rapid filters and final sand filters. It may be necessary to take such precautions with the water from the Elbe, but the installation is certainly very expensive and the cost of filtration must be high. A very good description of these filters has been written by Clemenee.[1]

[1]Clemence, **Walter, The treatment of water antecedent to filtration: Engineering, 89,** 117.

The sewage of Munich is allowed to flow into the swift-flowing Isar River without any purification whatever, because the water below the city is not used for drinking purposes and is too cold for bathing. The engineer stated that all traces of sewage disappeared within 60 miles. Owing to the outbreak of war, Munich was the last German city visited.

The cities visited in Germany furnish a good series of illustrations of sewage-disposal methods from straight dilution up to the most thorough treatment.

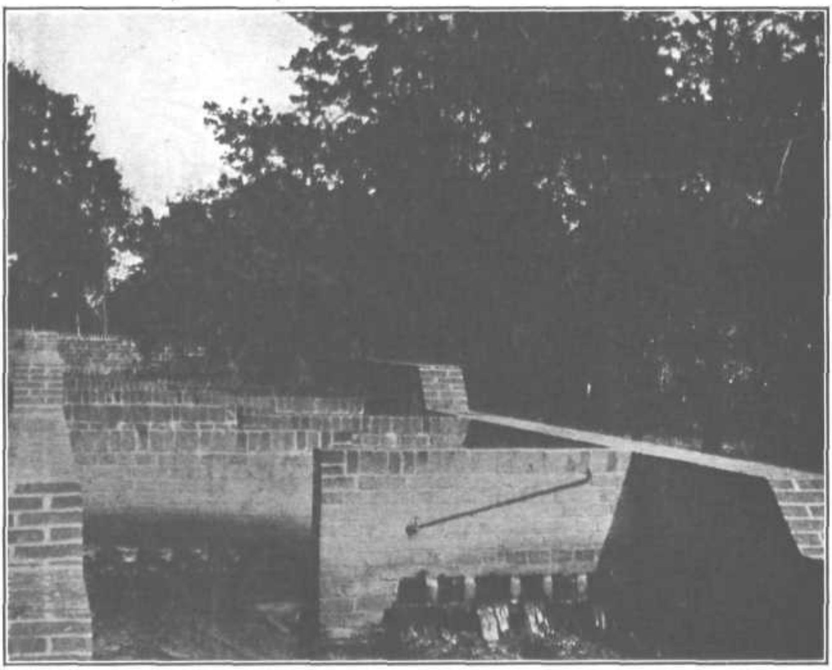


Figure 11.—Perforated baffle, Copenick, Germany.

An interesting plant visited in England was the water-softening plant of the Woolcombers Ltd., at Bradford, where 50,000 gallons a day of water having a hardness equivalent to 30 grains per gallon (425 parts per million) were softened to zero by lime, soda, and permutit. Permutit alone was not satisfactory and the combined soda ash, lime, permutit plant was installed. The water is first treated with lime and soda, passed through a settling tank, and over calcium permutit to remove the suspended matter and excess alkalinity. A permutit filter gives the final product of zero hardness. The process is said by the chemist and superintendent to be very satisfactory. The saving effected is two pounds of soap per grain per gallon per 1,000 gallons, or a saving of 60 pounds of soap per 1,000 gallons of water consumed.

The largest and probably the only municipal premutit water-softening plant is located at Hooten near Liverpool. This plant was built to furnish water guaranteed to have less than 10 grains per gallon of hardness. The original water contains about 30 grains per gallon. Two-thirds of the water is reduced to a hardness of zero and is then mixed with one-third its volume of the original water. Owing to lack of time I did not see the plant but in an interview with Mr. P. H. Bettle, the superintendent, I was informed that the process was satisfactory and that if it were necessary to enlarge the plant the same process would be used.

An interesting feature in sewage purification, aeration, was brought to my attention at Manchester. The preliminary experiments have been described in the 1914 annual report of the Rivers Department of the Corporation of Manchester.[1] This process consists in blowing compressed air through sewage until what is known as activated sludge is developed. This sludge added to sewage and stirred by air has the property of purifying the sewage very rapidly. For example, with a tank containing 1,300 cu. ft. of liquid in which are 300 cu. ft. of activated sludge, 1,000 cu. ft. of sewage can be treated every six hours, or 4,000 cu. ft. of sewage a day. This allows four hours for treatment and two hours for settling, emptying, and filling. It is claimed that by this process a sewage effluent can be obtained which is in better condition than an effluent which has passed through Imhoff tanks and sprinkling filters. If the claims of the process are borne out by further experience it is expected that considerable sums will be saved in the construction of sewage-purification works. Professor Fowler, under whose direction the experiments have been carried out, has consented to serve as advisor for carrying on experiments in the laboratory of the Water Survey. Later his services would be available as consultant for the construction of plants on a larger scale.

[1]Adern and Lockett, J. Soc. Chem. Ind., S3, 523-39.

EXAMINATION OF DRINKING WATER ON RAILWAY TRAINS[1]

By Edward Bartow.

In order to determine the character of water furnished to the passengers on railway trains, 102 samples from water containers on trains have been collected and analyzed by members of the staff of the Illinois State Water Survey. Although the number of samples examined is small, the information obtained concerning the actual condition of the waters should be valuable in formulating practical standards. The samples were taken from trains at Champaign, Urbana, Kankakee, and Chicago. It was thus possible to procure samples from cars coming from Boston, New York, and other points in the East, Jacksonville, New Orleans, and Galveston in the South, San Francisco, Los Angeles, and Denver in the West, and from Minneapolis, Duluth, and Sault St. Marie in the North. The water is usually a mixture from several sources. It was impossible to learn the points from which all the water had been taken, but with five exceptions the table indicates the points at which the tanks were last filled.

Of the 102 samples, 28 of the tanks were said to have been last filled at Chicago, 9 at Peoria, 8 at Centralia, 6 at Detroit, 5 at Cincinnati, 4 at Indianapolis, 3 at Kansas City, Missouri; 2 each at Memphis, Tennessee; Salamanca, New York; and New York City; 1 each at Boston, Massachusetts; Buffalo, New York; Champaign, Illinois; Dubuque, Iowa; Effingham, Illinois; Forrest, Illinois; Ft. Madison, Iowa; Ft. Wayne, Indiana; Grand Rapids, Michigan; Havana, Illinois; Lincoln, Nebraska; Mason City, Iowa; Mattoon, Illinois; Minneapolis, Minnesota; Montreal, Province of Quebec; Nashville, Tennessee; Parsons, Kansas; Pittsburgh, Pennsylvania; St. Louis, Missouri; St. Paul, Minnesota; Sioux City, Iowa; South Bend, Indiana; Springfield, Illinois; 4 were bottled water from Hammond, Louisiana, and 1 bottled from Waukesha, Wisconsin, and unknown 5. The majority of samples, 57, were taken from coaches, 19 from sleepers, 8 from dining cars, 7 from smoking cars, 6 from parlor cars, 2 from tourist sleepers, and of 3 there was no record.

The analyses include both bacteriological and chemical examina-

[1]Published in J. Am. W. W. Assoc., 2, 74-82 (1915).

tions and an attempt has been made to make them as complete as possible when using 120-cc. samples for the bacterial examination and one-liter samples for the chemical tests.

METHODS OF ANALYSIS

The determinations of turbidity, color, odor, residue, chlorine, and iron were made in accordance with prescribed methods,[1] except that the residues were dried at 180° C. one hour instead of at 103° C. one-half hour. All analyses made after May 1, 1914, include confirmations of *B. coli* made in accordance with the methods adopted by the Treasury Department for testing drinking water supplied to the public by common carriers in interstate commerce.[2] Certain special chemical procedures are outlined in the following paragraphs.

Magnesium. Neutralize 100 cc of the sample with N/50 sulphuric acid in presence of methyl orange indicator. Boil to expel carbon dioxide. . Add 25 cc. of a saturated solution of lime water. Dilute to exactly 200 cc. with boiled distilled water. Cool and filter through a dry filter paper, rejecting the first 25 cc., and titrate 50 cc. with N/50 sulphuric acid in presence of methyl orange indicator. Make a parallel determination with 100 cc. of pure distilled water. The number of cubic centimeters of N/50 acid required for the distilled water, minus the number of cubic centimeters of N/50 acid required for the second titration of the sample, multiplied by 9.7 equals parts per million of magnesium (Mg).

Alkalinity. Titrate 100 cc. of the sample in a 200-cc. flask with N/50 sulphuric acid first in presence of phenolphthalein and then in presence of methyl orange indicator. The number of cubic centimeters of N/50 acid required times 10 equals parts per million of alkalinity in terms of $CaCO_3$.

Hardness. To the 100 cc. neutralized in determining alkalinity, add 10 cc. of soda reagent (a mixture of equal parts of approximately N/10 sodium hydroxide and N/10 sodium carbonate). Boil 15 minutes. Dilute with distilled water to exactly 200 cc. Boil 15 minutes. Allow, to filter through dry filter paper, rejecting the first 25 cc, and titrate 50 cc. of the filtrate with N/50 sulphuric acid in presence of methyl orange indicator. Make a parallel determination with 100 cc. of distilled water. The number of cubic centimeters of N/50 acid used for

[1] Standard methods for the examination of water and sewage, Am. Public Health Assoc, Boston, 1912.

[2] Bacteriological standards for drinking water: U. S. Public Health Service, Pub. Health Repts., 29, 2959-66. (1914).

the distilled water, minus the number of cubic centimeters of N/50 acid used for the sample, multiplied by 40 equals parts per million of hardness as $CaCO_3$. If the alkalinity exceeds the hardness the presence of an excess of carbonate or bicarbonate over calcium and magnesium is indicated, and sodium carbonate would be calculated if hypothetical combinations were made.

Lead and copper. To 100 cc. of the sample, add 2 grams pure crystals of ammonium chloride, 2 cc. acetic acid, and 2 or 3 drops of 10 per cent sodium sulphide. Compare immediately with standards containing amounts of lead nitrate equivalent to 0.01, 0.02, 0.03 mg. of Pb. This test determines the heavy metals as a group and does not differentiate lead from copper.

Sulphate. Acidify 100 cc. of the sample with hydrochloric acid. Heat to boiling and unless silica, iron, or aluminum is known to be present in excessive amount, add barium chloride, and determine sulphate gravimetrically.

Number of bacteria per cubic centimeter. The total number of bacteria developing on gelatin incubated 48 hours at 20° C.[1] Total number of bacteria developing on standard agar plates incubated for 24 hours at 37° C.[2]

DIFFERENCES IK MINERAL CONTENT

Ninety-nine samples were examined for turbidity. Of these 70 showed a turbidity less than 5 parts per million; 82 less than 10; 89 less than 15; and only 10 showed turbidity of 15 or greater. A turbidity less than 10 would not make the water appear unattractive and it would seem not unreasonable to require a standard of 10 or less.

Ninety-nine samples were examined for color. Seventy-nine of the samples had a color less than 5 parts per million; 88 less than 10; 93 less than 20; and only 6 had a color of 20 or more. A color requirement of 20 or less should be easy to meet and it would not be impossible to meet a requirement of 10 or less.

Ninety-nine samples were examined for residue. Of these 28 had a residue less than 50 parts per million; 36 less than 100; 75 less than 200; 84 less than 300; 90 less than 400; 95 less than 500; and only 4 more than 500. The very low residues are undoubtedly due to the presence of melted ice in the coolers. The few samples containing more than 400 parts per million would indicate that a standard of 500 or less could easily be made.

[1]Standard methods of water analysis: J. Infect. Diseases, supp. 1, p. 81, May, 1905.
[2]Pub. Health Repts. 29. 2960, (1914).

TABLE 8.—ANALYSES OF WATER FROM RAILWAY TRAINS.

Sample No.	Date of collection.	Collector[a]	City.	Railroad.	Train No.	Car.	Tank filled at—	Turbidity.	Color.	Odor.	Residue.	Chlorine.	Alkalinity.	Iron.	Bacterial count. Gelatin.	Bacterial count. Agar.	B. coli in lactose broth special 10 cc.
	1913																
1	Dec. 29	H.	Champaign.	I. C.	2	Diner	Hammond, La.	[b] 2	0	0	182	3	96	0.3	30,000	8,000	5–
2	"	H.	"	I. C.	2	Coach 28	Memphis	0	0	0	19	0	12	.0	280	14	5–
3	"	H.	"	I. C.	2	Coach 8127	Centralia	1	0	0	344	23	92	.0	187	5	3– 2+
4	Dec. 30	H.	"	I. T. S.	.....	Coach	....	1	0	0	18	0	10	.0	125	18	5–
5	"	H.	"	Big Four	16	Coach 644	Peoria	3	0	0	80	27	20	.0	.....	13	3– 2+
6	"	H.	"	Wabash	86	Smoker	Champaign	8	20	0	426	0	356	.6	10,000	1,500	5–
7	Dec. 31	H.	"	I. C.	1	Diner	Hammond, La.	[b] 2	0	0	191	4	96	.2	15,000	10,000	1– 4+
8	"	H.	"	I. C.	1	Sleeper	Chicago	15	20	0	147	1	94	.4	1,500	510	2– 3+
9	"	H.	"	I. C.	1	Coach 2109	"	10	5	0	159	3	96	.0	54	23	5–
	1914																
10	Jan. 5	T.	"	I. C.	1	Diner	Hammond, La.	[b] 2	0	0	205	10	100	.3	1	4	5–
11	"	T.	"	I. C.	1	Coach	Chicago	5	0	0	357	50	76	.0	600	61	2– 3+
12	"	T.	"	I. C.	1	"	"	20	5	0	170	3	108	.1	90	36	2– 3+
13	"	T.	"	I. C.	24	Smoker	Centralia	3	0	0	148	32	28	.0	20	15	4– 1+
14	"	T.	"	I. C.	24	Coach	"	0	0	0	42	2	26	.0	160	75	5–
15	"	T.	"	I. C.	24	"	Effingham	0	0	0	150	12	84	.0	61	24	5–
16	"	H.	Kankakee	C. I. & S.	.....	"	South Bend, Ind.	0	0	0	331	10	216	.0	140	30	5–
17	Jan. 7	T.	Champaign	Big Four	16	"	Peoria	7	3	0	526	22	268	.5	36	14	5–
18	"	T.	"	Big Four	16	"	"	7	0	0	524	2	260	.0	52	19	4– 1+
19	Jan. 12	M.	Chicago	I. C.	18	Buffet	Springfield	5	5	0	43	8	8	.0	60	13	5–
20	"	M.	"	I. C.	18	Sleeper	Parsons, Kan.	0	0	0	29	3	12	.0	140	200	5–
21	"	M.	"	Big Four	31	Parlor car	Cincinnati, O.	5	0	0	25	2	10	.05	10,000	2,500	5+
22	"	M.	"	Big Four	31	Sleeper	"	0	0	0	163	6	36	.0	300	220	5–
23	"	M.	"	Big Four	43	Coach	"	2	0	0	102	9	24	.05	50	10	4– 1+
24	"	M.	"	Big Four	43	Sleeper	"	12	0	0	91	15	36	.0	400	54	4– 1+
25	"	M.	"	Soo	2	Diner	Waukesha, Wis.	[b]	....	....	....	....	....	....	3,500	300	5–
26	Jan. 19	S.	Chicago	C. & E. I.	21	Car 492	....	3	0	0	161	24	62	.1	1,100	69	2– 3+
27	"	S.	"	Santa Fe	9	Tourist	Chicago	.....	....	....	....	....	....	....	790	40	4– 1+
28	"	S.	"	Santa Fe	9	Diner	"	2	0	0	458	16	278	.2	18	3	5–
29	"	S.	"	Santa Fe	6	Smoker	Ft. Madison	5	0	0	95	4	38	.0	6,000	46	5–

30	"	S.	"	C. & E. I.	9	Car 432	Chicago	20	5	0	125	4	86	.2	1,000	130	3- 2+
31	"	S.	"	C. & E. I.	6	Car 976	Nashville, Tenn.	0	0	0	85	4	46	.0	50,000	6	5-
32	"	S.	"	Erie	47	Sleeper	Salamanca, N. Y.	20	5	0	114	4	78	.6	500	24	4- 1+
33	"	S.	"	Erie	47	Car 1037	" "	2	10	0	37	4	14	.1	23	4	5-
34	"	S.	"	Wabash	50	Car 1082	Forest, Ill.	25	35	0	48	4	16	1.9	5,000	20	5-
35	"	S.	"	Wabash	7	Sleeper	Montreal	20	20	0	123	6	76	.0	710	100	5-

[a]Collections have been made by W. W. Hanford (H), F. W. Tanner (T), P. W. Mohlman (M), and C. H. Spaulding (S).
[b]Bottled water.

TABLE 8.—ANALYSES OF WATER FROM RAILWAY TRAINS (continued).

Sample No.	Date of collection.	Collector.[a]	City.[b]	Railroad.	Train No.	Car.[c]	Tank filled at	Turbidity.	Color.	Odor.	Residue.	Chlorine.	Magnesium.	Alkalinity as $CaCO_3$.	Hardness, $CaCO_3$	Sulphate.	Iron.	Copper and lead.	Bacterial count. Gelatin	Bacterial count. Agar	B. coli. Gas formation. 10 cc. L. B.	B. coli. Gas formation. 10 cc. Conf.
	1914																					
36	May 6	M.	Chi.	M. C.	7	S	Grand Rapids	10	5	0	170	5	8.6	[d]72	112	35	0.0	.0	300	200	5−	5−
37	"	M.	"	M. C.	7	S	Detroit	8	10	0	118	7	4.8	54	48	14	.2	.1	9	10	3− 2+	3− 2+
38	"	M.	"	Big Four	31	S	Cincinnati	2	0	0	28	0	.0	7	8	.0	.4	.05	850	600	5−	5−
39	"	M.	"	I. C.	10	S	Memphis	5	0	0	113	4	4.8	76	72	4.9	.0	10	700	1,000	2− 3+	5−
40	"	M.	"	I. C.	12	S	Sioux City	15	5	0	298	6	18	188	196	35	.2	.05	50,000	125	4− 1+	5−
41	"	M.	"	Big Four	3	D	Buffalo	10	10	0	165	4	3.8	100	88	12	.15	.0	950	35	1− 4+	1− 4+
42	"	M.	"	I. C.	30	S	St. Paul	0	0	0	81	0	.0	5	4	.0	.1	.0	10,000	1,800	5−	5−
43	"	M.	"	M. C.	13	S	Detroit	2	3	0	27	0	.0	10	4	.0	.4	.0	400	200	3− 2+	3− 2+
44	"	M.	"	M. C.	13	T	Boston	2	0	0	20	0	.0	5	8	.0	.5	.0	80	5	5−	5−
45	"	M.	"	I. C.	28	P	Dubuque	2	0	0	123	5	9.6	86	76	8.6	.1	.0	550	375	5−	5−
46	"	T.	Cha.	I. C.	1	C	Chicago	5	0	0	44	1	1.9	20	12	.0	.05	.0	850	320	5+	2− 3+
47	May 13	T.	"	I. C.	24	C	Centralia	2	0	0	31	0	1.0	.8	4	.0	.0	.0	20	14	5−	5−
48	"	T.	"	I. C.	24	C	"	2	0	0	48	1	2.9	20	12	3.7	.0	.0	35	20	5−	5−
49	"	T.	"	I. C.	1	C	Chicago	3	0	0	32	0	4.8	14	8	.0	.05	.1	1,350	900	1− 4+	1− 4+
50	"	T.	"	I. C.	1	C	"	3	0	0	130	1	5.8	34	32	44	.0	.0	10	4	3− 2+	3− 2+
51	"	T.	"	I. C.	24	C	Centralia	2	0	0	38	0	1.0	14	12	3.3	.0	.0	80	10	5−	5−
52	May 18	T.	"	Big Four	16	C	....	2	0	0	85	19	.0	50	32	.0	.2	.0	10,000	3,000	3− 2+	3− 2+
53	"	T.	"	Big Four	16	C	....	3	0	0	55	3	8.8	16	24	trace	.0	.1	27,000	3,000	5−	5−
54	"	T.	"	Big Four	16	Sm.	Peoria	10	0	0	330	30	21.6	170	244	55	.15	.2	500	800	5+	5+
55	"	T.	"	Big Four	16	C	"	10	0	0	260	20	15.4	136	176	45	.15	.0	......	1,200	5+	1− 4+
56	May 24	T.	"	I. C.	1	C	Chicago	2	0	0	60	2	6.7	38	28	trace	.0	.0	860	500	5−	5−
57	"	T.	"	I. C.	23	C	"	....	....	....	....	....	....	....	....	....	....	.....	90	25	5−	5−
58	"	T.	"	I. C.	1	C	"	1	0	0	48	2	2.9	20	16	trace	.0	.0	850	400	5−	5−
59	"	T.	"	I. C.	23	C	"	1	0	0	118	2	7.7	62	28	21	.0	.0	75	25	5−	5−
60	May 28	T.	"	I. C.	1	C	"	2	0	0	110	12	6.7	36	48	79	.0	.0	1,200	350	5−	5−
61	"	T.	"	I. C.	23	Sm	"	2	0	0	34	3	2.9	14	12	28	.0	.0	30	3	5−	5−
62	"	T.	"	I. C.	1	C	"	2	0	0	570	42	22	139	260	256	.1	.1	4,000	130	4− 1+	4− 1+
63	"	T.	"	I. C.	23	C	"	2	0	0	163	5	15	103	140	49	.15	.0	20,000	210	4− 1+	4− 1+
64	June 1	T.	"	Big Four	9	C	Indianapolis	20	5	0	502	24	29	280	420	130	.5	.3	600	350	4− 1+	4− 1+
65	"	T.	"	Big Four	9	C	Peoria	2	0	0	253	14	15	143	224	69	.25	.0	6,000	1,800	5−	5−
66	"	T.	"	Big Four	9	C	Indianapolis	2	0	0	467	25	26	263	424	124	.4	.1	180	90	1− 4+	1− 4+
67	"	T.	"	Big Four	16	C	Peoria	2	0	0	202	23	15	95	128	40	.2	.0	160	20	5−	5−

[a]Collections were made by F. W. Mohlman (M), F. W. Tanner (T), A. N. Bennett (B), H. P. Corson (C), W. W. Hanford (H).
[c]S, sleeper; D, diner; T, tourist; P, parlor; C, coach; Sm, smoker. [d]Alkalinity in presence of phenolphthalein, 4.0 parts.
[b]Chi. = Chicago; Cha. = Champaign.

