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WATER SURVEY SERIES NO. 11

CHEMICAL AND BIOLOGICAL SURVEY OF THE WATERS OF ILLINOIS

REPORT FOR YEAR ENDING DECEMBER 31, 1913

EDWARD BARTOW

DIRECTOR

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*To May, 1913.
†To July, 1913.
‡To September, 1913.
§To October, 1913.
¶To December, 1913.

LETTER OF TRANSMITTAL

STATE WATER SURVEY.

UNIVERSITY OF ILLINOIS,
Urbana, Illinois, February 1, 1913.

EDMUND JANES JAMES, PH.D., LL.D.,
President University of Illinois.

SIR: Herewith I submit a report of the work of the State Water Survey for the year ending December 31, 1913, and request that it be printed as a bulletin of the University of Illinois, State Water Survey Series No. 11.

The report contains an account of the work done by the Water Survey in accordance with the laws (Laws of Illinois, 40th General Assembly 1897, 12; 47th General Assembly, 1911, 43. Bulletin University of Illinois, State Water Survey Series, 9, 7-8).

The General Report gives a summary of the chemical, biological and engineering work done and an account of the special investigations made during the year. Some interesting and valuable scientific investigations have been carried on by both the chemists and engineers.

Advice relative to public water supplies has been given a large number of cities and plans for all new projects have been reviewed and reported upon.

Extensive sanitary surveys of watersheds have been made which are proving of much value to cities facing the problem of sewage treatment. This work should be continued to cover all the watersheds of the state. During the year a co-operative arrangement has been perfected with the Rivers and Lakes Commission which increases the effectiveness of the Survey's work along the lines of stream cleaning.

Thorough investigations have been made of several typhoid fever epidemics, suspected of being water borne. The most important of these was made at Rockford at the request of the State Board of Health.

During the Ohio River floods of April, the Survey was able to render valuable service in protecting water supplies and establishing sanitary conditions.

Respectfully submitted,
EDWARD BARTOW,
Director.

GENERAL REPORT

GENERAL STATEMENT FOR THE YEAR ENDING DECEMBER 31, 1913.

During the year 1913 the laboratory and field work of the State Water Survey has been conducted along the lines inaugurated in the latter part of 1911. A slight expansion was made possible owing to an increase in the appropriation by the Legislature from $15,000 to $21,500 per annum. The Trustees of the University of Illinois have assigned $7,500 for the educational and scientific work of the Survey for the year.

The staff has been slightly changed during the year. Mr. W. G. Stromquist, Assistant Engineer, resigned to accept a position with the Sanitary District of Chicago. Mr. E. E. Hollman, Assistant Chemist, resigned to accept a position with the St. Louis Water Department. The following have been appointed to the active staff:

Assistant Chemist, Henry Lawrence Huenink, B.S. Carroll College, 1911; M.S. University of Illinois, 1913.

Engineering Assistant, Maurice Charles Sjoblom, B.S. University of Wisconsin, 1913.

Engineering Assistant, John Francis Schnellbach, B.S. University of Illinois, 1913.

Assistant Chemist, Charles Herbert Spaulding, B.S. University of Illinois, 1912; Chemist A.T. & S.F. R.R., 1912-1913.

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 watersheds, 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 Water Works, 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."

Instructional work in water and sewage analysis and purification have 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 undergraduates and graduates are allowed to prepare theses on subjects connected with water chemistry. Several of the theses thus prepared have been of sufficient merit to warrant their publication not only in the bulletins of the State Water Survey but also 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 water and sewage purification.

The increase since 1911 in the number of members on the active staff of the Water Survey is noteworthy. The enrollment in Water Chemistry as shown in the table has increased during the years 1905-1914.

Year—	Chem. 10	Chem. 110	Thesis	Total	Members of Staff
1905-06	3	..	..	3	3
1906-07	6	1	1	8	3
1907-08	16	3	1	20	3
1908-09	9	5	4	18	3
1909-10	15	9	3	17	3
1910-11	11	7	2	20	3
1911-12	18	7	3	28	8
1912-13	10	9	4	23	11
1913-14	15	14	10	39	14

These figures given for the members of the staff, do not include the consulting staff, clerical help, laboratory assistants, or field assistants employed during the summer vacations.

The Water Survey has always occupied quarters in the Chemistry Building and at the present time, 1913, is using nine rooms in the Chemistry Building and two in Engineering Hall. Plans are completed for an addition to the Chemistry Building. The appropriation for the construction of the building has been made by the University Trustees. Quarters have been assigned to the Water Survey in the northeast part of the basement of the addition. The laboratories, which are used at present will be remodeled for the instructional work in Water Chemistry.

ENGINEERING WORK.

The work accomplished by the Survey has been described in ten bulletins. Until the fall of 1911 the work was practically all analytical, being confined almost exclusively to chemical and bacteriological analyses of samples of water sent to the laboratory. In the fall of 1911 an engineering division was established. The establishment of this division has provided for personal visits by members of the staff to cities throughout the state. Descriptive reports have been prepared of the public water supplies, sewerage systems and sewage disposal works located in the cities visited. Advice has been given to municipal authorities regarding plans for construction of new plants or additions to old plants. The work of this kind accomplished during 1911 was briefly described in bulletin No. 9, pages 15-33; that accomplished during 1912 was described in bulletin No. 10, pages 89-185, and that accomplished in 1913 is described later in this bulletin.

The engineering activities of the State Water Survey during 1912 and 1913, the first full years following the establishment of the engineering division, may be briefly summarized as follows:

INVESTIGATIONS, CONFERENCES AND INSPECTIONS.

	1912	1913	Total
Inspection of existing public water supplies	60	101	161
Conferences concerning the installation and extension of public water supplies	1	59	60
Inspection of existing sewerage systems	25	28	53
Conferences concerning proposed sewerage systems	3	24	27
Special investigations such as surveys of watersheds	18	41	59

REPORTS.

Existing public water supplies	60	85	145
Proposed water supplies and extensions	19	34	53
Existing sewerage systems	11	6	17
Proposed sewerage systems	14	10	24

New Water Supplies. The State Water Survey has continued its policy of encouraging the installation of municipal water supplies where such do not already exist, as a measure for protecting the public health. Efforts have been directed primarily to those communities of 1,000 and over in population. It is believed, however, that many communities much smaller than this (say of 500 and over) may install public water supplies to their economic advantage.

During the year 1913, 21 communities were visited for the purpose of investigating the installation of original water supplies or new water supplies of superior quality and more adequate in quantity to replace existing supplies. During the year, however, there have been but 4 original water supplies actually completed, namely, at Arthur, Assumption, Hamilton and Harmon. Three places, namely, the Anna State Hospital for the Insane, Pana, and Rushville, have installed new supplies to replace existing water supplies that were of poor quality or inadequate. It is probable that the general business depression experiencd during the last year has been partly responsible for the rather slow installation of new water works, but judging from the number of towns that are contemplating the installation of water supplies, it is anticipated the number of new installations will be greatly increased during the next few years.

Water Purification Plants. Eliminating from consideration the city of Chicago, there were during 1913, 332 public water supplies serving about 1,630,000 people. 73 of these supplies, or 22 per cent, obtain water from surface sources and supply a population of approximately 680,000 people, or about 42 per cent of the entire population served with public water supplies. Of the surface water supplies, 37 are treated as follows:

Filtered for purification, 30; filtered for iron removal, 2; treated by coagulation and sedimentation without filtration, 2; treated for sterilization purposes with hypochlorite of calcium, 3.

The population served by these purification works is approximately 468,000, or 69 per cent of the population using surface water supplies, or 29.3 per cent of the entire population served by public water supplies.

Purification plants completed during 1913 are located at: Champaign, population, 22,420; Mt. Vernon, population, 8,880; Pana, population, 6,190; Charleston, population, 5,950; Breese, population, 2,300; Anna State Hospital, population, 1,800; Hamilton, population, 1,690; Ft. Sheridan, population, 1,400. Plants under construction and nearing completion at the end of 1913 are located at Evanston, population, 26,693; Decatur, population, 34,255, and Quincy, population, 36,687.

Sewage Disposal Along the North Branch of Chicago River and Its Tributaries. In response to a request of Mr. P. R. Barnes, attorney for the Northwest Sanitary Drainage Association, the State Water Survey made a study of sewage disposal conditions along the North Branch of Chicago River and its tributaries. The Northwest Sanitary Drainage Association is an incorporated organization of citizens having for its object the securing of adequate sanitary drainage for that portion of the Chicago Sanitary District and adjacent territory having natural drainage to the North Branch of Chicago river. This stream which is of unusual beauty and lies in a territory which will ultimately be built up largely with residences, gives an excellent example of the frequent necessity of treating streams as a whole in order that they may be maintained in a clean and sanitary condition. Detailed report upon the North Branch of the Chicago river and its tributaries is presented elsewhere in this bulletin.

Control Laboratories. While the State Water Survey can make examinations of water at intervals for the various municipalities, daily control at the water works plant, especially of surface supplies, is of far greater value. The first control laboratory installed upon the advice and under the direct supervision of the State Water Survey was at Kankakee, in 1907, and to date 19 laboratories have been installed. Water works officials having laboratory facilities and laboratory control of their water soon learn to appreciate the value thereof in securing pure water economically.

LABORATORY WORK.

From the time of its foundation, September, 1895, to December 31, 1913, 26,529 samples of water (see Table I) have been received by the State Water Survey. Of these 16,318 were sent by private citizens, health officers or water works officials. The remaining samples, with the exception of 2,800 collected in connection with a study of the Chicago Drainage Canal, have been collected by members of the staff or under their direction for the study of special problems.

The waters have been classified according to the sources from which they have been derived. As would be expected, the greatest number, 6,413, have been taken from shallow wells in drift. Such wells furnish by far the greatest number of the supplies for residences. Shallow wells in rock are comparatively rare, 457, because the greater part of the state is covered by glacial drift from 50 to 300 feet deep. Deep wells in rock and deep wells in drift furnish a large number of samples, 2,111, and 1,548 respectively. In many parts of the state a very satisfactory water can be obtained from such sources.

The large number, 3,801, from surface waters, is due to the monthly control tests of filter plants. These tests are increasing rapidly in numbers as the filter plants increase in numbers.

The number of samples 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 must be approved by a health department.

During the year 1913, 2,216 samples of water were received (see Table II), 1,756 having been sent to the laboratory by health officers or private citizens. The number received during 1913 was greater than in any year since the establishment of the Survey. The total number examined was greater than in any year except 1900 when the special investigations of the Chicago Drainage Canal were being made. The greatest number of samples was received during July, and the smallest during January and December.

The number received during 1913 was 16 per cent greater than the number received during 1912 and more than double the number received during 1911, during which year it was necessary, owing to lack of funds, to charge a fee for water analysis.

We have classified all well waters sent to the Survey for examination during the years 1907 to 1913. (See Table III.)* The waters have been classified according to the depth of the wells. The number condemned decreases as the depth of the wells

*See also Bulletin University of Illinois, State Water Survey, Series 10, 81.

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

SOURCES	October 1895, to Dec. 31 1896	YEARS																	Total from each source
		1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	
Surface waters, rivers, lakes and ponds	69	72	102	54	59	61	97	75	80	107	304	336	356	372	428	196	393	640	3801
Springs	16	21	34	23	22	35	28	18	28	41	63	52	68	62	41	29	73	50	704
Cisterns	12	19	17	7	7	3	10	6	7	5	13	29	28	31	21	25	27	25	292
Natural ice	4	12	1	11	9	4	9	3	12	6	......	1	5	1	12	9	10	19	128
Artificial ice	....	1	......	2	1	......	1	1	1	......	4	......	......	0	0	1	0	......	12
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	16
Shallow wells in rock	28	16	8	22	12	22	10	17	25	25	19	45	32	53	43	29	31	20	457
Deep wells in rock	58	48	34	26	36	56	59	23	28	66	170	159	258	345	207	119	299	320	2111
Flowing wells in rock	45	8	16	12	13	14	3	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	142	514	683	614	344	256	436	435	6413
Deep wells in drift	64	68	43	30	24	36	63	54	51	40	114	154	160	159	95	103	138	152	1548
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	209
Distilled water	....	....	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	3	3
Miscellaneous	....	....	......	......	......	......	......	......	......	......	......	......	......	......	......	......	53	......	53
Unknown	....	....	......	......	......	......	......	......	......	......	......	......	......	......	......	20	30	72	122
Total samples from citizens	899	517	448	467	471	444	529	463	525	613	1182	1365	1682	1651	1201	795	1510	1756	16318
Other samples	888	811	988	1579	1866	778	147	419	555	466	445	55	87	73	101	279	214	460	10211
Total for year	1787	1328	1436	2046	2337	1222	676	882	1080	1079	1627	1420	1769	1724	1302	1074	1724	2216	26529
....	....	......	......	......	......	......	......		......	......	......	......	......	......	......	......	......		

TABLE II. SHOWING THE NUMBER OF WATER SAMPLES EXAMINED DURING THE YEAR ENDING DECEMBER 31, 1913 ARRANGED BY MONTHS ACCORDING TO THE NATURE OF THE SOURCE.

SAMPLES BY REQUEST	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
Surface water, rivers, lakes and ponds..........	49	71	63	61	52	54	98	40	30	46	30	46	640
Springs................................	7	7	6	6	2	3	2	1	5	7	3	1	50
Cisterns................................	2	....	....	3	6	3	2	3	4	1	1	....	25
Natural ice................................	....	2	2	1	2	1	1	4	1	5	....	....	19
Shallow wells in rock........................	1	....	....	....	1	2	5	5	2	2	2	....	20
Deep wells in rock........................	29	25	22	29	18	28	29	22	34	35	27	22	320
Flowing wells in rock........................	....	....	....	....	....	....	....	....	2	2	2	....	6
Shallow wells in drift........................	19	18	9	25	32	30	61	62	65	37	45	32	435
Deep wells in drift........................	2	5	17	1	8	15	22	23	19	17	13	10	152
Sewage................................	....	....	....	....	1	....	....	1	....	....	1	....	3
Distilled water................................	....	....	....	2	....	....	....	....	....	....	1	....	3
Mine water................................	....	2	4	....	2	....	2	1	....	....	....	....	11
Unknown source................................	4	3	4	11	9	9	6	1	12	4	4	3	72
Total........................	113	133	127	139	133	145	228	163	174	156	129	116	1756
MADE ON INITIATIVE OF WATER SURVEY													
Surface water, rivers, lakes and ponds..........	4	4	6	....	....	....	12	38	8	....	1	15	88
Springs................................	1	....	1	....	....	....	....	....	....	....	....	2	4
Cisterns................................	....	....	....	1	....	....	....	1	....	....	....	....	2
Deep wells in rock........................	1	5	1	1	8	....	1	3	3	15	9	35	82
Flowing wells in rock........................	....	....	....	....	1	....	....	....	....	2	....	....	3
Shallow wells in drift........................	....	4	2	....	7	....	6	2	2	7	16	4	50
Deep wells in drift........................	....	....	11	63	28	11	17	5	5	26	25	9	200
Sewage................................	....	....	....	1	....	....	....	4	....	....	....	7	12
Mine water................................	....	1	....	....	....	....	....	....	....	2	....	....	3
Unknown source................................	....	1	1	3	....	2	1	....	3	....	....	5	16
Total........................	6	15	22	69	44	13	37	53	21	52	51	77	460
Grand Total of samples by request and those on initiative of Water Survey...........	119	148	149	208	177	158	265	216	195	208	180	193	2216

PURITY OF WELL WATERS.

TABLE III. SHOWING PER CENT OF WELL WATERS CONDEMNED ANNUALLY BY THE WATER SURVEY. ARRANGED ACCORDING TO DEPTH OF WELL.

	1907	1908	1909	1910	1911	1912	1913	Total
Less than 25 feet—								
Number examined	284	254	242	148	113	168	230	1,439
Number condemned	240	192	183	118	74	113	155	1,075
Per cent condemned	85	75	75	79	65	67	67	74
25 to 50 feet—								
Number examined	224	395	354	201	196	353	262	1,985
Number condemned	173	250	226	137	122	185	166	1,259
Per cent condemned	77	63	63	65	62	52	63	65
50 to 100 feet—								
Number examined	111	192	161	90	89	129	164	936
Number condemned	42	66	54	46	8	28	54	298
Per cent condemned	37	34	53	51	9	22	33	31
Over 100 feet—								
Number examined	161	312	376	205	171	339	603	2,167
Number condemned	22	31	62	43	30	49	59	296
Per cent condemned	13	9	16	20	17	14	10	13
Unknown—								
Number examined	88	46	72	67	19	27	83	402
Number condemned	34	22	38	35	9	6	21	165
Per cent condemned	38	47	52	52	47	22	25	41
Total number examined	868	1,199	1,205	711	588	1,016	1,342	6,929
Per cent of total cond'd	60	46	47	53	41	38	34	44
Total number condemned	511	561	563	379	243	381	455	3,093

increases. The water is condemned from the 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. Of those wells less than 25 feet in depth, 74 per cent were condemned; of those 25 to 50 feet, 65 per cent were condemned; of those from 50 to 100 feet, 31 per cent were condemned; of those over 100 feet in depth, only 15 per cent were condemned; and many of the deepest were condemned because of the excess of the mineral content and not because of contamination. Of those of unknown origin, 41 per cent were condemned. Of the well waters received during the six years 44 per cent were condemned. We note an improvement in the character of the waters received for analysis during the latter part of the period. 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 larger number of samples were sent because of suspected contamination. In order to obtain a knowledge of the true condition analyses must be made of many representative samples collected from all parts of the state.

SCIENTIFIC INVESTIGATION AND SPECIAL STUDIES.

In addition to the routine analytical work and routine inspection, the members of the Water Survey staff are constantly occupied with problems relating to water and water supplies. In nearly every case the problems are suggested by difficulties arising at various water works or sewage disposal systems or from unsatisfactory sewerage arrangements. Inaccuracies in analytical methods have also suggested special work. The regular staff has been assisted in this work by instructors and students in the University. During 1913 such assistance was given by Messrs. D. T. Englis, J. F. Garrett, V. R. Fleming, C. R. Newell and F. G. Norbury.

The Comparative Value of a Calcium Lime and a Magnesium Calcium Lime for Water Softening. Manufacturers have claimed that magnesium calcium limes are equally as well adapted for water softening as are the calcium limes. From a consideration of the chemical reactions involved it is found that such claims are unwarranted. Lime for water softening should be bought on the basis of the content of calcium oxide.

Water Purification in Illinois. In this paper the growth and present status of water purification is described. There are 68 surface water supplies in the state, all of which are subject to contamination. Of this number, 33, including most of the larger supplies, are now being subjected to some form of purification. The different methods in use and their relative efficiencies are discussed.

The Relation of the Mineral Content of Boiler Waters to the Scale Formed. This study was made to ascertain if it is possible to predict accurately the character of boiler scale from a knowledge of the mineral constituents of the water used. The results indicated that while the mineralization of the water is important and permits drawing certain conclusions, there are still other factors, as, for example, type of boiler, circulation, frequency of blowing off, etc., which in certain types of waters are of even greater importance. No numerical formulæ can be derived from the composition of the water which will give the composition of the scale formed.

The Relation of the Electrical Conductivity of the Water to the Soluble Mineral Matter. All water conducts electricity in a greater or lesser degree, which is roughly proportional to the total mineral content. These experiments show that this relation is not constant enough to warrant the conductance replacing the determination of total mineral content by evaporation with subsequent weighing. In special cases however the conductance method may be used to advantage.

The Perchlorate Method of Determining Potassium as Adapted to Water Analysis. This investigation has shown that while this method has never been used in water analysis, it possesses many advantages over the method now in general use. The method is accurate, the manipulation very simple, and the time required is short.

The Composition of Sludge and Bottom Deposits of the Illinois River. Analyses of sludges or river sediments were made of samples collected throughout the length of the stream under winter conditions. The results obtained, indicated by the percentages of nitrogen, fats, etc., agree with other chemical and biological data and show the improved condition of the river below Marseilles.

Hydrogen Sulphide from Wells in Illinois. Determinations of hydrogen sulphide in water are usually made in the field immediately after the collection of the sample. This article describes a method which is being tried in this laboratory whereby the volatile gas is fixed or changed to a stable form in the field and the analysis completed in the laboratory. The advantage of such a method is evident. Our results thus far show very excellent possibilities. A table gives the results of 8 analyses, varying in the quantity of hydrogen sulphide present from 0 to 16 pts. per million.

Improved Management of Waterworks. Investigations of a large number of the smaller waterworks plants in Illinois have shown that a more general employment of consulting experts, in the supervision of operating conditions, would result in a saving for the water company or water department. The paper is discussed by a number of hydraulic engineers.

Sewage Disposal in Small Communities. During the year the State Water Survey has been called on by the city of Geneseo to advise the city officials concerning the proper method of solving its sewage disposal problem. The problem at Geneseo is similar in many respects to that which is being encountered in small communities throughout the state and, therefore, the report is believed to be of sufficient general interest to be presented in full elsewhere in this bulletin.

A Study of Typhoid Fever in Rockford, Illinois. A detailed report has been prepared embodying all the important facts and a full discussion of the methods used in conducting the investigation of the epidemic. It was proven that the water supply was not responsible and the report sheds much light on bread, milk and vacation outings as causes of typhoid.

Work of the State Water Survey During the Ohio Valley Flood. Representatives were engaged in protecting the water supplies and in supervising sanitation. This article describes the extent and character of the work done.

ASSOCIATIONS AND COMMISSIONS.

Special phases of Illinois water problems are of interest to several State, Interstate, National and International Associations and Commissions. These have been co-operating as far as possible in the study of water problems in order to prevent useless duplication of the work. The organizations interested are noted below, together with a brief statement concerning that part of their work during 1913, which concerned water supplies.

Illinois State Board of Health. (1877.) Water analyses for the State Board of Health have been made when requested. The care of the water supplies of the State has been given over to the State Water Survey.

American Water Works Association. (1880.) Robert J. Thomas, Lowell, Mass., President; J. M. Diven, Troy, N. Y., Secretary. The 1913 annual meeting was held at Minneapolis.

State Laboratory of Naturul 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 the Illinois river. The chemical work has been done under the direction of the State Water Survey.

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 1913 proceedings contained four papers and reports relating to water and sewage problems. A brief review of these is given elsewhere.

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 the City of Chicago during 1913.

Western Society of Engineers. (1895.) Albert Reichmann, Chicago, President; C. R. Dart, Room 700, 900 Michigan Ave., Chicago, Treasurer. The annual meeting is held in Chicago.

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.

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 supply of pure water for those cities and towns which depend on Lake Michigan for their source of supply. The members of the Commission are appointed by the governors of the states, and the mayors of several cities which border the lake. There are also representatives from the United States Army and the United States Public Health Service. No special appropriations are made for this commission. The members are, for the most part, officials connected with state, federal, or municipal bureaus. No meetings were held during 1913.

Lake Michigan Sanitary Association. (1908.) A. J. Horlick, Racine, Wisconsin, President. This association is composed of representatives of city councils, health departments and engineering departments of cities in the territory draining into Lake Michigan. It has for its object the protection of the water supplies.

North Shore Sanitary Association. (1908.) James O. Heyworth, Lake Forest, President; James F. King, Lake Forest, Secretary. This Association during the past five years has been working toward a solution of the sewage disposal and water supply problems of the north shore municipalities bordering on Lake Michigan. Until recently the work has consisted mainly in accumulating necessary data and promoting a campaign of education. In 1913 a bill was passed by the State Legislature which granted permission to organize a Sanitary District in Lake County. 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. It is expected that the Trustees will immediately adopt a plan of work.

Illinois Water Supply Association. (1909.) C. H. Cobb, Superintendent Water Works Company, Kankakee, 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. The annual meetings are held at the University of Illinois in February or March. Papers dealing with topics of interest to waterworks men are read. The program of the fifth meeting is published elsewhere in this report.

Rivers and Lakes Commission. (1909.) A. W. Charles, of Carmi, Chairman; Charles Christmann, Transportation Bldg., Chicago, Secretary.

Great Lakes International Pure Water Association. (1911.) Dr. Chas. J. Hastings, Medical Health Officer, Toronto, Canada, President; Paul Hansen, Illinois State Water Survey, University of Illinois, Urbana, Secretary. At a meeting of representatives from various municipalities throughout the country held in Chicago, September 29, 1911, an association was formed of those interested in the character of the water of the Great Lakes.

National Association for Preventing the Pollution of Rivers and Waterways. (1911.) Calvin W. Hendrick, American Bldg., Baltimore, Md., Chairman; H. de B. Parsons, 22 William St., New York City, Secretary. This association has for its object the prevention of excessive pollution of streams.

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

Public Health Service. Dr. Rupert Blue, Surgeon-General, Washington, D. C. The Hygienic Laboratory of the Public Health Service has undertaken the investigation of the quality of interstate streams.

International Joint Commission of the United States and Canada. Th. Chase Casgrain, Chairman. To this commission has been referred the sanitary condition of the boundary waters between Canada and the United States. On December 17, 1912, a conference was held in Buffalo for the purpose of outlining the course to be pursued in investigating the pollution of boundary waters. The conference decided on certain fundamental conditions and adopted a resolution recommending that the commission secure a joint appropriation with which to carry out the preliminary work.

Illinois Public Utilities Commission. (1913.) James E. Quan, Springfield, Chairman. The Commission has jurisdiction over all private corporations or individuals owning or operating water or power plants, but its powers do not extend to municipal plants. It has extensive authority over reports and accounts; capitalization, mergers and intercorporate contracts; and rates, services and facilities. A certificate from the commission is necessary to authorize any new plant by a private company or individual; and the operation of the undertaking may be brought under its active control and regulation.

ENGINEERING REPORT

GENERAL.

The work of the Engineering Division of the State Water Survey may be classed broadly into water supply investigations, sewerage and sewage disposal investigations and investigations of water borne epidemics.

Investigations relative to sewerage and sewage disposal may seem somewhat foreign to the duties of the State Water Survey, but when it is considered that the surface water supplies of the state constitute the most extensive and most valuable sources of water supply for domestic and industrial purposes, it becomes of paramount importance to examine into the conditions of surface waters with reference to their pollution. This pollution is brought about primarily as a result of the discharge of large quantities of sewage from various municipalities. The water of streams is also affected detrimentally by the discharge into them of manufacturing wastes.

While the primary object of investigating the pollution of streams is to preserve them so far as practicable, as sources of water supply, there are also many other evils resulting from stream pollution, such as odor nuisances, the destruction of fish life and the rendering of the streams unfit for navigation and pleasure purposes. These factors must necessarily be considered when investigating any particular problem of stream pollution and thus the State Water Survey has been led into a consideration of the broad problem of stream sanitation.

Upon the creation of the Rivers and Lakes Commission in 1909, the Legislature gave this body authority with reference to stream sanitation in the following clause:

"It shall be the duty of said Rivers and Lakes Commission to see that all the streams and lakes of the State of Illinois, wherein the State of Illinois, or any of its citizens, has any rights or interests, are not polluted or defiled by the deposit or addition of any injurious substances, and that the same are not affected injuriously by the discharging therein of any foul or injurious substances, so that fish or other aquatic life is destroyed. And if, upon investigation the commission shall find that any of such streams and lakes are so polluted and defiled, or are affected injuriously by the discharging therein of any foul or injurious substances so that fish or other aquatic life is destroyed, it shall be the duty of said commission to enter an order commanding the abatement of such nuisances within such time as may be fixed by the commission."

During the first several years of the existence of the Rivers and Lakes Commission, the provisions of this clause were not actively pressed, owing to lack of appropriations, to more immediate demands made by other considerations under the Rivers and Lakes Act, and owing also to the fact that these matters were being handled in an advisory way by the State Water Survey. During the month of December, 1913, a co-operative agreement with the Rivers and Lakes Commission was made with reference to the investigation of matters relating to stream sanitation, so as to avoid duplication of effort. By this arrangement, the State Water Survey is to use its already developed organization for making necessary investigations, and is to render reports to the Rivers and Lakes Commission. The Rivers and Lakes Commission in turn conducts hearings and issues necessary orders under its legal authority for correcting abuses. In this manner there results an effective legal means for preventing the undue contamination of streams and places the state of Illinois on much the same basis as the states of New York, Massachusetts, Pennsylvania, New Jersey and many other of the more progressive states with respect to state control over that part of the common property which obtains in surface streams and lakes.

The work of the Engineering Department may also be subdivided as follows: (1) Regulative; (2) Special Investigations; (3) Statistical; (4) Educational. This subdivision gives a better basis for a description of the various activities of the department than does the classification first mentioned.

Regulative. The regulative work of the department relates to the examination of plans and specifications for new projects. New projects may involve the installation of entire new water supplies or sewerage systems or may involve important modifications in existing water supplies or existing sewerage systems. It is of special importance that new water supply projects be investigated promptly in order that any unwise selection of a source of supply or method of treating a water for purification purposes may be brought to the attention of the local authorities. In the case of new sewerage systems, it is likewise important that the local authorities be advised with reference to the proper final disposal of sewage so that the surface water resources of the state may not be unduly jeopardized. Accordingly, the department has regarded the investigations of new projects as an immediate demand upon its attention.

To carry out this branch of the work of the department, all sources of information such as newspaper clippings and engineering periodicals are regularly reviewed to learn of new undertakings. When information is obtained of a project which seems to require the services of the Survey, a communication is sent to the local authorities requesting the submittal of plans and specifications before special assessments are spread. This often enables the Survey to secure the plans at a time when changes can be most readily made. Plans and specifications are then carefully reviewed and in practically all instances a representative of the engineering department visits the community in question for the purpose of making an examination on the ground. Upon the basis of the information thus acquired, a detailed report is prepared descriptive of the project and conveying approval or disapproval of the design and construction proposed. In actual practice it is rarely necessary to submit an outright disapproval and in most cases approval is given with certain conditions attached.

Very often the Survey is able to get in touch with local authorities before plans and specifications are prepared. In this event an endeavor is made to co-operate with the engineer employed and place before him various information which the Survey has at hand. This results in the production of plans and specifications which require but perfunctory review.

The State Water Survey does not attempt to act as consulting engineers, but strongly advocates the immediate employment of a competent consulting engineer by the local authorities. This leaves the State Water Survey in the attitude of an advisory board of review.

In the regulative work of the State Water Survey there is opportunity for duplication of the work of other state departments such as the State Board of Health and the Rivers and Lakes Commission. Such duplication is, however, effectively avoided by cooperation with both of these departments. The method of co-operation with the Rivers and Lakes Commission has already been described. The State Board of Health has referred to the State Water Survey all inquiries relating to water supply, and sewerage and has upon occasion, called upon the State Water Survey for assistance in the investigation of typhoid fever epidemics where water supplies have been suspected. The most notable example of this sort is the typhoid fever epidemic at Rockford, which is described elsewhere in this report.

Following is a list of cities and villages that have been reported upon with reference to new projects to the end of 1913:

Albion
Altamont*
Anna
Anna State Insane Hospital
Arthur
Assumption
Astoria
Barrington
Bellwood
Benton
Breese
Camp Point
Carlyle
Carrollton
Casey
Charleston
Chester
Chrisman
Colfax
Collinsville
Creal Springs
Decatur
Deer Creek
East Peoria
Effingham
Eldorado
Evanston
Fairfield
Flora
Geneseo
Genoa
Georgetown
Girard
Grand Ridge
Granite City
Greenville
Hamilton
Harmon
Harrisburg
High Lake
Highland

*Places printed in ordinary type are discussed in some detail in this bulletin. Those written in italics are discussed in preceding bulletins.

Litchfield
Macon County Alms House
Madison
Mattoon
Maywood
Melrose Park
Moline
Mounds
Mt. Sterling
Mt. Vernon
New Athens
Oglesby
Palatine
Pana
Peoria Heights
Peoria Insane Hospital
Petersburg
Piper City
Princeville
Rankin
Reddick
Roanoke
Rushville
Saint Anne
Salem
Tiskilwa
Vandalia
Warsaw
West Frankfort
Wheaton
White Hall
Wilmington
Winchester
Witt
Yorkville

Special Investigations. From time to time the Engineering Department is called upon, or finds it necessary, to the proper performance of its duties, to carry out special investigations of a scientific or research character. Such investigations directly bear upon or are closely allied to problems of water supply and stream sanitation. The principal special investigations during the year 1913 were examinations of watersheds, notably those of the Sangamon river and the Fox river, and the study of the treatment of liquid wastes from canning factories so as to prevent undue stream pollution. The rather extensive investigation of typhoid fever at Rockford may also be classed under this head. Special investigations which have been conducted during 1913 are listed as follows:

Sanitary survey of the Fox river watershed.

Sanitary survey of the Sangamon river watershed.

Flood relief work along the Ohio and Wabash rivers.

Typhoid investigations at New Windsor, Lawrenceville and Rockford.

Sanitary survey of the North Branch of the Chicago river.

Studies on the treatment of cannery wastes at Washington.

Statistical. To conduct the work of the engineering department of the State Water Survey so that the services of the Survey may be equitably distributed throughout the state and accomplish the greatest good with the means at hand, it is necessary for the department to acquire a knowledge of water-supply conditions throughout the state. To accomplish this, representatives of the engineering department are visiting all of the communities in the state which have public water supplies or sewerage systems for the purpose of securing detailed and accurate descriptions of these utilities. The information obtained is embodied in reports which include recommendations for improvements where such seem desirable, and copies of these reports are transmitted to the local authorities for their information. The statistical work is being carried on as rapidly as possible, consistent with giving due attention to regulative work and special investigatons.

The most valuable results of water supply inspections relate to the discovery and elimination of possible sources of contamination which endangers public health. A striking example of how insidious is this danger, is had in the city of Rockford, which obtains its water supply from deep rock wells. The general public had the greatest confidence in the purity of the supply, and, as a matter of fact, the water in the deep-lying rock strata is absolutely pure from a sanitary standpoint. The method of handling the water, however, subjected it occasionally to grave contamination, which in the early part of 1912 resulted in a most disastrous epidemic of typhoid fever. It is to safeguard the cities against such disasters that special cognizance is taken of the possibilities of contamination.

Of secondary importance, yet of great practical value to local authorities are recommendations made by the Survey with reference to the improvement of service and increasing economy of operation. These matters, however, have not been dealt with so exhaustively as has the general character and sanitary quality of water supplies. Improvement of service and economy of operation, however, constitute a broad field of profitable activity which the Survey will cover as soon as more pressing duties permit.

A list of cities visited with reference to existing water supplies is given as follows:

Abingdon*
Alton
Amboy
Anna State Insane Hospital
Arcola
Arlington Heights
Aurora
Batavia
Beardstown
Belleville
Belvidere
Benton
Bloomington
Breese
Byron
Cairo
Cambridge
Canton
Carbondale
Carlinville
Carlyle
Carmi
Carthage
Cedar Point
Centralia
Chadwick
Charlestoa
Chatsworth
Chenoa
Chester
Chicago Heights
Chrisman
Clinton
Collinsville
Crystal Lake
Danville
Deer Creek
Dixon
DuQuoin
Earlville
East Dubuque
East Dundee
East St. Louis
Effingham
Elgin
Elmhurst
El Paso
Evanston
Fairbury
Farmer City
Forest Park
Forreston
Fort Sheridan
Franklin Park
Freeburg
Freeport
Fulton
Galena
Galva
Geneva
Genoa
Gibson City
Gilman
Glencoe
Granite City
Grayville
Greenview
Harrisburg
Highland Park
Hillsboro
Hinckley
Hoopeston
Jacksonville
Johnson City
Joliet
Kewanee
Kirkwood
Knoxville
Ladd
LaGrange
Lake Bluff
Lanark
LaSalle

*Places printed in ordinary type are discussed in some detail in this bulletin. Those written in italics are discussed in preceding bulletins.

Lena
Leroy
Libertyville
Lincoln
Litchfield
Lostant
Marengo
Marion
Maroa
Mattoon
Maywood
McLeansboro
Melrose Park
Milford
Minooka
Monmouth
Monticello
Mounds
Moweaqua
Morrisonville
Mt. Carroll
Mt. Morris
Mt. Olive
Mt. Pulaski
Mt. Vernon
Murphysboro
Nauvoo
Naval Training Station
New Athens
Newton
Nokomis
Normal
North Chicago
Olney
Onarga
Oregon
Palatine
Pana
Paris
Paxton
Pecatonica
Peooria State Hospital at South Bartonville
Pekin
Peotone
Petersburg
Pinckneyville
Pittsfield
Polo
Pontiac
Rantoul
River Forest
Rochelle
Rockford
Rock Island Arsenal
Roodhouse
Savana
Shelbyville
Sheldon
Springfield
Staunton
St. Elmo
Sterling
Stockton
Stonington
Streator
Sullivan
Tiskilwa
Toluca
Toulon
Utica
Warren
Warsaw
Waterloo
Watseka
Waukegan
Winnetka
White Hall

Educational. The educational work of the State Water Survey is certain to be productive of great public good, and is given greater effectiveness through the close relation between the Survey and the University of Illinois. One form of this educational work is involved with the general activities of the Survey and consists in discussing water supply and sewage disposal problems with various city officials having such matters under their supervision. Frequently this work is broadened by addressing public meetings on requirements for adequate public water supplies and sewage disposal.

At the University the engineer of the Survey lectures and has classes in water purification, sewage treatment, and other sanitary engineering subjects. The reports of the Survey furnish a fund of practical information for students and are suggestive for thesis work.

In the following pages are given brief accounts of the various investigations made by the engineering department during 1913.

WATER SUPPLIES AND SEWERAGE.

ABINGDON, WATER SUPPLY.—Visited December 10, 1913, to obtain a general description of the public water supply. This was embodied in a report and a copy was sent to the local authorities.

The population of Abingdon, which is now about 2,500, has shown a marked increase due to the acquisition of several small factories. Water works, installed in 1902, obtained water from a well in the eastern part of the city. The well is 9 inches in diameter at the top and 6 inches at the bottom, terminating in St. Peters sandstone at a depth of 1,350 feet. The water is of good quality from a sanitary point of view. When drawn from the well it has a slight odor of hydrogen sulphide, but no odor is noticeable when the water is drawn from the distribution system. The water has a high mineral content, 1,318 parts per million, of which 233 parts are magnesium sulphate, 224 parts calcium carbonate and 553 parts sodium sulphate. If used in boilers the water will form scale and will cause foaming.

Until a year ago, the water was raised from the wells by means of a deep well pump into a 94,000 gallon cement lined brick collecting reservoir, but on account of frequent breakdowns and the desire for a greater yield, the pump was replaced by air lift. The water is pumped from the reservoir into a distribution system by a 750,000 gallon duplex steam pump. The distribution system comprises 5.44 miles of mains, all of cast iron pipe. A 36,000 gallon steel tank, connected with the distribution system, is placed on a brick tower and affords a pressure of about 50 pounds per square inch. Records of consumption are not maintained, but it is estimated to average 90,000 gallons per day or 36 gallons per capita.

ALBION, PROPOSED WATER SUPPLY.—See Bulletin No. 10, page 89.

ALEDO, WATER SUPPLY.—See Bulletin No. 10, page 90.

ALTAMONT, PROPOSED WATER SUPPLY.—Visited May 29, 1913, to secure information relative to a proposed water supply and assisting at a pumping test on a test well. Observations made were embodied in a report, copies of which were sent to the village officials and consulting engineers.

The population is about 1,325. having remained nearly stationary during the past decade. There are a few small industries, but agriculture is the principal pursuit.

A well drilled in the northwest part of town yielded little water until a vein of unusable salt water was encountered at 328 feet. A second well drilled about 250 feet north of the above well encountered a flow of water in a 5-foot layer of sand rock at 145 feet. The well was extended to 225 feet without increasing the yield. At first the water rose to within 100 feet of the surface and the yield was very small; after blasting. the water level rose to within 58 feet of the surface. During a pumping test the well yielded 10 gallons per minute and the water level was lowered about 100 feet.

An existing 6-inch well, 131 feet deep entering rock at 55 feet, is located about 50 feet south of the above well at the municipal light plant. It has a yield of about 15 gallons per minute which is available for water supply purposes. The character of water from this well is believed to be similar to that from the test well which on analysis showed a mineral content of 780 parts per million, about 135 parts being carbonates of calcium and magnesium and the remainder mostly salts of sodium and potassium.

The combined yield of the two wells, when pumped continuously on test, was but 25 gallons per minute or 36,000 gallons per day, a quantity scarcely sufficient to meet immediate demands and wholly inadequate for future requirements. Recommendations were made that further investigation of the water bearing strata be carried out before installing waterworks.

ALTON, PROPOSED IMPROVEMENTS IN WATER SUPPLY.—Visited April 23 and July 23, 1913, for the purpose of discussing proposed modifications in the purification plant with the water works officials. (See Bulletins 9 and 10.) Preliminary plans were carefully reviewed and a number of suggestions made with reference to the filters, operating valves, coagulating basin and arrangement of pipe in the pipe gallery. The completed plans will be submitted to and reviewed by the State Water Survey.

AMBOY, EXISTING PUBLIC WATER SUPPLY.—Visited October 8, 1913, to obtain information for a descriptive report on the public water supply. Amboy has a population of about 1,700. Slight decreases are shown by the last two census reports.

Water works have been installed for about 20 years. A 2,400 foot well that has since furnished the supply was drilled into Potsdam sandstone near the center of town. The well is 10 inches in diameter at-the top and 5 inches at the bottom. It is pumped with air lift and discharges into an 80,000 gallon brick collecting reservoir. Water is pumped from the reservoir into the mains by a triplex pump, of about 575,000 gallons per day capacity, belt connected to a 20 H. P. electric motor. The distribution system comprises about 2 miles of 4 to 8 inch cast iron pipe and an elevated wooden tank of 60,000 gallons capacity. A pressure of about 40 pounds is maintained in the mains. The consumption averages about 50,000 gallons per day. No test of the well's yield has ever been made, but its capacity is known to greatly exceed the demands made upon it. The supply is of good, sanitary quality, but rather hard and little used for laundry purposes on account of a high iron content.

ANNA, WATER SUPPLY.—Visited February 24, 1913, to obtain information relative to recently installed water supply and sewerage systems. (See Bulletin 9, page 15.) This was embodied in a report, copies of which were sent to the local authorities and the Central Illinois Public Service Company.

The population of Anna is about 3,200 and is slowly increasing. A few small factories are located within the city and fruit growing is carried on extensively in the surrounding country.

The municipality, in 1912, installed a distribution system comprising 4.37 miles of 4 inch to 8 inch cast iron pipe and a 100,000 gallon steel tank on a 70-foot tower. It contracted with the Central Illinois Public Service Company, which operates a combined electric light and ice plant at Anna, to supply water from wells and also to provide a collecting reservoir. The water supplied is pumped by air lift, into a 100,000 gallon concrete open reservoir, from a well 650 feet deep, 12 inches in diameter at the top and 8 inches in diameter at the bottom. A second well 4 inches in diameter and 350 feet deep is available, but as yet no connections have been made to it.

From the reservoir the water is pumped into the distribution system by a 500,000 gallon simplex steam pump. The tanks and tower afford a pressure in the city of from 50 pounds to 80 pounds. The air compressors are in duplicate. Although three triplex power pumps and one duplex steam pump are used at the service company's station, only the simplex pump is connected to the city supply.

The water is of good quality from a sanitary standpoint and unusually low in mineral content for a southern Illinois ground water. Total residue is but 375 parts per million. The water bearing stratum is in limetsone and limestone was encountered throughout most of the depth penetrated. Contamination entering through sink holes at the surface and following water worn passages in the rock is possible. Frequent control analyses are desirable.

Only about 20 per cent of the population use the public supply, which accounts for a small consumption of only 25,000 gallons per day.

ANNA, SEWERAGE SYSTEM.—A sewerage system installed in 1912 comprises 4½ miles of 8-inch to 15-inch vitrified pipe sewers and a septic tank 60 feet by 24 feet in plan and 5½ feet deep to the flow line. The system serves about three-fourths of the city, but the remaining portion, because of the topography, will require a separate outlet.

The effluent from the septic tank discharges through about 500 feet of pipe into a small tributary of Cache river. This tributary has its source within the city limits, but is fed by springs and condenser water and is said never to go dry. Owing to the few connections as yet made to the system, the load on the tank is light and both the influent and effluent were quite clear. After the sewerage system comes into general use, treatment by septic tanks only, will in all probability prove insufficient. Further treatment might be arranged jointly with the Anna State Hospital, which at present is discharging about 400,000 gallons per day of raw sewage at a point about ½ mile below the city's septic tank. Gross contamination of the stream by the hospital sewage is now an offensive nuisance to riparian owners down stream.

ARCOLA, PUBLIC WATER SUPPLY.—See Bulletin No. 10, page 91.

ARLINGTON HEIGHTS, SEWAGE TREATMENT WORKS.—See Bulletin No. 10, page 91.

ARTHUR, PROPOSED WATER SUPPLY.—See Bulletin No. 10, page 94.

ASSUMPTION, PROPOSED WATER SUPPLY.—Visited December 5, 1912, January 11, March 18, and August 13, 1913, relative to a proposed water supply and a proposed sewerage system. Data obtained together with recommendations were embodied in reports, copies of which were sent to the local authorities.

The population of Assumption which is increasing slowly is now about 1925. Agriculture and mining are the principal pursuits.

During 1912, the city officials took advantage of a surplus in the treasury and installed a 60,000 gallon tank 100 feet high and about 2,150 feet of 6-inch and 8-inch mains with hydrants in the central part of the city. An adequate source of supply had not been secured at that time so the tank was filled temporarily from shallow wells to gain immediate though limited fire protection.

Search for an adequate source of supply was attended with considerable discouragement. The private wells are from 20 feet to 40 feet deep in drift which is mainly blue till varying from 60 feet to over 100 feet in thickness. Many of these wells are dry during the summer. In the south part of town a coal mine 1,000 feet deep encountered rock at 80 feet, with little water in the drift above and only salt water in the rock below. Several drillings were made in different parts of the city in an attempt to win a prize of $2,000 in city bonds offered by the city to the person locating a supply satisfactory in quality and quantity.

Finally six four-inch test wells were put down within 100 feet of Spring Creek about 2½ miles south and 1¼ miles east of the city. These wells enter a sand and gravel deposit 11 feet thick, 6 feet below the surface. This gravel bed outcrops into Spring Creek about ¼ mile south of the test wells. Springs emerging from the gravel produce a flow in the creek below throughout the year. A 54 hour pumping test on the 6 test wells at a rate of 100,000 gallon per 24 hours lowered the water in an open dug well, 60 feet away, 12 inches in the first 24 hours. Thereafter it remained stationary. Assumption will require more than 100,000 gallons per day as the distribution system grows; but the test would seem to indicate that additional quantities may be obtained by sinking additional wells.

The water is of excellent quality with a low mineral content, 200 parts per million, practically all of which is carbonates of calcium and magnesium.

ASSUMPTION, SEWERAGE SYSTEM.—A combined sewerage system was under construction during 1913. The completed system will cost about $31,000 and will comprise about 8 miles of from 6-inch to 30-inch vitrified pipe, with necessary appurtenances. The discharge will be into Big George Creek in the northwestern part of town. The creek runs through an undeveloped section of the city. Below the city it flows through pastures and fields with the first dwelling about 2 miles below the sewer outlet. Near Assumption the creek is about 50 feet wide and the stream bed is about 6 or 8 feet below the general level of the land. The ordinary flow is very small and in dry seasons there is no flow.

Treatment is not contemplated, although during dry weather the discharge will no doubt create a nuisance. Citizens of the city who own the land below the city through which the stream passes, are favorable to the sewerage improvement and will waive any objections to stream pollution. The installation of a treatment plant would require pumping the sewage.

During the construction of the sewers, a disagreement arose between the city's engineer and the pipe company over the quality of the pipe furnished. For the purpose of effecting an adjustment, a visit of inspection was made and a report was rendered embodying recommendations for an equitable settlement.

ASTORIA, PROPOSED ADDITION TO WATER SUPPLY.—Visited July 17, 1913, after learning that an addition to the public water supply was contemplated. Observations were embodied in a report, copy of which was sent to the local authorities.

Besides agriculture, coal mining had been a prominent industry at Astoria but the mines have not been operated for several years, with a consequent decrease in population between 1900 to 1910 of about 19 per cent. The population now is about 1,350, the same as in 1890.

Water works, installed in 1897 primarily for fire protection, comprise a 1,650-foot drilled well, a deep well pump, a 105,000-gallon collecting reservoir, a 1,000,000-gallon duplex steam pump for pumping into the distribution system and an 80,000-gallon steel standpipe. Later the deep well pump was replaced by air lift equipment, presumably to increase the yeld.

The well passes through the coal measures and probably enters St. Peters sandstone. The water is wholly unsatisfactory for general domestic use owing to its high mineral content, 3,620 parts per million. Of this 1,744 parts are sodium chloride and most of the remainder is carbonates or sulfates of calcium and magnesium. The water is corrosive and has caused much trouble with the hydrant valves. It is not used for drinking or culinary purposes, though used in houses for flushing closets and for power purposes as pumping cistern water into elevated tanks. The greatest. demand comes during the sprinkling season and then the consumption is dependent upon the yield which at present is about 54,000 gallons per clay. Lawn sprinkling often leaves no water for fire protection and consequently efforts have been made to increase the available supply.

An effort to explode dynamite in the present well was for some reason unsuccessful and at a distance of 10 feet a new well was drilled to a depth of 320 feet without securing sufficient water. The air lift as now arranged is inefficient and a rearrangement would increase the yield.

Abandoned coal mines about ¾ mile south of the city have been considered as a new source of supply. These would provide large storage but a long test would be necessary to ascertain the true yield. The mine water was considered satisfactory for the mine boilers and the mules liked, or at least drank it. Although containing much less salt than. the city supply, it is highly mineralized, has a high turbidity and color and a disagreeable taste that would not meet with popular approval. This supply may be satisfactory for fire protection, but would not be suitable for domestic uses.

A surface supply developed on Otter Creek would seem to offer the best solution. Such an installation should include a filter plant.

ATLANTA, WATER SUPPLY.—Visited September 3, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities. Atlanta is a farming center with a population of about 1,500. Future growth will probably be moderate.

Water works, installed in 1891, comprise an 8 inch well 151 feet deep, a 190,000 gallon per day deep well pump, a distribution system and a 130,000 gallon standpipe; the latter affording a range in pressure within the city of from 32 pounds to 43 pounds. A second well 10 inches in diameter 151 feet deep and equipped with a deep well pump has since been added. A third well is available, but is not equipped with pumping machinery.

The water comes from a 12-foot layer of sand and gravel at the base of the drift and the yield is very abundant. It is of excellent quality and has a mineral content of about 500 parts per million.

The water has been and will continue to be pumped directly from the wells into the mains; but a 32,000-gallon storage reservoir and an additional pump are to be provided for emergency use. It probably would be found more economical to pump the water in two stages. The city formerly maintained its own boiler plant, but now steam is furnished from a privately owned electric plant adjoining the pumping station.

The present distribution system comprises about 6¾ miles of from ¾-inch to 8-inch mains. Those under 4 inches are of wrought iron and those 4 inches in diameter and over are of cast iron.

Pumpage records are not kept, but the daily consumption is estimated to average about 125,000 gallons.

AURORA, POLLUTION OF PUBLIC WATER SUPPLY.—Visited. Octotober 8, 1913, for the purpose of making inquiry into pollution of the public water supply indicated by bacterial analyses by the State Water Survey and by the analyses of the C. B. & Q. railroad at Aurora. (See Bulletin 9, page 16.) An inspection of the water works was made in company with the superintendent of water works. Several possible sources of contamination were discovered. The greatest opportunity for contamination was afforded at the discharge of several of the deep wells which constitute the source of supply. This discharge is received from air lift equipment into open shallow basins which are visited by the neighboring population to obtain drinking water. It is conceivable that the water as it passes through these basins may be contaminated by careless or malicious persons. A second possibility for contamination is leakage of polluted ground water into the collecting reservoir. The collecting reservoir is known to be in a leaky condition, but ordinarily the water level is maintained at an elevation above the ground. At times of unusual consumption, however, it is possible that the water level may be lowered at which time more or less polluted ground water and even infiltration from the polluted Fox river nearby may enter. A third possibility is the pollution of the water in the reservoir by quantities of dust blown from nearby roadways. A heavy wind from the right direction may blow considerable quantities of dust into the reservoir, the dust being more or less mixed with horse droppings may account for the presence of intestinal bacteria.

A fourth possibility is the possible mixing of water from the Fox river with-the well water supply through a direct river intake. Investigation of this possibility showed that the intake is so arranged that pollution in this manner is practically out of the question. The valve shutting off the direct intake from the pump suctions should, however, be kept under careful supervision, for if opened only slightly, it will draw in river water.

The polluted condition of the water from its first detection was noted to regularly decrease until it entirely disappeared. Doubtless the contamination of the water was a temporary occurrence that might have taken place by the throwing of polluting material into one of the collecting basins.

AVISTON, COPPER SULPHATE TREATMENT OF RESERVOIR.—This visit was made on November 4, 1913. An experiment was tried with the use of copper sulphate for removing a troublesome growth of "Deckweed" in a reservoir owned by the Aviston Milling Company. A quantity equal to 10 pounds per million gallons was applied. Immediate satisfactory results were not obtained, but further experiments will be made in the spring of 1914.

BARRINGTON, PROPOSED SEWERAGE.—See Bulletin 10, page 94.

BATAVIA, EXISTING WATER SUPPLY.—See Bulletin 9, page 16.

BEARDSTOWN, EXISTING WATER SUPPLY.—Visited December 13, 1913. The information obtained was embodied in a descriptive report, copy of which was sent to the local authorities.

The population of Beardstown increased 26 per cent from 1900 to 1910 and is now about 6,200. Fishing and the manufacture of buttons from clam shells are the leading industries. Railroad shops and a large electric power plant are also located at Beardstown.

Water works were installed in 1892 and draw a supply from a number of 6-inch wells about 100 feet deep, located on the east side of the city. Below 12 feet, a water bearing sand and gravel stratum about 100 feet thick is encountered, affording an abundant yield.

After a time there was a tendency for the strainers to become encrusted and clogged and it proves expensive to pull the 6-inch pipes. To avoid this difficulty, smaller and shallower wells were adopted for further developing the source of supply. The old wells are, however, kept in service. At present besides 8 old 6-inch wells, there are 72 2-inch wells 40 feet deep. About ½ of the small wells are pulled and replaced each year at a cost of about $12 each. All the wells are confined to an area 75 feet by 25 feet.

The water is of excellent quality from a sanitary standpoint. The mineral content is about 373 parts per million mainly in the form of carbonates of calcium and magnesium. One serious danger of contamination exists, due to a 4-inch connection between the city distribution system and a supply obtained by the railroad shops from the Illinois river. The object of the connection is mutual fire protection but it places the health of the community in grave danger. One occasion at least is recalled when polluted water was forced through this connection into the city mains. The connection should be eliminated.

The water from the wells is pumped directly into the distribution system for which two 750,000-gallon duplex steam pumps are available. The distribution system comprises about 9 miles of from 4-inch to 12-inch cast iron mains and 6 miles of wrought pipe ¾ inches to 2 inches in diameter. Connected to this is a 35,000 gallon steel tank on a 68-foot brick tower. Records of consumption are not kept but average consumption is estimated at 450,000 gallons per day.