	1914																					
68	June 10	T.	Cha.	Big Four	16	C	Peoria	0	0	0	286	38	12	130	120	43	.0	.0	12,000	8,000	5+	5+
69	"	T.	"	Big Four	9	C	Indianapolis	0	20	0	441	21	4.8	248	220	88	.8	.0	20,000	11,000	5+	5+
70	"	T.	"	Big Four	16	C	Peoria	0	0	0	219	11	3.8	112	104	48	.1	.0	25,000	15,000	4− 1+	4− 1+
71	"	T.	"	Big Four	9	C	Indianapolis	0	5	0	369	20	17	234	200	76	.1	.0	30,000	10,000	5+	5+
72	June 11	T.	"	I. C.	622	C	Havana	0	3	0	25	3	5.8	10	44	6.2	1.4	.0	160	40	5−	5−
73	"	T.	"	I. C.	1	C	Chicago	0	0	0	173	3	2.9	93	44	14	.1	.0	1,350	800	5+	1− 4+
74	"	T.	"	I. C.	1	C	"	0	0	0	127	2	2.9	94	36	8.2	.0	.0	1,800	1,000	5+	5+
75	June 19	B	Chi.	C. B. & Q.	2	C	Lincoln, Ill.	2	0	0	293	18	12	162	112	57	.4	.0	7,000	2,250	3− 2+	3− 2+
76	"	B.	"	C. B. & Q.	58	S	Minneapolis	2	0	0	146	3	6.7	45	36	31	.6	.0	30	3,600	5−	5−
77	"	B.	"	Penn.	15	C	Ft. Wayne	0	0	0	162	16	2.9	26	56	65	.6	.0	15	1,850	5+	5+
78	"	B.	"	C. & A.	10	Sm	Kansas City	30	15	3m	268	12	4.8	88	104	84	.0	.0	80,000	80,000	5+	5+
79	"	B.	"	(e)	2	C	Mason City	0	0	0	170	17	11	66	92	40	.0	.0	5,500	1,500	3− 2+	3− 2+
80	June 18	B.[1]	"	C. & A.	8	C	St. Louis	0	0	0	169	2	12	116	116	none	.0	.0	10,000	180	5+	1+ 4−
81	June 19	B.	"	Penn.	25	S	Pittsburgh	0	0	0	145	4	12	116	96	none	.0	.0	220	35	3− 2+	5−
82	"	B.	"	C. B. & Q.	56	S	Kansas City	0	0	0	185	7	12	64	76	69	.0	.0	340	450	3− 2+	3− 2+
83	"	B.	"	(e)	12	S	"	5	0	0	142	6	5.8	50	48	43	.0	.0	900	2,250	3− 2+	3− 2+
84	"	B.	"	Penn.	....	P	Chicago	10	0	0	158	5	9.6	114	76	21	.0	.0	10,000	5,400	3− 2+	3− 2+
85	June 25	C	"	M. C.	17	S	Detroit	2	0	0	128	4	11	64	48	trace	.0	.0	1,350	230	5−	5−
86	"	C.	"	M. C.	17	S	"	2	0	0	23	10	6.7	18	8	trace	.0	.0	2,900	1,260	5−	5−
87	"	C.	"	M. C.	17	P	"	2	0	0	58	3	11	36	32	trace	.0	.0	5,000	510	3− 2+	5−
88	"	C.	"	M. C.	13	C	"	2	0	0	166	25	18	96	48	trace	.0	.0	9,000	520	5−	5−
89	"	C.	"	M. C.	13	S	New York	2	0	0	48	3	5.8	22	8	trace	.0	.0	1,560	640	3− 2+	4− 1+
90	"	C.	"	M. C.	13	S	"	3	20	0	120	5	15	58	72	trace	.0	.0	220	91	3− 2+	5−
91	"	C.	"	I. C.	24	P	Mattoon	5	15	0	302	12	34	252	144	trace	trace	.0	8,100	6,600	4− 1+	4− 1+
92	"	C.	"	I. C.	24	C	"	1	0	0	44	2	8.6	16	4	trace	.0	.0	260	183	5−	5−
93	Dec. 30	H.	Cha.	I. C.	23	Sm	Chicago	2	3	0	24	6	4.8	21	16	.0	.1	.0	10,000	17	5−	5−
94	"	H.	"	I. C.	24	C	Centralia	2	0	0	124	5	12	95	76	.0	.1	.0	25	2	5−	5−
95	"	T.	"	I. C.	1	C	Chicago	2	0	0	426	35	19	124	192	17	.2	.0	13	33	5−	5−
96	"	H.	"	I. C.	24	C	Centralia	2	2	0	28	6	.0	21	0	.0	.3	.0	14	4	5−	5−
97	"	T.	"	I. C.	1	C	Chicago	0	0	0	81	8	6.7	35	32	trace	.5	.0	3,000	120	4− 1+	5−
98	"	T.	"	I. C.	1	C	"	0	2	0	132	16	10	42	54	4.8	.1	.0	1,200	14	5−	5−
99	"	H[c]	"	I. C.	1	D	Hammond	0	2	0	179	7	21	100	un-det.	.0	.3	.0	250	110	5+	5+
100	Dec. 31	T.	"	I. C.	1	C	Chicago	3	0	0	60	5	4.8	32	un-det.	.0	.0	.0	5	6	5−	5−
101	"	H.	"	I. C.	1	P	Chicago	25	0	0	175	6	6.7	114	80	.0	1.6	.0	1	10	5−	5−
102	June 25	C.	Chi.	I. C.	25	C	Chicago	1	0	0	27	3	.0	6	0	trace	.0	.0	580	260	4− 1+	5−

[1] Bottled water. [b] Chi.=Chicago; Cha.= Champaign. [c] O. M. & St. P.

Chlorine was determined in 99 samples. Of these 46 had less than 5 parts per million; 66 had less than 10; 75 had less than 15; 82 had less than 20; 90 had less than 25, and only 9 more than 25 parts per million. It should not be difficult to obtain a water containing less than 15 parts per million of chlorine and it should certainly be easy to obtain water containing less than 25 parts per million.

Sixty-six samples were examined for magnesium. Of these 39 contained less than 10 parts per million; 51 less than 15; 60 less than 20, and only 6 more than 20 parts per million. In the large majority of cases, therefore, it should be easy to obtain waters containing less than 20 parts per million of magnesium. If the magnesium were all present as sulphate, 20 parts of magnesium would be equal to 100 parts of magnesium sulphate.

The alkalinity in presence of phenolphthalein and methyl orange was determined in 99 samples. Only one water was alkaline to phenolphthalein. A requirement that the alkalinity to phenolphthalein shall not be greater than one-half the alkalinity to methyl orange would be easy to fulfill and would guard against the use of water over-treated with lime. Forty-three samples contained less than 50 parts of alkalinity to methyl orange; 71 less than 100; and 89 less than 200. Only 10 had an alkalinity of more than 200, and only one of more than 300. A standard of 300 or less Avould be very easy to maintain and a standard of 200 or less would not be impossible.

The total hardness was determined on 64 samples. Of these 34 had a total hardness of less than 50; 45 less than 100; and 57 less than. 200. Only 7 had a hardness of more than 200 and but 2 a hardness of more than 300. A limit of 300 would be very easy to maintain and it should not be difficult to obtain waters containing less than 200.

Sixty-six waters were examined for sulphate. Thirty-six waters contained less than 10 parts per million; 42 less than 25; 54 less than 50; 63 less than 100, and only 3 more than 100. It should be apparently very easy to furnish waters having less than 100 parts per million of sulphate.

Ninety-nine samples were examined for iron. Eighty-six of these contained less than 0.5 part per million; 94 less than 1.0; and only 5 had more than 2 parts per million. A standard of less than 1 part per million would be very easy to maintain and it would not be unreasonable to ask for less than 0.5 part.

Sixty-six samples were examined for lead and copper. Fifty-six of these showed no trace of either metal; 7 contained 0.1 part per million; 2 contained 0.2, and 1 contained 0.3. It would not seem difficult to maintain a standard of less than 0.3 part per million.

It is interesting to note the limits below which the various contents of mineral matter fell. Less than 90 per cent of the waters examined contained more than 25 parts per million of chlorine, 20 parts of magnesium, 100 parts of sulphate, 1.0 part of iron, 500 parts of total solids, or exceeded 200 in alkalinity and 300 in total hardness. People almost invariably select for drinking those waters lowest in mineral content and almost invariably object to those having a definite mineral taste. Consequently it seems highly desirable to furnish for drinking purposes water as low as possible in mineral content. It would seem entirely practicable to keep railway drinking supplies within the limits just mentioned in Illinois and in fact throughout the States east of Mississippi River. Where it is not possible to obtain waters so low in mineral content exceptions might perhaps be made with the reservation that no constituent should be present in sufficient quantity to cause disagreeable taste or definite physiological reaction.

Bacterial content. One hundred samples were plated on gelatin and the number of colonies counted at the end of 48 hours. Of these, 29 samples had less than 99; 16 samples from 100 to 499; 16 from 500 to 999; 9 from 1,000 to 1,999; 9 from 2,000 to 9,999; and 21 more than 10,000.

One hundred and two samples were plated on agar and incubated at 37.5°C. for 24 hours. Forty samples showed less than 50 bacteria per cubic centim'eter; 7 from 50 to 99; 8 from 100 to 199; 14 from 200 to 499; 8 from 500 to 999; 10 from 1,000 to 1,999; 10 from 2,000 to 9,999 ; and 5 had more than 10,000.

While the large number of bacteria may consist for the most part of harmless forms, the results would indicate unsatisfactory conditions, either in the original water taken or in the conditions of storage and delivery.

The Commission on Standards have made no recommendation concerning the use of gelatin but their standard of less than 100 growing on agar would mean that 53 per cent of the waters examined were unsatisfactory.

One hundred and nine positive tests for gas formation were obtained in 67 samples examined after May 1. Ninety-one, or 83 per cent, of these were shown by the confirmatory tests to contain *B. coli.*

Twenty of the 67 waters were shown to be unsatisfactory by both the standard for *B. coli* and agar count of the Commission on Standards of Purity for Common Carriers. Four more did not conform to the *B. coli* standard alone and 24 more did not conform to the agar count standard, making a total of 49 of 67 samples or 73 per cent which did not conform to the standards set by the Commission.

Though our methods differ from those of Creel[1] the results judged by the *B. coli* standard are similar, showing that better water is found in sleeping cars and parlor cars than in coaches and smoking cars.

Mr. W. W. Hanford of the Illinois State Water Survey is making a study of the character of the water supplied to railway trains from points in Illinois. As time permits we expect to make more analyses of samples of water taken from trains. An improvement is to be expected as the railway officials are endeavoring to improve conditions as rapidly as possible.

[1]U. S. Public Health Service Hygienic Laboratory Bull. 100, 43-57.

CHEMICAL AND BACTERIOLOGICAL EXAMINATION OF NATURAL ICE [1]

By Edward Bartow.

During the past two or three years the Illinois State Water Survey has been called upon to make some sanitary examinations of natural ice. Samples of a few of the waters from which the ice was harvested also have been received. The comparative analyses are especially interesting, and the data obtained are enough to warrant some interesting conclusions.

The analyses made have been arranged in tables 9 and 10. The first table shows the data obtained by the analyses of the specimens of ice. The second table shows a comparison of the analyses of some specimens of ice with the analyses of the water from which the ice was harvested.

The determinations made are the ordinary determinations of chemical and bacteriological analysis, including turbidity, color, odor, residue, chloride, oxygen consumed, ammonia nitrogen, albuminoid nitrogen, nitrite and nitrate nitrogen, alkalinity, the number of bacteria, and gas formers. Some of these tests are of little significance in ice analysis but others have a decided value.

Turbidity refers to the insoluble matter in suspension. It may be dangerous or harmless. Even if harmless it renders a water or an ice less attractive than a clear water. In only one ice did the turbidity exceed 5 parts per million and in the one which is reported as greater there is so small a residue that one must conclude that there may have been an error in the work.

Color refers to colored substances in solution. It is due usually to an extract of vegetable matter. Color is usually harmless, but a colored water or ice arouses suspicion and people will not use it. The color of all of the samples was very low, and in no sample would it be detected in an ordinary drinking glass.

Odor is a descriptive term and is reported as aromatic, earthy, vegetable, etc. Only one of the samples was reported as having a noticeable aromatic odor. Only one other sample was reported as having a noticeable odor.

[1] Pub. in Proc. Natural Ice Assoc. of America, 87, 1914.

TABLE 9.—ANALYSES OF ICE, 1910-1914

[Parts per million.]

Source.	Date.	Turbidity	Color.	Odor.	Total residue.	Chloride.	Oxygen consumed.	Nitrogen.				Alkalinity.	Bacteria per cubic centimeter.		Gas formers.			Indol.
								Ammonia.	Albuminoid.	Nitrite.	Nitrate.		Gelatin.	Agar.	10 cc.	1 cc.	0.1 cc.	
Alton	Dec. 21, 1914	8	0	10	31	3.0	2.0	0.632	0.126	0.015	0.48	4	0	6	1—	2—	2—	.....
Anchor, Mackinaw River	Mar. 13, 1914	2	0	0	34	1	2.5	.090	.150	.002	.08	12	20	60	1—	2—	2—	—
Anna, Distilled water	Mar. 16, 1914	0	0	0	10	2	2.2	.110	.074	.010	.28	4	0	3	1—	2—	2—	—
Do.	Oct. 20, 1914	0	0	0	10	2	1.1	.090	.046	.000	.64	8	20	4	1—	2—	2—	+
Belleville	Apr. 13, 1914	0	0	0	5	1.4	1.1	.220	.156	.002	.48	2*	3	10	1—	2—	2—	—
Aroma, Kankakee River	Mar. 16, 1914	0	0	0	12	2	1.8	.068	.070	.007	.28	10	1	4	1—	2—	2—	—
Cedar Falls, Ia., Cedar Falls River	June 18, 1912	1	2	1	17	1	.9	.080	.104	.000	.16	4	65	.....	1+	2—	2—	—
Champaign, Artificial																		
Do. from core	Mar. 2, 1914	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	30	0	1—	2—	2—	+
Do. from side of cake	Mar. 2, 1914	0	0	0	13	4	1.8	.344	.080	.007	.12	10	0	0	1—	2—	2—	.....
Chester	July 11, 1911	0	0	3a	14	3	.2	.118	.098	.000	.04	0	6	.....	1—	2—	2—	—
Do	Dec. 21, 1914	2	0	1e	46	4.2	4.8	.392	.246	.015	.43	4	4	9	5—	2—	2—	.....
Danville, Artificial	Apr. 13, 1914	1	0	0	24	1.4	.8	.110	.064	.000	.00	4	12	5	1—	2—	2—	—
Decatur, Distilled water	Mar. 3, 1914	0	0	0	22	5	4.5	.118	.060	.015	.44	8	Liq.	10	1—	2—	2—	.....
Dixon, Rock River	Feb. 19, 1912	2	0	1	34	.8	1.8	.096	.104	.002	.20	4	22	.....	1—	2—	2—	—
Effingham, Artificial	May 16, 1914	0	0	0	8	3	1.8	.162	.122	.001	.20	10	5	10	1+	2—	2—	—
Do from ice plant	Oct. 14, 1914	0	0	0	132	56	2.0	.952	.094	.012	.32	2	2	3	1—	2—	2—	—
Fairbury	Aug. 1, 1914	15	0	1e	22	2	4.4	.068	.196	.000	.28	3	190	50	1—	2—	2—	—
Galesburg, Lake Rice	Jan. 22, 1911	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	125	.....	1—	1—1+	2—	—
Do.	1911	5	0	0	7	3	1.8	.112	.200	.000	.16	6	20	.....	1—	2—	2—	—
Do	Feb. 5, 1912	3	0	0	10	.2	1.5	.118	.156	.000	.04	1	16	.....	1—	1+1—	2—	+
Do	Feb. 26, 1912	2	0	1e	7	.4	.7	.094	.068	.004	.00	2	6	.....	1—	2—	2—	—
Jacksonville	Dec. 22, 1914	0	0	0	34	6.0	1.6	.146	.080	.007	.12	6	15	30	5—	2—	2—	—
Kankakee, Spring Creek	Feb. 19, 1912	2	0	1e	27	.8	.9	.090	.094	.000	.08	4	6	.....	1—	1+1—	2—	—
Do.	Mar. 10, 1913	5	0	1e	24	1	1.3	.150	.204	.000	.12	20	60	50	1—	1+1—	2—	—
La Salle	Feb. 15, 1913	0	0	0	19	.0	1.1	.128	.058	.000	.60	4	32	3	1—	2—	2—	—

Mendota, Natural..........	Apr. 2, 1912	1	2	2m	5	2.2	2.5	.166	.140	.001	.00	2	17	.....	1—	2—	2—	—
Do	Feb. 19, 1913	2	0	0	27	1	1.0	.052	.124	.000	.24	4	20	15	1—	2—	2—	—
Moline, Sylvan Island Pool...	Jan. 25, 1912	2	0	0	11	.0	5.6	.154	.364	.000	.00	1	3	.....	1—	2—	2—	—
Do. Pool 24th St.......	Jan. 25, 1912	3	0	0	9	.1	6.0	.166	.360	.000	.00	2	8	.....	1+	2—	2—	—
Do Sylvan Island Pool..	Jan. 25, 1912	2	0	0	10	.1	2.6	.096	.128	.000	.00	3	6	.....	1—	2—	2—	—
Momence................	Mar. 31, 1918	0	0	0	33	1	.9	.040	.068	.000	.12	8	7	7	1—	2—	2—	—
Mounds..................	Oct. 19, 1914	0	0	0	15	3	1.7	.162	.130	.007	.52	4	2	3	1—	2—	2—	+
Murphysboro.............	Dec. 28, 1914	0		0	6	2.2	2.0	.208	.070	.007	.28	6	2	0	1—	2—	2—	—
New Boston, Sturgeon Bay...	Jan. 21, 1911	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10	.....	1—	2—	2—	—
Do.	Feb. 5, 1912	2	0	0	9	.2	.9	.040	.082	.000	.16	1	7	.....	1+	2—	2—	+
Pana....................	Mar. 28, 1913	0	0	0	33	1	.9	.428	.048	.008	.80	10	1	0	1—	2—	2—	—
Pekin...................	June 14, 1913	2	5	0	9	1	1.2	.064	.078	.000	.04	2	106	7	1—	2—	2—	—
Do.	Feb. 26, 1914	0	0	0	52	2	4.9	.090	.116	.002	.28	10	8	10	1—	2—	2—	+
Do. Artificial...........	Dec. 22, 1914	8	0	0	26	2.0	1.3	.226	.050	.030	.04	4	15	8	5—	2—	2—	—
Pontiac..................	Oct. 15, 1912	5	0	2v	10	1.6	1.8	.088	.186	.000	.36	0	50	4	1—	2—	2—	—
Quincy, Quincy Bay........	May 26, 1913	0	5	0	3	3.2	.8	.048	.020	.010	.20	2	120	20	1—	2—	2—	—
Do.	May 8, 1912	0	0	0	31	.5	1.2	.150	.182	.002	.28	6	45	.....	1—	2—	2—	—
Do.	June 1, 1911	10	0	0	12	2	1.7	.040	.090	.003	.00	4	Liq.	.....	1—	2—	2—	—
Do.	Feb. 26, 1912	2	4	0	8	.6	1.5	.118	.206	.000	.04	2	17	.....	1—	2—	2—	—
Do. Natural...........	May 13, 1914	5	0	1v	35	0	1.4	.100	.040	.005	.20	4	350	900	1+	2+	2+	+
Salem, Unfrozen ends of cakes................	July 6, 1914	25	0	1v	20	2.0	7.6	4.728	.126	.001	.16	18	12	9	1—	2—	2—	—
Springfield, Artificial.......	Dec. 30, 1914	0	0	0	40	2.0	3.9	.230	.204	.030	.24	8	4	0	5—	2—	2—	.....
Spring Valley, Illinois River..................	Feb. 12, 1912	4	0	1a	6	.1	.9	.118	.122	.000	.12	1	234	.....	1—	2—	2—	+
Sterling, Rock River........	May 16, 1910	5	0	·0	23	1	.8	.062	.076	.004	.200	12	330	.....	1—	2—	2—	—

TABLE 10.—ANALYSES OF WATER AND OF ICE FROM THAT WATER.

[Parts per million.]

Source.	Date.	Turbidity.	Color.	Odor.	Total residue.	Chloride.	Oxy. cons.	Nitrogen. Ammonia.	Nitrogen. Albuminoid.	Nitrogen. Nitrite.	Nitrogen. Nitrate.	Alkalinity.	Bacteria per cubic centimeter.	Gas formers. 10 cc.	Gas formers. 1 cc	Gas formers. 0.1 cc.	Indol.
Dixon, Rock River......	Feb. 19, 1912	.....	....	....	....	....	....	.....	.....	.....	......	....	4,060	1+	2+	2+	+
Ice from same..........	....do.....	2	0	1	34	0.8	1.8	0.096	0.104	0.002	0.200	4	22	1—	2—	2—	—
Galesburg, ½ mile east of, Lake Rice...........	Jan. 22, 1911	.....	....	....	....	....	....	.....	.....	.....	......	....	12,000	1+	2+	2+	+
Ice from same..........	....do.....	.....	....	....	....	....	....	.....	.....	.....	......	....	125	1—	1—1+	2—	—
Galesburg, east of, Lake Rice...........	Feb. 5, 1912	7	20	1e	277	3	4.6	.274	.810	.005	1.12	180	1,400	1+	2+	2—	+
Ice from same..........	....do.....	3	0	0	10	.2	1.5	.118	.156	.000	.040	1	16	1	1+1—	2—	+
Moline, Pool opposite channel.............	Jan. 25, 1912	8	50	1e	183	2.4	9.1	.072	.152	.004	.680	144	520	1+	2+	2—	+
Ice from same..........	....do.....	2	0	0	11	.0	5.6	.154	.364	.000	.000	1	3	1—	2—	2—	—
Moline, Pool opposite Moline Ice Co.	....do.....	7	50	1e	194	2.3	7.9	.080	.150	.004	.680	144	675	1+	2+	2+	+
Ice from same..........	....do.....	2	0	0	10	.1	2.6	.096	.128	.000	.000	3	6	1—	2—	2—	—

Total residue comprises the solid matter left on evaporating the water. It includes both organic and inorganic constituents. Unless the quantity is excessive, it does not injure the water for domestic use. Five hundred parts per million is a usual allowance in a drinking water. Ice should have very little residue. The highest residue found in the ice examined was 34 parts per million, but in most samples it was less than 10, which is the equivalent of distilled water.

Chloride refers to the quantity of chlorine in combination with metals; for example, sodium chloride (common salt). Chloride is a constant and considerable constituent of sewage. Unless the source is near a salt deposit or other chloride-bearing rocks or the sea the presence of much chloride in a water is a cause for suspicion. The chloride in the ice examined never exceeded 3 parts per million. It usually could be determined with difficulty, and could well be reported as a trace.

The alkalinity refers to the soluble carbonates or hydrates, and helps to determine the value of a water for household uses. There should be a very low alkalinity in an ice, as was found to be the condition of the specimens examined.

Though they indicate very well the purity of the ice from a physical and chemical standpoint, the tests for turbidity, color, odor, total residue, chloride, and alkalinity are of no significance with respect to the hygienic condition of the water.