BEARDSTOWN, POLLUTION OF ILLINOIS RIVER BY CHICAGO DRAINAGE CANAL.—Visited December 8, 1913, to collect samples of Illinois river water and to make arrangements for the periodical collection of samples for analysis from that river, in connection with a survey of the river to determine the amount of pollution of the river by the Chicago Drainage Canal, and its effect on the fish life.

BELLEVILLE, WATER SUPPLY.—Visited January 20, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Belleville has had a steady growth and the present population is about 22,500. Besides coal mining, there are a few other small industries.

Water works installed about 25 years ago secured a supply from Christina Lake, a small body of water east of town. This proving of unsatisfactory quality, a number of 400 foot tubular wells were sunk at the south edge of the city. These wells, supplemented by the lake, constituted the source until 1908, but the yield was always inadequate.

About this time the water works went into the hands of the American Water Works and Guarantee Company of Pittsburgh, Pa., this company also owns and operates the nearby water works at East St. Louis and Granite City. The company sank five 8-inch tubular wells about 75 feet deep in the Mississippi bottom land at Edgemont about 7 miles northwest of Belleville. The city was supplied from these wells, retaining the old pumping station for fire service. The water from the new wells is harder, contains considerable iron and did not prove popular. In 1912 the supply became inadequate and a 16-inch pipe line was laid from East St. Louis to Edgemont a distance of about 5 miles and now the Edgemont pumps draw from the company's East St. Louis supply which is filtered Mississippi river water.

Daily analyses are made at the East St. Louis plant but the results are not made public. Analyses made at the Water Survey laboratories show the water to be of satisfactory quality and it has proved popular at Belleville.

Two 750,000-gallon triple expansion duplex pumps are maintained at Edgemont and can draw either from the Edgemont wells or from a 750,000-gallon steel tank fed by the 16-inch pipe from East St. Louis. From Edgemont the water is pumped through a 12-inch and an 8-inch pipe to the Belleville distribution system to which is connected a 450,000-gallon standpipe. A 600,000-gallon reservoir is also kept full at Belleville and in case of fire, to avoid high pressures in the mains from Edgemont, the flow is diverted into this reservoir and then repumped into the distribution system by special fire pumps. The daily consumption averages about 700,000 gallons or 270 gallons per service.

BELVIDERE, PUBLIC WATER SUPPLY.—Visited October 20, 1913. Information obtained was embodied in a descriptive report. Belvidere is a city of about 8,000 population and is experiencing quite a substantial growth. There are several manufacturing industries, the most important of which is a sewing machine factory. The city has a complete system of sewers with five outlets to Kishwaukee river which flows through the center of town. Dilution is slight at times, but no nuisances are reported.

Water works were first installed in 1891 when a 2,000 foot well was drilled to Potsdam sandstone. The well flowed at first but later the water level receded slightly and pumping became necessary. Two more wells have been added, one in 1901 and the other in 1908. All three are 8 inch wells and the last two are drilled to a depth of about 1,800 feet. Connected with each of two wells is a triplex pump of 200,000 gallons capacity per day, both driven by a steam engine through belt transmission. On the third well is a duplex steam pump of about 350,000 gallons capacity per day. These pumps discharge into a covered brick collecting reservoir of 265,000 gallons capacity equivalent on an average day to about 12 hours storage. Water is pumped from the reservoir into the distribution system by two duplex steam pumps each of 1,000,000 gallons capacity per day, and one cross-compound, crank and fly-wheel pump rated at 2,500,000 gallons per day.

The supply is of good sanitary quality, but quite hard. It is in very general use as evidenced by the large number of services, namely, about 1,700. The system of mains includes about 24.5 miles of cast iron pipe. About 66 per cent of the services are metered and the average consumption is approximately 325 gallons per service daily or 70 gallons per capita. The management is efficient. Good records are maintained and finances are kept in such form as to permit of satisfactory analysis. The total cost of operation and maintenance in 1912 was equivalent to 6.1 cents per 1,000 gallons pumped.

BELLWOOD, PROPOSED WATER SUPPLY.—Visited October 25, 1913. A descriptive report was prepared.

Bellwood is a small manufacturing village on the outskirts of Chicago. The population is about 1,000. Since 1908 Bellwood has had a distribution system and has been connected through a meter with the Melrose Park water supply, paying that city for the water furnished. (See Bulletin 10 for a brief description of the Melrose Park water works.) During 1913 the village began the installation of a complete water works system of its own and at the time of the visit the installation was complete except for the power to operate the pumps. Electric power was to have been secured from the Chicago Sanitary District but trouble over the right-of-way for the transmission line has thus far prevented.

The new source of supply is a drilled well 1,400 feet deep, 12 inches in diameter at the top and 8 inches in diamefer at the bottom. The water stands 75 feet below the surface. After completion the well was tested for 75 hours at a rate of 200 gallons per minute.

The water will be pumped from the wells into the distribution system by a 235 gallon per minute deep well power pump. The distribution system quite thoroughly covers the village and is of 6-inch cast iron pipe with the exception of one block of 10-inch cast iron pipe.

connecting the system with the new pumping station. A 60,000-gallon steel elevated tank has been erected near the pumping station. At present Melrose Park supplies about 200,000 gallons per day to the village.

BEMENT, EXISTING WATER WORKS. See Bulletin 10, page 95.

BENTON, PROPOSED CHANGES IN PUBLIC WATER SUPPLY.—On May 16, 1913, a conference between the engineer of the Survey and Mr. Charles E. Hamilton was held in Urbana with references to proposed changes in water supply.

The company does not believe at the present time that it can finance the construction of a filter plant, and, therefore, proposes to improve the supply by utilizing an old ballast pit adjacent to a railroad as a coagulating and sedimentation basin. This basin has hitherto been used as an impounding reservoir for a very limited watershed, but since the addition of a 200,000,000-gallon impounding reservoir, the ballast pit is no longer needed for this purpose. The ballast pit is one-half mile long and 50 feet wide and probably affords 10 or 15 days' retention period. It should be possible to secure in this manner a highly clarified water and the addition of hypochlorite for sterilization should render it perfectly safe. It was specifically pointed out, however, that this method could not be regarded as an entirely satisfactory and permanent method.

BLOOMINGTON, EXISTING WATER WORKS.—See Bulletin 10, page 96.

BRADLEY, PROPOSED SEWERAGE.—On February 1, 1913, there was received from Bradley a set of plans and specifications for a proposed sewerage system prepared by Mr. T. R. Strobridge, civil engineer.

These plans were reviewed by the Engineering Department and a report approving the plans was prepared.

Bradley is located just north of the city of Kankakee and in 1910 had a population of about 2,000. The growth is likely to be moderately rapid in the future. The area within the corporation limits is about one-half square mile. Only a few streets within this area are built up at the present time.

The proposed sewerage system is on the combined plan and is laid out in a manner that will, ultimately permit of conveying sewage from all parts of the corporation to a single outlet discharging into the Kankakee river below the city of Kankakee. Ten thousand five hundred feet of sewers will be installed immediately, varying in diameter from 33 inches to 22 inches and will serve the main streets of the community and the David Bradley Manufacturing Works. All sewers will be of vitrified sewer pipe laid with cemented joints.

The sewers are amply large to take care of all the sanitary sewage for the village, even if it becomes densely populated, and probably the storm water from the main streets can also be carried off; but the main outfall is not large enough to take the run-off from exceptional storms over the entire area of the corporation. Larger sewers are not warranted because of lack of funds and the present size of the town but it will be feasible at a later date when the streets are more completely paved to find some other means of getting rid of the surface run-off.

The discharge of crude sewage into the Kankakee river should not give rise to nuisance because at this point the river has an ample flow to care for the sewage of a town the size of Bradley. Furthermore any refinement with respect to the disposal of the sewage from this community would be unwarranted as long as the city of Kankakee discharges unpurified sewage into the stream. In the somewhat remote future, it may be necessary to partially treat the sewage from Bradley in order to remove unsightly floating matter and to prevent the formation of sludge banks. This would involve the installation of some form of sedimentation tanks. In view of these considerations, the method of final disposal was approved.

BREESE, WATER PURIFICATION. Visited January 22, 1913, for the purpose of observing the operation of a recently installed water treatment plant. (See Bulletin 9, page 16.) A report was prepared embodying the information obtained and modifications in the plant were suggested.

Breese has a population of about 2,500. Besides serving as a farming center, the city contains three coal mines, a condensed milk factory and a flour mill. A public water works was installed in 1902 and until 1912 the water was pumped directly from Shoal Creek into the distribution system.

During 1912, a purification works, comprising coagulant preparation and feed devices, four settling tanks and a clear water reservoir, were installed. The plans for this plant were not sent to the Water Survey until after construction was begun and none of the numerous changes advised by the Survey were adopted by the city.

Lime and iron sulphate are used as coagulants. Only one 200 gallon solution tank is provided for each chemical and there are no feed devices, consequently the strength of solution and rate of application cannot be controlled. The strength of solutions added to the raw water vary widely during the day.

The settling basins have a retention period of less than 20 hours and this is insufficient where the water is not to be subsequently filtered. The introduction of a hanging baffle in the first compartment of the basin produces bottom scour and cuts down the settling capacity.

The settled water reservoir holds about 16 hours' supply; but since the pumps take their suction from the bottom of the reservoir the additional settling capacity that might be obtained is not taken advantage of.

The results obtained have been very poor. Some suspended matter is removed, but the treated water is never very clear and one sample analyzed at the Water Suryey laboratories showed a turbidity of 1,500. The results may be improved by proper addition of chemicals and minor changes in the settling basins, but for good results sand filters must be added as originally recommended by the Water Survey.

BROOKPORT, PUBLIC WATER SUPPLY.—Visited April 9, 1913, during flood relief work then being carried on by the State Water Survey. The principal object of this visit was to ascertain if the public water supply had been affected by the floods and also to render safe the various sources of private supply. The public water supply is derived from a deep well in drift deposits and was found to be on sufficiently high ground not to be influenced by the flood waters. Many private wells were treated with bleach.

BUSHNELL, DISPOSAL OF SEWAGE.—See Bulletin 9, page 17.

BYRON, PUBLIC WATER SUPPLY.—Visited October 25, 1913. Information was obtained which was embodied in a descriptive report.

Byron has a population of about 1,000 and is having little or no growth. The city is mainly an agricultural center, but, due to natural beauty of the surroundings, has also acquired some popularity as a summer resort. A sewerage system is contemplated for the near future, but plans have not yet been prepared.

Water works were installed in 1900 and have been little changed since. A well was drilled 2,000 feet deep into Potsdam sandstone at the south end of town. It is 12 inches in diameter at the top and finishes 5 inches at the bottom. The casing extends to rock at a depth of 213 feet. The well flowed slightly when first drilled but the water level has since receded somewhat. Water is withdrawn with a triplex pump of 400,000 gallons per day capacity direct connected to a 30 H. P. gasoline engine. Another gasoline engine of 50 H. P. capacity is also provided with belt transmission for emergency use. The pump discharges into the distribution system against pressures ranging from 30 to 75 pounds. A single 8 foot by 36 foot steel air pressure tank is connected with the discharge line at the plant. At times of fire this is cut off and direct pressure established. About two miles of mains have been laid, ranging in size from 4 to 10 inches, and another mile of 6 inch pipe is soon to be added. About 125 services are now in use, indicating that about 60 per cent of the population use the public supply. All services are metered.

CAIRO, WATER SUPPLY.—Visited April 10 to 17, July 23, and September 18 to 26, 1913. These visits were made in connection with the spring floods of 1913 and to establish a laboratory and instruct the superintendent in its operation. (See Bulletin 10, page 96.) Data obtained were embodied in several reports.

The water is filtered in six wooden tub filters of old design, but should give fair results if well operated. At the time of the first visit, there was insufficient sand in the filters and this was of poor quality. In the past, wash water for the filters had been drawn from the distribution system, but after the collapse of the standpipe in February, 1912, this practice seriously lowered the pressure in the mains. At the time of the first visit, a wash water pump had been installed, but the capacity was inadequate and only capable of producing a rise in the filters of 4.7 inches per minute. By the third visit, this pump had been replaced by a pump of proper size.

Laboratory equipment recommended at the time of a visit during 1911 had been purchased and during the three visits of 1913 instruction was given in laboratory control methods to the superintendent for the water company.

An elevated tank to replace the collapsed standpipe is under construction near the center of the distribution system where it will provide greater effective storage and more uniform pressure than that obtained with the old standpipe.

CAMBRIDGE, WATER SUPPLY.—See Bulletin 10, page 96.

CAMP POINT, PROPOSED WATER SUPPLY.—Visited July 2, 1913, upon learning that a public water supply was proposed.

Camp Point is a residence village in an agricultural district and has a population of about 1,150.

No active steps had been taken toward the installation of a public water supply before the above visit and at the end of the year, the project was in temporary abeyance.

Wells at Camp Point average 25 feet to 30 feet deep with a few extending to 50 feet at which depth rock is struck. Two sources for a public supply had been suggested, one, a 300 foot drilled well at the electric power plant and the other, a spring in a ravine at the southwest end of town. Pumping tests or analyses of either source have not been made.

The village is said to be in a strong financial position and might well consider installing a public water supply.

CANTON, WATER SUPPLY.—Visited June 13, 1913, relative to a proposed change in the public water supply. The information obtained was embodied in a report, copy of which was sent to the local authorities. A visit was made Sept. 21, 1911, in connection with sewage disposal nuisance. (See Bulletin 9, page 17.)

Due to the development of industries, at Canton the population increased 59 per cent from 1900 to 1910 and is now about 11,000. A moderate future growth is expected.

Water works were installed in 1880 deriving a supply from an 8 inch well 2,500 feet deep in the southwest part of the city. The water was pumped into a distribution system of calamine pipe to which was connected a standpipe. This well has since been abandoned and the supply is now obtained from two wells 1,646 feet and 2,042 feet deep in the same locality, but on lower ground. The shallower well draws from St. Peters sandstone and the other reaches Potsdam sandstone.

The quality of the water as drawn from the wells is good from a sanitary standpoint, but has a very high mineral content, namely 1,740 parts per million. Of this about 300 parts are sulphates of magnesium and calcium. About 460 parts are sodium chloride and about 750 parts are sodium sulphate.

A serious possibility of contamination exists due to the connection of the distribution system with a factory fire and supply system using polluted creek water. This connection should be eliminated.

When sunk the water in the shallower well had a static head about 15 feet above ground, but now the water stands about 50 feet below ground. The yield with present pumping equipment is sufficient to meet demands. Daily consumption is estimated to average about 450,000 gallons per day.

Two collecting reservoirs of 50,000 gallons and 1,130,000 gallons capacity are used. The standpipe has been abandoned.

Pumping equipment includes 2 air compressors for operating the air lift in the wells and 4 high service pumps of 500,000, 1,000,000, 1,500,000 and 2,000,000 gallons per day capacity. The first two are old and will soon be taken out.

Because of incrusting action in boilers and corrosive action on metals, the supply is unsatisfactory and the development of a surface supply from Big Creek west of town is being considered. An earthen dam 17 feet high, will, according to local estimates, flood about 90 acres and give an impounding capacity of 150,000,000 gallons. Considering the limited drainage area, 9½ square miles, this storage would hardly be sufficient during dry years.

Purification would render the water safe, but an analysis of a sample collected at low water shows no superiority over the well water as regards incrusting constituents. It contains more magnesium sulphate and calcium carbonate and less sodium salts. A series of samples covering all stages and stream measurements should be made before deciding definitely on the use of Big Creek.

CARBONDALE, EXISTING WATER SUPPLY.—Visited August, 1913. A report embodying the information obtained was sent to the local authorities and the Central Illinois Public Service Company.

The population of Carbondale, which is now about 5,500, increased 63 per cent from 1900 to 1910, due largely to the city's increasing importance as a railroad center.

Water works were installed about sixteen years ago and have always been owned by private interests, but there have been four changes of ownership. The supply was originally obtained from two 415 foot drilled wells in the northwest part of the city. More recently two more wells about 410 feet and 610 feet deep were drilled one-fourth mile east of the old water works site and a fifth well is now contemplated.

All wells are fitted with deep well pumps. Water from the old wells is pumped into a 25,000 gallon covered reservoir from which it flows by gravity to a 200,000 gallon open concrete reservoir at the main plant. The two wells at the main station discharge into this latter reservoir, the shallower one directly while water from the other is first passed over steam and ammonia condensors at a nearby ice plant operated by the water company.

From the reservoir, water is pumped by a 1,500,000 gallon duplex steam pump into a distribution system comprising approximately 7 miles of cast iron pipe 4 to 10 inches in diameter. Connected with the distribution system is an 85,000 gallon steel standpipe affording a hydrant pressure of from 43 pounds to 55 pounds per square inch.

The yield of the wells, which is about 155,000 gallons per day, is little more than sufficient to meet the demands, and in the Spring of 1913, during a breakdown to one of the well pumps, polluted water from Crooked creek was pumping into the mains.

The mineral content of the water from the wells is high, 1,205 to 2,474 parts per million, over half of which is common salt. The people have become accustomed to the taste and prefer it to more tasteless waters. A number of recent analyses have shown the presence of gas formers which has suggested contamination. The cause of this is not apparent and further investigation will be made in this connection. The company officials state that the mains were flushed after the use of the creek water and it seems hardly likely that the effect of the creek water would have persisted for several months.

A number of typhoid cases developed in Carbondale during the summer and late fall of 1913, but these apparently had no relation to the public water supply. Evidence pointed to an infected milk supply. When the sale of milk was stopped the epidemic subsided.

CARLINVILLE, EXISTING WATER SUPPLY.—See Bulletin 10, page 97.

CARLYLE, PROPOSED IMPROVEMENTS IN WATER SUPPLY.—On October 2, 1913, the engineer of the Survey visited Caryle at the request of the local authorities for the purpose of conferring with the city engineer relative to the feasibility of installing a filtration plant for treating the water of the Kaskaskia river. (See Bulletin 9, page 17.) At the same time a public address was delivered on the general subject of water supplies. The local authorities were advised that the water from the Kaskaskia river could be made in every respect a suitable water for all domestic purposes by filtration, provided the filters are properly designed, constructed, and operated. Mention was made of frequent failure in the smaller communities in securing these three essentials to producing a good filtered water and it was therefore suggested that the ground water resources of the neighborhood be more fully studied with a view to developing a ground water supply if possible. Subsequent investigations indicated that water from wells could not be obtained either in adequate quantity or sufficiently free from iron to render their utilization advisable for a public supply. The only recourse seems to be filtering the water of the Kaskaskia and such a project was under consideration by the city at the end of the year.

CARMI, EXISTING WATER SUPPLY.—Visited April 13, 1913, to assist in removing the danger of an epidemic following the spring floods. For an account of flood relief work see report on Ohio River Floods, page 432. This visit afforded an opportunity to secure data for a descriptive report on the public water supply; copy of which was sent to the local authorities.

Carmi has a population of about 2,800. Water works were installed in 1894 with the Little Wabash river as the source of supply and no extensive changes have since been made. The river has a watershed area of about 3,200 square miles at Carmi and no reservoir is used. The water is pumped by duplex steam pumps directly into the distribution system to which is connected a 95,000 gallon standpipe.

The water is always more or less turbid and sewage from cities up stream renders the use of the water for general domestic purposes dangerous. It is claimed the water is not used for drinking or culinary purposes and if this is so, it leaves the population subject to the dangers of numerous polluted wells. The daily consumption is estimated at 400,000 gallons which is very high and the use of meters for restricting waste is impracticable on account of their stoppage by mud.

CARROLLTON, WATER SUPPLY.—Visited Jan. 9, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Carrollton is a residence city in a farming community and has a population of about 2,300. Water works were installed about 25 years ago with a well penetrating St. Peters sandstone as a source of supply. Owing to the high mineral content of the well water, especially salt, a new source was developed in 1900 when a large spring 4½ miles northwest of town was enclosed by a collecting reservoir.

The water is pumped from this reservoir by a duplex steam pump into a distribution system consisting of about 5 miles of 6 inch and 8 inch pipe. A 17,000 gallon steel tank on a brick tower affords a pressure of 137 feet or 60 pounds. The service could be improved by installing duplicate pumping equipment and a larger elevated tank.

The water is of good quality and has proven popular. The average daily consumption is estimated at 175,000 gallons.

The overflow outlets from the reservoir enclosing the spring are at times submerged by high water in an adjacent polluted creek. The outlets are provided with flap valves, but these do not furnish sufficient safeguard against contamination and it would be advisable to raise them above high water. After heavy rains, the water becomes somewhat turbid and it is possible depressions or sink holes, said to exist in the country back of the springs, may contribute surface water to the water bearing strata. It was recommended that analyses be made whenever the spring shows turbidity.

CARTHAGE, SEWAGE DISPOSAL.—See Bulletin 10, page 99.

CASEY, PROPOSED WATER SUPPLY.—See Bulletin 10, page 100.

CEDAR POINT, WATER SUPPLY.—Visited Feb. 7, 1913. The information obtained was embodied in a descriptive report, copy of which was sent to the water works authorities.

Cedar Point is a small mining town with a population of about 1,300. Water works were installed in 1913 and are controlled by the La Salle County Carbon Coal Company, which company has developed the town. A well 1,750 feet deep terminating in St. Peters standstone is the source of supply. The water is pumped from the well by a steam head deep well pump into a 15,000-gallon steel tank placed on a low timber frame at the pumping station and thence by a simplex steam pump into a distribution system of 4-inch to 8-inch pipe. Connected with the distribution system is a 35,000-gallon elevated tank affording a pressure of about 46 pounds.

The water is of good quality from a sanitary point of view, but is highly mineralized. It has a total residue of 1,030 parts per million, the largest constituents of which are sodium chloride, 469 parts per million; sodium sulphate, 269 parts per million and calcium carbonate 179 parts per million. At the time of the visit, the plant had been in operation only about a month and the number of consumers was, therefore, small and the average daily consumption was about 13,500 gallons.

CENTRALIA, PROPOSED FILTRATION.—Visited June 19, 1913, for the purpose of conferring with the local authorities relative to the feasibility of improving the new water supply from an impounding reservoir by means of filtration. (See Bulletin 10, page 102.) It was ascertained that filtration works can be installed without any unusual difficulty and also that they will render the water entirely satisfactory from both a sanitary and physical point of view. The financial condition of the city does not permit of this improvement at the present time, nor is there much likelihood that funds can be raised within any reasonable time in the future. Accordingly it is proposed to finance the installation of the filter plant in a manner similar to that utilized for financing the construction of the reservoir, namely, through private capital. Under this arrangement, a holding company will advance the necessary moneys for constructing the plant and will lease the plant to the city with a provision in the contract for turning over the property to the city at the end of a definite term of years.

It is believed by those who are in favor of the installation of a filter plant, that even this financial arrangement cannot be carried out successfully without a popular approval of the project, and accordingly a campaign of education is now being conducted in which the State Water Survey has participated by giving to the local authorities certain data for newspaper use. At the end of 1913, no definite plans had been consummated for securing the installation of the proposed improvement.

CHADWICK, PUBLIC WATER SUPPLY.—Visited October 13, 1913. An inspection was made of the public water supply as a basis for a descriptive report. Chadwick is a village of about 600 population and material growth in the near future is not likely.

Water works were installed in 1895, when a 6 inch well 215 feet deep was drilled near the center of town. Another well, 8 inches in diameter and 600 feet deep, was later drilled, 30 feet from the first, and now supplies all water used. The old well is capped but can be put into service again if desired. Both wells are cased to rock at a depth of about 65 feet. Water rises to within about 100 feet of the top and the water end of a 4 inch by 24 inch deep well pump is placed at a depth of 300 feet. The pump is connected to a power head operated through a belt by a 15 H. P. steam engine. The discharge is directly into the distribution system. An elevated wooden tank of 68,000 gallons capacity and a total height of 84 feet is connected with the mains.

Water consumption is estimated at about 25,000 gallons per day. No station records are kept. The supply is of good sanitary quality and only moderately hard. Slightly more than one mile of main has been laid and on this are about 75 services. Water is sold only through meters.

CHARLESTON, EXISTING WATER SUPPLY.—Visited March 22, 1913, to inspect the recently installed water purification plant. (See Bulletin 10, page 103.) A copy of the report embodying the information obtained was sent to the local authorities.

The plant is constructed in essential accordance with plans prepared by the Pittsburgh Filter Manufacturing Company and in general presents a neat appearance. Attention was called to the following defects: (1) The location of the plant with reference to existing structures, thus making future extensions difficult. There will be no need for enlargement, however, for ten years or more. (2) An unevenness in the distribution of air and water in washing the filters. This was remedied by removing the sand from the filters and repairing the defective strainer, heads. (3) Absence of light in the pipe gallery, in which is also located the blower and a steam engine for driving same. This may be remedied by inserting a window. (4) Imperfect drainage of the pipe gallery. This may be corrected by sloping the floor and introducing a drain. (5) Absence of suitable space for a control laboratory. To meet this need an extension to the building over the coagulating basin should be made.

With the several minor defects corrected, the filter plant may be counted upon to produce excellent results, provided it is properly operated.

CHATSWORTH, EXISTING PUBLIC WATER SUPPLY.—See Bulletin 9, page 17.

CHENOA, EXISTING PUBLIC WATER SUPPLY.—See Bulletin 9, page 17.

CHESTER, EXISTING WATER SUPPLY.—Visited February 27, 1913. Information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities. (See Bulletin 9, page 18.)

Chester has a population of about 2,750. Water works were installed in 1902, through private enterprise. The water is drawn from the Mississippi river and pumped directly into the mains.

Because of the extreme range in elevation between that part of town near the river and that part on the bluffs, namely about 300 feet, it was found desirable to have two separate distribution systems. The upper distribution system consists of about 2 miles of 4 inch and 8 inch pipe, to which is connected a 30,000 gallon wooden tank on a steel tower, affording a pressure of 40 pounds at its base. The lower distribution system consists of about ¼ mile of 4 inch pipe, to which is connected a 15,000 gallon wooden tank half way to the top of the bluff. This tank affords a pressure of 60 pounds along the river road. One 500,000 gallon duplex steam pump serves both systems alternately.

The consumption ranges from 40,000 to 100,000 gallons per day. The water at all times is turbid and colored and of little use for drinking and culinary purposes. Moreover, it is polluted by sewage from cities upstream. The nearest point of such pollution is the sewer outlet from the State Penitentiary and Hospital at Menard, about a mile above the Chester intake.

The installation of a water purification plant at Chester is necessary to secure a good quality of water.

CHICAGO HEIGHTS, EXISTING WATER SUPPLY.—Visited March 26, 1913. Chicago Heights is an industrial community, having a population of about 16,500. The population in 1900 was only about 5,000 and the increase has, therefore, been very rapid. Water works were installed in 1894 and now supply practically all occupied districts within the city limits and a few consumers outside.

The supply is now obtained from 4 wells, 15 inches in diameter for 150 feet, at which point they are reduced to 12 inches, at which diameter they extend to a depth of 300 feet into the Niagara limestone stratum. These wells were drilled in 1910. Since 1894 the water level in this stratum has fallen from elevation 75 to 24 (datum, mean level of Lake Michigan), but during the past four years only a comparatively slight depression has taken place. It is stated that a one-hour test of the wells at the time of their installation gave an average discharge of 2,950 gallons per minute from each with a lowering of water level from elevation 28.5 to 27.5. In reserve are 10 wells sunk in two pump pits. They are still connected up, but the lift is high and their use is not probable.

The water is of good sanitary quality, but the mineral content is high, namely, about 650 parts per million. Of this about 200 parts are sulphate or permanent hardness and 360 parts carbonate or temporary hardness.

In each well in regular service is an impellor pump driven by an electric motor. Each pump has a gated discharge connection to a line supplying the high service pumps and also to a 170,000 gallon, brick reinforced concrete collecting reservoir. One well has a discharge line gate automatically controlled by a float valve in the reservoir and furnishes sufficient water, except at times of the highest consumption, to keep the reservoir full.