In Table 10 are shown analyses of ice and the water from which the ice was taken. A consideration of the degree of purification effected by freezing is quite interesting from both a chemical and bacteriological standpoint. The turbidity, although not high in the original water, is practically eliminated. The high color in most of the samples was also eliminated, in two being reduced from 50 to 0. The total residue was reduced from 183 to 11, 194 to 10, and 197 to 10, respectively. The chloride, was reduced from 2.4 to 0, 2.3 to 1, and 3 to 0.2; the alkalinity from 134 to 1, 144 to 3, and **180** to 1. **The** oxygen consumed was less, and in most ices ammonia, albuminoid, nitrite, and nitrate nitrogen were less. Where comparisons of the number of bacteria were made, the purification was very striking. In one, with 12,000 bacteria in the raw water, there were but 125 in the ice; 520 were reduced to 3, 675 to 6, 1,400 to 16, and 4,060 to 22, in every one practically 99 per cent reduction. Gas-forming bacteria were also greatly reduced in number.

In the purification of water by freezing both suspended matter and soluble substances are removed. The removal of the suspended matter is explained by the fact that water in freezing solidifies on top. The formation of the coating of ice protects the water from disturbance and enables the particles heavier than water to sink to the bottom. Also in the normal formation of the crystalline ice there is no room for solids between the crystals. This accounts for the decrease in the turbidity and bacteria. For the removal of soluble substances another explanation must be sought. The solubilities of the dissolved substances ordinarily found in water are far greater than the solubility of ice in water at 0°C. Ice is soluble in water at 4°C. (39.2° F.) when the water is at its maximum density, but insoluble in water at 0° C. (32° F.). The substances occurring in river and pond waters are, as a rule, soluble in water to much greater extent than their concentration in the rivers and ponds. For example, the least soluble of the common substances occurring in pond waters is calcium carbonate. At 0° C. 1,000,000 parts of water saturated with carbon dioxide will dissolve 700 parts of calcium carbonate. Most streams of the United States contain less than 200 parts per million of residue and hence much less than that amount of any one compound. Before much calcium carbonate would be taken from the water by the ice, there must be a concentration several times the ordinary concentration in the water. The same is true of other salts. Magnesium carbonate is soluble to the extent of 1,300 parts in 1,000,000 parts of water. Calcium sulphate is soluble to the extent of 2,050 parts. Magnesium sulphate is soluble to the extent of 257,000 parts. Of the salts of sodium, sodium chloride (common salt) is soluble to the extent of 356,000 parts. For other salts, sodium carbonate is soluble to 70,000 parts, and sodium bicarbonate to 79,000 parts.[1] None of these exist in the rivers and streams of the United States to an extent greater than 200 parts per million. Only in sea water are these salts present in sufficient quantities, so that on cooling to zero Centigrade are they taken out with the ice. Sea water contains 3.5 per cent of salts. The water obtained from the melted ice from sea water is said to be fresh, but it has a bitter taste, because only four-fifths of the salts present are removed.

Nature certainly does its share toward furnishing pure natural ice. If reasonable precautions are taken so that no ice is obtained from grossly polluted ponds or rivers and the surface of the ice is protected, there need be no difficulty in placing pure ice on the market.

[1]Roscoe, H. E., and Schorlemmer, C, A treatise on chemistry, New York, 1886.

SEWAGE TREATMENT IN SMALL COMMUNITIES WITHOUT SEWERAGE SYSTEMS

By Paul Hansen.

Many inquiries are received in the office of the State Water Survey concerning treatment of sewage, especially that from school houses in small communities in which sewerage systems have not been constructed. The notion has in some way become fixed in the popular mind that it is necessary merely to install a sort of septic tank. The popular conception of the character of such a tank is exceedingly vague; it is generally believed that the effluent from it is quite clear and free from objectionable characteristics and may be discharged into a ditch or drain without creating offense. As a matter of fact, however, the problem of sewage disposal is not so simple as that, as many communities have learned through experience. The most that can be expected of a septic tank or any other form of sewage tank is that it will remove about 30 per cent of the suspended matter and effect a slight reduction in those substances that tend to putrefy. The final effluent discharged into an open watercourse may be less offensive than the crude sewage because the finely-divided solids remaining are not likely to form heavy deposits of sludge. Nevertheless the effluent is likely to be highly putrid, dark colored, and unsightly. If the point of discharge is remote from habitations, 300 feet or more, there may be no complaint, but if it is discharged into a ditch beside a village street or a drain tile that has catch basins for receiving storm water and house connections for draining cellars a very serious nuisance may be produced. The State Water Survey has found many storm-drain tiles that have become highly offensive because they received overflows from cesspools and septic tanks or, worst of all, were overloaded during periods of heavy rainfall and backed up house sewage into cellars and basements.

The only ultimate means of sewage disposal in a small community, and the only means that should be used, is installation of a correctly constructed sanitary sewerage system which conveys all the house sewage to points where it may be inoffensively diluted in large watercourses or to a point where it may be adequately treated before being discharged into a small watercourse. Properly planned sewerage systems may be built, section by section as needed, the financial burden on the community being thus distributed over a term of years. Yet however desirable that may be, many communities do not put in sewerage systems at the time and in the manner that such systems should be installed, and occasions arise where some other means of final disposal of the sewage must be adopted. All such otner methods, however, should be regarded as temporary expedients pending the time that an adequate sewerage system can be installed.

The simplest form of treatment and the one most frequently resorted to is the passage of sewage through a tank, generally called a septic tank. Two forms of tank are shown in the accompanying illustrations. Figure 12 (below) shows the simplest form of tank that

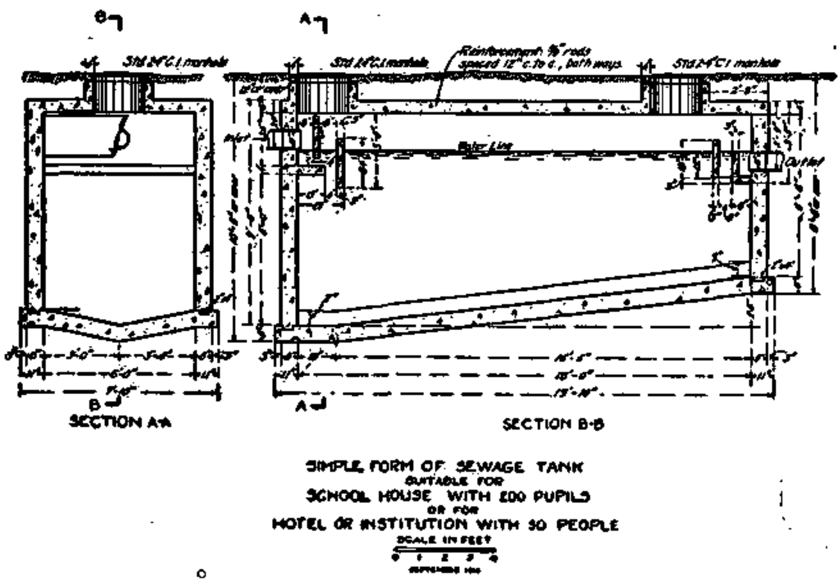


Figure 12.—Simple form of sewage tank for a schoolhouse with 200 pupils or for a structure with 50 inmates.

should be used. This tank should be designed with a capacity for holding the sewage produced in 24 hours. The outlet should be conveyed into a large stream, or if only small watercourses are available the outlet should be remote from habitations where it will not injure the stream for watering cattle or other legitimate uses. The effluent may in some place be discharged into a tile surface drain, but if that is done the connections should be made below house cellar-drain connections or great precaution should be exercised to ascertain that the

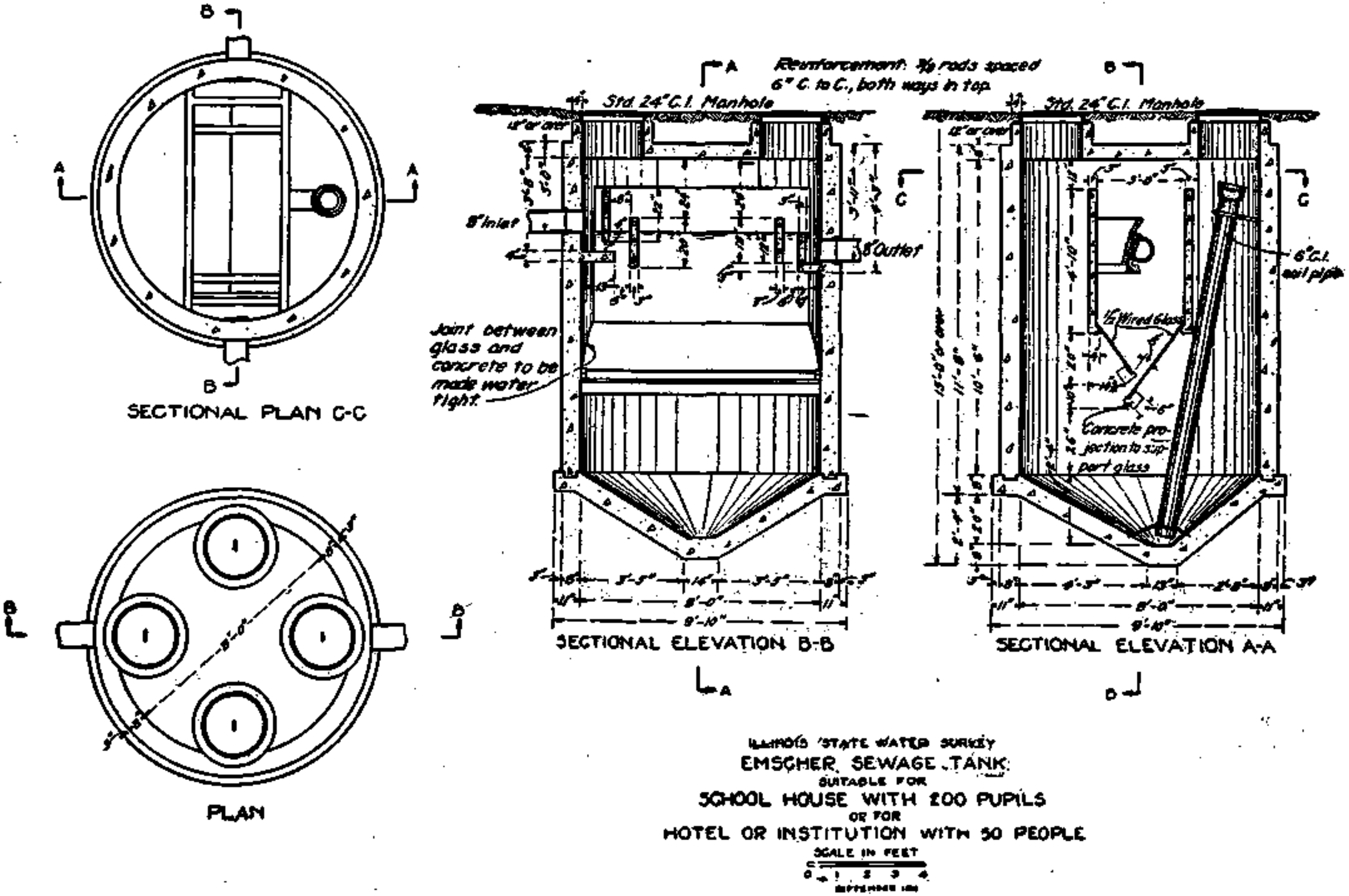


Figure 13.—Emscher sewage tank **for** a schoolhouse with 200 pupils or for a structure with 50 inmates.

tile is sufficiently large to prevent backing up of the effluent into cellars. This tank should be cleaned once a year. The accumulated sludge will not be excessively offensive and may be spread on land. When it has dried out it has little odor.

Figure 13 (p. 191) shows another form known as the Emscher tank, which may be described as a double-decked or two-chambered tank. The upper chamber is the sedimentation chamber and should be large enough to retain the sewage about 3 hours if the tributary population does not exceed 200. During the passage of the sewage through the sedimentation chamber a certain portion of the suspend-

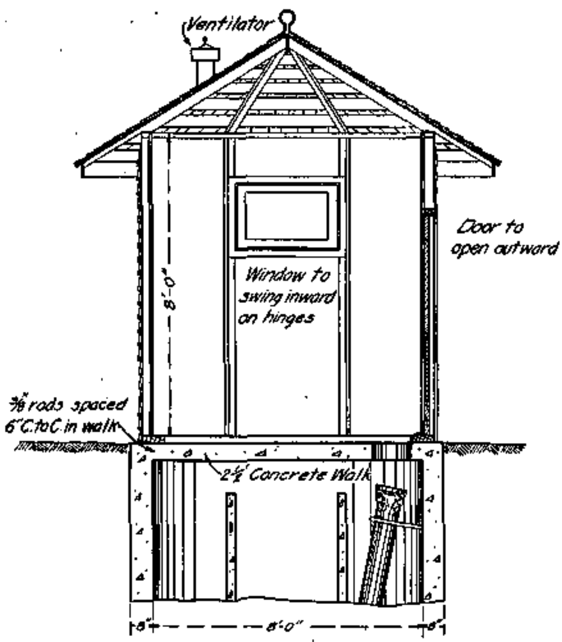


Figure 14.—Emscher sewage tank with superstructure.

ed solids sinks into the digestion chamber through the slotted opening shown in section elevation A A (Fig. 13) where it accumulates and undergoes thorough digestion. The digestion chamber should have a storage capacity for one year's sludge. If the chamber is 15 feet deep as shown in the drawing and the tributary population does not exceed 200 proper storage will be provided for the sludge. It has little odor and is much less offensive than that from the simple sewage tank just described. It may be spread on land and after it has dried it has the consistency of rich loamy earth. This tank is preferable to the simpler form because the effluent from it is fresh and thus has a less penetrating and disagreeable odor. Discharge of the effluent, therefore, into a small watercourse, especially one with a steep gradient and a rapid flow, gives rise to little odor. The liquid is not, however, free from odor or otherwise inoffensive, and serious complaint may confidently be expected if the stream into which it is discharged is used for watering cattle. If the tank must be inconspicuous it may be covered as shown in Figure 13. A superstructure like that shown in Figure 14 is preferable as it permits easier access for inspection, cleaning, and repairs.

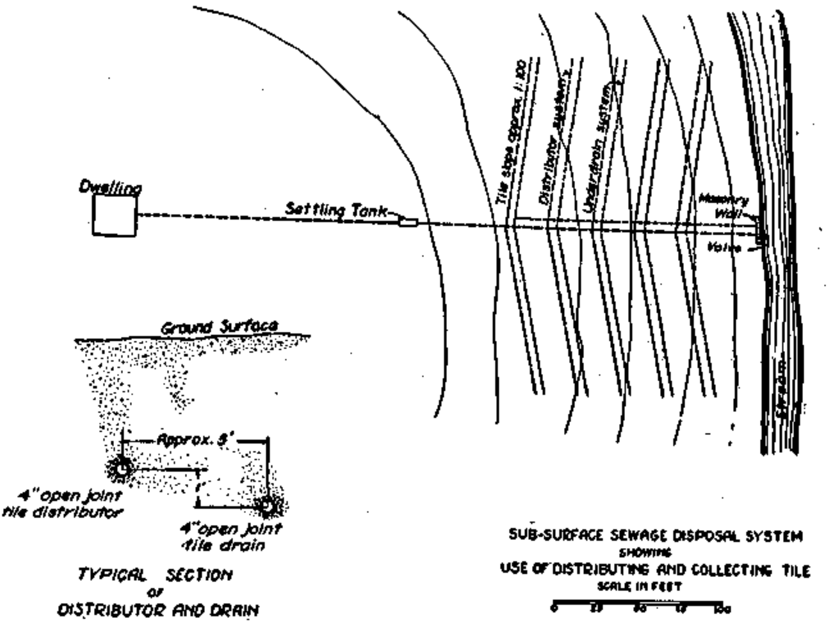
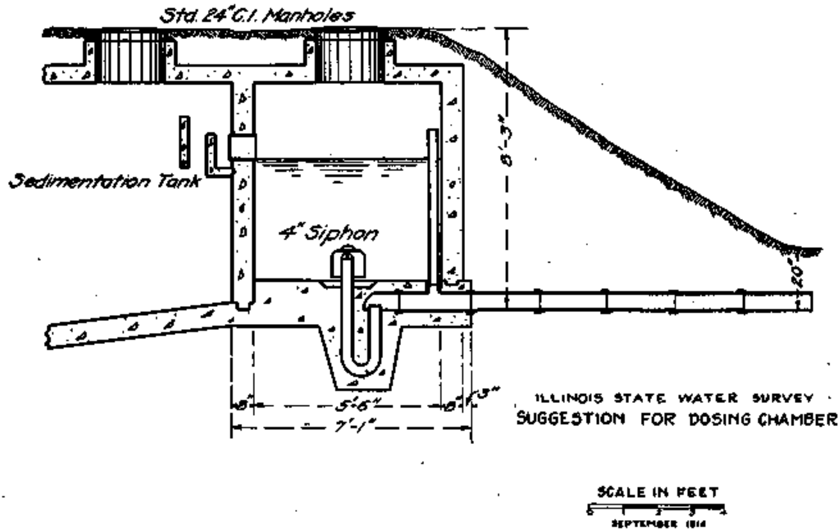


Figure 15.—Subsurface sewage-disposal system showing use of distributing and collecting tile.

If sufficient land is available the subsurface-irrigation system, which is illustrated in Figure 15, may be used. This consists of a system of distributing tiles laid with open joints 12 to 18 inches below the surface. Sewage entering these tile seeps into the soil and is thus disposed of. Generally an overflow or emergency outlet from the system of distributing tile into a watercourse is desirable. The space within the system of tile should in general be equivalent to that of 24 hours' sewage, but this proportion varies with the character of the soil, loose soil requiring less and clayey soils requiring considerably more distributing tile. In some places a farm drain tile of considerable length already laid may serve as the distributing system.

Subsurface irrigation works best in sandy and gravelly soil. In many clay and loess soils of Illinois, however, it is necessary to provide means of removing the liquid from the soil by installing a separate system of collecting tile as shown in Figure .15. In extremely impervious soil it may be even necessary to build a bed of sand or gravel round the distributing and collecting tiles to permit passage of fluid from one to the other. The collecting tile should be at least 5 feet from the distributing tile.

The best results are obtained with subsurface irrigation where the sewage is applied in regular doses discharged rapidly into the tile. This is accomplished by adding to the sedimentation tank a dos-



Figuro 16.—Dosing chamber adjoining the sewage tank shown in Figure 12.

ing chamber as shown in Figure 16, which can be made to discharge part of its contents automatically by installing a discharge siphon. The addition of a dosing chamber to very small installations is, however, questionable because the siphon is subject to occasional derangements and thus requires certain oversight and care. The dosing chamber may well be added to sewage-disposal systems for schoolhouses and courthouses.

The subsurface-irrigation system, like any that permits sewage to soak into the soil, has an element of danger in that near-by private wells may be contaminated; consequently no part of a subsurface-drainage system should be within 200 feet of a well in ordinary gravel or sand. If limestone is near the surface the danger to wells is infinitely increased. It may not, however, be amiss to state that the subsurface-irrigation system is of far less danger to wells than the ordinary leaching cesspool, which is an abomination that should not be permitted in any settled community as it is almost impracticable to keep it at safe distance from shallow wells.

Though there are many other methods for the treatment of sewage they are rarely applicable to the conditions under consideration in this article. If they are applicable installations of them should be specially designed by an expert engineer with full knowledge of local conditions. In conclusion it is desired to emphasize that, so far as municipalities are concerned, the methods herein described must be regarded as makeshifts to be utilized only until such time as an adequate sewerage system may be installed.

THE POLLUTION OF CEDAR CREEK BY GALESBURG

By Paul Hansen and others.

INTRODUCTION

A communication was received from the Rivers and Lakes Commission January 21, 1914, requesting an investigation of Cedar Creek at and below Galesburg with reference to objectionable pollution. This request was accompanied by a petition signed by several farmers owning land along Cedar Creek below Galesburg. The test of the the petition is as follows:

To the Eivers and Lakes Commission of the State of Illinois.
Gentlemen:

WHEEEAS: The waters of a running stream known as Cedar Creek are so polluted by the sewers of the city of Galesburg, Illinois, emptying therein, which sewers have house connections, receive laundry waste water, also gas factory waste products, without any filtration plant or other means of purifying the same before it is emptied into said stream, creating thereby a great stench, making the water utterly unfit for stock, a menace to health, and altogether an intolerable nuisance.

THEREFORE: We the undersigned respectfully petition your honorable board to thoroughly investigate the matter and take such action as the equity and exigency of the case demands.

(Signed) Granville Jones, *et al.*

In compliance with the request of the Rivers and Lakes Commission a visit to Galesburg was made, March 4, by Paul Hansen, engineer, to arrange preliminaries for an investigation; March 16 to 18 by M. C. Sjoblom, engineering assistant, to make inspections and to obtain certain data in the office of the city engineer; June 29 to July 1 by Ralph Hilscher, assistant engineer, M. C. Sjoblom, engineering assistant, H. E. Babbitt, engineering assistant, and C. R. Newell, engineering assistant, to make stream measurements, to collect samples, and to inspect conditions along Cedar Creek at and below Galesburg. The results of these studies together with much information generously furnished by Mr. F. M. Connely, city engineer, constitute the basis of this report.

DEVELOPMENT AND IMPROVEMENTS

Galesburg is in the west-central part of Knox County, of which it is the county seat, near the divide between the basin of Henderson

River, a tributary of the Mississippi, and that of Spoon River, a tributary of the Illinois. The city occupies high generally level ground between the two drainage basins. Cedar Creek, a branch of Henderson River, rises a short distance northeast of the city and flows westerly through the city, receiving practically all the drainage from the city. A small amount of sewage and surface drainage from the southeastern part of the city enters Court Creek, a tributary of Spoon River. The glacial drift in the area occupied by Galesburg is 30 to 40 feet thick in the uplands. In the valley of Cedar Creek, however, which appears to be a preglacial valley, the drift is said to be as much as 120 feet in depth. The drift occupying the old preglacial valley of Cedar Creek contains water-bearing strata which yield large quantities of water compared with the limited drainage basin of the present surface stream.

The population of Galesburg, according to reports of the United States Census in 1890 was 15,264; the population in 1900 was 18,607, an increase of 21.9 per cent; in 1910 it was 22,089, an increase of 18.7 per cent. Thus the growth has been good though not exceptionally rapid. The present population is about 25,000. The population in 1935 will probably be about 35,000 and that is the population for which provision should be made in planning improvements of sewerage. It is also to be borne in mind that the present consumption of water is abnormally low; if the city should procure a more abundant supply prior to 1935 the consumption of water and consequently the production of sewage will be much greater per capita than at present. As it is inevitable that Galesburg must do something to increase its water supply normal conditions rather than present conditions should be considered in connection with any project for treatment of sewage.

Galesburg is an important center for the Atchison, Topeka, and Santa Fe Railway, the Chicago, Rock Island, and Pacific Railway, and electric interurban lines to neighboring towns, and the Chicago, Burlington, and Quincy Railroad has shops at Galesburg employing about 1,200 men. Other leading industries are a large works for the manufacture of engines, boilers, and brick-making machinery and a large brick works which produces high-grade paving bricks. Galesburg also is the seat of Knox College with about 500 students and Lombard College with about 200 students.

Galesburg has many well improved streets, attractive public buildings, and other evidences of general municipal efficiency. Yet the city is exceedingly backward in the development and operation of its two most important municipal improvements, the public water supply and the sewerage system. There are other defects in the municipal administration that may be noted. Many private wells, the existence of which may be attributed to the imperfect service given by the public water supply, still remain within the city limits. Many of these wells, like wells especially of the shallow dug type in thickly settled communities, are subject to dangerous contamination as is revealed by numerous analyses by the State Water Survey. Disposal of garbage and other solid wastes is handled in rather crude manner for the material is still dumped into abandoned clay beds and thus gives rise to much nuisance. A more sanitary and less offensive method of garbage disposal should at least be instituted. The meager data available shows that Galesburg has been reasonably free from diseases indicative of unsanitary conditions though cases of typhoid fever occasionally occur as in 1911 when there were 25 cases with 3 or 4 deaths and in 1910 when there were 30 or 40 cases. The origin of these cases was never ascertained, but the existence of an open sewer in Cedar Creek, several crudely constructed outdoor privies, and the polluted private wells already referred to may offer a partial explanation. The typhoid record of Galesburg, while not so unfortunate as that of some other cities, still emphasizes the strong desirability of improvement of the public water supply and the sewerage.

The public water supply of Galesburg has been derived chiefly from water-bearing strata in the valley of Cedar Creek though this source is supplemented by a limited quantity of water from deep rock wells. The maximum yield of the drift is about 1,000,000 gallons, all of which has not yet been developed. The city is experiencing a serious shortage of water. Several possibilities have been suggested for procuring an increased supply, the most practicable and economical of which appears to be development of a surface supply in the valley of Haw Creek south of Knoxville and 6 miles from the center of Galesburg. This project involves an expenditure of about $380,000, which the city officials and the people are unwilling to appropriate. A deep-well system could be installed for less money, but the operating cost of it would probably make the eventual total cost greater than that of the Haw Creek project. Moreover, deep-well water is less satisfactory because it is high in mineral content and the quantity available is uncertain. The problem of sewage disposal has a relation to water supply in that it has kept down the consumption of water to an exceptionally low figure for a city of this size. The present •consumption of water probably does not exceed 750,000 gallons, equivalent to 30 gallons per capita.

The sewerage system of Galesburg, built mostly on the combined plan, has been extended from time to time as immediate requirements have demanded, but little thought has been given to the need of rendering it sufficiently comprehensive to meet future requirements or to proper final disposal of the sewage. Many sewers, especially in the extreme northern and southern parts of the city, are laid at such shallow depths as to prevent proper drainage of cellars. The lower ends of the sewers apparently have not been placed sufficiently deep to permit proper extension into newly developed areas. The various outlets, 20 in all, discharge at the most convenient points into Cedar Creek. As this stream has no natural flow during dry weather it has become virtually an open sewer constituting through the heart of the city a gross nuisance by foul odors and unsightly appearance.

CEDAR CREEK

DESCRIPTION OF BASIN

Cedar Creek has a drainage area of 6,860 acres above the western corporation line. The stream originally had a perennial flow probably due to the inflow of ground water from the areas since developed for public water supply. The ground-water level has been lowered to such extent by public and private wells that the ground-water effluent of the creek is now negligible. Considerable seepage enters the sewers, which is more or less normal to any sewerage system. The volume of this seepage has never been determined but estimates based on stream flow indicate about 25,000 gallons a day in dry weather. Below the city Cedar Creek meanders southwesterly without any material accession of flow during ordinary dry weather from tributary watercourses until a small watercourse draining Monmouth, 16 miles below, is reached. This stream brings the sewage of Monmouth. The gradient of Cedar Creek is relatively slight as shown by its rather sluggish flow. At points several miles downstream the flow is so sluggish as to be barely perceptible during low water. This condition prevents the extension of nuisance conditions for greater distance downstream.

"Water-level gages were established during the investigation at various points along Cedar Creek, and one set of stream gagings has been made. It is hoped to procure, with the assistance of various interested parties, enough gage readings and stream gagings to ascertain the length of periods during which nuisance conditions persist. As this information is necessarily acquired but slowly figures cannot be presented within six months or longer.

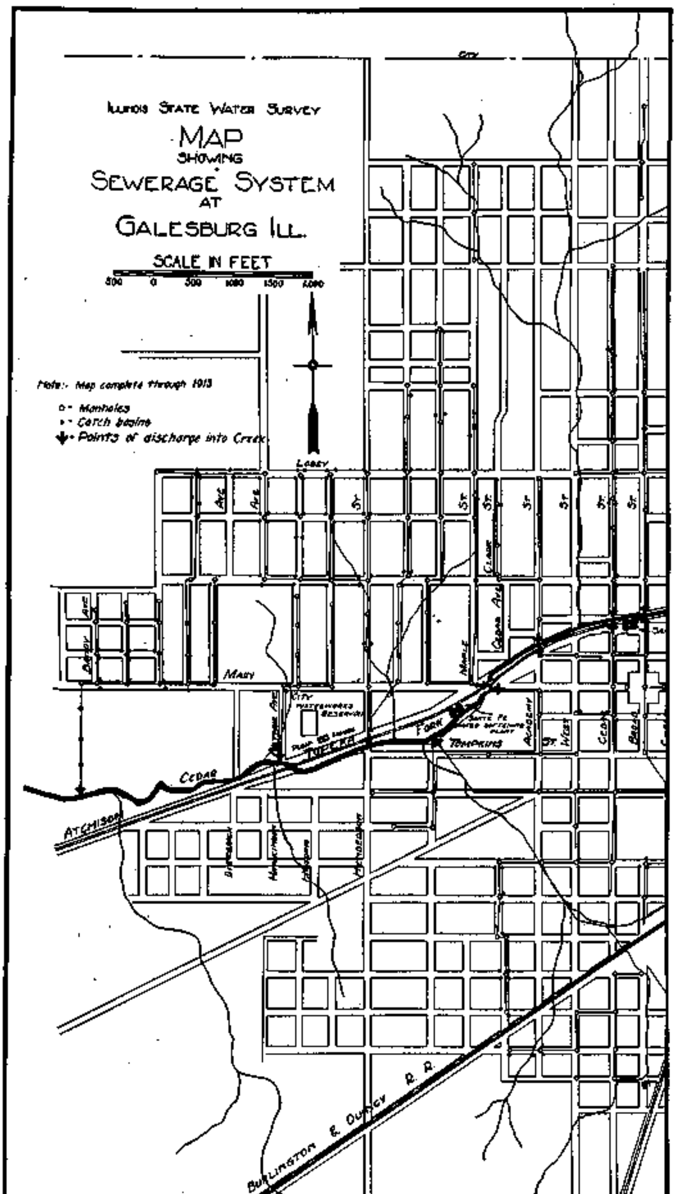
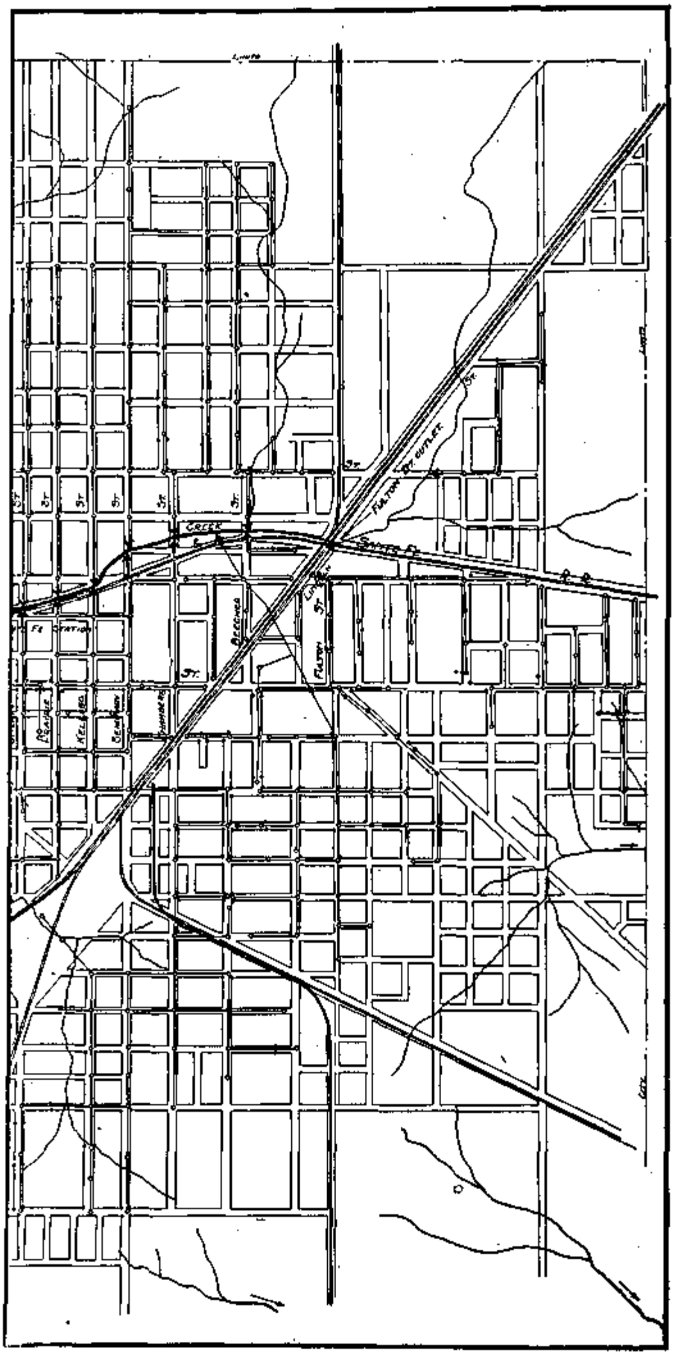


Figure 17.—Map showing sewerage system



at Galesburg at end of 1913.

INSPECTIONS OF CREEK

Visual inspections of the most important points along the stream were made twice in March and once in June, and the results of these inspections are summarized.

The stream had a small discharge March 4, but as the weather was cold little odor was observable nor was there much active fermentation in the sludge and sewage occupying the bed of the stream below the city. The flow was said to be exceptionally low March 16 to 18 and somewhat warmer weather made conditions worse than on the previous trip. The stream flow was moderately low June 29 to July 1, but preceding rains had flushed out the deposits of sludge so that conditions were not at their worst.

The first observation on all three trips was made above the entrance of all pollution from Galesburg. At all three inspections the watercourse was practically without flow though some water stood in pools just above Losey Street (See Figure 19) and it was, therefore, impossible to obtain what might be regarded as normal samples of unpolluted water from Cedar Creek. Accompanying photographic reproductions show Cedar Creek above Losey Street on March 18 and June 29, respectively.

The first evidence of pollution was found at Losey Street in the eastern part of Galesburg, where a sewer discharges a small volume of domestic sewage into the stream. The quantity was so small that it could not be regarded under ordinary circumstances as either unsightly or malodorous though disagreeable odors could perhaps be detected in the vicinity under certain atmospheric conditions. The first pronounced nuisance was encountered at Lincoln Street, where the Fulton Street sewer, serving approximately 140 acres of residence district, discharges a considerable sewage, which forms a gray malodorous stream containing much offensive floating matter. The stream flows through back yards of inferior residence property for several blocks below this point. Persons living in the vicinity of this outlet complain of frequent bad odors, especially after nightfall. Willows that have been planted along the bank of the stream, apparently to hide it from view as well as to prevent the banks from caving, do much to retard the flow of flood waters with resulting injury to adjoining property. A general view of the stream between Lincoln and Pearl streets, showing the back yards, is given in Figure 20.

At Chambers Street about 2,100 feet below the outlet of the Fulton Street sewer the stream enters a high-class residence district and continues near it about 1,200 feet. The discharge within this distance

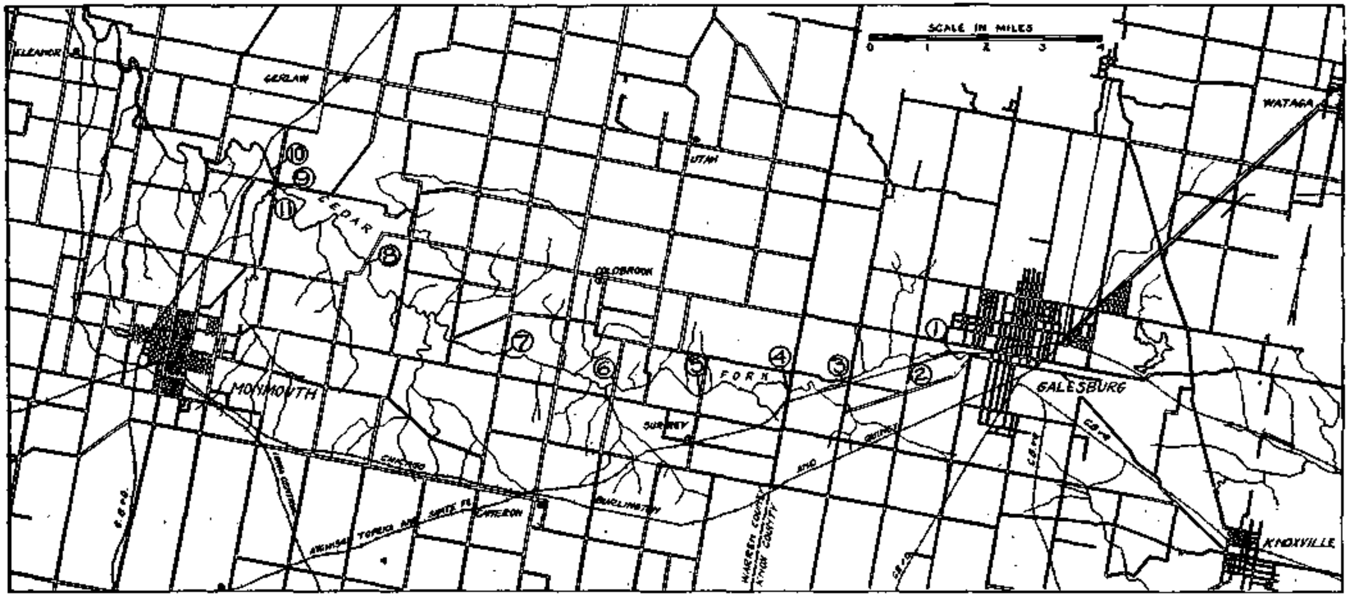


Figure 18.—Map showing sampling and stream-gaging stations on Cedar Creek below Galesburg.

is steadily increased by the discharge of several sewers. At Kellogg Street, 1,300 feet below Chambers Street, a 24-inch sewer discharges less than 40 feet from a dwelling and in plain view from all windows on the south side of the dwelling. The sewage is likewise unsightly and malodorous to users of the bridge at Kellogg Street. (See Figure 21.) Conditions in the vicinity of Kellogg Street are rendered still more objectionable by promiscuous dumping on the stream banks (See Figure 22).

Figure 19A.—Cedar Creek above Losey Street, Galesburg, March 18, 1914.

Several outlets between Kellogg and Cedar streets add to the general unsightliness of the stream at the various street crossings. The drain from the gas works discharges gas-house wastes just below Cedar Street. These wastes at times of inspection were not specially unsightly at the point of discharge, but they carry much oily and tarry matter which forms deposits and produces an unsightly oily film. Moreover, the wastes themselves are malodorous and impart to the stream a distinct odor that is traceable for miles downstream. The creek below the gas-house drain is so foul that it is difficult to understand how near-by residents have been able to endure the stench that rises from it. The apparent explanation of this tolerance is that the stream at this point passes through an inferior residence district.

Below the passenger station of the Santa Fe Railway the stream passes principally through industrial districts or through territory that has not been extensively settled. At several important crossings, however, notably at Academy, Main, and Maple streets, the num-

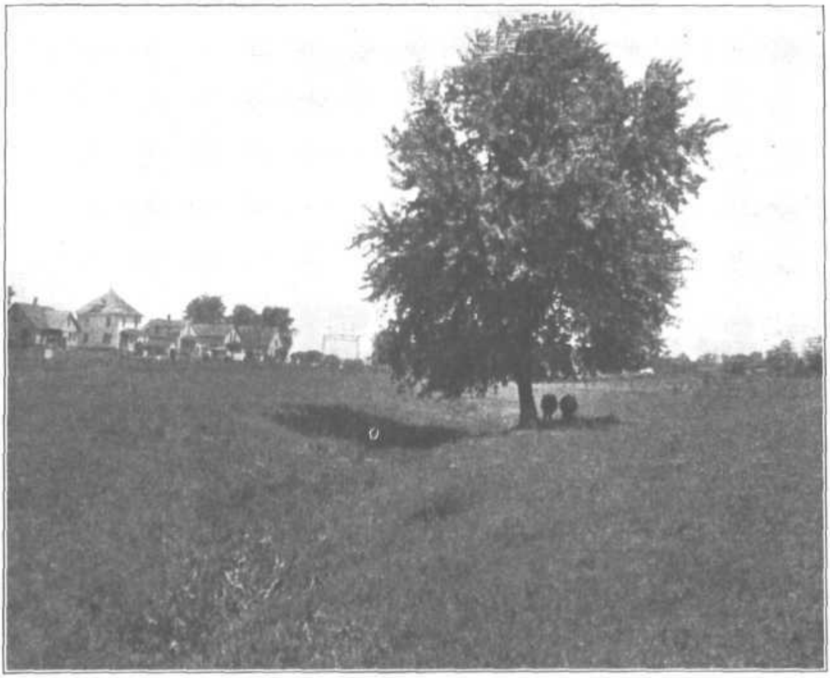


Figure 19B.—Cedar Creek above Losey Street, Galesburg, June 29, 1914.

erous passers-by are assailed by odors that are exceedingly objectionable. Figure 23 shows the creek opposite the passenger station.

Where the creek borders the grounds of a well-kept cemetery between Main and Tompkins streets it constitutes a most decided nuisance. The condition of the creek behind the pumping station of the Santa Fe Railway near Maple Street is more or less characteristic of the stream from this point to the west boundary of the city. Below Maple Street the stream is somewhat discolored and the channel is partly filled by a sludge of carbonates of calcium and magnesium from the water-softening plant of the Santa Fe Railway.

A sewer near Henderson Street, serving a district of several hundred acres, enters from the southeast and materially augments the volume of sewage in the stream. Several minor sewers enter at Arthur Avenue and nearly south of Bandy Avenue, but they serve only small districts and their discharge has no visible influence on the grossly polluted stream. At the Santa Fe crossing just below the waterworks the creek is foul, sluggish, and malodorous.

Stations of inspection below the main sewer outlets of Galesburg are designated in order downstream by number (See Fig. 18, p. 203).

Figure 20.—Cedar Creek between Lincoln and Pearl streets, Galesburg, 1914, showing back yards.

At station 1, just below the outlet of the Henderson Street sewer, the creek is about 9 feet wide. The banks of the stream here and for one-fourth mile below are planted with willows, which constrict the channel and accumulate more or less rubbish. The water had become nearly black through putrefaction and very malodorous. It carried on its surface an oily film and numerous gas bubbles. The odor and appearance of the water were offensive March 16 though rather cold weather then prevailed. Probing the bottom indicated that the stream was filled to a depth of one foot or more with sewage mud impregnated with large quantities of tar, evidently from the gas works, which adhered tenaciously to the boots of the stream gagers.

The stream at station 2, a highway bridge near the farm of Mr. Granville Jones about one mile below station 1, is about 8 feet wide with an average middle depth of one foot. The water was black and differed little in appearance from the water at station 1, though there was somewhat less oil on the surface. The bed was filled with actively fermenting sewage sludge that gave off many bubbles of gas when disturbed. The sludge could easily be penetrated to a depth of 10 inches. Large growths of vegetation lined the banks but there were

Figure 21.—Cedar Creek at Kellogg Street, Galesburg, showing large sewer entering creek within 40 feet of house.

no green growths below the water line. Odors were distinctly perceptible one-fourth mile south of the stream on June 29. Mr. Granville Jones, who lives about one-eighth mile from this point, and a number of his neighbors who live at greater distances have frequently complained of the foul condition of the stream and became parties to the complaint submitted to the Rivers and Lakes Commission. It was stated by Mr. Jones that fish could be caught in abundance in the sixties and early seventies before the stream was polluted by the sewage of Galesburg; that before the natural flow of the stream was depleted by the waterworks of Galesburg the stream was then extensively used for watering cattle; that it was regarded as one of the attractive features of the landscape; and that its banks were extensively used for recreation. A general view of the creek at station 2 is given in Figure 24. Close examination of the photograph will reveal sludge banks on the edges of the stream and some floating matter on the surface. Land adjoining the creek in this vicinity is used ex-

Figure 22.—Dumping grounds near Kellogg Street, Galesburg.

tensively for pasturing and the stream would under normal conditions be available for watering stock.

Station 3 is about 1.4 miles below station 2. The odor of the stream is regarded as highly objectionable by those obliged to cross two highway bridges near this station. The sluggish stream is about 10 feet wide and 2 feet deep. Its banks support a heavy growth of weeds and its channel is more or less clogged by sticks, brush, and other debris. Tarry wastes from the gas works were still obvious, but in much less quantity than at preceding stations. The slack current favored a marked septic condition. About 18 inches of dark-colored sludge coated the bed of the stream and lined its banks. The sludge gave off on probing a vigorous ebullition of gas. A near-by farmer declared that the offensive odor was noticeable at distances of two miles during low-water periods, but this is rather difficult to believe. It is quite possible, however, that the odor may extend one-half mile under certain atmospheric conditions. The same farmer also declared that cattle drink from the stream.

When the stream at station 4, at a highway bridge about 1.2 miles below station 3, was inspected it was about 10 feet wide and 2 feet

Figure 23.—Cedar Creek opposite station of Santa Fe Railway, Galesburg.

deep. Marked decrease in the offensiveness of the water was noted on all inspections though the stream still showed distinct signs of pollution and gave off an offensive odor. Green scums were attached to the banks and floated on the water. The banks were heavily grown with weeds, and logs and branches obstructed the channel. Sludge deposits several inches deep in the bottom of the stream yielded on probing large quantities of gas.