The high service pumping equipment comprises 2 compound condensing duplex pumps of 5 million gallon and 3 million gallon capacities respectively. The distribution system comprises about 25 miles of 4 inch to 14 inch cast iron pipe and connected to it is a 180,000 gallon steel stand pipe. The average daily consumption is about 4,400,000 gallons.

CHICAGO HEIGHTS, SEWERAGE.—Visited July 11, 1913, and again September 13, 1913, for the purpose of inspecting the sewage treatment plant. Copies of the reports embodying the information obtained were sent to the local authorities.

Chicago Heights has experienced an exceedingly rapid growth and has a population now of about 17,000, whereas in 1900 the population was but 5,000.

The western half of the city is rather completely served by a system of sanitary sewers, which have an outlet about 1 mile north of the city. At the point of outlet is constructed a sewage treatment plant consisting of 2 septic tanks, 4 contact beds and a dosing chamber. The effluent is discharged into Thorn creek.

The east side of the city is still unprovided with a sewerage system and large quantities of foul wastes are discharged through private drains into a small branch of Thorn creek. The nuisance is aggravated by the fact that the tributary passes through flat, marshy land, allowing objectionable liquids to spread out over wide areas. It is proposed at an early date to provide sanitary sewerage for the east side, and in connection with this project some means must be provided for adequately treating the sewage. It seems to be the local impression that the treatment works for the west side sewers were designed for treating the sewage flow from the entire town at some future date, but inasmuch as the plant is scarcely capable of handling the sewage that now reaches it, a thorough examination of the existing works is desired.

It is estimated that the population tributary to the treatment works is about 8,000. The volume of sewage has never been measured, and estimates based on water consumption are misleading for the reason that much water is used for manufacturing purposes. Assuming a consumption of 100 gallons per capita gives a sewage flow of 800,000 gallons per day.

The septic tanks are each 122 feet by 40 feet by 9 feet deep, representing a total capacity of 656,000 gallons. Based on the above assumed sewage flow of 800,000 gallons per day, the retention period is about 20 hours. If the assumed sewage flow is correct, the retention period is too great to produce an effluent susceptible to satisfactory treatment in contact beds. The sewage may be by-passed around the tanks and discharged directly into Thorn creek. Each tank has a hanging baffle near each end and one in the middle. Provision is made for withdrawing sludge from the tanks by sludge troughs placed about one-third the distance from the inlet to the outlet end. The outlets of these sludge troughs are connected with the by-pass for crude sewage and thus sludge must be disposed of by direct discharge into Thorn creek. Because of lack of knowledge as to the exact construction of the interior of the tanks, it was suggested that the tanks be emptied and a thorough inspection made. Between the first and second visits an effort had been made to pump out the tanks, but they were not completely emptied. The sludge removed did not give off a particularly objectionable odor.

Each of the four contact beds is 150 feet by 80 feet by 5 feet deep. The area of each is thus 0.275 acres, making a total area of 1.1 acres. The effective depth of contact material is about 3 feet 5 inches. The average rate of treatment on the basis of the assumed flow would thus be 727,000 gallons per acre or 213,000 gallons per acre foot. The bottom of each basin slopes from the ends toward the traverse center line, along which is a depression or gutter covered with half tile. This serves as the main underdrain. All drains have open joints of ½ to ¾ inch. The bottom 34 inches of the bed is filled with broken stone, varying in size from 6 inches at the bottom to 7/8 inch at the top. On top of this is 5 inches of material, varying in size from 7/8 inch to 1¼ inches, and above this is 18 inches of cinders. The distribution system, which rests on the broken stone and within the cinders, comprises 6 inch tile laid with open joints and on 8 foot centers.

The main distributors and main effluent pipes are manifestly too small and have caused difficulty in operation. The beds have also been subject to marked clogging. At the time of the first inspection not only were the interstices of the broken stone filled with a slimy mass, but both the distributors and the underdrains were completely filled with sludge. The sludge in the distributors was of a black granular consistency, suggesting the presence of considerable quantities of fine cinders.

It was recommended that the cinders be removed to help prevent further clogging and also allow better aeration of the beds. This had been partly done before the second visit. Further recommendations made regarding the beds were: (1) The replacement of the finest contact material with that ranging in size from 7/8 to 1½ inch, and so arranging the strata of the material that finer material will not underlie coarser material. (2) An increase in the depth of the contact material, and (3) a corresponding increase in depth to which the sewage can be applied. (4) The flushing out of the underdrains. (5) Rearrangement of distribution system and increase in size of main effluent drain

The automatic dosing apparatus is housed in a dosing chamber which is located at the center of the group of four contact beds. The apparatus has given some trouble, but has been rearranged and as it now stands reasonably satisfactory results should be obtained, provided the apparatus is properly cared for.

Even with the above defects corrected, the plant can take care of the sewage from the west side of the city only in a lame sort of way, that is, it may produce an effluent free from much suspended matter, but which is still putrescible or very nearly so. The first steps toward improving the present condition will involve a measurement of the sewage flow, accompanied by the collection of a weighted sample for analysis.

CHILLICOTHE, POLLUTION OF ILLINOIS RIVER BY CHICAGO DRAINAGE CANAL.—Visited December 10, 1913, to collect samples of Illinois river water and to make arrangements for the periodical collection of samples for analysis at that point, in connection with a survey of the river to determine the amount of pollution of the river by the Chicago Drainage Canal and its effect on the fish life. (See Bulletin 9, page 19.)

CHRISMAN, PROPOSED SEWERAGE.—Visited April 26, 1913, with reference to the installation of a sewerage system.

Chrisman is located on a divide between two branches of Brulette creek, a tributary of Wabash river. The surface drainage is naturally poor, owing to a flat topography, and conditions have been rendered worse by the existence of two railroad embankments with insufficient storm water outlets under them.

The city is now contemplating the installation of a sewerage system which will promptly carry off the storm water and which will serve sanitary needs. The system proposed is on the combined plan and this may, on account of the peculiarities of the local topography, prove more economical than the separate system, even though purification of the sanitary sewage will be necessary in the course of time. However, to ascertain the relative advantages of the combined and separate system of sewerage for Chrisman, recommendation was made that comparative estimate of cost be prepared and that the matter of sewage treatment be studied.

COLFAX, PROPOSED SEWERAGE.—Visited August 28, 1913, relative to a proposed sewerage system. The information obtained was embodied in a report, copy of which was sent to the local authorities.

Colfax (population about 1,000) is a farming center and has one small coal mine. A small stream flows in a southerly direction through the central part of the village, then turns west and enters the Mackinaw river about 600 feet beyond the western corporation limits. In the central part of the village the stream is carried under some building by means of a vitrified tile conduit. This tile has become broken and the channel obstructed so that storm water is not promptly removed. A controversy as to whether the city or owners of the building under which the obstructed portion of the tile lies should repair the damage has blocked the making of suitable repairs.

It is now proposed to build a combined system of sewers with the main pipe following in a general way the stream bed, but laid in the streets, thus avoiding passage under all buildings. An examination of the situation at Colfax showed the installation of a combined system of sewers to be unwise and uneconomical, and it was recommended that a system of sanitary sewers be built and that the open channel within the city be improved so as to care for storm drainage.

COLLINSVILLE, SEWERAGE.—Visited January 30, 1913, for the purpose of explaining somewhat in detail to the city officials the methods of sewage treatment discussed in a general way in a report under date of November 6, 1912. (See Bulletin 10, page 104.)

Intermittent sand filters were recommended and various details of design, arrangement of beds, method of dosing, etc., were discussed with the city engineer.

COLUMBIA, PROPOSED WATER SUPPLY.—Visited January 23 and March 29, 1913, relative to a proposed water supply. A copy of a report embodying the results of the visit was sent to the local authorities. A record of previous visits to Columbia is given in Bulletin No. 10, page 105.

A test well in the southwestern part of the city had been sunk to a gravel stratum at a depth of 45 feet and a test had been made. The test indicated that the construction of the well was such that the full yield of the water-bearing stratum was not obtained. Advice regarding the reconstruction of the strainer was given and also methods for observing the character and extent of the circle of influence surrounding the well.

The analyses of samples collected showed a water somewhat higher in total solids than two sources previously considered, namely, a driven well in the Mississippi river bottom lands and a spring south of town. The hardness is entirely in the form of carbonates, however. A more serious objection is a considerable amount of iron, and any plans for developing this source should take into account the necessity of removing the iron.

COOK COUNTY POOR FARM, SEWAGE DISPOSAL.—Visited October 25, 1913, relative to an existing sewage disposal plant and proposed addition thereto.

Owing to the absence of the superintendent and engineer, very limited information was obtained. The plant, which was installed in 1910, consists of a septic tank, four contact beds and a dosing chamber. The plant has been overloaded and has not given good results. Improvements and additions to the plant are under way.

CREAL SPRINGS, WATER SUPPLY CONDITIONS.—Visited July 5, 1913. A copy of report embodying the information obtained was sent to the local authorities.

Creal Springs is a small residential town in an agricultural community, and has a population of about 940. A considerable number of people congregate each summer at a hotel and health resort located there.

Water is derived from private shallow-dug wells, and at the resort from six shallow-dug wells and one 200 foot well. The shallow wells are open at the top and analyses indicate pollution. The yield of the wells at the health resort is limited and at times not sufficient for the guests' use.

An adequate public supply may probably be obtained from wells about 300 feet deep, at which depth is encountered a water-bearing sand rock which outcrops to the southward in the Ozark uplift. Owing to financial reasons, it is not practical for the town to install water works at once. Recommendation was made that all wells be better protected against pollution.

CRYSTAL LAKE, WATER SUPPLY .—Visited October 23, 1913. Information obtained was embodied in a descriptive report, copy of which was sent to the local authorities. (See Bulletin 9, page 19.)

Crystal Lake is a farming community and summer resort and has a population of about 1,300. Water works were installed in 1912 with a dug well 32 feet deep in the central part of the village as a source of supply. The water is pumped from the well by means of an electrically driven triplex pump into a distribution system consisting of 4.5 miles of 4 to 8 inch pipe, to which is connected a 50,000 gallon elevated steel tank, affording a pressure of about 50 pounds.

The water is of good quality from a sanitary standpoint, but care will be necessary to avoid future contamination owing to the central location of the well and its limited depth. The mineral content of the water is moderately high, namely, 435 parts per million, mostly in the form of carbonates of calcium and magnesium, though some sulphates of magnesium are also present.

DANVILLE, EXISTING PUBLIC WATER SUPPLY.—See Bulletin 9, page 19.

DECATUR, NEW FILTER PLANT.—Visited January 10, 12, 16 and February 11, 1913, for the purpose of attending meetings and conferring with the consulting engineer employed by the city with reference to plans for the proposed filtration plant. (See Bulletin 10, page 106.)

On the last mentioned date the contract was awarded to the New York Continental Jewell Filtration Company and construction at the end of 1913 was well under way.

The new purification works have a nominal capacity of 9,000,000 gallons, will be constructed of reinforced concrete throughout and will represent the most modern filtration practice. The plant comprises six filter units, each having a nominal capacity of 1,500,000 gallons per 24 hours. There is a reaction chamber with a retention period of about 16 minutes, two coagulating basins having a combined retention period of 4 hours, and clear water reservoirs also having a retention period of about 4 hours. The filter equipment will comprise hydraulically operated valves which will be operated by hand levers on the operating platform. All accessories, such as rate controllers, loss of head gages, water level gages, and so forth, will be provided so as to place the operation of the plant under the most effective control. Within the superstructures will be included a laboratory of large size which can readily be developed into a general municipal laboratory, and which may also serve as a laboratory to be used in connection with preliminary experiments and later on in connection with control of the proposed sewage treatment plant.

DEER CREEK, WATER SUPPLY.—Visited September 4, 1913. The information obtained was embodied in a descriptive report of the recently installed water works, copy of which was sent to the local authorities. (Mention of the installation is made in Bulletin 10, page 107.)

Deer creek is a small farming community, having a population of about 400. In 1907 a 6 inch well was sunk to a depth of 267 feet near the center of the village and a 155,000 gallon power pump and a 12 H. P. gasoline engine were installed. Further appropriations were defeated by popular vote until 1912, when a pressure tank 8 feet by 36 feet was purchased and installed. Not until 1913, however, were mains laid and the water works put in operation. This step was hastened by the occurrence of fires in the village. As yet no taps have been made, but this will be done in the near future. The distribution system comprises about 1.16 miles of from 2 inch to 6 inch pipes and 16 hydrants.

Analyses indicate the water to be of good sanitary quality and low in mineral content for an Illinois ground water. The total residue is 308 parts per million, most of which is in the form of carbonates.

DES PLAINES RIVER, REPORT ON A SANITARY SURVEY ABOVE RIVERSIDE.—During 1912 an extensive sanitary survey of the Des Plaines river was made by the State Water Survey, which was reported in Bulletin No. 10, page 66. During the latter part of 1913 a bill of complaint made by a number of citizens of Riverside against the village of Maywood, Melrose Park, River Forest and Forest Park was being actively pushed forward, but by the end of the year the matter had not yet received a hearing in court. It is probable now that the matter will not get into the courts inasmuch as these several communities have been incorporated with the Sanitary District of Chicago, and it is expected that the Sanitary District will take suitable measures for relief. The State Water Survey was requested by the complainants to make further investigations and be prepared to give expert testimony as required. In partial compliance with this request, on Octbber 19, 1913, the engineer of the Survey made a motor boat trip from Riverside to Forest Park in company with Mr. Langdon Pearse, engineer, and Dr. Arthur Lederer, chemist, employed as experts by the complainants.

At the present time the pollution of the stream is exceedingly great and there is much complaint at and below Maywood and this condition requires immediate remedy. There are points above Maywood where the stream is seriously polluted, but the conditions have not yet become sufficiently aggravated to demand immediate remedy.

The communities upon the watershed may be divided into two groups, one group comprising those which are isolated and must solve their sewage disposal problem independently, and the other comprising those communities located adjacent to each other and which may profitably work out a joint solution for their sewage disposal problems. In the first group are Franklin Park, Des Plaines, Libertyville and St. Mary's Training School. All of these communities are so far removed from each other that their problems are independent. In the other group belong Maywood, Melrose Park, River Forest and Forest Park. These four towns constitute virtually one community. The solution of their sewage disposal problem is a crying necessity and a combination of effort would undoubtedly render the solution more economical and effective.

It is especially important that all of the communities in the Des Plaines watershed realize that they have a sewage disposal problem to meet now or in the near future and that it is highly desirable for them to at once make engineering studies for the purpose of determining upon what works are required to adequately dispose of the sewage and what modifications in the existing sewerage systems this may entail. This will serve as a basis for extending the sewerage systems and for installing purification works at the proper time in the best and most economical manner.

As already indicated, the last mentioned four communities have become a part of the Sanitary District so that a joint treatment of the sewage from the four towns may be undertaken.

The temperature on the morning of October 19 was in the neighborhood of 55° F. with a tendency to fall close to the freezing point during the latter part of the day. The temperature of the water in the stream averaged close to 12° C. or 53.6° F. The flow in the stream was not measured, but judging from the quantity of water passing over the dam, the river was at medium low stage. Immediately above the dam at Riverside and below the confluence with Salt creek the water gave distinctly visible evidences of pollution, such as a rather dark color, slimy growths (characteristic of polluted waters adhering to banks and floating objects) occasional dead fish. There was no objectionable odor, however, that could be detected. No dissolved oxygen determinations were made at this point because the pollution coming from towns north of Riverside on the main stream is masked by the pollution from Salt creek, which receives at the present time more or less untreated sewage from LaGrange and Grossdale.

Salt creek at its mouth had a yellowish color that stood out in contrast to the darker color of the main stream and carried a very noticeable sewage odor. Probing the bottom of the creek indicated a deposit of about 2 feet of sludge in an active state of fermentation. When this sludge was disturbed great numbers of bubbles came to the surface. The water nevertheless contained a considerable quantity of dissolved oxygen, namely, 4.2 parts per million, which would indicate (and this was also borne out by observation) that the sewage was in a fresh condition.

Immediately above the confluence of Salt creek the main stream was not offensively polluted, but bore much the same appearance as the body of water immediately above the dam. It contained dissolved oxygen to the extent of 2.4 parts per million.

Between Forest Avenue bridge and the electric railway bridge, approximately one mile above the confluence with Salt creek, the water was still of the same dark color, visibly polluted, but free from objectionable odor. The dissolved oxygen content at this point was 3.2 parts per million. Probing of the bottom indicated the absence of sludge deposits.

In passing in an upstream direction above the electric railway bridge a change in the appearance of the water became perceptible. The dark color gave place to a grayish appearance and along with this a stale sewage odor was noted. At Della Plain road, which marks the northern boundary line of Riverside, the stream had become distinctly gray in appearance and the odor was offensive, though not very strong. Analysis indicated the absence of dissolved oxygen. The algae growth which had been observed further down the stream was entirely absent and characteristic sewage fungus constituted the only vegetation in the stream. The depth of the water at this point was 3 feet and the bottom was hard, with no deposits of sludge. There are a number of picnic grounds and residences not far from Della Plain road and there can be no doubt that these places are subject to offensive odors at times.

Passing northward a short distance, approximately one-half mile, one reaches the Golf Club, at which point the stream gave every evidence of being grossly contaminated with sewage. Sewage fungi are very plentiful and are found adhering to the banks and to a number of barrels that are used as pontoons for a floating bridge. At this point also the dissolved oxygen is zero.

Proceeding up the stream to 22nd street, which marks the crossing of the Illinois Central Railroad, the offensive conditions became steadily worse with the odor more and more pronounced. Also sludge deposits came into evidence, but these were of a very slight thickness.

At 12th street, perhaps 1½ miles north of the Illinois Central crossing, is encountered the first sewer outlet in the southern part of Forest Park, and at this point the decomposition of the sewage was so violent that the entire stream was covered with gas bubbles. The gray appearance had given away to an inky black appearance very characteristic of stale sewage in an active state of decomposition. Up to this point but little refuse and few floating objects were observed, but as indicating the use of the stream as a general dumping ground there were here encountered decomposed bodies of a dead dog and a dead hog.

Above the 12th street sewer outlet the stream was somewhat less offensive, nevertheless grossly contaminated, and this became steadily worse until the crossing of the Great Western Railroad was reached, where another sewer enters from Maywood. Here the water was quite black, very odoriferous and the ebullition of gas was so violent as to be distinctly audible.

The stream was not navigable for the motor boat above this point, but inspections were made of the stream at Maywood and below Franklin Park. At Maywood marked pollution was observable, but it was not nearly so offensive as the conditions encountered at points below. Above Maywood and below Forest Park the stream was found to be in a very clean condition with none of the evidences of pollution encountered at any of the points below Maywood. The dissolved oxygen at this point which may be accepted as approximately normal for the unpolluted stream on the date of inspection was 8.2 parts per million.

The results of the inspection made on October 19 indicate very clearly that the Des Plaines River from Maywood down to the confluence of the stream with Salt creek is subject to marked sewage pollution. On the date of inspection the pollution was quite offensive down as far as the northern corporation limits of Riverside. In view of the fact that the weather was cool and that there was a considerable volume of water flowing in the stream, it is apparent that nuisance conditions are much worse at other times.

There is nevertheless a marked tendency for the stream to purify itself, even at stages of minimum low water. This results even at lowest stages in a fairly satisfactory condition of the water at Riverside for part of the time. A very characteristic phenomenon observed on the river, however, is that nuisance conditions recur at intervals. A logical explanation of this phenomenon has been offered by Mr. Langdon Pearse, namely, that the fermentation taking place in sludge deposits in an upstream direction periodically causes these deposits to float to the surface, due to the entrained gas, and pass down the stream as a sort of sludge piston and resettle. This action may be given considerable impetus by a slight increase in the stream flow. Thus it appears that at times, as on the date of inspection, the condition of the water in the stream at Riverside is not seriously offensive, but that at intervals it may become highly offensive.

The fact should not be overlooked that the portion of the Des Plaines River which lies between Maywood and the dam at Riverside is very fortunately located for recreation purposes and has many elements of natural beauty. Because of this it is extensively used for canoeing, motor boating and picnicking, nothwithstanding the very unfavorable conditions. On the date of visit, in fact, it was observed that many canoeists were plying up and down the river at points where a sewage odor was distinctly perceptible. It was also observed that several automobile parties gathered for an outdoor luncheon on the banks of the stream. It should be recorded, however, that these parties were not seen actually eating their luncheons.

In conclusion, it may be said that there can be no question that an obligation rests on the communities of Maywood, Melrose Park, River Forest and Forest Park, or the Sanitary District acting for them, to so treat their sewage or otherwise dispose of same as to render the water in the river below, not only free from odor, but also free from objectionable appearance. This rather stringent requirement is warranted by the unusual extent to which the river is used for recreation purposes.

DIXON, PUBLIC WATER SUPPLY.—Visited August 1, 1913, for the purpose of securing a general description of the public water supply.

Dixon is primarily an industrial community, with a population of about 8,000, and is located on the south bank of the Rock river. The water works were established in 1883 by the Dixon Water Works Company and have ever since been owned and operated by this company.

The supply is obtained from three artesian wells having approximate depths varying from 1,630 to 1,830 feet. The water is derived principally from the Potsdam sandstone, but also in part from the St. Peter's sandstone. The net combined artesian flow of the wells is about 600 to 700 gallons per minute, and during a large portion of the year this meets the requireemnts of the community. At other times it is necessary to increase the yield by pumping several of the wells with air lift. At the end of 1913 the installation of an additional well was contemplated so as to reduce the periods during which pumping must be resorted to and also for the purpose of providing an additional supply in case of breakdown or other emergency.

Storage is afforded in a circular masonry covered collecting reservoir about 80 feet in diameter and 16 feet deep, thus having a capacity of about 600,000 gallons. Connected with the distribution system are two standpipes, one of which has a capacity of 41,000 gallons and the other has a capacity of 250,000 gallons. The pumping equipment comprises the following:

One air compressor of unknown capacity.

One Gordon cross-compound pumping engine with a nominal capacity of about 700,000 gallons per 24 hours. This pump is so arranged that each side may be operated independently of the other. Thus it has the effect of two pumps of the combined capacity indicated. New pumping machinery is about to be installed.

DUQUOIN, WATER SUPPLY.—Visited February 6, February 25 and May 1, 1913, for the purpose of obtaining a description of the existing public water supply and discussing with officials proposed municipal ownership. A descriptive report dealing also with improvements, management and rates was sent to the local authorities. Mention of a previous visit in 1911 is made, in Bulletin 9, page 19.

DuQuoin is primarily a coal mining town and has a population of about 6,000. Water works were first installed about 15 years ago with an impounding reservoir, about 3½ miles west of town, as a source of supply. The mains were of wrought iron.

By 1907 little was left of the old mains and an entire new water works was installed with a supply obtained largely from an abandoned mine at the northeastern edge of town and partly from a dug well. The city owns the system with the exception of the sources of supply, which are the property of the DuQuoin Utilities Company. This company maintains and operates the system under a franchise.

The mine is 60 feet deep and the underground workings extend beneath an area of 600 acres. A pump pit placed part way down in the shaft contains an electric driven centrifugal pump and a simple duplex steam pump, either of which may be used to pump into the distribution system. The interior of the building over the pump pit is ill kept and unsanitary and, since the floor of the pit is not watertight, dirt and filth may be washed down into the source of supply. The adjoining boiler room and entire surroundings of the plant are slovenly kept.

The dug well, from which a small amount of water is used, is 30 feet deep and located near the company's electric light and ice plant. The protection at the top is wholly inadequate, permitting the entrance of surface water, while a barnyard and stable are only 30 feet from the well.

A 1,000,000-gallon open reservoir with earthen embankments receives the excess discharge from the mine pumps and two compound duplex steam pumps may pump from this reservoir into the distribution system. The distribution system consists of 11 miles of from 4 inch to 10 inch cast iron pipe. There is no tank or standpipe.

Analyses indicate that pollution occasionally exists. Part of such pollution may be eliminated by better sanitation, and improvements at the pump pit at the mine and more adequate protection at the dug well. The abandoned mine is subject to pollution also through abandoned shafts at various points and the extent of such pollution warrants further investigation.

The mineral content of the mine water at first was about 3,000 parts per million, but decreased rapidly the first year and slowly since that time, until now the mineral content is about 900 parts per million. Over half the content is magnesium sulfate and carbonates of magnesium and calcium. Part of the water in the reservoir is used for cooling the ammonia condensers at the ice plant and becomes heated to 150° F., resulting in the removal of a large portion of the carbonate hardness.

Only about 20 per cent of the population use the public supply, but the consumption per service is high and the total daily consumption is estimated to be 300,000 gallons.

The contract under which the Utilities Company operates the water works may be terminated during 1913 if the city so desires and this has aroused considerable local interest. There are three alternatives for the operation of the water works, namely: (1) Purchase of the entire plant by the Utilities Company with a modification of the rates to suit the increased capital outlay. (2) The purchase of the source of supply and other equipment belonging to the Utilites Company by the municipality and operation of the water works by the municipality. (3) Leave matters as they are, with the exception perhaps of some improvements in the source of supply and the manner of handling the water, with special reference to insuring a good quality of water from a sanitary point of view.

It was pointed out that the relative merits of the above alternatives could not possibly be determined without much more knowledge regarding the value of the several portions of the plant, the cost of operation and the cost of modifications in equipment and operation, incident to a possible change in ownership. It was, therefore, urged that a competent expert be retained to acquire such information. The relative merits of municipal and private ownership were discussed in a general way and certain phases to be considered, such as economical operation, dependability of service and quality of water, were dwelt upon. Emphasis was placed upon the fact that a sound decision cannot be reached until a complete financial analysis had been made of the plant, and then only with due considerations given to local conditions rather than to general and theoretical considerations.

EARLVILLE, EXISTING PUBLIC WATER SUPPLY.—See Bulletin 9, page 20.

EAST DUBUQUE, WATER SUPPLY.—Visited April 30, 1913. A descriptive report of the water works was prepared, a copy of which was sent to the local authorities.

East Dubuque is essentially a suburb of Dubuque, Iowa, across the Mississippi river, and has a population of about 1,300. Water works were installed about 28 years ago with a 940-foot artesian well, terminating in Potsdam sandstone, as a source of supply. The water was pumped from a collecting reservoir into the distribution system. A 115,000-gallon masonry reservoir on top of the bluffs acted as an equalizer.

The original distribution system of spiral riveted pipe corroded badly and was replaced with cast iron pipe. About 10 years ago the well casing also had become badly corroded and in attempting to remove the casing tools were lost in the well, causing a partial obstruction and preventing a continuance of the work. A 4-inch casing was eventually placed to the depth of the obstruction inside the old 6 inch casing. The obstruction caused by the lost tools, the escape of part of the flow through the old rusted casing into rock crevices, and the possible depletion of the supply in the Potsdam have either alone or in combination, cut down the original yield of 420 gallons per minute to about 60 gallons per minute.

The water is now pumped from a 35,000-gallon collecting reservoir into a distribution system, consisting of about 3 miles of 4-inch to 8-inch cast iron pipe, to which is connected a 72,000-gallon standpipe, affording a pressure range about town of 37 to 118 pounds. Pumping equipment consists of a 1,000,000-gallon compound duplex pump and a 200,000 gallon simplex pump. The original equalizing reservoir is still maintained as an emergency storage reservoir with a connection to the collecting reservoir.

The quality of the water from a sanitary point of view is excellent and the mineral content is low for a deep rock well.

EAST DUNDEE, EXISTING PUBLIC WATER SUPPLY.—See Bulletin 9, page 20.

EAST PEORIA, PROPOSED WATER SUPPLY.—Visited December 9, 1913. A copy of a report embodying the information obtained, together with advice and suggestions, was sent to the local authorities.

East Peoria has a population of about 1,500 and is a rapidly growing industrial town. To aid such growth it is proposed to install water supply and sewerage systems.