The stream at station 5, at a highway bridge 1.8 miles below station 4, was at times of inspection about 10 feet wide and about 1.5 feet deep. No offensive odors could bo detected though a farmer living three-fourths mile away asserts that a most offensive stench is perceptible nuder certain conditions of wind and atmosphere. Warm humid nights were said to be especially favorable to objectionable conditions. At the first two inspections the water was grayish, the bottom was soft and readily yielded gas bubbles, and the evidence of sewage pollution was marked. During the last visit the water was sufficiently clear to show the bottom. More or less greenish-black sludge lay along the edges of the stream, and the mud in the bottom

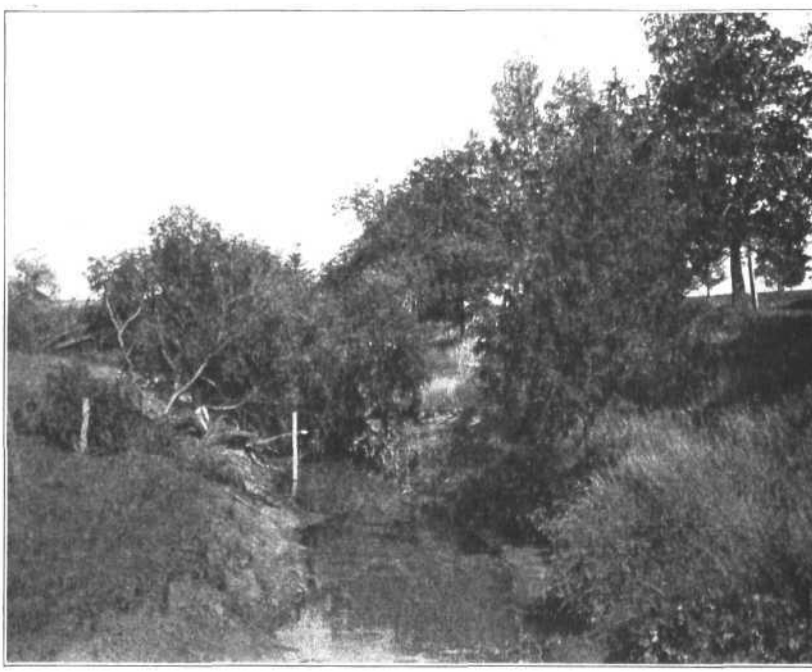
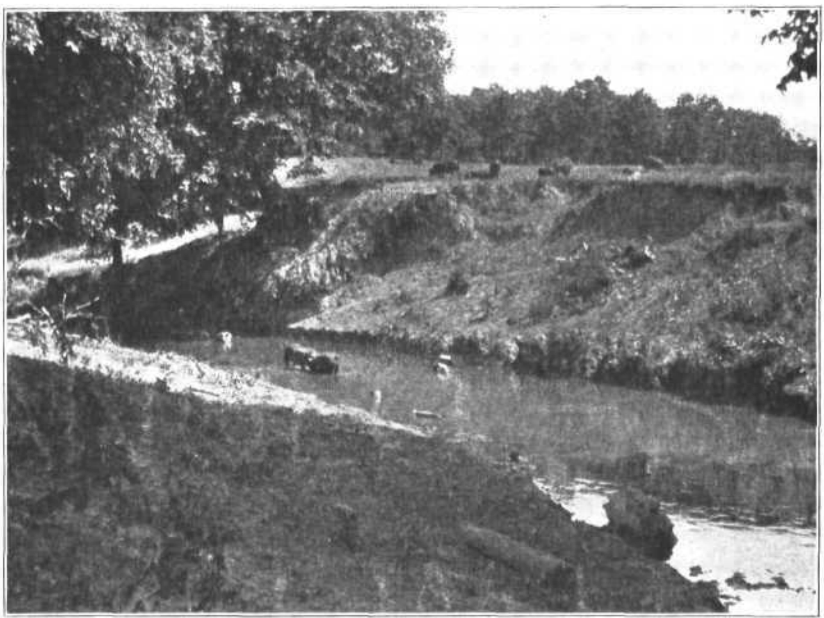


Figure 24.—Cedar Crock at station 2, Galesburg, showing sludge luniks and Hunting sewage.

when probed yielded much gas. There were sticks, vines, and logs in the channel. No fish life was observable.

Station 6 is near a highway culvert 1.8 miles below station 5. This station and the others farther downstream were inspected only once on June 29 and 30. Just above station G the stream meanders about one-fourth mile in a large pasture containing many cattle and hogs. The latter were wallowing in the bed of the stream and thus made it very muddy. (See Figure 25). Horses were freely drinking the water. The stream was moderately clear and gave no marked visible evidence of sewage pollution above the influence of the cattle.

Nevertheless a black muck, unmistakably of sewage origin, was uncovered at a depth of a few inches. Otherwise the bed was comparatively hard sand and clay. The stream was about 10 feet wide and the depth ranged from a few inches to several feet, apparently as a result of hog wallowing. Little vegetation occupied the banks of the stream because of the presence of cattle and hogs and no large growths suggestive of pollution were observed in the water. It cannot be said from evidence of the single observation made at this point that it was objectionably polluted except for the disturbance caused by hogs.



F'igure 25.—Cedar Creek at station 6, Galesburg, showing hogs wallowing in sewage-polluted stream.

Farmers familiar with the stream, however, state that pollution by sewage at times extends to this point.

Station 7 is at a highway bridge 2.2 miles below station 6. Below the bridge the stream was sluggish, its banks were overgrown by trees **and** weeds, and the channel was obstructed by brush and logs. It was about 10 feet wide and 3 to 18 inches deep in different places. The bed was principally mud though there was some gravel. The mud was suggestive of sewage sludge and evolved a few bubbles of gas. No odor, however, was perceptible in the vicinity of the stream, **but** the water was slightly muddy, possibly due to disturbance by wading animals.

Station 8 is about 3.5 miles below station 7 and 12.9 miles below station 1. The stream was 10 to 15 feet wide and varied in depth from a few inches to a few feet or more. It flows through pastures and the stock have free access to it. Hogs doubtless wallow in the channel and roil the water, but no evidences of pollution by domestic sewage were apparent. The channel above the bridge was consider-

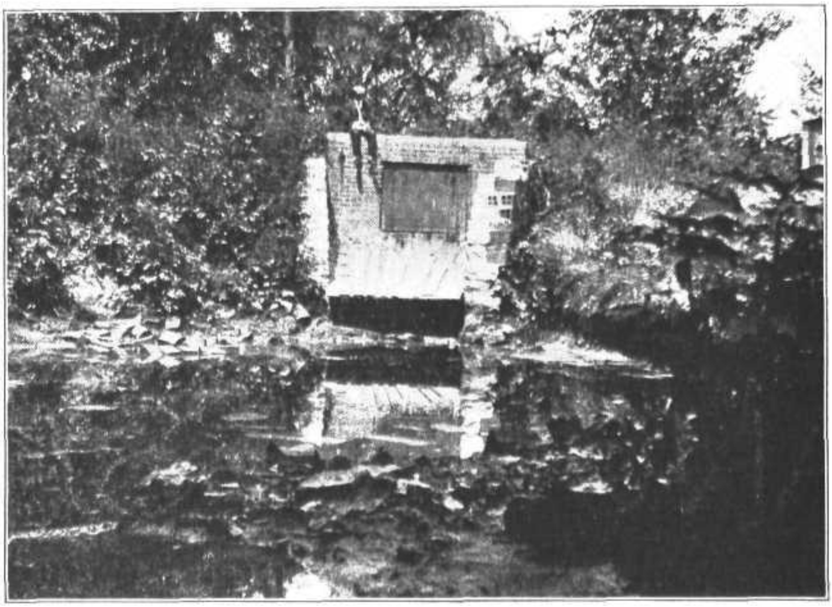
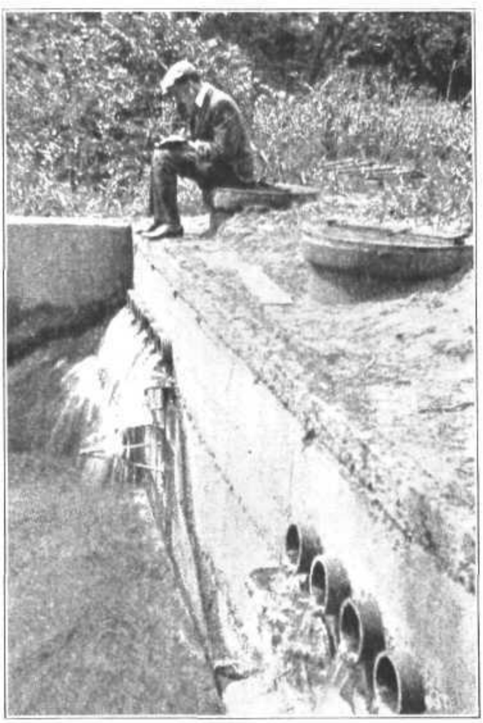


Figure 26.—Sedimentation tank at Monmouth showing place of direct discharge of sewage when the septic tank is cut out.

ably overgrown with vegetation and more or less obstructed. Little vegetation was observed in the water itself though there were small growths of green slime.

Station 9 is 3 miles below station 7, about 16 miles below station 1, and just above the entrance of a tributary draining the city of Monmouth. The stream above the station expanded into wide deep pools of nearly quiescent water. At the sampling station it was 25 feet wide and 8 inches deep. The water was turbid with a perceptible greenish hue due to chlorophyl-bearing organisms and the current was sluggish. Vegetation was luxuriant along the edge of the water but there were no slimes. No fish life was present but frogs were seen and heard. A few outcroppings of bedrock were noted along the channel. The stream on the whole had the appearance of an unpolluted country watercourse.

The tributary draining Monmouth has a catchment area of about 15 square miles and has no natural flow in dry weather. The entire flow at the time of inspection consisted oC the discharge from the sewers of Monmouth. This sewage is first passed through a septic tank about two miles above the confluence with Cedar Creek (See



Tigure 27.—Effluent outfall of septic tank, Monmouth.

Figures 26, 27, and 28). The liquid, though somewhat clarified, is very foul when it reaches Cedar Creek. It had a blackish color typical of rather stale sewage in a rapidly-flowing stream. Deposits of sludge and septic action were not in evidence because of the rapid current. A broad bend in the creek near the outlet has been by-passed by a trench 12 inches wide and 400 feet long; this removes the sewage rapidly from the vicinity of a highway bridge, where it would otherwise stand in pools and become offensive. Several complaints have been made regarding the condition of this stream, and some of the farmers along Cedar Creek are inclined to attribute the nuisance to sewage from Galesburg. There are no dwellings near the confluence of the tributary with Cedar Creek, but passers-by on two highway bridges below the septic tank frequently complain of the disagreeable odor. An attractive wooded area near the confluence, formerly extensively used as a picnic ground, has been practically abandoned for recreation because of foul odors.

Figure 28.—Bed of stream below diseharge at Monmouth. Sludge about 18 inches deep and very odoriferous.

Station 10 is just below the entrance of the tributary from Monmouth and one-tenth mile below station 9. The stream there was 10 to 25 feet wide and was more than 12 inches deep in few places. At points 200 feet or more below the tributary there was little evidence of sewage pollution. The bed of the stream is a mixture of sandy gravel and clay and is relatively firm. The surrounding land is used for pasture, and the banks are free from vegetation except for a few large trees. The conditions of Cedar Creek at this point could not possibly give rise to complaint on account of sewage from Galesburg though that from Momnouth may at times be offensive and undoubtedly the offensiveness will continue to increase. The sewage of Monmouth, according to the testimony of near-by farmers, has destroyed fish life in Cedar Creek in this vicinity. No evidence of fish life was observed at the time of inspection.

The results of inspections show that Cedar Creek is rendered exceedingly offensive in Galesburg by sewage and other wastes and that this offensive condition continues downstream at least 5 miles below the outlet during ordinary dry weather and may continue at times 7 miles below the outlet. The odors from the stream are unquestionably offensive to farmers living near the stream within the limits mentioned. The water is rendered unfit for all legitimate uses and its condition unquestionably depreciates seriously the value of bordering farm lands. Some reports of the pollution of the creek are exaggerated especially with reference to the extent of the pollution downstream for one or both of two reasons. First, hogs wallowing in the stream pollute the water and give it a turbid and unsightly appearance though such pollution does not tend to make the stream offensively malodorous. Second, the pollution by Monmouth apparently is sometimes ascribed to Galesburg. Monmouth, like Galesburg, is an offender, but to less extent, and property owners injured by the method of disposal of sewage from Monmouth have the same recourse for securing abatement of the pollution as have Granville Jones, *et al.* Though the complaint under which this investigation has been made relates to the stream below Galesburg the most serious conditions exist within the city itself; indeed it is difficult to understand how a city so large and apparently so progressive has endured existing conditions so long.

DISCHARGE

Permanent water-level gages were established at stations 1, 2, and 10, and persons living in the vicinity were requested to record the water level daily in order that these records may be used in conjunction with additional gagings to ascertain the daily discharge for a period of one year at least. The results of measurements of discharge are given in Table 11.

TABLE 11.—DISCHARGE AND GAGE HEIGHT OF CEDAR CREEK AND ITS TRIBUTARY.

Date.	Time.	Station.	Discharge.		Gage height.
			Second-feet.	*Gallons a day.*	*Feet.*
March 16	1 p.m.	1	3.02	1,954,000	
June 29	1 p.m.	1	2.20	1,426,000	
July 1	9 a.m.	1	1.55	1,003,000	0.79
June 29	3 p.m.	2	2.55	1,660,000	2.42
29	5 p.m.	6	2.17	1,410,000	
30	10 a.m.	7	1.64	1,060,000	
30	11 a.m.	8	1.70	1,103,000	
30	2 p.m.	10	1.71	1,110,000	2.48
30	3 p.m.	Monmouth tributary	.36	235,000	

The figures in Table 11 indicate downstream decrease of discharge but that is improbable and the variations must be ascribed to unavoidable inaccuracies of the method of measurement. The measurements do, however, show that the discharge of the stream is but little more than the dry-weather discharge of sewage from Galesburg, which according to the consumption of water is about 700,000 gallons a day. In other words any method of sewage treatment employed by Galesburg must be of such completeness that no diluting water will be required for the effluent. This means that the effluent must be nonputrescible and reasonably free from suspended matter. Quantities up to about three times the dry-weather flow can be treated to obtain such an effluent by a plant consisting of grit chambers, coarse screens, settling tanks, sprinkling filters, and secondary sedimentation tanks for the sprinkling-filter effluent, all correctly designed and properly managed. Provision must also be included for drying and disposing of the sludge removed from sedimentation tanks. Special treatment, possibly in sedimentation tanks alone, must be provided for additional volumes of storm water.

SANITARY ANALYSES AND BACTERIOLOGICAL EXAMINATION

As it was possible to collect for analysis only one series of spot samples from Cedar Creek below Galesburg the results of the analyses are more or less erratic because of variations from moment to moment in the composition of water at the various sampling points, which can be eliminated only by averaging the results on serial samples collected regularly at certain points during long periods. The results of the analyses confirm, however, in a general way the results of the inspections, and they also throw some interesting light on the changes that take place downstream in the composition of the water of Gedar Creek. The results of the analyses are presented in Table 12.

The sample taken at station 1 shows a weak domestic sewage in an active state of putrefaction. The only way, however, in which the general composition of the sewage could be determined would be to analyze a sample composed of portions taken at frequent intervals throughout twenty-four hours; it is also desirable to make the portions of the composite proportional to the discharge of sewage at the moment of collection; because of the difficulties of measuring the discharge of sewage at Galesburg this would probably be impracticable.

The turbidity is fairly high throughout the 151/4 miles covered by the sampling points. The marked increase of turbidity at stations 6 and 7 is due chiefly to agitation of the soft mud by wading hogs

TABLE 12.—ANALYSIS OF WATER FROM CEDAR CREEK, GALESBURG, JUNE, 1914.

[Parts per million.]

Station.	Hours of collection.	Day.	Turbidity.	Color.	Residue on evaporation.						Chloride.	Oxygen consumed.	
					Total.			Dissolved.					
					Total.	Fixed.	Volatile.	Total.	Fixed.	Volatile.		Total.	Dissolved.
1	11 a.m.	29	75	40	1,817	1,638	179	1,650	1,474	176	350	29.0	20.0
2	11:30 a.m.	29	45	80	1,024	880	144	1,004	874	130	190	17.1	18.0
3	12 m.	29	60	40	1,160	1,015	145	1,091	960	131	230	17.5	12.8
4	12:30 p.m.	29	60	50	1,296	1,163	133	1,274	1,154	120	300	17.0	12.8
5	1:45 p.m.	29	60	50	1,354	1,163	191	1,313	1,159	154	350	15.6	14.5
6	2:45 p.m.	29	225	100	816	685	131	633	527	106	60	17.2	16.6
7	3:30 p.m.	29	225	20	1,510	1,332	178	1,313	1,137	176	360	16.1	14.7
8	11 a.m.	30	60	25	1,128	979	149	1,065	942	123	275	14.8	13.3
9	12 m.	30	75	45	1,099	931	168	1,049	904	145	250	34.9	33.5
10	11:30 a.m.	30	90	45	1,294	1,151	143	1,231	1,088	143	260	25.9	21.0

Station.	Nitrogen.							Alkalinity.	Dissolved oxygen.		Ether-soluble matter.	Bacterial count.		
	Ammonia.	Albuminoid.		Organic.		Nitrite.	Nitrate.		Field.	After 5 days at 20° C.		Gelatin.	Agar.	Litmus-lactose agar.
		Total.	Dissolved.	Total.	Dissolved.									
1	19.0	8.68	2.64	3.92	3.84	0.001	0.44	406	0.0	0.0	5.6	1,200,000	495,000	80,000
2	14.08	1.120	.96	4.40	2.80	.001	.32	366	.0	.0	6.6	950,000	360,000	1,600
3	17.20	2.40	1.216	3.04	1.76	.001	.24	392	.0	.0	5.4	750,000	510,000	40,000
4	16.0	2.56	1.344	3.04	2.96	.001	.60	412	.0	.0	4.2	195,000	121,000	3,000
5	13.44	1.44	1.280	3.04	2.88	.001	.88	420	.2	.0	5.0	500,000	640,000	4,000
6	10.24	1.28	.752	1.76	1.52	.024	.80	280	6.8	.0	5.6	60,000	150,000	1,200
7	7.68	1.024	.672	5.10	4.50	.600	.92	460	7.0	.5	5.0	45,000	135,000	0
8	8.80	1.280	.80	4.40	3.60	2.500	.50	352	12.2	1.2	3.6	17,000	3,000	0
9	.64	6.80	2.56	8.50	7.90	3.000	.20	288	17.2	.0	9.6	....	2,000	0
10	3.04	1.52	1.12	7.30	6.70	2.400	.80	314	15.0	.0	4.0	11,000	7,500	0

and cattle. The increase of turbidity at the last two stations may be similarly explained. Color brings out nothing of great significance. The alkalinity determinations contain little of significance to this study. The slight decrease in alkalinity at station 2 and the successive increases downstream to station 6 probably indicate changes in the concentration of the sewage. Under ordinary circumstances this decrease in alkalinity would indicate a decrease in strength of sewage as the alkalinity of the water supply is greater than that of normal surface water in this region; but the alkalinity of this sewage is affected so much by the discharge of carbonate sludge from the softening plant of the Santa Fe Railway that little significance can be attached to these fluctuations.

The content of chloride of the water in the creek is much greater in all the determinations except two than the chloride content of the public water supply even when the deep wells are used. The difference in chloride generally parallels the difference in alkalinity exeept that the chloride difference is more pronounced.

The bacterial contents of the waters excepting that from station 6 show the reduction of pollution downstream in Cedar Creek. This reduction is most strikingly shown by the determinations on gelatin and by the marked reduction of the number of acid-producing colonies on litmus-lactose agar. The determinations on agar are somewhat more erratic. The determinations of ammonia nitrogen confirm the bacterial results and are less erratic. The apparent decrease in pollution at station 2 indicated in ammonia as well as in bacterial content leads to the conclusion that the sewage at station 2 represented the weak mid-morning sewage flow. The determinations of albuminoid nitrogen confirm those of ammonia nitrogen. The marked rise in albuminoid nitrogen at station 9 without a correspondingly large quantity at station 10 at first seems erroneous, but the observed greenish hue of the water at station 9, indicating the presence of microscopic organisms, and the tendency of the water to pond, thus producing specially favorable conditions for development of organisms, explain the increase of organic matter. Nitrite nitrogen is present in small quantity until station 7 is reached when it snows marked increase. The high contents at stations 8, 9, and 10 indicate pronounced self-purification of the creek water. Nitrate nitrogen was not present in large quantities.

The contents of dissolved oxygen are consistent with the inspections. Above station 5 no dissolved oxygen was found and throughout that section the stream was in an active state of putrefaction. At station 5, where offensive conditions ceased, a small quantity of oxygen was found. At stations 9 and 10 the water is supersaturated with dissolved oxygen; this coincides with the marked development of chlorophyl-bearing microorganisms in this part of the stream. Though these add to the organic matter of the water they are instrumental in purifying the stream by greatly increasing the content of oxygen. After 5 days' incubation at 20° C. the dissolved oxygen entirely disappears from the samples taken at stations 9 and 10, which were high in organic matter due to the presence of microorganisms. Under the conditions of incubation the organisms had no opportunity to replenish their oxygen and in their decomposition all the oxygen in solution was consumed. The oxygen consumed shows little of interest beyond that shown in the other determinations of nitrogen. The oxygen consumed by the suspended matter shows very clearly the self-purification of the stream. The residues on evaporation are chiefly mineral matter and throw little light on sanitary conditions. The total content of suspended matter ranged from 20 to 197 parts per million, and the content of dissolved matter, except that of the sample collected at station 6, ranged from 1,004 to 1,650 parts per million.

PREVIOUS INVESTIGATIONS

Elimination of the nuisance caused by pollution of Cedar Creek within the city limits has long been before Galesburg, and successive municipal administrations have sought some solution of the problem that would meet the approval of the people. The results of the first extensive investigation were presented April 25, 1900, in a report by Alvord and Shields, consulting engineers. Three projects were presented as follows:

Project 1. Installation of intercepting sewers for carrying about six times the dry-weather flow to sewage-treatment works and improvement of the channel of Cedar Creek by deepening and straightening it in several places to facilitate the discharge of flood waters.

Project 2. Installation of intercepting sewers for carrying about six times the dry-weather flow to sewage-treatment works and paving the channel of Cedar Creek with a semicircular invert section of masonry so constructed that it may be covered at some future date with a semicircular arch.

Project 3. Construction of a large combined sewer along the course of Cedar Creek for carrying both dry-weather flow and storm flows now carried in the open stream and interception of about six times the dry-weather flow near Henderson Street to be diverted to sewage-treatment works. Sewage-treatment works included in all three projects comprised a combination of septic tanks and double contact beds with an area of 3.64 acres. Project 3 was strongly recommended though it was stated that project 1 would be the cheapest. The estimated cost of project 1 with purification works was $139,-945, and of project 3 was $218,695. These estimates include also the cost of construction of several connecting sewers necessary to join existing systems to the interceptors or to the main combined sewer. In estimating the capacity of sewers necessary to convey storm water it was assumed that a rainfall of 2 inches an hour must be provided for and that local conditions would give a maximum run-off at the outfall of 650 second-feet. None of the projects contemplates marked modification of the existing system other than the short connecting sewers just noted.

Hering and Fuller, consulting engineers, submitted November 6, 1903, a report in which they definitely recommended construction of a trunk combined sewer along the general course of Cedar Creek, construction of various systems of main and submain branches, and construction of purification works. This report gave particular attention to the sewerage system as a whole and pointed out the present difficulties in effecting drainage of cellars in the north and south parts of the city. It was, therefore, recommended that the trunk sewer be placed at a considerably lower level than had been proposed by Alvord and Shields in order to secure better grades and to make greater areas tributary to the laterals entering the trunk sewer. Improvement of the present channel for carrying off storm water was considered neither desirable nor economical. The first cost would probably be relatively small, but the deepened channel deemed necessary by the engineers involved a large cost for maintenance and also for maintenance and construction of new bridges. Furthermore, unless large sums of money were spent for landscape features the open ditch would be exceedingly unsightly and would prevent the utilization of valuable areas that would be rendered available by a covered channel. Attention also was called to the fact that the open ditch would not eliminate all nuisance as the first overflow from the sanitary interceptor during a storm would be offensive; and that, moreover, the storm-water diversion chambers which would be always likely to be out of order would sometimes admit dry-weather sewage into the open ditch. In estimating the quantity of storm water to be conveyed it was assumed, as in the report of Alvord and Shields, that a rainfall of 2 inches an hour should be cared for, but it was proposed to take care of only 1.75 inches an hour in the trunk sewer while the remaining 0.25 inch would be carried off in surface channels. Without reference to any special floods the report noted a run-off that is nearly twice the maximum referred to in the report of Alvord and Shields. Moreover, Hering and Fuller's computations led them to recommend a maximum carrying capacity of trunk sewer of 1,000 second-feet at its lower end as compared with 650 second-feet recommended in the earlier report. The report of Hering and Fuller recommended a trunk sewer of horseshoe section, 12 feet 6 inches by 13 feet 6 inches with side channels. The side channels were for conveying dry-weather flow to a point below all tributaries, where it might be intercepted for diversion to purification works. The purification was to include as main features septic-tank and single contact treatment. The septic tanks were to have a detention period of about 12 hours and the contact beds were to have a total area of 2 acres. The total estimated cost of the interceptors alone recommended by Hering and Fuller was $239,940, or 96 per cent greater than the estimate of Alvord and Shields. The difference in cost is principally represented by a sewer of larger size, more substantial construction, and greater depth, and by more liberally estimated cost. The purification works provided less purification" than the works outlined by Alvord and Shields, yet the estimate of cost was placed at $86,000, as against $55,550 for the project outlined by Alvord and Shields. The difference in cost here is difficult to explain, but it is partly due to more liberal estimates by Hering and Fuller of the cost of materials and construction.

Both reports include acceptable means, in so far as the pollution of Cedar Creek is concerned, for removing the storm water and sewage, but the project of Hering and Fuller is more comprehensive and more liberally designed. The estimates of cost in the two reports do not afford fair basis for comparing the relative merit and practicability of the projects as they are evidently based on different unstated cost units and possibly on different classes of material not fully specified. The purification works in each report represent what was regarded as best practice when the reports were prepared, but the art of sewage purification has made very rapid advances in the last few years, and it would be very unwise to construct either of the plants recommended. It is possible now to construct with newer devices a plant that would give better results at much less cost. Though both reports contain much valuable material and many excellent suggestions and recommendations it. would be highly desirable before attempting the preparation of detailed plans and specifications to have the entire problem reviewed, possibly by the same engineers, for the purpose of bringing all the recommendations into conformity with present practice in construction and methods of design. One feature that was not sufficiently considered in either report should be thoroughly studied before any definite conclusions are reached; namely, the quantity of storm water in addition to the dry-weather flow that should be treated before the discharge of any sewer is permitted to flow into Cedar Creek. This would involve the maintenance of sewage-flow records, collection of stream-discharge measurements by means of automatic registering gages, and careful study of the composition of the sewage, not only during dry weather but also from minute to minute following the onset of storms. Further than this, careful observations during storm flows should be made at various points on Cedar Creek below the outlet of the proposed sewer with a view to determining the effect of storms of various magnitude on the pollution of the creek.

CONCLUSIONS

The problem at Galesburg from a sanitary and an engineering point of view consists in preventing a nuisance in Cedar Creek under conditions imposed by the following factors, which have been stated and discussed in the body of this report:

(1). A dry-weather daily discharge of sewage now of about 700,000 gallons and a probable daily volume in 1935 of 3,000,000 gallons.

(2). The presence in the sewage of very troublesome gas-house wastes, probably not exceeding 8,000 gallons a day.

(3). A flow in Cedar Creek that is practically nothing during ordinary dry weather and that is rarely sufficiently large to be available for dilution.

(4). An objectionable influence of pollution extending 5 to 7 miles downstream during ordinary low-water stages causing bad odors for one-half mile or more on either side of the stream and rendering the water unfit to be drunk by cattle or to be used for other legitimate purposes.

(5). The existence of a comprehensive system of combined sewers, which prevents the complete separation of dry-weather sewage and storm water for disposal.

(6). The existence of 20 or more sewer outlets into a small and constricted channel, which necessitates either extensive improvement of the channel and construction of dry-weather intercepting, sewers or construction of a large combined trunk sewer with provisions for diverting a suitable part of the flow for treatment.

(7). The necessity, because of lack of dilution, of intercepting and treating part of the. storm flow in addition to the dry-weather flow.

EECOMMENDATIONS

In the light of the foregoing conclusions and other considerations presented in the body of the report, the following recommendations have been submitted:

(1). That the city of Galesburg be required on or before July 1, 1918, to so collect and dispose of sewage and storm water from the city that offensive conditions in Cedar Creek below the city will be effectively eliminated; and that it be understood that not more than a year of the period granted shall be used for preliminary investigations and the preparation of plans and specifications prior to actual construction.

(2). That in view of the lack of data on variations in the discharge of Cedar Creek and on the quantity and character of sewage and storm water entering the creek the city should be advised that the following observations should be made, covering at least one dry season and one wet season, as a prerequisite to the economical design of interceptors and sewage-treatment works.

(a). A continuous record of water level in Cedar Creek just below the city by means of an automatic recording water-level gage.

(b). Enough measurements of discharge to give a reliable rating curve for all gage heights. It will probably be found most convenient to measure small discharge by means of a weir.

(c). Complete rainfall records by means of an automatic rainfall gage that will indicate minute-to-minute variations in the rate of precipitation.

(d). Numerous analyses of sewage and storm water especially during the onset of storms.

(e). Frequent inspections and analyses of the water of Cedar Creek below Galesburg. These inspections should cover all variations of flow, and special attention should be given to observing the influence of storms of various magnitude.

(3). That the city be advised to procure at once, competent engineering and other expert assistance to plan and make the studies herein recommended and to prepare on a basis of such studies complete plans and specifications, estimates, and other matters necessary for placing the project before the public for raising funds.

(4). That the city be advised to submit all plans and specifications to the State Water Survey for review and approval prior to the awarding of contracts.

POLLUTION OF THE CHANNEL OF MISSISSIPPI RIVER BETWEEN ROCK ISLAND ARSENAL AND THE CITIES OF MOLINE AND ROCK ISLAND

By Paul Hansen and M. C. Sjoblom.

There was submitted June 23 to the State Water Survey by the Rivers and Lakes Commission a complaint from the Fish and Game Commission regarding pollution of the channel of Mississippi River between Rock Island Arsenal and the cities of Moline and Rock Island. This complaint was investigated by the State Water Survey July 21—23, and a detailed report thereon has been prepared.

The cities of Moline and Rock Island are on Mississippi River opposite Rock Island, on which is situated Rock Island Arsenal of the Federal government. Rock Island divides the river into two channels; the flow in the minor channel, on the Illinois side, is controlled by a dam constructed for development of power. at Rock Island Arsenal. The mean minimum discharge is estimated by Federal engineers at about 5,000 second-feet, which is entirely adequate to dilute the sewage from both cities without production of a nuisance. The complaint did not relate to domestic sewage but to oily and tarry wastes which emanate chiefly from the gas works of the Peoples Power Co. and partly from the factories of the J. F. Lewis Manufacturing Co. and the Velie Motor Co.

It was alleged that the bottom of the river is coated with tarry deposits which influence fish life to such extent that all fish caught in the channel on the Illinois side below the gas works have so distinct a taste of gas-house wastes that they are totally unfit for food; that this influence at times extends downstream as much as 12 miles; that large areas of the surface of the stream fully 1½ miles below the waste drain of the gas works is covered with unsightly oily film's, which adhere to all kinds of water craft and thus make their hulls very unsightly; and that when the deposits on the bottom are agitated by propellers or paddle wheels they float and have similar effect. Characteristic gas-house odors are also objectionable near the river below the drain, but complaint regarding these odors was not made. Briefly, the river at and below Rock Island is seriously contaminated by the wastes from the gas works and the other factories, fish life within a certain area is rendered unsatisfactory for food, and the hulls of water craft are damaged.

The gas works manufacture water gas only and have a capacity of 2,000,000 cubic feet per 24 hours. As the plant is usually operated only 12 hours a day the average daily production of gas is about 800,000 cubic feet. The liquid wastes which are responsible for the objectionable conditions in the river consist principally of the wastes from the scrubbers, which contain some tar and oil. Most of the tar, which is a valuable by-product, is recovered in settling tanks and sold. The oily wastes, which are relatively small in quantity though they cover a very large surface when they spread out on the water, are not recovered. In addition to those from the scrubbers, there are other miscellaneous wastes, such as drips, sealed-pot liquors, and overflows from tar reservoirs and tanks, which could be collected in one drain for treatment. It was impossible to secure a reliable estimate of the quantity of objectionable wastes, but they probably would not exceed 15,000 gallons a day.

The company now maintains a plant for purifying the wastes before discharging them into the river, but the plant is incorrectly designed and is very inefficient. It comprises 2 sedimentation tanks and 2 coke strainers. Each sedimentation tank is 5 feet feet wide, 10 feet long, and 8 feet deep; this gives them a combined capacity of 6,000 gallons, representing a retention period based on the assumed volume of wastes of about 9½ hours. Each coke filter is 4½ feet wide and 16 feet long, has a screen with 1,4-inch mesh in the inlet corner, and is filled to a depth of 3 feet with coarse coke. The liquid enters one end of each filter from the adjoining sedimentation tank and passes diagonally partly downward and partly laterally through the coke about midway of the tank, where it is deflected abruptly downward and then abruptly upward by baffles into the second section filled with coke, at the end of which it is again deflected downward and upward and is decanted into the river. The filters are too small to perform their function properly; moreover they are incorrectly designed and the filtering material is too coarse. The coke may effect slight straining, but at the time of inspection its effect on the wastes was practically negligible because the coke had not been renewed for some months. The effluent, as it entered the river, created extensive oily films.

A suitable plant for treating the wastes would consist of a seditation tank, a chemical-treatment tank, and a filter containing fine coke. These installations are briefly described in the following paragraphs.

The sedimentation tank should have sufficient capacity to detain the wastes for 3 to 5. hours, during which the heavy tarry matters may be recovered from the bottom and the light oily wastes may be withdrawn from the surface. This tank may advantageously be heated in order to facilitate the separation of oil and tar. A suitable design would be a concrete tank 5 feet wide and 20 feet long, arranged with a series of hopper bottoms to facilitate drawing off the tar and a series of slightly submerged baffles at the surface to hold back and to divert the oily film through suitable outlets controlled by valves. A duplicate tank would permit repairs and cleaning without interrupting treatment of the wastes.

The chemical-treatment tank should have a retention period of about 3 hours and should be so arranged that the influent may be treated with milk of lime at the rate of 3 pounds per 1,000 gallons of dry calcium oxide. A suitable design would be a concrete structure 5 feet wide, 14 feet long, and 7½ feet deep. A hopper bottom would facilitate drawing off the sludge while the tank is in operation, but it might be necessary from time to time to empty the tank; consequently a duplicate tank should be provided.

The filter should be composed of fine coke with a depth of 2 to 3 feet, and it should have such area that the rate of filtration will not exceed 50 gallons per square foot per 24 hours. This filter should be arranged for downward filtration inasmuch as this would concentrate the matter filtered from the wastes at the surface, from which they may be readily removed. The filters may be located in a space 25 feet square, approximately equivalent to 600 square feet, which should be divided into three or four units, so that one may be cleaned or repaired. without unduly increasing the rate of filtration in the other units. Suitable devices should be placed on the beds to distribute the wastes gently to avoid eroding the surface, and an outlet should be provided which would keep the surface of the filter continually covered with liquid; this arrangement should be adjustable so that the filtering head may be increased as the filter becomes clogged up to a maximum head of 4 or 5 feet. This adjustment can perhaps best be obtained by narrow stop planks, which may be added one by one as greater head is required to force the liquid through the filter. It will be necessary to remove occasionally the filtering material, which may be dried and used under boilers, as the filtering material and the tar and oil which it retains are readily combustible.

The J. F. Lewis Manufacturing Co. is engaged chiefly in the manufacture of tar roofing and other building materials that involve the use of tar. The wastes from their plant consist of oils and tars that are carelessly permitted to escape from storage tanks and tank cars. Exercising a little care to keep these wastes out of the river would seem to constitute adequate relief from pollution from this plant. If it is impossible to prevent a certain amount of wastage this wastage should be collected in suitable drains and the liquids should be treated in a Jnanner similar to that suggested for wastes from the gas works.

The objectionable effluents from the plant of the Velie Motor Co. consist of oily wastes washed from the machinery and the manufactured products. These are comparatively small in quantity, yet the oil spreads over so large an area when it is discharged into a watercourse that it is very unsightly. Much of this oil probably could be recovered by added precautions, but if this is impracticable adequate relief could probably be obtained by constructing a small sedimentation basin arranged to trap the oily wastes.

It was recommended that the Peoples Power Co., the J. F. Lewis Manufacturing Co., and the Velie Motor Co. be required on or before July 1, 1915, to install arrangements effectively to prevent the entrance of oily and tarry wastes into Mississippi River. A copy of this report was sent to the Peoples Power Co. to serve as a suggestion for remedying present objectionable conditions.

INVESTIGATION OP AN OUTBREAK OF TYPHOID FEVER AT SPARTA

By Paul Hansen and H. F. Ferguson.

INTRODUCTION

At the request of the State Board of Health the prevalence of typhoid fever at Sparta was investigated on December 23 and 24. Sparta, an agricultural and mining community, is in the northeast part of Randolph County in the drainage basin of Marys River, a tributary of the Mississippi. Its population in 1910 was 3,081. The rolling land affords good natural drainage east and south.

A public water supply owned by a private company has been in use since 1908. The water is obtained from 2 small reservoirs south of town and a well about 400 feet deep at the waterworks. The limited supply is unsuitable for domestic use, and a new and larger impounding reservoir with a mechanical filter and a comprehensive distribution system are being constructed. Water for domestic use is now obtained from shallow dug wells and cisterns, many of which are subject to contamination.

As there is no public sewerage privies are generally used. Most of them are poorly constructed and are placed dangerously close to cisterns and wells. Private drains and overflows from cesspools that have been installed discharge into two ditches in the south and east parts of the city. During warm weather the ditches become offensive and have been the cause of numerous complaints. Though some persons have attributed the typhoid fever to these ditches, as a matter of fact the privies are more insanitary and more likely to cause typhoid fever than the ditches as they pollute the soil near wells and furnish breeding and feeding places for flies. Construction of a combined system of sewers was considered about four years ago, but the proposition met with much opposition and was dropped because an adequate water supply was not then available to permit full use of a sewerage system. Construction of sanitary sewers will undoubtedly follow the present installation of an adequate water supply, however, and private drains and insanitary privies should then be abandoned.

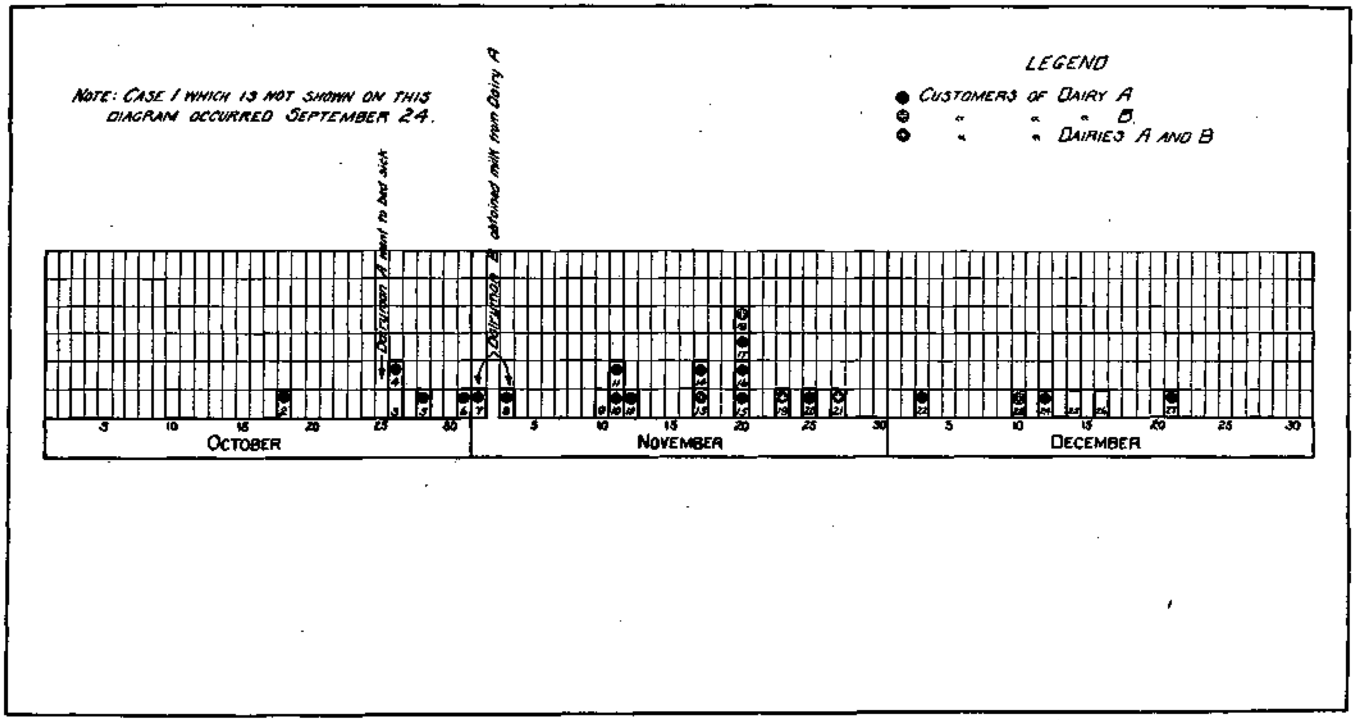


Figure 29.—Diagram showing chronological distribution of cases of typhoid fever at Sparta.

SUMMARY

The usual scarcity of records of transmissible diseases generally found in small communities was a serious obstacle in making the investigation, but the data relative to the 27 cases involved in the outbreak pointed conclusively to infection by milk from a dairy in the eastern part of the city. The fact that the outbreak lacked the explosive characteristics that would result from general infection of the supply indicates that only part of the milk sold or delivered to customers was infected. The owner of the dairy was unwell for some

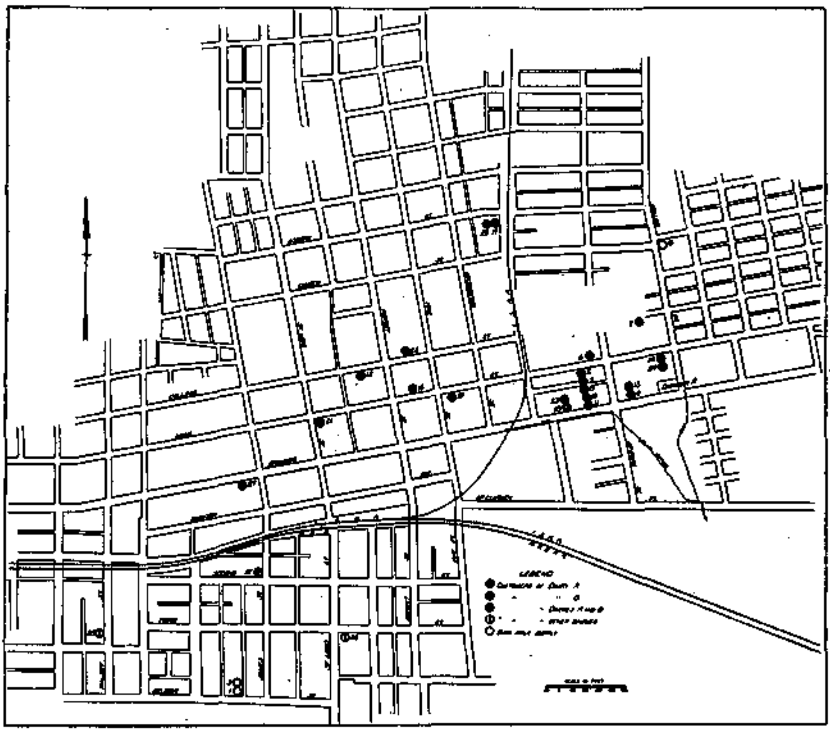


Figure 30.—Map of Sparta showing location of cases of typhoid fever.

time before the outbreak and went to bed just before the eases began to develop. His trouble was not diagnosed as typhoid fever, though no Widal tests were made. Many symptoms of his sickness were typical of typhoid fever, and circumstantial evidence indicated that the dairyman had that disease in so mild form as to permit him to handle the milk and thus occasionally to. infect portions of it before his illness confined him to bed.

This outbreak is a striking example of the need of adequate sanitary supervision of milk supplies and it illustrates the danger of allowing persons not in good health to be employed in the business. Several cases that occurred later in the houses occupied by earlier cases indicate contact infection. This resulted from the lack of appreciation of the necessity of sanitary precautions on the part of persons who nursed cases. This was especially true with reference to disinfection and disposal of discharges from patients.

THE OUTBREAK

According to statements of local physicians and city officials typhoid fever has been more or less prevalent in Sparta for several years. Cases are not reported by physicians and consequently it was impossible to obtain vital statistics, but the rate apparently has been high. The outbreak comprised 27 cases with 2 deaths between September 24 and December 21. Figure 29 shows the chronological distribution of the cases numbered in order of their occurrence. Four cases started on one day, 2 cases started on each of three days, and the other cases started on the separate days indicated. The cases were not confined to one section of the city, as shown in Figure 30, in which the location of each is indicated. Some are on high ground and others on low ground near the ditches. The only semblance of grouping is in the east part of the city where six houses within two blocks contained cases. The 27 cases were distributed among 19 families as follows: one family had 5 cases; each of 5 families had 2 cases; each of 12 families had one case. The aggregate membership of the families was 75, and 36 per cent of this number had the disease. The cases (See Table 13) were not confined to any age though the majority of the cases were among persons less than 20 years old. Sixty-three per cent of the cases were males and 37 per cent were females.