Ground water is apparently plentiful in East Peoria, both in the Illinois River bottom and in the valley of Farm Creek, a tributary of the Illinois. Possible sources of supply include springs to the northeast of town, a well or wells in the valley of Farm Creek, deep drilled wells near town and water from the Peoria water works. The latter would prove very expensive, as a submerged pipe under the river would be necessary.

Analyses of samples from various sources showed that all would be acceptable from a sanitary point of view, but that the waters from wells in the Farm Creek valley and from the springs were far superior as regards mineral content. Owing to the industrial character of the town, the mineral content is of special importance. The Farm Creek valley well water contained about 350 parts of incrusting solids, but only 67 parts were in the form of sulphates.

EAST ST. LOUIS, EXISTING WATER SUPPLY.—Visited January 20 and 21, 1913, for the purpose of securing a description of the public water supply. Information obtained was embodied in a report, copy of which was sent to the local superintendent.

East St. Louis is a rapidly growing city of about 70,000 population, where about twelve railroads converge before crossing the river to St. Louis, Missouri. Railroads constitute the most important interest in East St. Louis, but the city is also of growing importance as a manufacturing center. Neighboring suburbs, including Granite City, Venice, Madison and Belleville, are all primarily manufacturing cities and bring the total east side population up to well over 100,000. The principal manufacturing interests of this locality include extensive manufactories of steel and iron products, and corn products. East St. Louis is an important live stock market and packing center.

Water works were first installed in 1885, when a 30-year franchise was granted certain St. Louis interests. The properties were later bought by the American Water Works and Guarantee Company, which also owns the plants at Granite City and Belleville. The supply has always been obtained from the Mississippi River about three-fourths mile north of the Eads bridge, and has received treatment of one kind or another since first provided. The system has been broadly extended as the community developed and now includes nearly 100 miles of mains. The city of Belleville has been taken on as a regular water customer, and Granite City, Venice and Madison take a portion of their supply from East St. Louis. The pumpage averages now about 11,000,000 gallons per day.

The first water works included a settling basin through which the river water was passed and a portion of the suspended matter thereby removed by plain sedimentation. Later a secondary settling and coagulating basin was added and 18 Jewell filters installed. These are shell filters and were originally in service as pressure filters at New Orleans, but at East St. Louis they are operated under a low head as gravity filters with an outlet to a filtered water basin. The next extension consisted of adding 10 open gravity filters designed by engineers of the company. These filters are all housed in a brick building about 270 feet by 45 feet in plan, at one end of which is a three-story chemical house containing storage room for chemicals, solution tanks and a laboratory. During 1913 there were added four more open gravity filters housed in an addition to the old building. The plant now has a nominal capacity of about 20,500,000 gallons per day.

Preliminary sedimentation is accomplished in a basin 222 feet by 200 feet in plan and 14 feet deep, having a capacity of about 4,650,000 gallons and affording a retention period of about 5½ hours based on the nominal capacity of the plant.

Flowing from this basin water receives a charge of either alum or lime and iron and passes into a coagulating basin 460 feet by 150 feet in plan and 15½ feet deep. This basin has a capacity of about 8,000,000 gallons and provides a nominal settling period of about 9.4 hours.

The kind of coagulant used depends primarily upon the character of water treated. Alum is ordinarily used, but lime and iron may be substituted when the raw water is low in color. The alum, or iron, as the case may be, is dissolved in two tanks of about 3,000 gallons each and the solution fed through an orifice box. The dry feed system is used in applying lime. This is accomplished by means of a revolving worm which pushes the powdered slaked lime at a uniform rate from the bottom of a hopper-shaped container into a stream of water flowing to the water receiving treatment.

The filter units number 32 at present and have a total filtering area of about 7,100 square feet. The old shell filters are 28 feet long and 8 feet in diameter, each with a rated capacity of 640,000 gallons per day. The ten so-called American filters, designed by the company, are contained in iron tanks 15 feet in diameter and 9½ feet high, each having a nominal capacity of about 500,000 gallons per day. The four filters installed in 1913 are of concrete construction and have capacities of 1,000,000 gallons per day each. Neither loss of head gages nor rate controllers are used on any of the older filters and control is obtained wholly by manipulation of gate valves. Details of construction of the new filters have not yet been investigated by the State Water Survey.

A 20-inch pipe collects the filtered water from the various units and carries it to the clear water reservoir. As this pipe leaves the filter house a solution of hypochlorite of lime is forced into it by means of a water jet. The solution is prepared in the chemical house and its application is controlled by a constant head orifice box.

The clear water basin is 155 feet by 85 feet in plan and 16 feet deep, and has a capacity of about 1,500,000 gallons or about 1.75 hours retention period based on the nominal capacity of the plant. It is of concrete construction and has a flat slab roof. The side walls rise about 4 feet above surrounding ground level. The need of greater clear water storage is strongly felt.

A small laboratory equipped for bacterial and simple chemical tests is maintained at the plant and the company employs a chemist, who has immediate charge of the operation. The operation of the plant appears to be quite efficient and such analyses as have been made by the State Water Survey indicate that a uniformly good water is being supplied. The company does not make public its daily analyses.

Two separate pumping stations are operated, one delivering raw water under a low head to filter plant through a distance of about a quarter of a mile, and the other containing the high service machinery. In the low lift station there are three vertical, duplex, triple-expansion pumping engines, two rated at 10,000,000 gallons per day each and one of 6,000,000-gallon capacity. The high service pumps consist of two triple-expansion duplex pumps, one of 7,000,000 and the other of 6,000,000 gallons per day capacity and three compound duplex pumps, one rated at 5,000,000 gallons, one at 6,000,000 and the other of 8,000,000 gallons per day capacity.

The management of the system is very efficient and regular control is maintained over all operations. The company's franchise expires in 1915, when the city will have the privilege of purchasing the system or otherwise obtaining a water supply. No move has yet been made by either city or company in regard to future supply, but local opinion seems to be that the city's financial condition will not now justify owning its own water works system.

EFFINGHAM, WATER SUPPLY.—Visited March 22, 1913, for the purpose of discussing with local officials and a representative of the Water Company terms relating to quality of water to be furnished under a proposed new franchise. (See Bulletin 9, page 20, and Bulletin 10, page 108.)

ELDORADO, PROPOSED WATER SUPPLY AND SEWERAGE SYSTEM.—See Bulletin 9, page 20.

ELGIN, INSTALLATION OF CONTROL LABORATORY, EXISTING PUBLIC WATER SUPPLY.—See Bulletin 9, page 20.

ELGIN INSANE HOSPITAL, WATER SUPPLY.—See Bulletin 10, page 109.

ELMHURST, WATER SUPPLY.—Visited March 27, 1913. The information obtained was embodied in a descriptive report of the water works and sewerage system, copies of which were sent to the local authorities and water works officials.

Elmhurst had a population of about 2,400 until 1913, when additional territory was annexed, thus increasing the population to between 3,000 and 4,000. Elmhurst is essentially a residence suburb of Chicago, though it has a few industries, notably a large limestone quarry.

Water works were installed in 1890 and have since been owned and operated by a private company. The source of supply is a spring about 3 miles south of town and about 300 feet from Salt Creek, a tributary of the Des Plaines River. From a concrete basin surrounding the spring the water is pumped by two 216,000-gallon triplex power pumps into a 6-inch wood pipe line to town. The distribution system consists of about 16 miles of pipe, a large part of which is 2-inch wrought iron pipe. The larger conduits are chiefly 4-inch wood pipe and none are larger than 6 inches. Connected with the distribution system is a 30,000 gallon standpipe.

The water is of good sanitary quality and the mineral content is slightly less than 500 parts per million, of which about 250 parts are carbonate or temporary hardness and 85 parts sulfate or permanent hardness. It is stated that the pumps deliver about 170,000 gallons per day.

Public sentiment favors the installation of a municipally owned plant, obtaining water from deep wells. The present installation is unsatisfactory on account of the large percentage of small mains and the inability to obtain good fire pressure without bursting the wood stave pipe. The company has a franchise extending to 1920 and an agreement on the purchase price if taken over by the city cannot be reached. The city may install a system for fire protection until the franchise expires and then take over the domestic consumption.

ELMHURST, SEWERAGE.—A system of sewers built on the combined plan serves all the built-up portion of the original town. The sewage is discharged without treatment into Salt Creek about 1½ miles west of the center of town. There are no houses near the outlet.

The channel of the creek is very shallow and at times the surrounding land is under water.

Annexed territory lying to the north of the original town is to be sewered. To conduct the drainage from this section into Salt Creek would require long expensive cuts. Another solution of the problem would be to carry the sewers eastward to a wet weather tributary of Salt Creek and install. treatment works. The city has engaged a consulting engineer to investigate the matter.

EL PASO, EXISTING WATER SUPPLY.—See Bulletin 10, page 109.

EUREKA, LIQUID WASTES FROM CORN CANNING FACTORY.—See Bulletin 9, page 21.

EVANSTON, PROPOSED PURIFICATION OF EXISTING WATER SUPPLY.—See Bulletin 9, page 21. EXISTING WATER WORKS.—See Bulletin 10, page 110.

FAIRBURY, EXAMINATION OF PUBLIC WATER SUPPLY.—See Bulletin 9, page 22.

FAIRFIELD, PROPOSED NEW WATER SUPPLY.—See Bulletin 9, page 22. PROPOSED WATER SUPPLY.—See Bulletin 10, page 110.

FARMER CITY, EXISTING WATER WORKS.—See Bulletin 10, page 111.

FLOOD RELIEF WORK.—During March and April, 1913, there occurred in the Ohio and Wabash rivers and a number of tributary streams of Illinois unprecedented floods which gave rise to much suffering and distress and greatly endangered public health. At the request of the governor, the State Water Survey joined in the relief work during and following the flood and gave special attention to the protection of water supplies and general sanitation. The work is described somewhat in detail on page 432 in this Bulletin.

FLORA, PROPOSED PUBLIC WATER SUPPLY.—See Bulletin 9, page 22.

FOREST PARK, EXISTING WATER WORKS.—See Bulletin 10, page 112.

FORRESTON, PUBLIC WATER SUPPLY.—Visited October 10, 1913. Information was obtained which was embodied in a descriptive report. Forreston's population has been slightly decreasing during the past twenty years and now numbers about 900. There are no industries of importance, the village being primarily an agricultural center. There is no sewerage system and apparently no prospect of such an improvement being made in the near future.

Water works have been installed since 1894, when a well 300 feet deep was drilled into water-bearing limestone. The well is cased with 8-inch pipe to rock at a depth of 40 feet and from there the hole reduces to 6 inch. Water is withdrawn from the well by a 200,000 gallon triplex pump belt connected to a 10-h. p. gasoline engine. The normal water level in the well is about 25 feet below the pump and the high suction lift necessary has made pumping quite inefficient. The average daily pumpage is estimated at 60,000 gallons. No test has been made of the maximum yield of the well but it is known to be adequate to meet demands. The water is of good sanitary quality, but quite hard. The system of mains includes about 1.6 miles of cast iron pipe from 4 to 8 inches in diameter. About 130 services are in use, none of which is metered. An elevated wooden tank of 62,000-gallon capacity is provided and affords an average pressure in the mains of about 40 pounds.

FORT SHERIDAN, EXISTING WATER SUPPLY AND SEWERAGE.—See Bulletin 9, page 23 and Bulletin 10, page 112.

FOX RIVER WATERSHED.—Visited August 18 to 22, 1913, for the purpose of collecting samples and making flow measurements on the main stream. A sanitary survey was made of this river in 1911, at which time detailed information was obtained relative to the numerous sources of pollution entering the stream and inspections were made of the various public water supplies. (See Bulletin 9, page 147.) During the latter trip samples were collected and field analyses were made at 15 stations distributed along that portion of the river lying within Illinois, a stretch about 100 miles in length. From samples obtained the following analyses were made:

- Dissolved Oxygen in the field
- Dissolved Oxygen 5 days later in laboratory
- Carbon Dioxide in the field
- Complete sanitary, chemical and bacteriological, made in laboratory.

Stream flow measurements were made at five different points. Much of the discharge data were of little value, due to the influence of numerous power dams in the river past which water flows intermittently.

Further investigations are under way and all data will later be included in a comprehensive report.

FREEPORT, EXISTING WATER WORKS.—See Bulletin 10, page 113.

FREEBURG, WATER SUPPLY.—Visited February 7, 1913, for the purpose of inspecting the water works system. Information obtained was embodied in a descriptive report sent to the local authorities with recommendations for improvements in the supply. Treatment with calcium hypochlorite was urged as a temporary measure to eliminate existing dangers due to pollution and the installation of a filtration plant at the earliest date practicable was recommended.

Freeburg is a village having a population of about 1,400. It has no industries of importance, being primarily a residence center in an agricultural community, and apparently there is little prospect of any rapid future growth. Water works were first installed about 15 years ago, when permission was obtained by the village to construct a dam across a ravine on the east edge of town. The reservoir thus formed is on private land, for the use of which a small annual rental is paid.

The dam is of earthen construction, about 150 feet long and 30 feet high, at one end of which is a concrete spillway about 20 feet long. There are no accurate data available relative to the capacity of this reservoir or its drainage area. When it is full, about six or eight acres are flooded, and it is estimated that about 20,000,000 gallons are impounded, or enough to supply the village for almost a year, at the present time. The tributary watershed is roughly estimated at four square miles. There are no records of water consumption, but it probably does not exceed 25,000 gallons per day.

Little or no pretense is made at protecting the supply against pollution. A portion of the town is on the watershed and drains directly into the reservoir. The banks are wooded and have been made into an attractive park. Boating and fishing are permitted, and it is understood that the owner of the land contemplates building a number of summer cottages on the banks of the rservoir.

The public water supply is not extensively used for drinking, as private wells are in very general use and yield a water that is at all times clear. These wells, however, are of the dug type and are often subject to contamination.

Water is drawn from the reservoir by a 4-inch low lift centrifugal pump, directly connected to a 10-h. p. electric motor, and forced against a head of about 15 feet through half a mile of 6-inch pipe to the electric plant on the opposite side of town. At this plant is installed a high lift centrifugal pump driven by a 15-h.p. motor. This pump forces the water against a discharge head of about 110 feet into the distribution system and into an elevated tank of 60,000-gallon capacity.

The village keeps no records of operation and has no accurate record of its distribution system. The mains are 4 inches and 6 inches in diameter and serve quite completely the built-up portion of town. The 84 services in use indicate that about 30 per cent of the population uses the supply.

FULTON, WATER SUPPLY.—Visited May 2, 1913. A descriptive report on the water supply and sewerage systems was prepared and a copy submitted to local authorities.

The city has a population of about 2,200 with no prospect of any material increase in the near future. Directly across the Mississippi River are the cities of Clinton and Lyons, Iowa, having a combined population of about 30,000. The C. & N. W. R. R. has shops and a roundhouse at Fulton and there are one or two small factories.

The water supply is owned by the city and was first installed about twenty-six years ago, when a well 1,246 feet deep was drilled into Potsdam sandstone. Water flowed from this well into a collecting basin, from which it was pumped into the distribution system, the excess over consumption passing to a 120,000-gallon masonry reservoir on a hill in the northern part of town. The well at first yielded about 300 gallons per minute and alone supplied the city until about five years ago. By that time its yield had fallen off considerably and a second well, 1,500 feet deep, was drilled about 300 feet from the first. The new well at first had a flow of 270 gallons per minute, but a year ago its yield had fallen to 80 gallons, when both wells were equipped with air lift. After the air lift had been operated a short time the natural flow of the new well increased to about 125 gallons per minute, enough to supply the city's ordinary needs. A second collecting basin has been added which is connected with the old one, so the two act as one reservoir. They are circular in plan and have a combined capacity of about 180,000 gallons. These basins are of brick construction, well covered and protected against contamination.

Water is delivered to the distribution system by two duplex steam pumps, one rated at 750,000 gallons per day and the other of 1,000,000 gallons per day capacity. Air for operating the wells is supplied by a two-stage compressor of 327 cubic feet per minute capacity, running 210 revolutions per minute. About 5½ miles of 8-inch, 6-inch and 4-inch main have been laid.

Only occasional observations of water consumption have been made. These indicate an average pumpage of about 90,000 gallons per day, or 284 gallons per service. Practically all water sold is metered. Analyses of the Fulton supply have indicated water of excellent sanitary quality. The water is only moderately hard as compared with other Illinois well supplies. It meets with popular favor and is used by about 70 per cent of the population.

FULTON, SEWERAGE SYSTEM.—At the time of the visit the city was about to award a contract for a sewerage system. Plans for the proposed improvement showed 4.74 miles of pipe sewers, ranging in size from 8 inches to 30 inches. It was proposed to admit both storm water and sanitary sewage to the system and to discharge into the Mississippi River at a point near the center of the city's water front. About one-third of the town's area was included in the sewered district and the estimated cost was about $30,000. There appeared to be no particular objection to the proposed method of disposal. The river bank is occupied by railroad tracks and complaints are not likely to arise, unless, possibly, from persons boating in the vicinity of the outlet.

GALENA, WATER SUPPLY AND SEWERAGE.—Visited April 29, 1913, for the purpose of obtaining a description of the water supply and drainage conditions. Information obtained was embodied in a report submitted to local authorities.

Galena is a city of about 4,800 population. Little growth is expected in the near future. In fact, the two last census reports have shown falling off in population. Galena is on the edge of a lead and zinc mining district. There are several lead mines in the vicinity and one smelter. Industries include two breweries, an axle grease factory and two foundries. Galena River passes through the center of town. On the north side land rises very abruptly to a height of about 200 feet, while land on the south is flat. Government locks in the Galena River below Galena make the stream navigable to the Mississippi, but shipping by water is not extensive. At time of heavy rainfall this stream rises rapidly and it is always expected that the lower part of town, including the business district, will be inundated at least once a year. The river at Galena in summer is stagnant and receiving, as it does, the city's sewage, becomes excessively polluted. No complaints, however, have been reported.

Water works were first installed in 1886, when a thirty-year franchise was granted private interests operating the local gas plant. The gas and water properties later went into the hands of W. N. Coler & Company of New York, who still hold them. Water has always been obtained from a single well 1,530 feet deep. It enters the Potsdam sandstone and has a flow at present of about 480 gallons per minute. There is said to have been no falling off in yield apparent in the past five-years. The 12-inch casing extends to rock at a depth of 60 feet. This pipe rises above ground about 3 feet, at which level a right angle bend directs the overflow into a waste drain. The pumps take their suction from the well a few feet below the ground surface and discharge directly into the distribution system. This arrangement is not wholly satisfactory, as almost continuous pumping is necessary, due to the fact that the rate of pumping cannot exceed 480 gallons per minute or the yield of the well with present pumping arrangements. A collecting reservoir would afford more economical operation and greater reserve in case of heavy draft for fire protection. A storage of 235,000 gallons is now afforded by a 120-foot standpipe at the top of a hill on land 110 feet higher than the pumping station.

Water is pumped by two tandem-compound duplex pumps rated at 1,000,000 gallons per day each, and operating against an average head of about 210 feet. Records of pumpage and coal consumption are maintained. An average station duty of about 22,800,000 foot pounds per 100 pounds of coal burned was attained in 1912. The average daily pumpage during that year was 362,000 gallons, equivalent to 800 gallons per service. Only 13 per cent of the services are metered.

City water is used by about 45 per cent of the population. Approximately 5½ miles of mains have been laid and these serve quite completely the lower part of town. Only limited service is afforded on the hill. Expensive rock excavation necessary on the higher land has retarded extensions, Analyses show the supply to be of excellent sanitary quality and one of the softest ground supplies in the state.

GALESBURG, EXISTING WATER SUPPLY AND SEWAGE DISPOSAL. —See Bulletin 10, page 114, and Bulletin 9, page 23.

GALVA, EXISTING WATER SUPPLY AND SEWERAGE SYSTEM.—See Bulletin 10, page 115.

GENESEO, PROPOSED SEWERAGE.—Visited July 30, 1913, for the purpose of gaging Green River, into which stream it is proposed to discharge the sewage of Geneseo without treatment. The sewage disposal problem is described in detail on page 374 of this Bulletin. (See also Bulletin 10, page 116.)

The flow as measured was 73.6 second feet. It is stated lower stages than that found have at times prevailed, but are of infrequent occurrence. This volume is sufficient to dispose of the sewage of Geneseo by dilution. Sedimentation to prevent sludge deposits and treatment of gas house wastes are, however, advisable.

GENEVA, EXISTING PUBLIC WATER SUPPLY.—See Bulletin 9, page 23.

GENOA, WATER SUPPLY.—Visited October 24, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Genoa, besides being a farming center, contains a few small industries. The population is about 1,300. Water works were installed in 1900 and practically all houses along the mains are now connected with the system. The supply is obtained from a well 1,500 feet deep and entering St. Peter sandstone. The water is of good sanitary quality and the mineral content is comparatively low, namely, 334 parts per million. All hardness is in the form of carbonates.

The water is pumped from the well directly into the distribution system, by a 300,00-gallon double-acting deep well pump driven by a 30-h. p. gasoline engine. Connected with the distribution system are two 10,000-gallon pressure storage tanks. There are 3.54 miles of cast iron mains ranging in size from 4 inches to 12 inches. The estimated average consumption is 60,000 gallons per day.

GEORGETOWN, PROPOSED WATER SUPPLY.—See Bulletin 9, page 24. See Bulletin 10, page 117.

GIBSON CITY, EXISTING WATER SUPPLY.—See Bulletin 10, page 118.

GILMAN, WATER SUPPLY.—Visited September 9, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Gilman is a farming center and has a population of about 1,300. Water works were installed in 1896 with a flowing well 120 feet deep as the source of supply. At the present time three 2-inch wells and three 6-inch wells, all 120 feet deep, are used. The water comes from a sand and gravel stratum found at a depth of 100 feet. Analyses show the water to be of good sanitary quality. It has a total residue of 1,029 parts per million and alkalinity of 312 parts per million.

The water flows by natural pressure into either of two collecting reservoirs of 60,000 and 50,000 gallons capacity respectively. An air lift system is available for use when the consumption exceeds the natural yield. From the reservoir the water is pumped by a 115,000-gallon simplex pump and a 192,000-gallon compound duplex pump into a distribution system comprising 2.2 miles of 4-inch, 6-inch and 8-inch pipe. Connected with the distribution system is a 52,000-gallon steel tank and tower affording a pressure of 45 pounds. The estimated average consumption is 75,000 gallons per day.

GIRARD, PROPOSED WATER SUPPLY.—Visited September 20, 1913, for the purpose of obtaining information relative to a well proposed as a source of public water supply. This project was being promoted with the hope that a supply could be developed to supply a market demand of about 650,000 gallons per day in and around Girard. Girard itself is a town of about 2,000 population located in a coal mining district. The residents of this city have expressed no particular desire for a public supply, but for a number of years the. various mining companies have shipped in very large quantities of water for the reason that no supply of adequate yield and satisfactory quality has been discovered in that locality. These mines are looked upon as the most remunerative customers, but it is also expected that the water will be used for domestic and fire purposes in Girard.

The well under consideration was dug about 19 years ago by private interests with the expectation of installing water works at Girard. A franchise was granted, but financial difficulties prevented further construction. The same interests have now brought the matter up a second time. This well is situated beside a small stream about 2 miles west of Girard. It is 14½ feet in diameter and about 25 feet deep and extends into a water bearing gravel about 10 feet thick. Preparations for running a pump test had been made by installing a

6-inch centrifugal pump driven by a traction engine, but the accumulated debris had not been removed from the well and an extended pumping test was not deemed feasible at the time of visit. A limited test that had been made indicated that this one well would not yield more than 150,000 gallons per day.

A sample of the water analyzed for mineral content proved to be quite hard and not suitable for use in steam boilers without preliminary treatment. The iron content also is high.

GLENCOE, EXISTING PUBLIC WATER SUPPLY AND SEWERAGE.— See Bulletin 9, page 24.

GRAFTON, POLLUTION OF ILLINOIS RIVER.—Visited December 10, 1913, to establish a station for the periodical collection of samples for analysis from the Illinois river. This work forms a. part of an investigation to determine the extent to which pollution results by the discharge of sewage into the Chicago Drainage Canal.

GRAND RIDGE, PROPOSED WATER SUPPLY.—Visited December 15, 1913, with reference to a proposed water supply. The information obtained was embodied in a report, copy of which was sent to the local authorities.

Grand Ridge is a small farming community and has a population of about 425. The occurrence of a very disastrous fire brought up the question of a public water supply and a consulting engineer was retained to prepare preliminary plans and estimates. Since the visit the, installation of a public water supply has received favorable popular vote and complete plans and specifications are now under way.

The drift covering at Grand Ridge is very thick. At a depth of about 150 feet a 50-foot layer of water bearing sand and gravel is encountered and the city supply will be derived from this horizon by means of an 8-inch well. Private wells reaching this vein indicate abundant water of good sanitary quality and a comparatively low mineral content, namely, 311 parts per million. All the hardness is in the form of carbonates and the iron content is low.

The equipment will include a 150,000-gallon per day deep well pump for pumping from the well into the distribution system, a 100,000-gallon reservoir for fire emergency and an 800-gallon per minute centrifugal pump for pumping from the reservoir into the distribution system in case of fire. The estimated cost, not including a distribution system, is $8,210. The distribution system is to be paid for by special assessment, while the remainder of the works will be met by a bond issue based on general taxation.

GRANITE CITY, WATER SUPPLY.—Visited January 21, 1913. Information relative to the public water supply was obtained and embodied in a report, copy of which was sent to the local superintendent.

Granite City has a population of about 16,000 and is one of several east side communities that are essentially suburbs of St. Louis, Missouri. The city has had a remarkably rapid growth since its founding about 18 years ago. It is primarily a manufacturing city with a large output of steel and iron products, corn products and granite ware utensils. It is progressive and a well improved city considering its rapid growth. The city occupies low flat land in the so-called American bottoms that is normally subject to occasional overflow by the Mississippi river, but is now included in the East Side Levee and Sanitary District, in which low lands are well protected by dykes. A complete system of combined sewers is installed, with a pumping station for forcing the sewage through the levee to an arm of the river.

Water works were first installed in 1895 when a town development company laid out the city. The system was later purchased by the American Water Works and Guarantee Company, which also owns the neighboring systems at East St. Louis and Belleville. The Granite City supply was originally taken entirely from the Mississippi River, treated with coagulants and subjected to sedimentation in a basin of 8,350,000 gallons capacity. The point of intake chosen was off Cabaret Island, about 2½ miles northwest of the city. About 10 years ago sand began to deposit opposite the plant and by 1910 the river channel was filled to such an extent along this east bank that the supply was entirely cut off, except at high stages. At ordinary stages the plant was left half a mile from the water's edge.

A temporary supply was hurriedly obtained from Cabaret Chute, a slough about 800 feet inland, by installing a steam pump and laying a surface line to the settling basins. The water thus obtained had an objectionable taste caused by algae which could not be removed by coagulation, or even by treatment with copper sulfate. Another auxiliary supply was, therefore, obtained from a lagoon in the sand half a mile south of the station. This lagoon had a small connection with the river but was fed mainly by springs. Water from it mixed with the slough water and subjected to coagulation and sedimentation was acceptable from the public's standpoint. But the lagoon water was expensive to obtain and not of assured adequate quantity, so the development of a well supply was begun for use in connection with the slough water. Difficulties with quicksand resulted in delays in completing the wells, but at the time of visit these were in service.

The present main sources of supply are the slough and nine tubular wells each 50 feet deep and 140 feet apart along the original river bank. At times of high water, the river is drawn from as originally. All water is subject to sedimentation of about 2½ days and, treatment with hypochlorite. The well water has an extremely high iron content, about 20 parts per million, and when it is used with the slough water the mixture is treated with lime to precipitate the iron and afford partial softening. When river water alone is used, either lime and iron or alum alone is used as coagulant, depending upon the character of the water.