TABLE 13.—DISTRIBUTION OF CASES BY AGE AND SEX.

Age.	Males.	Females.	Total.
Years.			
4 or younger	2	3	5
5—9	4	1	5
10—19	6	1	7
20—39	4	4	8
40 or older	1	1	2
	17	10	27

There had been no general social gatherings immediately before the outbreak, and the occupations of the patients did not bring them together. Nine stayed at home, 7 were employed away from home, and 12 attended school, some in grammar and some in high school. The 7 persons employed away from home were distributed among 5 different occupations.

The water supplies used by the patients were obtained from private wells and cisterns, and very few had used water from the same wells. Most of the wells at Sparta undoubtedly are subject to contamination, but it is unreasonable to believe that the water of so many wells in different localities should have become infected at the same time. The usual data regarding oysters and other foods eaten raw were obtained; no such foods had been used in common by even a small group of the cases.

The distribution of the cases according to the milk supplies that they used is shown in Figure 29 and is summarized in Table 14. Two cases are counted twice in the table because they were customers of both A and B. B is the largest dealer and the only one maintaining a wagon delivery; his daily sales amount to about 130 quarts. A's business is small and his customers come after their milk. C and D do not operate dairies commercially as each keeps only a cow or two, primarily to furnish milk for his own use but occasionally to supply milk to neighbors as an accommodation. Eighteen, or 67 per cent, were customers of A. This indicated that the infection might have come from the milk furnished by A and further inquiry confirmed this belief.

TABLE 14.—DISTRIBUTION OF CASES BY DAIRYMEN.

Dairyman A	18 cases.
Dairyman B	6 cases.
Dairyman 0	1 case.
Dairyman D	1 case.
Three private supplies (each)	1 case.

A lives in the east part of the city and had at that time 7 cows. The milk and the dairy utensils were cared for at his house. His house is kept very neat and clean; though there are no special facilities for washing and sterilizing the utensils they are kept cleaner than in many other dairies where special equipment is lacking. A did the milking and his wife assisted in caring for the milk and the utensils at the house. As no delivery was maintained customers brought their own pails for the milk. Surplus milk was made into butter, and this butter and the buttermilk were occasionally delivered by A in town. For some time before the cases of typhoid fever began to develop A had not felt well, and on October 25, just as the cases of typhoid began to appear, his illness became so pronounced that he went to bed where he was still confined at the time of the inspection. That the infection had come from milk supplied by A was corroborated by studying the supply furnished by B. Two of the 6 cases on the route of B were also regular customers of A. The other four (Cases 12, 13, 18, and 23) bought milk regularly and exclusively from B. On November 1 and 3 B procured milk from A to supplement his own supply, and the 4 cases above noted occurred 11, 16, 19, and 39 days after they were first supplied by B with milk from A. The last of these (case 23), occurring 39 days after using milk from A, was probably a secondary case resulting from contact with case 18, a member of the same household. The time of development of the other three cases would strongly indicate that they had received their infection through milk from A supplied to them on two days by B.

B, who lives in the west part of the city, has by no means an up-to-date dairy, but an effort is made to keep things fairly clean and in good condition. Facilities and equipment for a dairy of that size, however, are lacking, and all water is drawn by bucket and rope from a shallow dug well. Water for washing the dairy utensils is heated on a small stove in the milk house, but sterilization is not attempted. It is doubtful if the utensils are always adequately washed and rinsed owing to the inaccessibility of the water supply. There was nothing, however, that would indicate that infection had in any way originated at B's dairy, but this dairy became involved only through purchase of milk from A.

Five cases(Cases 1, 3, 9, 25, and 26) had not used milk from either A or B. Case 1 was a boy about 9 years old, who was taken sick September 24. No information obtainable threw any light on the source of his infection. Case 3 occurred in the same family as case 1, and 32 days thereafter, and undoubtedly was a secondary case. Case 9 was a young girl attending high school, who had visited relatives about the city and may have incurred infection during such visits though no definite information on this point was obtainable. Case 25 was a small child in a family at whose home the washing for the family containing 5 cases was done. It may be, therefore, that this child was infected by means of clothes or bed linen used by earlier patients. Case 26 was attending school at Quincy and came home sick and, therefore, received his infection outside of Sparta.

INVESTIGATION OF DISPOSAL OP CORN-CANNERY WASTES AT EUREKA

By Paul Hansen and Ralph Hilscher.

During 1914 the State Water Survey continued in a general way the study of the disposal of wastes from canning factories that was conducted in 1912 and 1913 at the cannery of Dickinson and Co., at Washington (See Bull. 11, 339-373). The recent studies have been made on wastes from another corn cannery of Dickinson and Co., at Eureka. Before the experimental studies and the installation of the waste-disposal plant at their cannery in Washington, described in Bulletin 11, Dickinson and Co. had received complaints regarding the pollution of a small watercourse by the wastes from their corn cannery at Eureka. After a few unsuccessful experiments, Consisting of sedimentation and treatment with various chemicals, had been conducted temporary relief was obtained by extending the outlet from the factory downstream about two-thirds of a mile, well beyond the inhabited portion of the city. There had been no serious objection to the condition of the stream since the outlet had been extended, but, knowing that the creek became foul and having learned of a simple means of relieving the conditions through the studies conducted at Washington, the company decided to prepare irrigation beds for disposal of the wastes from their factory at Eureka. The waste at Eureka is similar in character to that produced at Washington, analyses of which are given in Bulletin 11. It has a milky appearance and it contains floating kernels, silks, and pieces of husks and cobs. It has the characteristic odor of corn, not disagreeable but objectionable to some. It is putrescible but decomposes more slowly than domestic sewage or waste from pea canneries. No measurements were made of the quantity of the waste, but on the basis of measurements made at Washington the quantity may be estimated at 10,000 to 50,000 gallons a day.

For treatment the waste is first passed through a screen at the factory having slots about one-half inch wide. It then flows about two-thirds of a mile through a tile to the disposal site, where it is collected in a 3,000-gallon sump. A motor-driven centrifugal pump started and stopped automatically by the rise and fall of the level of the liquid lifts the waste to irrigation beds. No settling tank is used. As the soil at the disposal site at Eureka is slightly more compact and less absorptive than that at Washington and the quantity of waste to be treated is larger it seemed advisable to prepare a larger distribution area than that used at Washington; consequently 6 beds, each of one-half acre, were laid out. The results obtained without a settling tank indicate that sedimentation is not absolutely necessary. Some kernels reached the beds, but the deposit was not heavy enough to interfere with absorption of the liquid by the soil and the decay of this solid material was not accompanied by noticeable odor. No attempt was made to use the beds in rotation. The waste was discharged at one point and allowed to flow from one bed to another through breaks in the dividing embankments. The soil was so dry that no trouble was experienced in disposing of the waste in this manner until two or three days of heavy rain occurred. The beds then became water-logged and the waste accumulated on the surface, decaying and becoming slightly odoriferous. Hereafter it is proposed to observe a strict rotation of beds.

The question arises as to what will be the ultimate effect of applying year after year finely divided organic matter on the soil of the irrigation beds. As the looseness and absorptive ability of a loamy soil like that at Eureka and Washington depends largely on the presence of plant roots continuously in the process of decay and as the beds are dosed only a few weeks each year the practice of raising deep-rooted crops has been recommended as a means of maintaining soil porosity. No opportunity has yet been afforded to observe whether any fertilizing effect has resulted from irrigation with the cannery wastes because little vegetation has been allowed to grow on the beds. Vegetation did not thrive on the beds at Washington, but this is ascribed to the presence of considerable salt deposited by the strong brine used in grading peas during the pea-canning season.

EXHIBIT OF THE STATE WATER SURVEY AT THE STATE FAIR, 1914

Definite information regarding the work of the Illinois State Water Survey was brought to the attention of the general public through an exhibit at the State Fair in 1914. Though most water-works men and many city officials are familiar with the work of the Survey it is safe to say that only a very small part of the general public has heretofore been informed regarding its functions and activities.

The exhibits were placed in the Exposition Building adjoining the booths of the State Board of Health[1] in a position where they could be viewed daily by thousands of visitors. The interest shown by the majority of these passers-by in one or more of the several exhibits displayed by the Survey was very gratifying. The exhibits included a large map of Illinois showing the character of the various public water supplies, a panel showing the benefits derived from the treatment of water for the removal of hardness by means of lime and soda, a panel showing the benefits derived from the treatment of water for the removal of iron by aeration and filtration, a model of a small municipal water filter, two miniature sanitary privies, and a model of a small municipal sewage-treatment plant.

A large map of Illinois mounted in a wooden frame was dotted with colored flags to indicate the character of municipal water supplies. White flags indicated cities and villages having public water supplies. White flags indicated cities and villages having pure public water supplies, red flags waters of questionable quality, and black flags with skull and crossbones indicated cities and villages having contaminated and unsafe waters. The map brought out clearly the relatively large number of unsafe or questionable supplies in the southern part of the State, in which surface water must generally be used in the absence of sufficient ground water free from objectionable mineral ingredients, like salt. Though these surface waters may be rendered safe and satisfactory by suitable treatment purification plants have not yet been installed so extensively as is desirable. The map also showed the relatively large number of safe supplies in the

[1]Exhibits of the State Board of Health were described in, Illinois Health News, 1, 37, (1915).

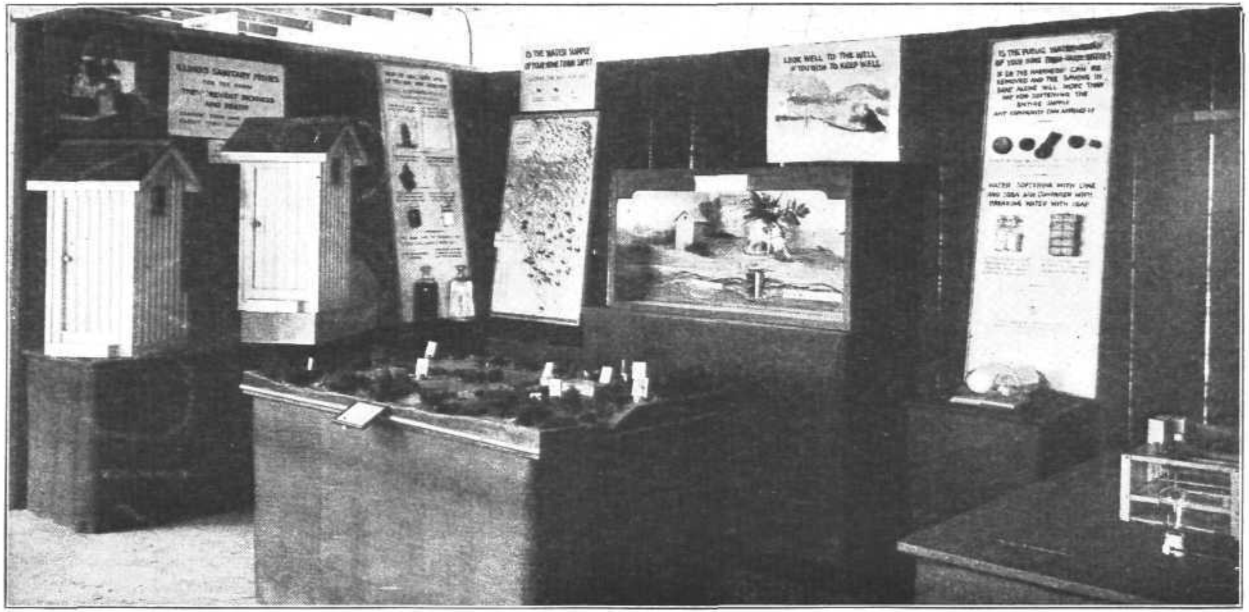


Figure 31.—Exhibit on water supplies and rural sanitation, Illinois State Fair, 1914.

northern part of the State, in which potable water tinder artesian pressure is generally available from deep rock wells. The exhibit attracted much attention and visitors were frequently found seeking the rating of the water supplies of their own and neighboring municipalities.

A large panel displaying specimens of hot-water pipe that had become clogged with incrustation and graphic models showing the quality and cost of soap as compared with the quantity and cost of lime and soda needed to soften a given water strongly contrasted the desirability and economy of soft clear water with that of hard water. To visualize the difference between hard and soft water in the laundry two half-gallon bottles, each containing the same weight of soap, were half filled, one with a sample of the Springfield water supply and the other with a sample of the same supply after It had been softened. The mixtures were agitated by a shaking device. The bottle containing the hard water showed merely a soapy curd, but the other containing the softened water developed a copious iather.

Another large panel displayed various articles showing the destructive effects of iron stains. Near the top were two pieces of white tile, one showing rust stains that had been produced by dripping on it an iron-bearing water. The other remained absolutely white after having been subjected to the same treatment but with water from which the iron had been removed. One of two fine lace handkerchiefs below the tiles was dirty red in color as a result of having been washed in an iron-bearing water and the other, which had been washed in the same water after the iron had been removed from it by special treatment, was pure white. Below the handkerchiefs were two large bottles, one of which contained a water colored deep reddish, representing many iron-bearing ground waters of Illinois, and the other of which contained crystal clear water representing the desirable condition that may be attained by treatment of iron-bearing waters.

Another model represented in miniature the general arrangement and construction of a small-sized water-purification plant. The models included were coagulation and sedimentation tanks, sand filters, and a clear-water reservoir, together with necessary piping and controlling devices.

The two miniature privies designed by the Survey illustrated how such structures can be built to conform to sanitary requirements and can also be made reasonably presentable at small expense. Each person making inquiry regarding this exhibit was given a small

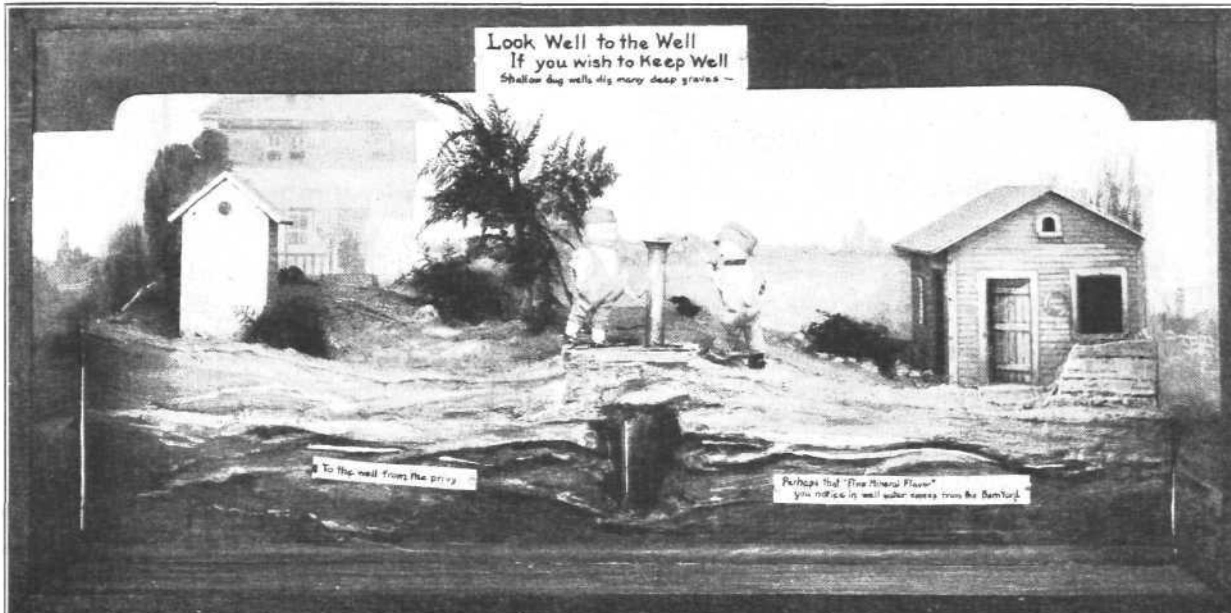


Figure 32.—Model showing pollution of dug well by drainage from barnyard and outhouse.

pamphlet containing information concerning cost and methods of construction.

A model of a sewage-treatment plant, one-hundreth of the actual size, represented a design suitable for a small town with a population of 1,000, and it included the following devices, in the order in which they are reached by the sewage: a screen chamber for removing coarse suspended matter; a sedimentation tank of the Imhoff type for removing solids that can be removed by sedimentation; a dosing chamber for applying in rotation doses of sewage to several filters; 6 intermittent sand filters representing a combined area of one acre for final purification; and a sludge bed for draining the sludge withdrawn from the bottom of the sedimentation tank. In order to emphasize the fact that sewage-treatment plants need not toe unsightly the devices were neatly arranged, and the surrounding grounds were attractively landscaped. The exhibit attracted much attention because it afforded a concrete conception of something concerning which relatively few people have specific knowledge though many have heard it.

Grouped with the exhibits of the State Water Survey was an exhibit of the State Board of Health showing the manner in which farm wells become polluted. This was a working model, in which a doll pumped water from a well whose cross-section was shown by a vertical cut through the ground. The percolation of polluted water from near-by barnyard and outhouses was depicted as it entered the well and also the back-flow, through the imperfect curbing of the well, of water once pumped. This model, partly because of the' attractive and ingenious method in which it was devised but primarily because of the impressive lesson which it taught, attracted the attention of great crowds.

COMPARISON OF THE NUMBER OF WATER BACTERIA GROWING ON AGAR AT 37°C AND ON GELATIN AT 20°C

By F. W. Tanner.

It was recommended by the committee of the American Public Health Association for the. examination of water and sewage in the revised report of 1912 that the colony count on agar at 37° C. be adopted as a standard. The recommendation was phrased in the following words:

"Since gelatin does not give the total number of bacteria in the water, the committee has thought it wise to use agar incubated at 37°C. as a standard medium. This admits of counts in one day instead of two, and gives results on the kind of bacteria growing at blood temperature and therefore more nearly related to pathogenic types."[1]

The recommendation of the committee has been received with disapproval by many bacteriologists, especially those who are concerned with the filtration of water. One of the first to oppose this standard was Whipple,[2] who, with the viewpoint of the filter operator in mind, advises against the abrupt change from gelatin to agar. "That the 37° count more nearly represents the sanitary quality of water than the 20° count is probably true in a general way, but it is not necessarily so." He cites counts made at the Watertown, N. Y., filtration plant and states:

"The difference between the two counts is striking. The **20°** counts are very high in the winter and spring but are low during the summer, whereas the 37° counts are low during the winter and spring and high during the summer, at which season the sewage which enters the stream is less diluted." He calls attention to the fact that this seasonable difference gives a varying ratio, and suggests that it would seem advisable to procure more comparative data before making the recommended change. Caird[3] thinks it advisable to continue the use of gelatin to determine the efficiency of water-treatment plants, and he appends to his paper discussions by various water-

[1] Standard methods for the examination of water and sewage, Am. Pub. Health ASSOC, New York, 77, (1912).

[2] Whipple, G. C, The 87° bacterial count: Am. J. of Pub. Health, 3, 36-48 (1918).

•Caird, J. M., The bacteria count on gelatin and agar media and its value in controlling the operation of water-purification plants: Proc. Am. W. W. Assoc., 325-351, (1913).

works men, whose opinions seem about evenly divided. Baton[1] also protests against the recommended change. He concludes that if only-one medium is to be used it should be gelatin as it is more reliable and serviceable.

Gaub[2] at the Washington, D. C., filtration plant found a variable ratio between counts on agar and on gelatin plated from the unfiltered water of Potomac River. He also found a seasonal ratio which seemed to remain constant for several months at a time and then changed. "With the filtered water there was a less constant seasonal ratio, which was much lower than that with the unfiltered water. This was not due to treatment of the water with calcium hypochlorite. The efficiencies in removal of *B. coli* correspond better to the counts on gelatin, but Gaub does not state how these efficiencies were computed. Gaub forms no conclusion and asks, "Which is the correct medium to use in order to show the efficiency of a plant?" Prescott and Winslow[3] state that the decomposition of organic matter may be measured either by the material decomposed or by the number of organisms engaged in carrying out the process of decomposition; and that the latter method has the advantage of far greater delicacy since bacteria respond by enormous multiplication to very slight increases in their food supply; thus the count on standard gelatin at 20° C. is roughly proportionate in not too heavily polluted waters to the free ammonia and oxygen consumed by chemical analysis. Savage[4] asserts that many water bacteria are unable to grow at 37° C. though most organisms associated with excreta grow readily at 37° C; unfortunately, many harmless soil organisms also grow readily at 37° C. An experiment by Savage illustrates the limitations of this enumeration. He plated on agar and gelatin a pure tap water collected in a sterile bottle; he then added one gram of soil to 500 cc. of the sample and plated on agar and gelatin the emulsion thus obtained. The agar plates were incubated at 37° C. for 40 hours and the gelatin plates at 21° C. for 3 days. The soil contained no *B. coli* in 3 grams. The water contained 3 bacteria per cubic centimeter by the agar count and 76 by the gelatin count. The emulsion contained 1,360 bacteria per cubic centimeter by the agar count and

[1]Baton, W. U. C, Investigation into the advisability of substituting agar (or gelatin as a medium for the determination of bacterial counts in water analysis: J. Am. W. W. ASSOC, 1, 11-23 (1914).

[2]Gaub, John, Some results from the use of gelatin and agar: Proc. Illinois Water-Supply Assoc, 155-159 (1913).

[3]Prescott, S. C., and Winslow, C.-E. A., Elements of water bacteriology, New York, 217 3rd ed., (1915).

[4]Savage, Water supplies, Philadelphia, 183-184, (1906).

1,970 by the gelatin count. Savage concludes that the count at 37° C. is an index of the presence of bacteria other than those natural to pure water, but not necessarily harmful ones.

Harrison expresses the following opinion: "The number of organisms which develop on beef peptone agar incubated at blood heat, commonly termed the "agar" or "blood-heat" count, is perhaps more important that the gelatin count, as many water bacteria do not grow at blood heat, whereas sewage and soil organisms grow readily at this temperature. The agar count eliminates the water flora, but obscures the sanitary results by reason of the presence of soil bacteria."[1] Muir and Ritchie[2] state that the count on gelatin plates incubated at 20° C. gives an idea of the number of bacteria which grow at summer heat and that the count on agar plates "incubated at 37° C. gives an idea of the numbers of those which grow at blood heat." The following comments are added: "As the pathogenic and intestinal bacteria grow at this temperature, [37° C.] the determination of the numbers of blood-heat bacteria is important. The counts on the two media usually differ as each is favorable to the growth of its own group of organisms." The same authors note that the presence of liquefying bacteria on the gelatin plates may make it necessary to count the plates at the end of 24 hours, or at the end of a shorter time than is directed in the commonly accepted procedure. Most bacteriologists apparently believe that the agar count at 37° C. indicates more nearly the bacteria of sewage origin and that it consequently is more important in ascertaining the potability of water. The results of Savage's experiment show, however, that erroneous conclusions will be drawn if the count at that temperature is considered to furnish indication of possible sewage pollution, because soil may contribute large numbers of harmless bacteria that grow at 37° C.