Chemicals are stored and made into solutions in a two-story frame building about 20 feet by 30 feet in plan. Coagulant feed is controlled by constant level orifice boxes, while lime is usually fed in a dry state to a small stream of water flowing to the water being treated. The feeding is accomplished by a slowly revolving worm that pushes the powdered slaked lime at a uniform rate from the bottom of a hopper-shaped container. Sedimentation takes place in the original basin, an excavation about 425 feet by 124 feet in plan and 12 feet deep, with sloping sides faced with concrete.

The average daily pumpage is about 3,500,000 gallons. It varies greatly, however, with the varying demand of the factories.

There is a connection between the Granite City mains and the company's East St. Louis plant which is partially opened at times. Madison and Venice, with a combined population of about 10,000, lie between Granite City and East St. Louis and are supplied from either one or the other.

Such analyses as have been made by the State Water Survey indicate that the Granite City supply is of good sanitary quality. The operation seems to be quite efficient and analytical control is exercised by the company's chemist at East St. Louis. The water is quite hard when part of it is taken from the wells, and for this reason river water alone is preferred.

The low lift pumping equipment includes three vertical duplex triple-expansion pumping engines, one double acting and having a rated capacity of 5,000,000 gallons per day and the other two single acting with capacity of 3,500,000 gallons per day each. For high service there are provided two compound duplex pumps, each of 3,500,000 gallons per day capacity, and two triple-expansion duplex pumps, each with a capacity of 5,000,000 gallons per day. Very complete records of operation are kept. A station duty of about 35,000,000 foot-pounds per pound of coal is attained.

There are two discharge lines to town, one an 18-inch and the other a 20-inch pipe. The supply is very completely distributed over Granite City, Venice and Madison, where about 2,700 services are in use. About 50 per cent of the services are metered.

GRAYVILLE, EXISTING WATER SUPPLY.—See Bulletin 10, page 119.

GREENUP, PROPOSED IMPROVEMENT IN PUBLIC WATER SUPPLY.—On July 9, 1913, Hon. Lincoln Bancroft, mayor of Greenup, visited the office of the engineer of the State Water Survey for a conference relative to proposed improvements in the public water supply recommended by the State Water Survey. For a description of the existing water supply, see Bulletin No. 10, page 119. During this conference, special stress was placed upon the danger of contamination of the public water supply, and its unsatisfactory physical characteristics owing to extreme turbidity and it was recommended that purification works be installed to render the water satisfactory. It appears that the present pumping equipment is very inefficient and ineffective and it would be desirable in connection with the installation of purification works to provide room for new pumping equipment.

The principal difficulties in the way of carrying out improvements are lack of funds and indifference of popular opinion.

At the end of 1913 plans and specifications for proposed improvements had not yet been received.

GREENVIEW, EXISTING WATER SUPPLY.—Visited December 13, 1913. Information was obtained for a descriptive report on the water supply, a copy of which was sent to local authorities.

Greenview is a small agricultural center having a population of about 1,000. Very little change in population has occurred in the past twenty years. The only industry other than farming consists of coal mining on a small scale. Practically the only public improvement is the water supply which was installed about 20 years ago. At that time a well was dug and a windmill installed with which water was pumped into an elevated wooden tank. About eight years ago the windmill was replaced by a triplex pump and gasoline engine and the old tank was replaced by an elevated steel tank of 40,000 gallons capacity. Mains have been extended until about a mile and a half are in use, serving quite completely the built-up portions of town.

Water is obtained from the original well, which is dug 7 feet in diameter to a depth of 40 feet, from which level a 4-inch perforated pipe extends a further depth of 40 feet. The dug portion is lined with a sheet iron casing and covered with an open jointed board cover. The well is in a public park, therefore should be more adequately protected against possible pollution. The yield of the well is limited, apparently exceeding but little the average daily pumpage of about 8,000 gallons.

An analysis of the water indicates that it was of good sanitary quality at the time the sample was collected. It is quite highly mineralized and contains considerable permanent hardness. Not more than 25 per cent of the population use the water in their homes.

GREENVILLE, PROPOSED SEWERAGE.—Visited April 30, 1913, relative to a proposel sewerage system. The information obtained was embodied in a report, copy of which was sent to the local authorities.

There are two feasible points of outfall, namely, into Shoal Creek direct or into Beaver Creek, a small tributary of Shoal Creek. To discharge into Shoal Creek direct will require a deep cut for a considerable distance, but the advantages of either scheme cannot be determined until a complete survey of the city is made.

Owing to an agreement with a milk condensery, the wastes from the latter, amounting to at least 300,000 gallons per day, must be cared for in the city sewers. The cost of treating the sewage and condensery waste would be great and possibly the problem can be most cheaply solved by reaching a suitable understanding with the riparian owners downstream as to the damage involved and make payments accordingly. The heavier suspended matter may be removed by sedimentation which would avoid unsightliness and prevent to a large extent the formation of sludge, but would not, however, produce an unobjectionable liquid.

Plans are to be submitted to the survey after a complete topographical survey and then more definite advice can be given.

HAMILTON, WATER PURIFICATION WORKS.—Visited June 13-21, 1913, for the purpose of observing the operation of a recently installed water purification plant. (See Bulletin 10, page 120, for description of installation). Results of this visit were embodied in a report, copy of which was sent to the local authorities and consulting engineer. Certain defects were discovered in the plant, which related to (1) insufficiency of wash water, (2) inadequacy of wash water troughs and sewer, (3) unsatisfactory arrangement of inlet and outlet devices in coagulating basins, (4) the effective size of sand which was found to be different than that specified, and (5) insufficient capacity of clear water reservoir. These matters have since been more or less satisfactorily adjusted and while no further tests of the plant have been made, it is understood that it is in satisfactory operation.

HARMON, PROPOSED PUBLIC WATER SUPPLY.—See Bulletin 10, page 121.

HARRISBURG, PROPOSED IMPROVED WATER SUPPLY.—Visited August 21, 1913, in company with Mr. A. J. Authenrieth, Engineer for the Central Illinois Public Service Co., for the purpose of investigating the possibility of an improved public water supply, the present supply being dangerously contaminated and of very unsatisfactory physical characteristics. For a general description of the public water supply and the consideration of previous propositions for improving the supply by filtration, see Bulletin No. 10, page 121, and Bulletin No. 9, page 124.

A number of wells of considerable yield were brought to the attention of the Central Illinois Public Service Company, which controls the Harrisburg water supply. Before installing a filter plant the company desired to investigate the practicability of developing one or more of these wells. Accordingly on the date above mentioned four wells were examined and arrangements were made for pumping tests and the collection of samples for analysis. These further investigations indicated in all cases either that the yield was inadequate or that the mineral characteristics of the water were so unsatisfactory as to render them unfit for public supply. At the end of 1913 the Central

Illinois Public Service Company had under way the preparation of plans and specifications, but the project was temporarily held up owing to the proposed discharge of sewage into the Saline River above the water works intake by a northern suburb of Harrisburg.

HARRISBURG, SEWERAGE.—Visited July 5, 1913, relative to a proposed sewerage system for a residential district north of the Harrisburg corporation limits. Two schemes were found possible, one with an outlet to Saline River and the other having a connection with the city sewerage system.

The first scheme would require expensive treatment because the outlet would be above the city water works intake. The second scheme has objections owing to the fact that the district to be sewered is outside the city limits and the promoters do not wish to enter the corporation because of increased taxes.

A satisfactory solution of the problem had not been reached at the end of the year.

HARVARD, SEWAGE TREATMENT WORKS.—See Bulletin 10, page 122.

HARVEY, INVESTIGATION OF NUISANCE.—See Bulletin 10, page 123.

HAVANA, POLLUTION OF ILLINOIS RIVER BY CHICAGO DRAINAGE CANAL.—Visited December 9, 1913, to collect samples of Illinois river water and to make arrangements for the periodical collection of samples for analysis from that river, in connection with a survey of the river to determine the extent of pollution by the Chicago Drainage Canal, and its effect on the fish life.

HENNEPIN, POLLUTION OF ILLINOIS RIVER BY CHICAGO DRAINAGE CANAL.—See Bulletin 9, page 24.

HENRY, POLLUTION OF ILLINOIS RIVER.—Visited December 9, 1913. An agent was employed to collect monthly samples of river water at this point during 1914,

HERRIN, PROPOSED PUBLIC WATER SUPPLY.—See Bulletin 10, page 12.5.

HIGH LAKE, PROPOSED PUBLIC WATER SUPPLY.—See Bulletin 9, page 24.

HIGHLAND, PROPOSED NEW WATER SUPPLY.—See Bulletin 10, page 126.

HIGHLAND PARK, EXISTING WATER SUPPLY AND SEWERAGE. —See Bulletin 9, page 24. EXISTING WATER SUPPLY.—See Bulletin 10, page 126.

HILLSBORO, PROPOSED WATER SUPPLY.—See Bulletin 10, page 127.

HINCKLEY, PUBLIC WATER SUPPLY.—Visited October 29, 1913, when information was obtained for a descriptive report on the public water supply. Hinckley is a small agricultural center of about 700 population and has had water works since 1893. In that year a 350-foot well was drilled and equipped with air lift. An elevated wooden tank erected at the same time began to rot about seven years later and was replaced by an air pressure tank. At the same time a deep well pump was substituted for air lift. About eight years ago, due to excessive cost of operating this system, the village contracted with a local clay company to supply water from a well in St. Peter's sandstone. This is an 8-inch well, 675 feet deep, in which water rises to within 3 feet of the surface. The village has recently drilled a well similar to this and will again supply its own water. The new village well yielded 250 gallons per minute on being tested. A motor driven centrifugal pump will be installed.

HINSDALE, WATER SUPPLY.—June 28, 1913. A conference was held with Village President J. C. Woods in Chicago, to discuss means for softening the village water supply. An estimate was made of the relative cost of softening the water with lime, lime and soda, and lime and permutit, and permutit alone. The cost of chemicals would be lower and the most satisfactory results could be obtained by the use of lime and permutit. The matter is to receive further consideration by the village authorities.

HOOPESTON, SEWERAGE SYSTEM.—Visited October 28, 1913, for the purpose of obtaining information relative to a recently completed sewerage system and septic tank. A descriptive report was prepared which was sent to the local authorities with comments and an offer of assistance in solving the sewage disposal problem when in the future this problem becomes acute. The public water supply at Hoopeston was reported upon in February, 1912. (See Bulletin 10, page 128.)

Hoopeston is a city of about 5,000 population, well improved and of attractive appearance. Industries include two factories that can corn and beans and two factories for the manufacture of cans and canning machinery. Large quantities of putrescible wastes are produced during certain periods at the canning factories and these, after preliminary settling, are discharged into the city sewers.

The sewerage system is designed to receive sanitary sewage and putrescible wastes only and includes about 11 miles of vitrified pipe ranging in size from 8 to 24-inch. The outlet is a drainage ditch tributary to the north fork of the Vermillion river and the septic tank is located on the bank of this ditch about one mile southwest of town.

The tank is of the horizontal flow type, with two equal compartments each having a capacity of about 54,600 gallons. A small power pump is provided for lifting sludge onto a nearby drying bed. The stream receiving the effluent has a watershed of only a few square miles and at times is almost dry. Nuisances have already been complained of and the pollution will undoubtedly be greatly increased as the sewerage system comes into more general use.

JACKSONVIELE, EXISTING WATER SUPPLY.—See Bulletin 10, page 129.

JOHNSTON CITY, PROPOSED IMPROVED WATER SUPPLY.—Visited August 22, 1913. Johnston City is a mining town in the southern part of the state and has a present population of about 5,000. The population is increasing rapidly, but will probably not exceed 10,000. In 1908 a public water supply was installed primarily for fire protection. The company installing same was granted a 45-year franchise and was permitted to serve private consumers at their option. No obligation is placed upon the company as to the quantity and kind of water to be furnished for domestic purposes, but rather explicit specifications are included in the franchise as to the extent of fire protection that shall be afforded.

The supply is drawn partly from two 300-foot tubular wells which yield a very limited quantity of highly mineralized water. The water from the wells is supplemented by water drawn from a small surface stream known as Pond creek flowing through the southern part of the city. The water in this creek is impounded by two small dams, but the storage thus afforded is very inadequate. When available, most of the water is drawn from Pond creek because it is cheaper to pump and is moreover preferable from a mineral point of view. During 1913, however, the creek went entirely dry and it was impossible to secure enough water to meet daily consumption from the wells.

The property was purchased in 1912 by the Central Illinois Public Service Company and they desire to improve the service by securing a new source of supply which will yield an adequate quantity of pure water for all purposes. Several coal mines were considered as possible sources of supply, but owing to the high mineralization of this water and the possibility of contamination, these projects have been abandoned. There are possibilities for securing an adequate supply by building impounding reservoirs in the vicinity of Johnston City and further surveys are now under way to ascertain necessary data for selecting and developing such a source. Should an impounding reservoir be adopted as a source of supply, filtration works will be installed. In due time plans will be submitted to the State Water Survey for review.

JOLIET, PUBLIC WATER SUPPLY.—Visited July 15-16, 1913, for the purpose of obtaining a description of the water supply, which description was embodied in a report. Joliet is a city of about 37,000 population, situated on the Des Plaines river just below where the Chicago Drainage Canal enters. The city is an important manufacturing center, with extensive steel mills, and is enjoying a substantial growth. The state penitentiary is located just beyond the city limits.

Water works were first installed by private interests in 1884 and purchased by the city four years later. Numerous changes and additions have been made since the first installation, the principal ones of which have had to do with the source of supply. Water was first obtained from a series of 40-foot drift wells on the east edge of the city, but the yield of these proved inadequate in a few years and six wells were drilled at the same site to depths ranging from 1,200 to 1,700 feet. The supply again became inadequate at times and Hickory creek, a small stream flowing near by, was resorted to and has continued in intermittent use to the present time. A small reservoir is excavated at the plant, into which creek water may be admitted as desired, and into the same basin the flow of about 1,000,000 gallons per day of spring water from a nearby quarry has been diverted. Through the efforts of the State Water Survey, hypochlorite treatment of the supply was instituted in 1910 and has since been practiced whenever creek water was used.

In 1907 further development of the deep well supply was begun when a well was drilled at Ottawa street near the center of town. In 1911 a well was drilled on Canal street and in 1912 another was added at Spruce Slip. These were all equipped so that water could be pumped directly into the mains. Two more wells, one on Des Plaines street and one on Van Buren street, had been drilled at the time of the visit and were to be similarly operated. These five wells scattered about town range in depth from 1,547 to 1,621 feet. Wells in Joliet enter the St. Peter's sandstone at a depth of about 715 feet and leave it at about 1,125 feet. The Potsdam sandstone is about 100 feet thick and is entered at about the 1,390 foot level. Ten of the eleven deep wells supplying Joliet with water pass through both these water bearing strata, while one passes through only St. Peter's. The Canal street well up to the time of the visit had been used but little, due to an objectionable taste of oil in the water, but an aerating basin which successfully eliminates the taste has since been put into operation.

The drift wells at the main plant, scattered over an area of about one-half acre, are now twenty in number and are all so connected up that they may be drawn from directly by the high service pumps. No accurate tests have been made of this system of wells, but its yield is estimated at 1,250,000 gallons per day. The six deep wells at the station are pumped with air lift and discharge into a circular masonry collecting reservoir of 1,000,000 gallons capacity and covered with a conical roof. These wells have not been tested since 1900, when their combined capacity was about 1,400,000 gallons per day.

High service pumping equipment at the main station includes three duplex pumping engines, two having capacities of 3,000,000 gallons per day each and one rated at 4,000,000 gallons per day. There are two air compressors, one a small machine capable of operating only two wells, the other with a capacity of 2,800 cubic feet per minute.

The Ottawa street well is pumped with air supplied by a 500 cubic foot compressor and a yield of about 1,000,000 gallons per day is obtained. The water is received in a small concrete basin and from there is pumped into the mains with a 1,000,000-gallon triplex pump. Both pump and compressor are driven by a 200-h. p. motor. The Canal street station is equipped with machinery similar to that on Ottawa street and a yield of about 1,000,000 gallons per day obtained. At Spruce Slip about 577,000 gallons per day are obtained from the well with a deep well impellor pump. This pump discharges into the suction of a 6-inch centrifugal pump which forces the water into the mains. Each pump is run by a 100-h. p electric motor. The Van Buren and Des Plaines wells are both equipped similarly to the Ottawa street well and each yields about 650,000 gallons per day.

The aggregate yield of all the wells is about 6,527,000 gallons per day, which is not greatly in excess of recent demands. The use of water has been very wasteful in Joliet, averaging over 1,250 gallons per service daily. An ordinance requiring meters on all services was recently adopted, which it is hoped will materially reduce the consumption and do away with the necessity of pumping from Hickory creek.

A number of analyses have been made of the Joliet supply and these have usually given satisfactory results, although occasionally high bacterial counts and positive gas formers have been shown. The supply has been made more or less unpopular by the knowledge that it comes partly from Hickory creek and by occasional high turbidities that have resulted. Bottled water and water from private wells are in common use for drinking purposes. The supply is widely distributed by about 40 miles of mains. The 4,200 customers indicates that about 55 per cent of the population uses the supply.

JOLIET PENITENTIARY, EXISTING WATER SUPPLY.—Visited November 12, 1913, for the purpose of inspecting existing conditions with reference to water supply.

The water supply at the penitentiary is derived from four sources as follows:

Reservoir Supply: This supply is derived from a 10-inch tubular well about 1,000 feet deep which is pumped with air lift. The water from the air lift is delivered into a collecting reservoir which has a capacity of about 130,000 gallons. This water is not, however, favored for drinking purposes, inasmuch as it has objectionable tastes and odors, which in all probability are principally imparted by the development of plant growths in the collecting reservoir which is uncovered. This source of supply is not subject to contamination, inasmuch as the

10-inch casing of the well is in very good condition and the reservoir while open is not subject to trespass. However, there exists an element of danger, for it would be possible for some careless or malicious person to introduce polluting matter into the reservoir.

Clothing House Well: The principal source of drinking water supply within the penitentiary enclosure is the so-called clothing house well. This is a deep rock well of unknown depth located in an alleyway near the dining room. The well is entirely covered so that there is no possibility of surface contamination, but nearby there is a sewer which, if in a leaky condition, may readily pollute the well through a defective casing. The condition of the casing and the condition of the sewer is not known. The water is delivered to several drinking fountain faucets, especially to a stone bowl located in the main street in the penitentiary enclosure. From this point the water is carried to various workshops in buckets for drinking purposes. In this way there is an abundant opportunity for contamination of the water through careless handling.

Spring Supply: The third source of supply is a spring outside of the penitentiary enclosure and the water is carried to the stone quarry within the enclosure through a wooden pipe. The spring emerges from a limestone formation of an open character, but it does not appear from examination of the land back of the spring that there is any serious danger of contamination through sink holes or otherwise. The spring itself, however, is very inadequately protected and subject to contamination by persons who may visit it.

Shallow Well: Another source used occasionally is a shallow dug well at a private residence nearby. This well is only used by those convicts who work on the outside of the enclosure. The water is subject to dangerous contamination from surface wash and is also objectionably near several privies.

After an examination of the various water supply conditions, the following recommendations were made:

(1) That a new water supply of satisfactory quality, remote from sewers or other possibility of contamination be sought and that this be distributed throughout the institution in such manner that drinking water will be drawn directly from faucets, thus making it possible to give up the system of carrying drinking water in buckets and other receptacles.

(2) That much larger storage and a more liberal distribution system be provided so as to give more adequate fire protection to the buildings within the penitentiary enclosure.

(3) That the collecting reservoir be covered so as to prevent the possibility of contamination.

(4) That if the spring supply now pumped to the creek is to be maintained in service, it must be much more adequately protected than at present.

KANKAKEE, PUBLIC WATER SUPPLY.—Visited November 7-8, 1913. Information was obtained for a descriptive report. Kankakee is a city of about 20,000 population and is having a substantial growth. A state insane hospital with a population of about 3,000 is situated just beyond the city limits. Kankakee is of increasing importance as a manufacturing center, with quarries, a brewery and several furniture factories. Limestone lies a few feet below the surface. Practically all wells are drilled into this rock. The sewerage system, built on the combined plan, is quite complete, includes about 27 miles of pipe and stone drains and has five outlets to the Kankakee river and a tributary called Soldiers creek.

Water works were installed by private interests in 1886. Since that time the ownership has changed twice and the system is now in the hands of the Northern Illinois Water Company. The present franchise dates from 1910 and has a life of 22 years.

Until 1901 raw Kankakee river water constituted the public supply. In that year a rapid sand filter plant was installed with a nominal capacity of 3,000,000 gallons per day. In 1910 the capacity was increased to 4,000,000 gallons. The average daily pumpage is now about 2,000,000 gallons per day, equivalent to about 590 gallons per service. Ten per cent of the services are metered.

Water is drawn from the river on the southeast edge of town before it flows through Kankakee. The stream is not excessively polluted at this point, although it does receive municipal sewage about 15 miles above. The raw water is extremely turbid at times. There is never any danger of shortage. The water when objectionably turbid is coagulated with alum and subjected to sedimentation in basins of 400,000 gallons capacity, affording a retention period of about 2.4 hours, based on the nominal capacity of the plant. Water flowing from the sedimentation basins receives a dose of hypochlorite of lime and then passes to the filters, beneath which is the clear water reservoir of 250,000 gallons capacity. There are eight filter units, each 12 feet by 16 feet. The settling basin, filter boxes and clear well are all of reinforced concrete construction.

Chemicals are dissolved and fed simultaneously by passing a small stream of water into a box containing the chemical and allowing the overflow to pass to the water receiving treatment. Reasonably uniform application is thereby obtained. A laboratory for bacterial and chemical control is fitted up but has not been used as such for the past two years. Numerous analyses made by the State Water Survey have with few exceptions indicated that a water of good sanitary quality is being delivered.

Water is pumped from the river to the settling basins by two 8-inch centrifugal pumps directly connected to 25-h. p. steam engines. Each pump is rated at 3,000,000 gallons per day. For high service, there are two tandem compound duplex pumps, one rated at 1,000,000 gallons per day, and the other 3,000,000 gallons per day, and one cross-compound duplex pump of the fly-wheel type rated at 3,000,000 gallons per day.

There are two 12-inch discharge mains leading from the station to the center of the distribution system. About 25 miles of mains have been laid to date, on which there are 252 fire hydrants and about 3,300 water customers. Domestic pressure of about 70 pounds is maintained at the plant and 50 pounds in the center of town. Pressure is increased to 125 pounds at time of fire.

KENILWORTH, EXISTING PUBLIC WATER SUPPLY AND SEWERAGE.—See Bulletin 9, page 24.

KEWANEE, EXISTING WATER SUPPLY.—See Bulletin 10, page 130.

KIRKWOOD, EXISTING WATER SUPPLY.—See Bulletin 10, page 131.

KNOXVILLE, EXISTING WATER SUPPLY.—See Bulletin 10, page 131, and Bulletin 9, page 25.

LADD, WATER SUPPLY.—Visited February 5, 1913. The information obtained was embodied in a descriptive report, copy of which was sent to the local authorities.

Ladd has a population of about 2,200. The leading industry is coal mining and the city is also a railroad division point. Water works were installed in 1893 with an abandoned coal mine as a source of supply. The mine water supply proved inadequate and of poor quality. In 1907 a well was sunk and a new pumping station built in the northwestern part of town.

The well is 6 inches in diameter, 187 feet deep and throughout this depth it remains in the glacial drift. The water is pumped into a 23,000-gallon collecting reservoir by means of air lift and from the reservoir into the distribution system by a 300,000-gallon triplex power pump. The distribution system consists of about 5 miles of 4-inch and 6-inch cast iron pipe, and connected to it is a 100,000-gallon elevated steel tank.

The water as drawn from the well is of good sanitary quality, but water seeps into the reservoir and impairs the quality. The effect of this seepage is also noticeable in the mineral content, which is increased from 400 parts per million as drawn from the well to 650 parts per million after retention in the reservoir. The well water contains no sulfate hardness, about 250 parts of carbonate hardness and 100 parts of sodium carbonate. After retention in the reservoir the carbonate hardness is increased to 350 parts per million, about 150 parts of sulfate hardness are added and the sodium carbonate entirely removed. Although a meter is placed on the discharge pipe of the service pump no records are kept. The estimated average daily consumption is 70,000 gallons in winter and 110,000 gallons in summer.

LAGRANGE, RECENTLY COMPLETED SEWAGE TREATMENT WORKS.—See Bulletin 10, page 134.

LAKE BLUFF, EXISTING PUBLIC WATER SUPPLY AND SEWERAGE.—See Bulletin 9, page 25. PROPOSED IMPROVEMENT IN PUBLIC WATER SUPPLY.—See Bulletin 10, page 135.

LAKE FOREST, SEWAGE DISPOSAL.—Visited June 2, 1913, relative to improving the present means of sewage disposal. (See Bulletin 9, page 25.)

At the present time the sewage is passed through septic tanks and a portion treated on intermittent sand filters. The filters have become clogged and cause odors in the neighborhood.

The Lake Forest problem cannot be solved independently of the problems that exist in the various north shore towns and thorough engineering studies within these towns is advisable before any final solution is attempted. However, it is practicable to reach a temporary solution by abandoning the filters and discharging the tank effluent into Lake Michigan at a considerable distance from shore. Disinfection with hypochlorite of calcium will eliminate any additional danger to public water supplies should such be found to exist.

This modification in the method of treatment, not including sterilization, was carried out before the end of 1913.

LANARK, WATER SUPPLY.—Visited October 15, 1913, for the purpose of inspecting the water works and obtaining information for a descriptive report. Lanark is the center of a farming community and has a population of about 1,200. Its size has changed but little in the past 20 years. The only manufacturing industry is a small canning factory. There is no sewerage system and there seems to be no immediate prospect of such an improvement being made.

The water works system is owned by the village and was first installed in 1888. A well 400 feet deep was drilled and this supplied water until 1895. At that time an increase in supply became necessary and a new 600-foot well into St. Peter's sandstone was drilled. The old well was capped and a pit around its top was converted into a collecting reservoir of about 47,000 gallons capacity. This reservoir is 20 feet in diameter and 20 feet deep and has brick walls with concrete bottom and cover. Water is drawn from the new well by a steam-head deep well pump and discharged into this basin and from there forced into the distribution system by a Smedley duplex pump with a capacity of 360,000 gallons per day. The yield of the well has not been tested, but has thus far proved fully adequate. Water consumption averages about 70,000 gallons per day, equivalent to about 465 gallons per service. Very few meters are used.

Analyses have shown the water to be of good sanitary quality and the method of handling seems to preclude all likelihood of contamination. The water is only moderately hard as compared with the average Illinois ground water. The iron content is quite high, but no inconvenience due to this cause has been complained of. The supply is used by about 60 per cent of the population and has met with general approval.

Slightly less than 2 miles of mains have been laid. On this system there are nine dead ends which are frequently flushed to remove accumulations of iron. A wooden tank of 45,000 gallons capacity supported by an 80-foot steel tower is connected to the system of mains and provides an average pressure of about 45 pounds per square inch.

LA SALLE, WATER SUPPLY.—Visited December 19, 1913. The information obtained was embodied in a descriptive report, copy of which was sent to the local authorities.

La Salle has a population of about 11,600. A prosperous farming community is tributary to La Salle, but the city is largely an industrial one. Water works were installed in 1888 with a spring about 2 miles east of town as a source of supply. In 1904 the spring supply was abandoned and the development of wells at the southeastern part of town in the Illinois bottom lands was begun.

Two unusually designed wells now serve as the source of supply and the sinking of another is contemplated. The wells are about 39 feet deep and made water tight for the first 25 feet. The top is sealed by means of a standard boiler manhole. This is necessary since the wells at high water in the nearby Illinois River are submerged several feet.

The water is of good sanitary quality and has a mineral content of about 600 parts per million. Of this about 300 parts constitute carbonate hardness and about 193 parts are magnesium sulfate.

The water is pumped from the two wells by two 3,000,000 gallon centrifugal pumps into a 35,000-gallon brick collecting reservoir and thence into the distribution system by two compound duplex pumps having rated capacities of 1,500,000 and 2,000,000 gallons respectively.

The distribution system comprises about 22 miles of 1-inch to 12-inch pipe and there is no equalizing tank or reservoir.

No pumping records are kept, but the average consumption is roughly estimated at 2,000,000 gallons per day.

Contemplated improvements include another well, a large collecting reservoir and a standpipe or tank and tower.

LA SALLE, INVESTIGATION OF THE POLLUTION OF TWO DEEP WELLS.—See Bulletin 9, page 25.

LAWRENCEVILLE, TYPHOID FEVER EPIDEMIC.—Visited August 14 and 15, 1913, at the request of local authorities for the purpose of making an investigation of the cause and extent of prevailing typhoid fever in that city. A report was prepared and sent to the city officials and the water company. This investigation was supplementary to and confirmatory of one made about two weeks previously by a representative of the State Board of Health, who after questioning local physicians had shut off the milk supply from a dairy suspected of being the source of the epidemic. The State Water Survey was called in when a fear arose that the infection might be due to the public water supply.

Lawrenceville is a city of about 5,000 population, located in the Illinois oil fields. It has had a very rapid development and public sanitary improvements have not fully kept pace with this growth. The water supply is taken from the Embarrass river and treated by coagulation, sedimentation, disinfection with hypochlorite and finally filtration. The plant is not of the best modern design and effective purification is not at all times obtained.

There is said to be more or less typhoid fever every year in Lawrenceville. At the time of the visit there was an unusually large number of cases and practically every home where the disease had occurred in the past three months was visited personally. Inquiry was made relative to 71 cases and information was obtained which may be summarized as follows:

Number drinking city water alone	0	0 %
Number drinking city water and water from other sources	29	41%
Number drinking no city water	42	59%
Number using milk from suspected dairy	59	83%
Number using other milk	8	11%

The investigation seemed to relieve the water supply of the responsibility for the outbreak, while the evidence pointed strongly to the suspected dairy as being the primary cause. The milk supply was resumed about the time of the State Water Survey's investigation and inspection of the premises seemed to indicate that it was then being operated in a cleanly and sanitary manner. City authorities were strongly advised to keep the milk supplies under closer observation in the future.

LAWRENCEVILLE, WATER SUPPLY.—See Bulletin No. 9, page 25.

LE CLAIRE, TYPHOID FEVER.—Water having been suspected of causing typhoid fever at Le Claire an investigation was made by the State Water Survey. Le Claire is a village of about 700 inhabitants founded in 1890 on the cooperative system by a manufacturer. Most of the citizens are employed in the one factory.

The city has no public water supply of its own, but distributes Edwardsville city water through its mains. Under normal conditions the water is received directly from the Edwardsville mains into the Le Claire mains. During a fire in Le Claire water may be pumped into the Le Claire mains by pumps located at the factory from a 100,000-gallon reservoir situated near the plant. This, however, has not been done for three years.

The investigation included twelve cases of typhoid spread over a period of nine months, namely, from August, 1912, to April, 1913, inclusive. Three cases occurred in August and one in November, 1912, and three in January, two in February and four in March, 1913. Each case was visited and detail information obtained as far as possible.

Eight cases were over 16 years of age and either worked at the factory or were occupied as housewives and four were school children. Seven cases were males and five were females.

All except two used the city water. There were no cases in Edwardsville during this period and the cases in Le Claire were not of the general nature characteristic of a water borne outbreak. Nothing pointed to the water as the source of infection. Milk was obtained from six different dealers, some of which had large routes in Edwardsville and so milk was apparently not the cause.

Owing to the time that had elapsed it was impossible to obtain accurate information regarding associations of the different cases just before their sickness, but all cases were more or less acquainted with one another and infection by contact probably played an important part.

LENA, WATER SUPPLY.—Visited October 17, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Besides being a farming center Lena has two small factories. The population is about 1,170. Water works were installed by the city in 1895 with a well 600 feet deep entering St. Peter's sandstone as the source of supply. The water was pumped directly from the well into the distribution system until 1908 when a storage reservoir and duplex pump were added and double pumping established. In 1911 the city contracted with the local electric light and power company for a ten-year period to do all the pumping.

The company pumps the water from the well with a 197,000-gallon-per-day deep well pump into a 160,000-gallon concrete reservoir and then from the reservoir into the distribution system with a 400,000-gallon-per-day centrifugal pump or with a duplex steam pump of unknown capacity.

The distribution system consists of 3.4 miles of 4-inch to 10-inch cast iron pipe and connected to the system is a 36,600-gallon wooden tank placed on a 100-foot stone and brick tower, thus affording a pressure of about 50 pounds at the ground level.

The water is of good sanitary quality and has a mineral content of 490 parts per million chiefly carbonates, but enough magnesium sulfate, namely, 72 parts per million, is present to cause hard scale to form when used in boilers.

No records are kept, but the average daily consumption is roughly estimated at 70,000 gallons, of which between 2,000 and 3,000 gallons are used by a railroad.

LEROY, EXISTING WATER SUPPLY.—See Bulletin 10, page 136.

LIBERTYVILLE, EXISTING WATER SUPPLY.—See Bulletin 10, page 137.

LINCOLN, WATER SUPPLY.—Visited July 18, 1913, for the purpose of securing a detailed description of the public water supply. The water supply of Lincoln was investigated during 1912, with reference to certain possibilities of pollution and at this time a general description was obtained which was embodied in the form of a report together with recommendations for eliminating the dangers of contamination which now exist. A general account of this investigation was presented in Bulletin No. 10, page 138, which also presents a brief description of the works.

LITCHFIELD, PROPOSED NEW WATER SUPPLY.—Visited February 5 and 6, 1913, with reference to proposed new water supply. For a general account of the situation at Litchfield see Bulletin No. 9, page 26, and Bulletin No. 10, page 141. At the time of visit, a water works committee, of council, had had preliminary surveys made of various reservoir sites and had secured options on the reservoir site which seemed to be the most promising of the various projects considered and which lies about two miles east of the town. The committee had also gathered a large mass of water works information by writing to other small municipalities.

The weather conditions were unfavorable for investigating thoroughly the feasibility of the project, but an inspection was made of the proposed reservoir site and the authorities were informally advised as to certain general features to be considered in connection with the new water works development. In particular it was urged that a competent consulting engineer well versed in water supply matters be retained to draw up complete plans and specifications.

On the evening of the 5th of February, an address was made before the council on the water supply project, in which the needs of the town were presented and a general description was given of the character of water works that would be necessary to meet local requirements. To the end of 1913 no means had been found of satisfactorily financing the new project, but it is anticipated that something definite will be done during 1914.

LITCHFIELD, TYPHOID FEVER CONDITIONS.—Visited October 24, 1913. Several cases of the typhoid fever were investigated and it was found that the infection was brought in from outside. City water is not used for drinking purposes and in all probability secondary cases developed from direct contact infection.

LOCKPORT, POLLUTION OF ILLINOIS RIVER BY CHICAGO DRAINAGE CANAL.—See Bulletin No. 9, page 26.

LOSTANT, EXISTING WATER SUPPLY.—Visited September 25, 1913, for the purpose of obtaining information for a descriptive report on the public water supply. Lostant is a village of about 500 population in a farming community. Water works were first installed two years ago when a well was dug in the center of town. The well was equipped with a pump for forcing water into a 50,000-gallon elevated steel tank. A single hydrant furnished limited fire protection to the business street. During the summer of 1913 a distribution system of about 1½ miles of mains was added.

The well is 5 feet in diameter and 70 feet deep, lined with a brick wall, the top 10 feet of which was laid in cement mortar and drawn in to a diameter of 3 feet. Over the well is built a small pumping station and protection of the supply appears to be adequate. In the bottom of the well is a simplex, single-acting plunger pump with a capacity of about 100,000 gallons per day. The pump is rod-connected to a power head at the top of the well and is driven by a 10-h.p. gasoline engine. The well will yield only a small quantity of water and this is reserved primarily for fire protection. The unusually high price of $1.00 per 1,000 gallons is charged to discourage wasteful use of the supply.

MACOMB, EXISTING PUBLIC WATER SUPPLY.—See Bulletin No. 9, page 26.

MACON COUNTY ALMSHOUSE, SEWAGE DISPOSAL.—Visited July 1, 1913, for the purpose of investigating alleged inadequate sewage disposal. Information obtained was embodied in a report submitted to the Board of Supervisors.

The institution is situated about 4½ miles northeast of Decatur and has, on an average, about 65 inmates. A small stream, known as Stephens creek, flows through the county's farm and serves as an outlet for the sewage. The stream below has been used for watering dairy cattle and land owners have claimed damages due to the presence of the sewage. Until two years ago sewage from the almshouse was discharged into a small brick settling tank from which the overflow entered the creek. Then, due to objections by farmers, a small septic tank was built from which the effluent was admitted to an open-jointed dead-end tile line about 500 feet long. It was expected that the liquid would seep away into the soil, but clogging soon resulted and sewage began to pond on the surface of the ground. The tile was then extended and for several, months previous to the visit the septic tank effluent had been discharged directly into the creek. Inspection and inquiry seemed to indicate that no nuisance was ever caused by the pollution, but, due to the possible danger of infecting a milk supply and the fact that the supervisors were anxious to avoid litigation, it was recommended that a small intermittent sand filter plant be built. Such a plant has since been built, but no engineer was consulted and plans were not submitted to the State Water Survey for approval as had been requested. Information gained through correspondence indicates that wholly satisfactory results will not be obtained with the means provided.

MARENGO, WATER SUPPLY.—Visited October 21, 1913.—The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Marengo is chiefly an agricultural center and has a population of 1,925. Water works were installed in 1893 and were operated by the city until five years ago when a private electric company purchased the pumping equipment and made a twenty-year contract to furnish the water.

The water is pumped from a well 20 feet in diameter and 14 feet deep directly into the distribution system by means of a 300,000-gallon triplex pump driven by a 20-h. p. electric motor. The distribution system comprises 5.7 miles of 4-inch to 8-inch cast iron mains and connected with it is a 63,000-gallon standpipe affording a pressure range about town of 35 to 60 pounds.

Sanitary analyses showed the water to be safe for drinking. Contamination, however, is possible at the well owing to a loose board cover almost flush, with the ground surface. Also privies are not far removed from the well and since the well is very shallow nearby pollution might affect the water, especially when the entire yield is being utilized. Mineral analyses showed a mineral content of 407 parts per million, of which about 270 parts are carbonate hardness and 70 parts sulfate hardness.

A meter is installed on the main from the pumping station and records show an average daily consumption of 95,000 gallons.

MARION, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 142.

MAROA, EXISTING PUBLIC WATER SUPPLY.—See Bulletin No. 10, page 143.

MARSEILLES, POLLUTION OF ILLINOIS RIVER BY CHICAGO DRAINAGE CANAL.—See Bulletin No. 9, page 26.

MATTOON, PROPOSED SEWERAGE.—Visited January 29, 1913, relative to a proposed change in the sewerage system. Recommendations based on the information obtained were embodied in a report, copy of which was sent to the local authorities.

At the present time about one-half of the built-up area of the city is sewered by several different systems which carry both storm water and domestic sewage. Additional storm drains are contemplated for the immediate future which will provide a satisfactory storm water system for the entire community.

Proposed sanitary sewers are intended to cover the town completely and present house connections into the storm drains will be eliminated. Preliminary plans call for four outlets, two to the northward into Riley creek, and two to the southward into Kickapoo creek. A septic tank is to be provided for each outlet.

After a review of the plans and a field examination it was decided that numerous features of the plans need further consideration. These relate especially to the arrangement of the system with a view to securing two outlets instead of four, the adoption of Emscher tanks in preference to septic tanks, design of outfall and treatment works with a view to ultimately providing more complete purification than that which can be provided by tank treatment alone, introduction of a greater number of manholes, elimination of some flush tanks and the modification of the specifications with respect to vitrified pipe.

It was recommended that revised plans be prepared and submitted to the State Water Survey for review.

MATTOON, WATER SUPPLY.—See Bulletin 10, page 144.

MAYWOOD, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 146.

McHENRY, EXISTING PUBLIC WATER SUPPLY.—See Bulletin No. 9, page 27.

McLEANSBORO, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 147.

MELROSE PARK, EXISTING PUBLIC WATER SUPPLY.—See Bulletin No. 10, page 148.

MENARD PRISON, WATER SUPPLY.—Visited February 27, 1913. Information relative to the water supply was obtained which was embodied in a descriptive report. The prison is situated on the bank of the Mississippi river about one mile north of the city of Chester and has a total population, including prisoners and employes, of about 1,500.

Water is obtained from three different sources, namely, the river, an impounding reservoir and springs.

River water is pumped to a 360,000-gallon standpipe on a hill back of the prison, and from there flows to the fire system and to mains supplying water used for stripping loose earth from rock at the quarries. Water is taken from the fire system for laundry purposes. A small charcoal filter in the standpipe acts to remove a portion of the suspended matter from the water. A lift of about 225 feet is necessary to pump river water into the tank and this is accomplished by two motor-driven triplex pumps with rated capacities of 600,000 gallons per day each.

An impounding reservoir of about 60,000,000 gallons capacity was recently formed by erecting a 40-foot dam across a ravine on the prison farm. There are about 300 acres in the watershed of which about 10 are flooded when the reservoir is full. The dam consists of a concrete wall 11.5 feet thick at the base and 3.5 feet thick at the top, supported by concrete pilasters and earthen embankment on the down-stream side. The reservoir is high enough to afford a gravity flow to the standpipe and this water will hereafter largely replace the use of river water.

The supply of water used for drinking and culinary purposes is obtained from two springs in the prison yard which were opened up in blasting out rock. They have both been lined and covered with concrete and pipes are laid underground to convey the water to a cistern at the back of the main building. This cistern is of concrete and a water-tight curbing rises about 3 feet above the surrounding pavement. The top is open, however, and water is drawn with buckets. This method of handling makes it comparatively easy for an infected person to endanger the entire population.

MENDOTA, PUBLIC WATER SUPPLY.—Visited October 7, 1913, to obtain a description of the public water supply and sewerage system. Mendota has a population of about 4,000. It is a railroad division point and supports several small implement factories.

Water works were first installed in 1888 when a 7-inch well was drilled near the center of town. Later another similar well was added about 40 feet from the first. The wells are 400 and 480 feet in depth, respectively, and enter the St. Peter's sandstone. Water is pumped with an air lift into a covered masonry reservoir of about 127,000 gallons capacity. Another reservoir holding 560,000 gallons is contemplated. For high srvice there are two duplex steam pumps, one rated 1,500,000 and the other at 1,000,000 gallons per day. The average pumpage amounts to about 575,000 gallons per 24 hours, equivalent to about 500 gallons per service. Complete records of station operation are kept.

The supply is of good sanitary quality and only moderately hard as compared with other Illinois ground waters, but has a high iron content. It is widely distributed and in very general use. About 11 miles of mains have been laid. There are approximately 1,100 services in use, all of which are metered. An elevated steel tank of 24,000 gallons capacity is connected with the system and maintains a domestic pressure of about 45 pounds. Pressures as high as 125 pounds are obtained for fire service by cutting off the tank and pumping direct.

MENDOTA, SEWERAGE.—Mendota has a partial system of sanitary sewers serving about half the population. There is an 18-inch outlet leading southward a distance of about 1½ miles to a small stream known as Mendota creek. At this point purification works are built consisting of approximately 2 acres of intermittent sand filters. There are four filter units, each 75 feet by 300 feet, consisting of about 20 inches of sand and gravel underlaid with 6-inch open-joint tile drains. In the corner of each bed is built a small grit chamber 10 feet by 16 feet in plan and 20 inches deep, through which the raw sewage flows before discharging onto the bed. One bed is maintained in use at a time, a new one being put into service each week. Some difficulty is being experienced due to the clogging of the beds, but this trouble, it is expected, will soon be partially overcome by adding a settling tank for preliminary treatment. The total filter area provided to date amounts to about 1 acre for every 1,000 inhabitants and the plant is probably treating about 100,000 gallons per acre daily.

It will be observed the filtering area is about sufficient to properly handle the quantity of sewage that reaches it, but the method of operation is wrong. Instead of using one bed continuously for a week with three beds idle, three beds should be kept in service by dosing in rotation to a depth of about 3 inches and the one remaining bed should rest idle for a week.

The city will in the near future complete its sewerage system so that all parts of the city will be served. The sewage from this new district will be discharged eastward about half a mile from the city where disposal works consisting of a septic tank and two intermittent sand filters, each 50x150 feet in plan, are to be built. The effluent is to be discharged into a branch of Mendota creek.

MEREDOSIA, POLLUTION OF ILLINOIS RIVER.—Visited December 8, 1913, to establish a station for the periodical collection of samples for analysis from the Illinois river. This work forms a part of an investigation to determine the extent to which pollution results by the discharge of sewage into the Chicago drainage canal.

METROPOLIS, PUBLIC WATER SUFFLY.—Visited April 8, 1913. High water in the Ohio river had entered the reservoir and was being pumped into the city mains. A hypochlorite plant was installed and the water was treated until danger of pollution was past. The source of water supply is a deep well, the water from which is stored in a reservoir: Many private wells were visited and instructions given how, to put them in good condition. See report on "Work of the State Water Survey in Flooded Districts of Illinois During April 1913."

METROPOLIS, WATER SUPPLY.—See Bulletin No. 9, page 27.

MILFORD, WATER SUPPLY.—Visited September 13, 1913. Information was obtained for a descriptive report on the public water supply. Milford has a population of about 1,500 and is a residence center in a farming community, and is having only a slow growth. The only industry of importance is a corn canning factory.

Water works were first installed in 1896. The supply is obtained from two wells, each 65 feet deep and entering a water-bearing stratum of sand and gravel at a depth of about 60 feet. Water rises in the wells to within about 40 feet of the ground surface.

A triplex power pump is placed in a circular pit 20 feet deep and takes its suction direct from the wells. This pump delivers into the distribution system and an elevated steel tank of 60,000 gallons capacity and 105 feet high. About 4.3 miles of cast iron mains have been laid, nearly all of which is 4-inch.

There are about 285 water services in use, all of which are metered. The metered consumption is in the neighborhood of 20,000 gallons per day, but this is not more than one-third of the actual quantity pumped.

The quality of the water is quite satisfactory from a sanitary point of view. The mineral content is high, with total solids of about 350 parts per million, and there is a serious corrosive action which has resulted in the necessity of substituting lead for galvanized iron in service pipe. The iron content of the water is sufficiently high to cause some turbidity, but the users seem to be generally satisfied with the supply for domestic purposes.

MILFORD, SEWERGE.—Milford has a sewerage system built to carry both sanitary sewage and storm water and made up of vitrified tile ranging in size from 6 inches to 18 inches in diameter. There are three outlets, all to Sugar creek, a stream having at this point a watershed area of about 50 square miles. The system is of inadequate capacity to properly remove storm water and some inconvenience consequently results. Wastes from the canning factory are also discharged into Sugar creek and, although no complaints have been made, objectionable pollution results. The creek at this point has very little flow at times and the time will very likely come when Milford will need to consider methods of treating its sewage and factory waste.

MINOOKA, WATER SUPPLY.—Visited July 13, 1912. Information was obtained for a descriptive report on water works and sewerage, a copy of which was sent to the village president.

Minooka is primarily an agricultural center having a population of about 400. Water works were first installed in 1886, when a well was drilled 2,100 feet deep. At first water in this well had a static head of 90 feet above ground and flowed about 100 gallons per minute at the ground level, so the well was simply connected with the mains and allowed to supply the town without pumping or storage. Six years ago the pressure had become considerably reduced and a change was deemed advisable.

Water from the old well had always been objectionable on account of its decided corrosive action, so another well 620 feet deep was drilled to take its place. The new well is cased with 12-inch pipe to rock at a depth of 100 feet and is 6 inches in diameter the remaining distance. It is equipped with a deep well pump and power head belt connected to a 15-h. p. gasoline engine. No test has been made, but the yield apparently is fully adequate to meet demands. The pump discharges into about one mile of distributing main to which is connected a 60,000-gallon elevated steel tank.

No analysis has been made of the water. There seems to be no reason to doubt its good sanitary quality, and it is more popular than the former supply due to its being softer.

MINOOKA, SEWERAGE.—At the time of visit construction work on a new sewerage system was in progress. The improvement includes about 3 miles of tile sewer ranging from 6 to 15 inches in diameter. The system is designed to receive sanitary sewage only and has its outlet to the Du Page river, about a mile east of town. About 2 miles below the outlet is the village of Channohan, where objections to the method of disposal were raised soon after the improvement was begun and litigation has been threatened. It is doubtful if any serious contamination of the river would result from the addition of Minooka's sewage for several years to come. The authorities at Channohan were advised to this effect.

MOLINE, ADDITIONAL SEWERAGE.—Visited July 25, 1913, for the purpose of discussing at a public meeting the practicability of disposing of sewage from a new residence district in the eastern part of the city by passing the sewage first through Imhoff tanks and then discharging same into the so-called pool about a mile above the emergency water works intake. The introduction of sewerage into this new residence district would be impracticable at the present time were it necessary to divert the sewage, because of the excessive cost.

Imhoff tanks will remove the solids, prevent the formation of sludge banks, permit of economically disinfecting the sewage, if found necessary, and furthermore the dilution afforded by the water flowing through the pool will be at least 1 to 5,000, so that the additional pollution at the emergency intake will be scarcely perceptible. The river is already dangerously polluted before it reaches the point of the proposed outlet.

It was decided that at the present time the additional burden of contamination will be inappreciable, though the time may come some years hence when the diversion of all of the domestic sewage from Moline below all water works intakes will be necessary. When this time arrives it will not be a matter of protecting the water supply of Moline alone, but of protecting the water supply of Rock Island as well.

MOMENCE, WATER SUPPLY.—Visited September 10, 1913. Information obtained was embodied in a report on the public water supply and sent to local authorities. Momence occupies both banks of the Kankakee river in the central part of Kankakee county. There are no manufacturing interests of importance and only a slight increase in size has been observed in the past several years. The population is now about 2,300.

Water works have been installed since 1895, when two 8-inch wells were drilled into limestone on the east side of town. Two similar wells have been added since and an adequate supply is now available to meet present needs. There is a river intake through which additional water may be obtained in case of emergency, but there is no immediate prospect of its being needed and it has been recommended that the connection be entirely removed. At present there is danger of a leak in the gate valve on the intake which would permit the polluted river water to enter the pump suctions.

The first equipment included two duplex steam pumps, each with a rated capacity of about 375,000 gallons per day. These are still available for use, but owing to the economy of using electric power water is now ordinarily pumped with a 500,000-gallon triplex pump driven by a 20-h. p. motor. The pumps take their suction directly from the wells and discharge into the mains and a steel standpipe 16 feet in diameter and 125 feet high. The system of mains includes about 8.8 miles of cast iron pipe ranging in size from 4 to 8 inch. About 250 water services are in use, of which about 10 per cent are metered.

The supply is quite hard, with total solids of about 550 parts per million, but the sanitary quality is good and the water meets with popular favor.

MOMENCE, SEWERAGE.—A combined sewerage system was recently installed at Momence, with two outlets, one on each side of the river. Sewage from the north side is passed through a settling tank, but that from the south is discharged without treatment. Disposal by dilution should result in no nuisance at least for a number of years if proper dispersion of the sewage is obtained in the river.

MONMOUTH, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 149.

MONTICELLO, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 150.

MORRIS, POLLUTION OF ILLINOIS RIVER BY CHICAGO DRAINAGE CANAL.—See Bulletin No. 9, page 27.

MORRISONVILLE, WATER SUPPLY.—Visited March 20, 1913, for the purpose of inspecting the public water supply. A descriptive report was prepared and a copy sent to the mayor, with suggestions for improving the quality of water and increasing available supply. Morrisonville is primarily a residence center in an agricultural community and has a slowly growing population of about 1,200. There is no sewerage system and no immediate prospect of such an improvement being made.

Water works are owned by the village and were first installed about 25 years ago, when a well 16 feet in diameter and 35 feet deep was dug near the center of town. During a severe drought in 1895 this source proved inadequate and another well, similar to the first and about 500 feet distant, was added. Over each well is erected a small wooden building which houses a single-acting simplex vertical power pump of about 50,000 gallons per day capacity, driven by a 3-h. p. electric motor. The pumps discharge into about 1½ miles of cast iron mains having an overflow to a 40,000-gallon elevated wooden tank that provides an average pressure of about 40 pounds.

The water consumption is probably not more than 20,000 gallons per day, but this is almost as great as the yield of the two wells, and an additional supply is highly desirable. Exploration of ground water resources in this locality has thus far revealed no water-bearing stratum of abundant yield.

There is sufficient iron in the present supply to be objectionable and the water is quite hard. Very likely the water is normally of good sanitary quality, but certain features of construction and opera-. tion place the wells in some danger of contamination by careless or malicious persons

MOUNDS, WATER SUPPLY.—Visited February 24, 1913, for the purpose of obtaining information for a descriptive report on the water supply. A copy of the report was sent to local authorities. (See Bulletin 9, page 27.)

Mounds is a slowly growing city of about 3,000 population, situated in the bottom lands near Cairo. High waters have occasionally reached its outskirts and in the flood of 1913 the town was almost entirely inundated. The principal industries are shops of the Illinois Central railroad and a large plant of the Central Illinois Public Service Company.

Water works were first installed in 1911, when a distribution system of about 4¼ miles of mains was laid by the city and a contract made with the public service company to supply water. The company has drilled two 10-inch wells 650 feet deep and about 300 feet apart. The wells enter a strong vein of water in limestone and overflow slightly at the surface. They are equipped with air lift, and a yield of about 1,500 gallons per minute from one and 750 gallons per minute from the other is obtained. The difference is thought to be due to the well of least yield being partially filled with caving material.

The water is discharged into a concrete collecting reservoir of about 33,000 gallons capacity and from there pumped into the mains. Domestic pressure varies from 25 to 40 pounds and a fire pressure of 100 pounds is provided. A large part of the water pumped is used at the plant of the company and by the railroad. The contract provides meter rates at which the city shall buy water from the company, but thus far the supply has not been metered.

The pumping equipment includes one simplex double-acting steam pump of 1,000,000 gallons per day rated capacity and two duplex pumps, each of 2,000,000 gallons capacity. A compound two-stage compressor with a capacity of about 250 cubic feet per minute supplies air for pumping the wells.

The water is apparently well protected against possible contamination. From a mineral standpoint the supply can be classed as soft, compared with other Illinois well waters. The total residue is about 250 parts per million, and there is no permanent hardness.

MOWEAQUA, WATER SUPPLY.—Visited July 16 and September 8, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Moweaqua has a population of about 1,500. Besides being a farming center Moweaqua has one small coal mine. Water works were installed in 1893. The installation comprised a dug well, located in the eastern part of town, a pump, tank and tower and a distribution system. Several years later, the supply proving inadequate, two wells we put down in the southern part of town. The tank was still used for a few years, when it was abandoned as unsafe. A collecting reservoir was then built at the station and two-stage pumping established. In 1906 the reservoir was abandoned and a new 50,000-gallon steel tank and tower installed. The second source of supply proving inadequate, in 1910 a new station was built and six wells were put down two miles north of the city. These wells are 6 inches in diameter and 56 feet deep.

The water is pumped from the six wells through an 8-inch wooden stave main to the distribution system. The distribution system comprises about 6 miles of 4-inch to 8-inch cast iron pipe, and connected with it is the 50,000-gallon elevated tank.