The advantages and disadvantages of each medium are well known to all bacteriologists. Agar is better for field work in warm weather because it can be transported with less trouble either in test tubes or in Petri dishes; great care must be used to prevent liquefaction if gelatin is used. As gelatin has to be shipped in cooled containers in warm weather it can seldom be used in the field. A less elaborate incubator is required for agar because no special precaution has to be taken to keep the temperature below a certain maximum. In some filter plants in which agar is used to control the oper-

[1] Harrison, F. C, Microbiology of water and sewage: [In Microbiology, edited by C. E. Marshall], 204 0912).

[2] Muir, Robert, and Ritchie, James, Manual of bacteriology, New York, 157, 5th ed., (1910).

ation agar plates are left at room temperature for two days before counting. This could not be done with gelatin plates, for which constant low temperature must be maintained. The count on agar is made at the end of 24 hours whereas the count on gelatin is made at the end of 48 hours. Spreaders often develop on agar plates but any inconvenience from these is offset by liquefiers on gelatin plates. The two media themselves differ in their properties; gelatin is good for bacteria, but no bacteria have been described that can metabolize agar. Both media are subject to wide variations in chemical content, but agar is more easily purified.

EXPERIMENTAL STUDIES

SCOPE

Because of the recommendation of the committee on standard methods (See p. 242) a series of comparative tests with both media was commenced by the Illinois State "Water Survey in June, 1912. Since then a large number of waters from all parts of Illinois have been examined in the routine tests of samples received by the Survey. The results of 4,379 of these tests have been taken to form the basis of this discussion. Others could not be considered for various reasons, such as the appearance of spreaders on. the agar plates and liquefiers on the gelatin plates. Media was prepared from meat infusion according to the directions of the committee on standard methods.[1] The samples were shipped to the laboratory in iced containers and were plated immediately on arrival.

As the relation of the number of bacteria developing on agar to the number developing on gelatin seemed very irregular the results were grouped in the four following classes according to the sources of the samples in order to attain a definite basis for comparison.

A. Deep wells.
B. Shallow wells.
C. Untreated water.
   a. River water.
   b. Lake Michigan water.
D. Treated water.

The group comprising untreated water is divided Decause the water of Lake Michigan is not so badly polluted as the water of the rivers in general in Illinois. The results of this comparison are summarized in Table 15.

[1] Standard methods for the examination of water and sewage, Am. Pub. Health Assoc., New York, 77, (1913). p

TABLE 15.—COMPARISON OF COUNTS ON AGAR AND ON GELATIN.

Group.	Source.	Number of samples.	Agar count greater than gelatin count.			Gelatin count greater than agar count.		
			Number.	Average ratio of count agar/gelatin.	Maximum ratio of count agar/gelatin.	Number.	Average ratio of count gelatin/agar.	Maximum ratio of count gelatin/agar.
A.	Deep wells....	712	54	1.1	25	658	1.4	76
B.	Shallow wells..	1,648	148	1.6	17	1,500	1.4	68
C. a.	Rivers........	537	56	1.4	4.1	481	9	250
C. b.	Lake Michigan	405	8	[a]156	[a]466	402	16	633
D.	Treated water.	1,077	151	1.9	12	926	1.8	35
		4,379	412	[b]1.6	[b]14	3,967	[b]2.4	[b]141

[a] Omitted from average.
[b] Weighted average.

A. DEEP WELLS

Wells whose depth exceeded 100 feet have been classified as deep wells. The deepest well from which a sample was examined was 4,000 feet deep. These waters characteristically contain few bacteria. The number of bacteria growing oil agar was equal to that on gelatin in many tests, but there were many more colonies on the gelatin plates in the great majority of tests. Of 712 samples that were examined only 54, or 8 per cent, had more colonies on agar than on gelatin. The average ratio was 1.1 colonies on agar to 1 colony on gelatin and the maximum ratio was 25 to 1. The water of 658 samples from deep wells, or 92 per cent, yielded more colonies on gelatin than on agar. The average ratio was 1 colony on agar to 1.4 colonies on gelatin, and the maximum ratio was 1 to 76.

B. SHALLOW WELLS

Wells less than 100 feet deep have been classified as shallow wells. Of 1,648 samples that were examined 148, or 9 per cent, had more colonies on agar than on gelatin. The average ratio was 1.6 colonies on agar to 1 colony on gelatin, and the maximum ratio was 17 to 1. The water of 1,500 samples from shallow wells, or 91 per cent, yielded the greater count on gelatin. The average ratio was 1 colony on agar to 1.4 colonies on gelatin and the maximum ratio was 1 to 68..

Ca. UNTREATED RIVER WATER

Of 537 samples that were examined from representative rivers in Illinois, including the Illinois, Fox, Eock, Kankakee, Little Wabash, Kaskaskia, and others, 56, or 10 per cent, had more colonies on agar than on gelatin, the average ratio being 1.4 colonies on agar to 1 colony on gelatin and the maximum ratio 4.1 to 1. The water of 481 samples yielded the greater number of colonies on gelatin, the average ratio being 1 to 9 and the maximum ratio 1 to 250.

Cb. UNTREATED WATER FROM LAKE MICHIGAN

Of 405 samples of untreated water from Lake Michigan that were examined 3, or less than 1 per cent, had the greater number of colonies on agar. The average ratio was 466 to 1. The water of 402 samples yielded the larger number on gelatin, the average ratio being 1 to 16 and the maximum ratio 1 to 633.

D. TREATED WATERS

Of 1,077 samples of treated water that were examined 151, or 14 per cent, had more colonies on agar than on gelatin. The average ratio was 1.9 colonies on agar to 1 colony on gelatin, and the maximum ratio was 12 to 1. The water of 926 samples yielded more colonies on gelatin than on agar, the average ratio being 1 colony to 1.8 and the maximum ratio 1 to 35.

SUMMARY

The average ratio of colonies on agar to colonies on gelatin among the samples of water that yielded the greater number of colonies on agar exceeds 1 to 2 in only one group, which includes only 3 samples and is therefore negligible. The average ratio of colonies on gelatin to colonies on agar among those that yielded the greater number on gelatin also exceeds 1 to 10 in only one group (untreated water from Lake Michigan) and exceeds 1 to 2 only in the two classes of untreated surface water. These two classes of water clearly differentiate themselves by their high ratios, a condition doubtless due, for mathematical reasons, to greater variation of number of colonies with increased content of bacteria. Only 412 samples in 4,379 samples examined, or 9 per cent, yielded more colonies on agar than on gelatin, and the weighted average ratio of this excess was 1.6; on the other hand 3,967 samples, or 91 per cent, yielded more colonies on gelatin than on agar and the weighted average ratio of this excess was 2.4. Similarly the weighted maximum ratio with colonies on agar in excess was only 14 whereas the weighted maximum ratio with colonies on gelatin in excess was **141.**

Several attempts were **made to compare tests for gas formers**

with the two media, but this classification was found inadvisable since the data were too cumbersome with a difference of dilutions. It would be interesting to compare the counts on agar and gelatin statistically with data secured by chemical analysis, such as the oxygen consumed and nitrate or nitrite nitrogen.

CONCLUSIONS

1. The ratio of the number of colonies on agar to that on gelatin is not constant, but it is related to the amount of pollution which a water receives.
2. Each filter operator should ascertain by experimental study the correct ratio for the water that he is treating.
3. Eesults on a large number of samples covering a long period of time are necessary for comparison in order to eliminate the influence of seasonal variations and the effect of a few widely different counts.
4. Both media should be used where it is possible to do so, as more data for judging the sanitary quality of a water predicate a more accurate opinion.
5. Results of a long study of samples from one river are likely to be different from those obtained in this statistical study.
6. The ratios obtained in this study are much lower than has been believed to exist and the reason for it is not obvious. It may be caused by a rhythmic compensation of winter and summer ratios.

REPORTS OF ASSOCIATIONS AND COMMISSIONS

References to articles regarding water, water supplies, and other subjects of interest to waterworks men, published during 1914, are given in the following lists. They are grouped by periodicals and arranged alphabetically by authors in each group.

ILLINOIS SOCIETY OP ENGINEEBS AND SUBVEYOBS

Official publication in 1914, the twenty-ninth annual report of the Illinois Society of Engineers and Surveyors.

Babbitt, H. E. Emergency sanitary measures following the 1913 flood in Ohio. The dangers to public health caused by the inundation of the populated districts were: (1) Stoppage of the water supply and its contamination; (2) Spreading of putreseible matter, particularly from privies, by flood waters; (3) Stoppage and backing up of sewers, thus adding to the accumulation of putrescible matter left exposed; (4) Filth and muck deposits; (5) Dead animals, garbage, and putrescible wastes; (6) Wet cellars and stagnant water; (7) Spoiled food stuffs; and (8) Contagious diseases and breaking of quarantine. The remedial measures adopted in the various communities are described and the results are discussed.

Committee on sewerage and sewage disposal, Report. The committee discusses various features of sewage treatment and gives the answers to a questionnaire.

Crozier, Ray. The Peoria waterworks. A description of the well and pump equipment.

Greeley, S. A., and Pearse, Langdon. Small sewage pumping stations. Cost data, and statistics of different plants using producer gas, coal gas, steam, electricity, and air for pumping are given.

Pearse, Langdon. Sewerage and sewage disposal in the United States. A review of recent development in methods of sewerage and sewage treatment. The author urges the collection of more and better cost and statistical data.

Sherman, L. K. Notes on the oxidation of sewage. The available data on the oxidation of sewage are reviewed and several conclusions are drawn.

ILLINOIS WATEB SUPPLY ASSOCIATION

The sixth annual meeting was held at the University of Illinois, March 9-11, 1914. The report of the secretary showed that the association was making very satisfactory progress. The active membership had increased 24 members, bringing the total to 264. Copies of the proceedings are sent to members; others may purchase them from the secretary. All persons interested in the water supplies and water problems of Illinois are eligible to membership.

The executive committee was authorized to take a vote of the members on the question of becoming a section of the American Water Works Association. On November 11 a meeting was held in Chicago at which the Illinois Section of the American Water Works Association was established. The following officers were elected at the March meeting.

President, H. M. Ely, superintendent Interstate Water Co., Danville.

First vice-president, W. J. Spalding, commissioner of public property, Springfield.

Second vice-president, E. MacDonald, superintendent Lincoln Water and Light Co., Lincoln.

Third vice-president, W. W. DeBerard, western editor, Engineering Record, Chicago.

Secretary-treasurer, Edward Bartow, Director State Water Survey, Urbana.

The papers presented before the meeting and published in the sixth volume of the proceedings of the association are listed.

Allen, W. J. Experiences with Waukegan water supply.

Alvord, J. W. Too much water.

Anderson, C. B. Character of artesian well waters in Chicago and vicinity.

Babbitt, H. E. The economic design of storage tanks.

Bardwell, E. C. Water treatment for railroads.

Bryant, J. M. Pumping city water by electricity.

Buzzell, R. S. The filter plant at Flint, Michigan.

Chamot, E. M. The addition of inorganic salts to culture Vnedia employed in water analysis.

Cobleigh, W. M. Chemical standards for the hygienic purity of Montana waters.

Craven, Jay A. A sanitary survey of White Eiver.

Enger, M. L. Locating leaks in water mains by means of the water-hammer diagram.

Fairlie, John A. Public control of water supplies in Illinois.

Fritze, L. A. Removal of anchor ice by means of air.

Frost, W. H. A sanitary survey of Ohio Eiver.

Gaub, John. The newly remodeled reservoir.

Gehrmann, Adolph. Underground movement of contamination.

Gelston, W. E. and Bartow, Edward. Eelation of sewer outfall to waterworks intake at Quincy.

Hansen, Paul, and Hilscher, Ralph. Surface water supplies of Illinois.

Herdman, F. E. Rates and their relation to meters.

Jackson, David H. The proposed North Shore Sanitary District.

Jennings, C. A. Hypochlorite treatment now firmly established.

Jones, Lloyd Z. Detection of leaks in deep wells by electric light.

Knowles, Morris, and Scharff, Maurice E. The relation of "out-of-pocket cost" to rate making.

McLaughlin, Allan J. Necessity for State supervision of public water supplies.

O'Callahan, C. D. Removing gas from water used for drinking purposes.

Pearse, Langdon. The rapid filter plant at Evanston, Illinois.

Bahn, Otto, and Hinds, M. E. Death of B. coli and *B. typhosus* in pure water.

Reid, Walter. Efficiency of the triple expansion pumping engine.

Boos, C. M. Experiences following the flood of 1913.

Roos, C. M. A standpipe failure.

Talbot, Arthur N. The iron-removal plant of the Champaign and Urbaha Water Co.

Trimble, Charles. Reservoir well for the Bobinson water supply.

Tufts, C. D. How Centralia's water supply was secured.

Wall, Edward E. St. Louis rapid sand filter plant'.

West, Francis D. The preparation of standards for the determination of the turbidity of water.

Worthen, Jesse M. Remodeled underdrain system for a mechanical filter plant.

SANITARY DISTRICT OF CHICAGO

Publications in 1914.

Beport on industrial wastes from the stockyards and Packingtown in Chicago, October, 1914. A report (346 pages) on experimental studies to determine the best method of handling the waste. It is entirely practicable to treat this waste either alone or mixed with sewage of domestic origin. Fine screening, sedimentation in double-deck tanks, and sprinkling filters appear most suitable.

'Beport on pollution of Desplaines Biver. This report of a survey of sanitary conditions along the river within the boundaries of the District shows the condition of the river, its flow, the nature and quantity of pollution entering, and the location and extent of existing sewers. Nuisances are greatest in the vicinity of the towns of Maywood, Biver Forest, and Forest Park. The river water is undesirable for drinking by man or by cattle, for ice harvesting, boiler use, boating, and swimming. The only practicable remedies involve the construction of intercepting sewers.

RIVERS AND LAKES COMMISSION

Horton, A. H. Beport of the water-resources investigation in Illinois. (400 pp., photographs and maps.) This report contains all the stream-flow data that have been collected in cooperation with the Water Resources Branch of the U. S. Geological Survey and in addition all run-off data that could be obtained. It also includes Weather Bureau rainfall records for stations in Illinois, evaporation estimates, river profiles, estimates of undeveloped water power, reservoir sites, a gazetteer of nearly five hundred streams in the State and a table of drainage areas.

INTERNATIONAL JOINT COMMISSION

Progress report on the reference by the United States and Canada in re the pollution of boundary waters (January 16, 1914). Though Lake Michigan is not included in this report the condition of cities on Lake Michigan is similar to that of cities on other lakes. The report is, therefore, of interest to citizens of Illinois and especially to those living on Lake Michigan. The investigations were made for the Commission by Dr. Allan J. McLaughlin of the United States Public Health Service, Dr. J. W. 8. McCollough, health officer for the Province of Ontario, Dr. J. A. Amyot, professor of hygiene at the University of Toronto, and F. A. Dallyn, C. E., provincial sanitary engineer of Ontario, assisted by a staff of 32 laboratory and field assistants.

The investigations included examination of waters of the Great Lakes system from Rainy River to St. Johns River. Samples to the total of 17,784, from 447 points were collected, and other samples were taken in the study of special problems, like the amount of pollution due to lake traffic. Most water in the Great Lakes remains in its pristine purity, but dangerous sewage pollution was shown to exist in certain localities in the lakes and in their connected water-ways. Water supplies should not be taken from the Great Lakes without purification. Some supplies were pure most of the time but pollution occurs at infrequent intervals. Such intermittency of pollution is a dangerous factor which must be obviated. No municipality using lake water without treatment can be said to possess a safe water supply. Use of untreated water has until recently been the rule. Typhoid-fever rates are high, because of unrestricted discharge of sewage from municipalities and vessels and failure to purify polluted water.

Unrestricted discharge of sewage should not be allowed if it imposes an unreasonable burden on any known method of water purification. If the water supply is liable to pollution only a few days each year purification is necessary. Efficient bacteriological control is necessary in order to protect communities against the dangers of polluted water supplies.

UNITED STATES PUBLIC HEALTH SERVICE

Eeports on water by the Public Health Service were issued as follows in Public Health Reports, vol. 29, on the pages indicated.

Carter, H. R. Impounded water. (pp. 3458-68). General considerations of the effect of impounded water on the prevalence of malaria.

Committee. Bacteriological standard for drinking water. (pp.. 2959-2966). The standards adopted by the U. S. Treasury Department for drinking water supplied to the public by common carriers in interstate commerce are given. Copies can be obtained by application to the Surgeon-General, U. S. Public Health Service, Washington, D. C.

Gimming, H. S. Safe ice. (pp. 2066-74). Clear ice is as free from danger of conveying infectious disease as we need, but dirty or cloudy ice may be dangerous. It should not be placed in water or on food which is to be eaten uncooked. Danger can be eliminated by avoiding the handling of ice with dirty hands, by washing the ice with pure water, and by using only clear ice.

DeValin, Hugh. The water supply of ships, (pp. 393-410). A discussion of the water furnished for drinking purposes and of the methods of sewage disposal on ships and inland waters.

Mullin, R. H., Whittaker, H. A., and Mohler, B. M. Railroad water supplies in Minnesota. (pp. 1222-45). The sources of supply were inspected and analyses were made. One-half of the 60 supplies investigated were condemned although it is believed that practically all could be rendered safe at small cost. Thirty-one supplies, only 16 of which showed analytical evidences of pollution, were condemned by the results of field investigation.

Phelps, E. B. Studies on the self-purification of streams. (pp. 2128-32). Extensive studies of Potomac and Ohio rivers are being made.

Phelps, E. B. The chemical disinfection of water. (pp. 2709-2715). Construction and operation of emergency hypochlorite plants.

AMERICAN WATER WORKS ASSOCIATION

Official publication, 1914, Journal of the American Water "Works Association, vol. I, issued quarterly. This replaces the annual volume of proceedings heretofore issued by that association.

Ackerman, J. Walter. Testing of check valves.

Ackerman, J. Walter. Legal decision in a water-supply pollution case.

Akimoff, N. W. Remarks on the theory of the Pitot tube.

Alvord, John W. Equitable hydrant rentals and better methods for apportioning fire-protection cost.

Amsbary, F. C. Pushing service pipes under pavements.

Bartow, Edward. Laboratory control of water supplies.

Baton, W. U. C. Investigation into the advisability of substituting agar for gelatin as a medium for the determination of bacterial counts in water analysis.

Booth, W. M. The use of nitrite test in determining source oi pollution of a water supply.

Committee on tabulation of water rates and other information of interest to water companies, Report.

Datesman, G. E. Brief review of sewage-disposal works in some European cities and comparison with the Pennypack Creek works at Philadelphia.

Diven, J. M. Use and benefits of pressure-recording gages.

Downes, J. E. Notes on the contamination of a drinking and railroad water supply by sea water and the removal of the salt water from the reservoir.

Folwell, A. Prescott. House to house inspections.

Fuller, George W. The Croton water supply: its quality and purification.

Gaub, John. Some relations between the water supply and typhoid fever at Washington, D. C.

Hansen, Paul. An undeveloped field in waterworks management.

Haseltine, W. E. A cheap homemade test plug for water mains.

Haseltine, W. E. Fire-alarm attachment for recording-pressure gage.

Hodgkins, H. C. Conservation of potable water and the dual system of distribution.

Hoopes, Edgar M. Jr., and Caird, J. M. The water supply at Wilmington, Delaware.

Johnson, G. A. Present-day water-filtration practice.

Keeler, H. E. Gravity water supply at the city of Manila, Philippine Islands.

Kay, Edgar B. Use. of concrete in waterworks construction.

LeConte, L. J. The growing value of ground-water supplies.

Lederer, Arthur, and Bachmann, Frank. The efficiency of household filters in Chicago.

McLaughlin, Allan J. Sewage pollution of boundary waters.

Miller, W. E. Diagrammatic method of determining the cost per foot of cast-iron pipe.

Miller, W; E. The individuality of public utilities notably waterworks.

Monfort, W. F. Note on ortho-tolidin test for free chlorine.

Powell, 8. T. Some observations of the effect of ozone on algae growths.

Tribus, Louis L. A wanderer's notes on foreign water supplies.

Van Gilder, L. Forty-eight inch cast-iron force main for Atlantic City, New Jersey.

Von Recklinghausen, M; Purification of water by the ultraviolet rays.

West, Francis D. Disinfecting 200,000,000 gallons of water a day—experience with chloride of lime and liquid chlorine at Torresdale filtration plant.

AMERICAN PUBLIC HEALTH ASSOCIATION

Official publication, 1914, American Journal of Public Health, vol. 4, issued monthly.

Barnard, H. E. Value of routine water analysis in sanitary surveys.

Cobleigh, W. M. Present status of waterways sanitation in Montana.

Gehrmann, Adolph. Counting of bacteria on surfaces.

Gill, A. H. Upon the determination of minute quantities of nitrates, pan ticularly in potable waters.

Hill, H. W. Protest against the thirty-seven degree C. requirement for bacterial counts.

Lederer, Arthur. Serious fallacy of the "standard" methylene-blue putrescibility test.

Lochridge, E. E. Decolonisation of Little Eiver water supply in connection with filtration at Springfield, Mass.

Morse, E. B. State control over water supply and drainage conditions in Maryland.

Norton, J. F. Study of a swimming pool with a return purification system.

Soper, G. A. Rational basis for the sanitation of rivers and harbors.

Sperry, W. A. Water softening and decolorization.

Stevenson, W. L. Examination of river bottoms at Philadelphia.

Thomas, J. B. and Sandman, E. A. Comparison between the twenty degree and the thirty-seven degree plate counts for enumerating bacteria in water.

Tully, E. J. Effect of; water of different quality on the longevity of some pathogenic bacteria.

Tully, E. J. Inhibiting action of a colored well water on bacteria and a study of the inhibiting effect of some inorganic salts.

Tully, E. J. Study of calcium hypochlorite as a disinfectant of water.

Whipple, G. C. Sewage-disposal problem in villages and small cities.

Whittaker, H. A. Use of hypochlorite capsules for the treatment of small quantities of drinking water.

Young, G. B. Result of the experimental employment of hypochlorite treatment to a portion of the Chicago city water supply.

Young, C. C. A new shipping outfit for iced water samples.

A symposium on stream pollution, States being represented as follows: California, Charles Gilman Hyde; Illinois, Paul Hansen; Indiana, Jay A. Craven; Kansas, C. A. Haskins; Louisiana, J. H. O'Neill; Maine, H. D. Evans; Massachusetts, X. H. Goodnough; Minnesota, Frederick Bass; Ohio, W. H. Dittoe; Virginia, Eichard G. Messer.

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