The water is of good sanitary quality. The mineral content is about 320 parts per million and the hardness is all in the form of carbonates. Records from a meter on the discharge of the pump show an average daily consumption of about 25,000 gallons.

MT. CARMEL, WATER SUPPLY AND FILTRATION PLANT.—See Bulletin No. 9, page 27.

MT. CARROLL, WATER SUPPLY.—Visited October 14, 1913. Information was obtained for descriptive report on public water supply. A copy of the report was sent to local authorities.

Mt. Carroll has a population of about 1,800, with little prospect of rapid growth in the near future.

Water works were first installed in 1888, when a well was dug 20 feet deep in the southwest corner of town. Later, as this well proved inadequate, its yield was increased by boring four 80-foot wells from its bottom. Still further increase in the supply was required in 1895, and a 2,500-foot well was drilled to the Potsdam sandstone. The dug well is now pumped down once each day and yields about 24,000 gallons. The deep drilled well is pumped with air lift, which discharges into a storage reservoir of about 28,700 gallons capacity. The maximum yield of this well has not been determined. The total daily consumption is estimated at about 325,000 gallons. The dug well and collecting reservoir are both well protected against contamination and there seems to be no occasion to question the sanitary quality of the water for other reasons. The supply is only moderately hard as compared with other Illinois ground waters, and has proved quite popular.

The pumping equipment includes two duplex steam pumps, one rated at 1,500,000 and the other at 1,000,000 gallons per day. These discharge into a distribution system of about 3.7 miles of main, with which is connected an elevated wooden tank of 100,000 gallons capacity. It is estimated that 85 per cent of the population use the public supply for domestic purposes.

MT. MORRIS, PUBLIC WATER SUPPLY.—Visited October 11, 1913, for the purpose of obtaining a description of the public water supply. Mt. Morris is a village of about 1,200 population, is primarily a farming center and supports a small college.

Water works were installed in 1894, when a well 500 feet deep was drilled, 10 inches in diameter at the top and finishing 6 inches at the bottom. The well passes through the St. Peter's sandstone and terminates in magnesium limestone. It is pumped with air lift and discharges into a 7,000-gallon concrete basin built around the top of the well. From the basin water is forced into the distribution system by a 500,000-gallon triplex pump. Both air compressor and pump are driven by a single 30-h. p. gasoline engine. The average daily consumption is estimated at 40,000 gallons. No station records are kept and the maximum yield of the well is not known. The supply is of good sanitary quality and not excessively hard. The system of mains provides quite complete service and the 215 services indicate that about 80 per cent of the population are using the supply. About 40 per cent of the services are metered. A 56,000-gallon wooden tank on a 90-foot steel tower is connected with the mains.

MT. OLIVE, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 151.

MT. PULASKI, WATER SUPPLY.—Visited July 17 and September 1, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Mt. Pulaski has a population of about 1,500. Besides serving as a farming center the city contains one small coal mine. Water works were installed in 1895 for the purpose of fire protection. The installation comprised a well 85 feet deep, a pumping station housing the deep well pump with accessories, a 15,000-gallon wooden tank and a 3-inch pipe line around the business district.

About 1907, in order to secure a more adequate supply, the original installation was abandoned and three new wells were dug in the southwest part of town. These wells are each 10 feet in diameter and 33 feet deep. About 1910 a bored well 56 feet deep was acquired in the same vicinity. The bored well is equipped with a deep well pump and is used in case of emergency only. Water from the three dug wells is pumped directly into the distribution system by a 500,000-gallon compound duplex pump and a 750,000-gallon simplex pump. The distribution system comprises about five miles of 4-inch to 8-inch cast iron pipe. Connected to the system is a 55,000-gallon tank placed on a 60-foot steel tower. The average daily consumption is about 50,000 gallons.

Analyses show an occasional contamination of the public supply, due, perhaps, to the facts that the well curbings do not extend above the surface of the ground and that the board covers are loose, thus allowing the entrance of surface washings. Another possible source of contamination, and a bad feature of the water works system, is a connection through a single gate valve with the water works system of the Illinois Central railroad. The latter uses polluted water from Salt creek, and though the city pressure is higher than that in the railroad system, a breakdown at the city plant would lower the pressure and the polluted creek water might then endanger the public supply should the gate valve be carelessly left open or be in a leaky condition.

MT. STERLING, PROPOSED SEWERAGE.—Visited August 19, 1913, for the purpose of conferring with the Honorable Thos. A.

Croxton, mayor, relative to the proposed installation of sewerage and the adoption of a new source of public water supply.

The community has long felt the need of an adequate sewerage system so as to render possible the use of indoor plumbing. Several private drains have been built, but these generally create considerable nuisance owing to improper outlet. Also because of crude construction they frequently become clogged and out of order. It is proposed to install a comprehensive system of sewers which will meet the needs of the entire community and provide an outlet into a neighboring small water course.

Purification works are not contemplated and they are not deemed necessary in view of the fact that the city has secured the right from the owners to discharge crude sewage into a small stream passing through neighboring property. The length of the stream through this property is about one-half mile and it is not likely that objectionable pollution from a small quantity of sewage would extend in a downstream direction further than this.

Late advice indicates that the sewerage project failed to receive a favorable vote and the project has been dropped as a public undertaking. Private individuals, however, contemplate building a private sewer essentially along the lines proposed for the municipal installation. At the end of 1913 plans and specifications for the proposed installation had not been received by the State Water Survey for review.

MT. STERLING, PROPOSED IMPROVED WATER SUPPLY.—The present water supply of Mt. Sterling is obtained from a deep rock well which yields a water so highly impregnated with salt as to be unfit for general domestic purposes. It is, therefore, used primarily for fire protection. There are many private wells throughout the community which are more or less contaminated, and inspection of some of the public wells revealed that they are subject to very serious contamination. There are various localities in and near Mt. Sterling where drift wells may be sunk with promise of securing an adequate quantity of water free from the objectionable mineral characteristics of deep rock wells in this vicinity. Some of these localities were considered and it was recommended that test wells be sunk in various places indicated. Also samples were analyzed from some existing wells in localities which gave promise of large yields. At the end of 1913 nothing definite had been done along the line of securing an improved water supply, apparently owing to popular indifference.

MT. VERNON, NEW FILTRATION PLANT.—Visited from April 2 to 9. The visit was for the purpose of starting the new filtration plant and instructing the men in its proper operation. Tests of various mechanical features were made, the results from which showed the plant to be in good working condition.

A later visit was made from April 28 to May 3. At this time Mr. Severson, the manager of the plant, was instructed in the method of making chemical and bacteriological control tests. The laboratory was not completely equipped owing to the fact that a desirable location for it had not yet been found.

On September 27 another visit was made and the plant was being well operated. Changes in the management and the location of offices had made it necessary to temporarily discontinue the laboratory control tests.

MT. VERNON, WATER SUPPLY.—See Bulletin 10, page 152.

MURPHYSBORO, PUBLIC WATER SUPPLY.—Visited July 4, 1913, for the purpose of ascertaining the status of a project for improving the public water supply. A descriptive report on this supply was prepared in 1912. (See Bulletin 10, page 155.) It was found that practically no advance had been made on the part of the water company toward improvement of its filter plant and otherwise giving better service. On the other hand, the new city administration seemed more active in securing the betterment of public utilities than those of former years, and in all probability some action will be forced upon the water company.

NAUVOO, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 157.

NEW ATHENS, PROPOSED WATER SUPPLY.—See Bulletin No. 10, page 158.

NEWTON, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 159.

NEW WINDSOR, TYPHOID FEVER.—Visited May 20, 1913, for the purpose of investigating the prevalence of typhoid fever. The information obtained was embodied in a report, copy of which was sent to the local authorities.

New Windsor is a small farming community and has a population of about 450. According to a physician who has practiced medicine in New Windsor for over twenty-five years, the village was comparatively free from typhoid fever until the fall of 1905. Since October, 1905, there have been 33 cases and 4 deaths, occurring as follows: 8 cases and 1 death in 1905, 3 cases in 1906, 10 cases and 2 deaths in 1907, 7 cases and 1 death in 1910, and 5 cases in 1913 (to May 20). With the exception of three cases beyond the village limits and one case in the village, the outbreaks have been located in the northwestern quarter of town.

The 33 cases have been divided among 21 families, the total membership of which is 60. Twenty-three cases were adults and 10 were children; 17 cases were males and 16 were females.

The case's occurring in 1905, in 1907, and, with one exception, in 1910, group themselves into three distinct outbreaks in the fall of the respective years. Accurate and definite data regarding associations, habits, etc., of these early cases at the time of their sickness was not obtainable at so late a date, and the outbreaks could be studied only in a general way.

The recent outbreak, occurring in April; 1913, has been of very limited extent. Five cases developed and four of these were in one family. All cases developed about the same time.

A review of all the cases indicates that there have been no pronounced secondary cases. It appears that the cases were better handled, especially the disinfection of discharges, than is usually the case in small communities, and this would materially lessen the possibility of secondary cases. Water used was obtained by most cases from private wells and by a few cases from a public well. Water from this public well was used by a large number of persons not taken sick, and thus would remove suspicion from it as a source of infection. Analyses made of several shallow well waters showed contamination, but such does not necessarily mean capability of causing typhoid fever. In any community having shallow wells and privies near together the wells will invariably show contamination.

The difficulty of securing circumstantial data concerning each case rendered it impracticable to present a conclusive report, but the fact that a large percentage of the cases obtained milk from a family maintaining one or two cows would tend to indicate that this milk was in large measure the cause. It is further significant that the first two cases in 1905 were in this family from which milk was obtained. These two cases were not pronounced typhoid, though they had many of the characteristics of mild typhoid fever. This circumstance suggests the possibility that one or both of these cases, who now handle the milk to a greater or less extent, may be typhoid carriers.

On the basis of the report the family which was suspected of having supplied infected milk voluntarily ceased the sale of milk. Other precautions to prevent further spread of the disease were recommended, such as protecting wells, cleaning privy vaults and sesspools and the general cleaning up of premises.

NEW WINDSOR, PROPOSED WATER SUPPLY.—During a visit of May 20, 1913, relative to a prevalence of typhoid fever (see page 103, this bulletin) it was learned that the village in 1910 had considered the installation of a public water supply. The information obtained regarding the proposed water works was embodied in a memorandum report.

New Windsor is a small farming center with a population of about 450. In 1910 a consulting engineer was retained and preliminary plans and specifications for a water works system were prepared. For financial reasons the system was not installed. The plans called for a deep well, a deep well pump and accessories housed in a suitable building, a 25,000-gallon elevated steel tank and a distribution system. The total cost of the system was estimated at $14,500.

NOKOMIS, PUBLIC WATER SUPPLY.—Visited March 19, 1913. Information was obtained for a descriptive report on the public water supply, A copy of this report was sent to the mayor.

Nokomis is a city of about 2,000 population and is enjoying a rather rapid growth, produced by the increasing importance of the locality as a coal mining district.

Water works were first installed about 18 years ago when a supply was obtained by drilling a 6-inch drift well about 41 feet deep at the south end of town. Similar wells have since been added as needed until there are six at present, arranged in two groups of three each. The wells are about 50 feet part in each group.

Either group may be pumped from separately by either of two pumps, one a duplex steam pump of about 800,000 gallons per day capacity and the other a motor-driven triplex pump rated at 400,000 gallons per day. Pumping was originally done entirely with steam and under the direction of a city employee, but a contract was lately entered into with the Central Illinois Public Service Company, whereby they took charge of operating and installed electrical equipment. The most severe test the wells have ever been subjected to was an average pumpage of 40,000 gallons per day for one month. There seems to be no danger of shortage.

From a sanitary standpoint the supply is of good quality, but it is very hard and the iron content is sufficiently high to be objectionable. The water is quite widely distributed by about 3 miles of mains connected to which is a 42,000-gallon elevated steel tank. It is estimated that about 75 percent of the population uses the supply for domestic purposes.

NORMAL, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 159.

NORTH CHICAGO, SEWERAGE.—Visited September 11, 1913. An inspection was made of the sewage disposal plant and a memorandum report prepared and placed on file. In 1911 a descriptive report was prepared on the North Chicago water supply and sewerage system, a copy of which was sent to local authorities with suggestions for improvements. (See Bulletin 9, page 28.) The city has a population of about 4,000 and is growing rapidly.

The sewerage system had been completed but a short time at the time of the last visit. The disposal plant was finished over a year previously, but stood idle until the completion of the sewerage system. The plant includes a grit chamber, a septic tank of about 155,000 gallons capacity, a sludge digestion basin, siphon chamber and a stone filter with an area of about .064 acre. It is placed in a ravine where future extensions can be made only at great expense. The filtering material consists of about 4 feet of gravel, the smallest of which is of half-inch size. Sewage is discharged intermittently onto the filter at eight scattered points and, at the time of visit, was observed to disappear almost immediately without spreading out over more than a few square feet of area. A large flow appeared in the effluent pipe within less than one minute after the siphons began discharging and apparently no change in the character of the sewage had taken place.

OLNEY, PUBLIC WATER SUPPLY.—Visited February 2, 1913, for the purpose of obtaining information for a descriptive report on the public water supply. A copy of the report was sent to the mayor with recommendations strongly urging an improvement in the quality of the supply.

Olney has a population of about 6,000 and has had a fairly substantial growth in the past 20 years. The most important industries include a large glass factory and brick and tile factories. The Illinois oil fields are not far distant from Olney and a marked growth of the city is expected with further extension of that industry in the direction of Olney.

Water works were first installed in Olney about 21 years ago, and are owned and operated by the city. A 6-foot dam was built across Fox river about 1½ miles west of town and the small reservoir thus formed supplied the city until about 10 years ago. At that time an additional reservoir supply was obtained by constructing a dam across a ravine about 1½ miles upstream from the old source. This reservoir has a capacity of about 100,000,000 gallons and it has been the practice to open a gate and allow this water to flow down the river to the pumping station whenever the flow in the stream is insufficient to supply the city. While neither of these sources of supply is subject to direct sewage contamination the Fox river watershed of about 80 square miles is too large to be controlled satisfactorily and dangerous pollution is always possible. Moreover, the water is frequently very turbid and quite unsatisfactory as a domestic supply.

The average daily pumpage is estimated at about 300,000 gallons, equivalent to 660 gallons per service, or 50 gallons per capita. This is delivered by two compound, duplex pumps, one of 500,000 and the other of 1,000,000 gallons per day capacity, operating against a discharge lift of about 170 feet.

The distribution system at the time of visit included approximately 8½ miles of pipe, from 4 to 10 inches in diameter and 9 miles more had been contracted for. Connected with the mains in the center of town is an elevated steel tank of 48,000 gallons capacity and 124 feet in height.

ONARGA, WATER SUPPLY.—Visited September 8, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Onarga is primarily a farming community, but also includes a few small industries. The population is about 1,275. Water works were installed in 1904 and about three-fourths the population now use the public water supply. The supply is obtained from a sand and gravel stratum in the glacial drift by three wells 6 inches in diameter, and about 110 feet deep. The water is of excellent sanitary quality, but has a rather high mineral content, namely, about 1,050 parts per million. The sulphate and carbonate hardness is over 800 parts per million.

The water is pumped by a 288,000-gallon triplex power pump directly from the wells into a distribution system consisting of about three miles of 4-inch and 6-inch cast iron pipe, Connected with the distribution system is a 55,000-gallon elevated steel tank affording a pressure of about 45 pounds. No means are provided for recording the consumption, but the pumpage is estimated to average 35,000 gallons per day.

OTTAWA, EXISTING WATER SUPPLY.—See Bulletin No. 9, page 28.

OREGON, WATER SUPPLY.—Visited October 13, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Oregon has a population of about 2,200. It is primarily a manufacturing city. Water works were installed in 1876 with Rock river as the source of supply. At first the raw river water was used, but later the supply was partially filtered through gravel. In 1897 the use of river water was discontinued and a deep well was drilled near the river. The well is 10 inches in diameter, 1,610 feet deep and enters St. Peter sandstone at a depth of 1,590 feet.

The water flows under natural pressure into a reservoir 20 feet in diameter and 20 feet deep, surrounding the well and is thence pumped into the distribution system by two triplex power pumps of 700,000 gallons and 430,000 gallons capacity per day respectively. The distribution system comprises about five miles of 4-inch to 8-inch pipe. On a hill in the north side of town is located a 1,500,000-gallon distribution and pressure reservoir.

The water is of good sanitary quality, but might at times become contaminated through an imperfectly constructed top on the collecting reservoir. The mineral content is low, namely 273 parts per million and all the hardness is in the form of carbonates. Meters on the discharges from the pumps are out of order, but an estimate places the average consumption at 143,000 gallons per day.

PALATINE, PROPOSED SEWAGE TREATMENT.—See Bulletin No. 10, page 161.

PANA, EXISTING WATER SUPPLY.—See Bulletin No. 9, page 29, and Bulletin No. 10, page 161.

PARIS, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 164.

PAXTON, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 165.

PECATONICA, PUBLIC WATER SUPPLY.—Visited October 18, 1913. Information was obtained for a descriptive report on the public water supply. Pecatonica is a small agricultural center of about 1,000 population with little prospect of material growth in the near future. A milk condensery and a creamery constitute the principal industries.

Water works were installed in 1889 when a well 12 feet in diameter and 20 feet deep was dug and blasted out of limestone at the south edge of town. The water comes mainly from fissures in the limestone. The maximum yield is not known, but there is quite sufficient water to supply the average daily demand of about 25,000 gallons. A stone wall is built around the well from bed rock to a height sufficient to exclude surface water and over the well is built a shingle roof. The supply is of good sanitary quality, as shown by analyses, and is only moderately hard as compared with other Illinois ground waters.

Water is pumped into the distribution system by a duplex steam pump of 275,000 gallons per day capacity. About, 1.6 miles of cast iron mains have been laid and on these are about 175 house connections serving approximately 80 per cent of the population. Very few meters are in use. A 15,000-gallon elevated steel tank is connected with the mains and maintains pressures ranging from about 40 to 55 pounds.

PEARL, POLLUTION OF ILLINOIS RIVER.—Visited December 9, 1913, to establish a station for the periodical collection of samples for analysis from the Illinois river. This work forms a part of an investigation to determine the extent to which pollution results by the discharge of sewage into the Chicago Drainage Canal.

PEKIN, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 166.

PEKIN, POLUTION OF ILLINOIS RIVER BY CHICAGO DRAINAGE CANAL.—Visited December 9, 1913, to collect samples of Illinois river water and to make arrangements for the periodical collection of samples for analysis from that river, in connection with a survey of the river to determine the extent of pollution of the river by the Chicago Drainage Canal, and its effect on the fish life.

PEORIA, EXISTING PUBLIC WATER SUPPLY.—Visited August 26, 1913, in connection with an investigation made to determine the cause and remedy for incrustation in service pipes of the city water system. (See Bulletin 9, page 29.)

PEORIA STATE HOSPITAL AT SOUTH BARTONVILLE, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 166.

PEORIA HEIGHTS, PROPOSED WATER SUPPLY.—Visited March 20, 1913, for the purpose of conferring with the consulting engineer, Mr. C. H. Dunn, relative to progress being made on proposed water supply for that community. A description of the project is given in Bulletin No. 10, page 166. (See also Bulletin 9, page 29.) The above visit added no new developments. At the end of 1913, the project had not yet been carried out, but it was understood that active progress is now being made.

PEOTONE, WATER SUPPLY.—Visited September 9, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Peotone is a farming community with a population of about 1,200. Water works were installed in 1895 with a well 10 inches in diameter, 100 feet deep and located near the center of the village as a source of supply. The city electric light company operated the pump until 1903 when the light plant was sold to another company. At that time a 230,000-gallon steam pump was replaced by a 288,000-gallon power pump, driven by a gasoline engine. The water is pumped from the well directly into a distribution system consisting of about two miles of 4-inch to 8-inch cast iron pipe. Connected with the distribution system is a 69,000-gallon wooden tank elevated on a brick tower. It was noted at the time of the visit that the tank showed marked signs of deterioration and was pronounced unsafe. On January 25, 1914, the tank failed, partially destroying the village hall and pumping station, but the brick tower and pumping machinery were not harmed.

The water comes from a sand and gravel stratum in the glacial drift and analyses show it to be of good sanitary quality. The mineral content is fairly high, namely, 510 parts per million, of which about 110 parts are sulfate hardness and 250 parts carbonate hardness. No means are provided for recording the consumption; rough estimates place the average at 40,000 gallons per day.

PERU, WATER SUPPLY.—Visited December 17, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Although there is a prosperous farming population tributary to Peru, the community is largely industrial. Water works were installed in 1891 with a well 1,365 feet deep in the south part of town as the source of supply. This well penetrates St. Peter sandstone and the water flows by natural pressure into a 250,000-gallon reservoir surrounding the well. From the reservoir the water flows by gravity into a pump suction well at the pumping station, a few hundred feet away. As the consumption increased three additional wells were drilled. These wells are 1,254 feet, 1,255 feet and 1,505 feet deep respectively, and flow by natural pressure directly into the pump suction well. The original well and one of the additional wells are equipped with air lift to increase the yield at times of high consumption. One well terminates in a 5-inch bore and all the others terminate in 6-inch bores.

A strong flow of salt water was encountered at the 700-foot level and was cased off. By means of a double casing this salt water from the last two wells has been made available for use at a bath house a few hundred feet from the pumping station. The casing of the original well has now become defective and salt water enters the well to such an extent as to make the water unsuitable for domestic use. Consequently the connection between the suction well and reservoir into which this well discharges has been kept closed except during the times of heavy consumption.

Analyses of a sample from the reservoir showed a mineral content of about 1,670 parts per million of which 1,210 parts were sodium chloride or common salt. Otherwise the mineral content corresponds with that of waters from the other three wells and all the hardness is in the form of carbonates. Analyses indicate the water from the three wells not discharging into the reservoir to be of excellent quality from a sanitary point of view, but the reservoir water showed evidence of contamination. Chicken yards and outhouses are located on the hillside above the reservoir and may be responsible for the pollution notwithstanding that the reservoir is believed to be water-tight. Possibilities of contamination pointed out above are being further investigated by the State Water Survey.

From the suction well the water is pumped by two compound duplex pumps into a distribution system which covers practically all the city. Connected with the distribution system is a 190,000-gallon steel standpipe, affording a pressure range throughout the city, of 43 pounds to 104 pounds. There are no records of consumption, but rough estimates place the daily pumpage at 300,000 gallons.

PETERSBURG, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 167.

PINCKNEYVILLE, PUBLIC WATER SUPPLY.—Visited February 5, 1913. Information was obtained for a descriptive report on the public water supply. A copy of the report was sent to the mayor with urgent recommendations that steps be taken to improve the quality of the supply and the services of the State Water Survey were offered in helping to bring about the desired improvement.

Pinckneyville has a population of about 3,000 and is situated in a coal mining region. Its growth has been quite substantial in the past few years and there is promise of further development.

Water works were first installed about 20 years ago when a pumping station on Breese Lake, at the edge of town, was acquired from the Illinois Central Railroad. Since that time the railroad has purchased water from the city. Breese lake is a small body of water containing about 10,000,000 gallons, lying in the valley of Beaucoup creek, within a few hundred feet of that stream. At times of high water in the creek the lake is flooded and thereby periodically replenished. A watershed estimated as over two square miles in area also drains directly to the lake. Breese lake finally proved inadequate to meet the increasing demands for water, so in 1900, a 6-foot masonry dam was built across Beaucoup creek, which above this point, has a watershed area of about 225 square miles. With both these sources of supply available there was, nevertheless, one occasion when a shortage was narrowly avoided. Both sources are subject to dangerous contamination and often yield water objectionally turbid.

Water is delivered by two compound duplex pumps, one rated at 1,500,000 gallons per day and the other at 2,000,000 gallons. Pumping averages about 325,000 gallons per day. The pumping station is operated under contract by private parties.

The system of mains includes about 5 miles of cast iron pipe and 45 hydrants. There are about 500 services, indicating that about 75 per cent of the population use the city water.

No records are kept and the whole system has been managed in a generally slipshod manner.

PIPER CITY, PROPOSED PUBLIC WATER SUPPLY.—Visited April 4, 1913, for the purpose of conferring with local authorities relative to a proposed new water supply. Piper City is a village of about 700 population and is primarily a residence center in a farming community. The water works installed subsequent to the visit include two 80-foot wells in drift from which water is drawn with a motor-driven triplex pump and discharged directly into the mains and an elevated steel tank. One of the wells is 6 inches in diameter and yielded about 70 gallons per minute under test. The other is an 8-inch well.

PITTSFIELD, WATER SUPPLY AND PROPOSED IMPROVEMENTS THERETO.—Visited September 3, 1913, for the purpose of obtaining information relative to the existing water works and a project for obtaining a new supply. A report was prepared and sent to the city engineer.

Pittsfield is a city of about 3,000 population. There are no manufacturing interests, the town being primarily a residence center in an agricultural community.

Water works were first installed at Pittsfield about 25 years ago when the city drilled a well 2,200 feet deep, laid a few blocks of mains and erected a 47,000-gallon elevated steel tank. The water is salty and not fit for anything except fire protection, street sprinkling and flushing purposes and, as a result, very few extensions have been made. Less than a mile of main is in use and there are only five private water customers.

The total pumpage for a year amounts to less than 4,000,000 gallons. The city has a pumping contract with the local Public Service Company, which owns the pumping equipment. A deep well pump discharging 30 gallons per minute is used and this is operated through a walking-beam by a 10-h. p. gasoline engine.

In 1895 investigations were made by the city engineer for the purpose of locating a possible new source of supply and be reported as the most feasible proposition, a series of wells driven into a gravel vein on the bottom lands of Bay creek. The proposed improvement failed to meet with public approval and nothing more was done until 1911. In that year a firm of Chicago engineers was employed to report on a plan for improving the supply and they recommended wells similar to those formerly suggested by the city engineer. The proposition, however, together with sewerage plans submitted by the same firm at the city's direction, was again defeated by popular vote. In the early part of 1913 a prominent local citizen made an offer to the city of $5,000, to be used toward securing a better water supply. This matter has been discussed at public meetings and means for raising the remaining funds required will be submitted to a vote of the people during the coming spring.

PLAINFIELD, WATER SUPPLY.—Visited September 24, 1913, for the purpose of making inquiry relative to reported objectionable conditions resulting from the discharge of sewage into the DuPage river. At the same time a description of the public water supply was obtained. Plainfield is a purely residence village of about 1,100 population. An amusement park maintained by the Joliet & Southern Traction Company attracts a rather large number of people from neighboring towns during summer months.

Waterworks were first installed at Plainfield in 1898, when a 6-inch well was drilled to a depth of 104 feet and equipped with a single acting deep well pump, driven by a 10-horsepower gasoline engine. A 55,000-gallon elevated wooden tank, together with about 3 miles of mains, were provided. Very few changes or extensions have since been made. The water comes from limestone entered at a depth of about 20 feet, to which depth the well is cased. The water is highly mineralized and quite hard. Its corrosive action on metals has resulted in discontinuing the use of meters. The supply is of good quality from a sanitary standpoint and is in quite general use.

SEWERAGE.—The sewerage system was installed in 1912 and includes 3.75 miles of pipe sewer, ranging from 8 to 30 inches in diameter. It was designed to collect both sanitary sewage and storm water and has its outlet to the DuPage river at the southwest corner of town. In August, 1913, it was learned through newspaper clippings that complaints, due to the method of disposal, had arisen. Inquiry, however, indicated that no serious objections had occurred and inspection of the outlet at a time when the river was unusually low revealed no objectionable conditions. The system has very few connections thus far and the sewage is quite weak. Local authorities are contemplating the possible necessity of sewage treatment at some future date.

PLANO, EXISTING PUBLIC WATER SUPPLY. See Bulletin No. 9, page 29.

PLEASANT HILL, TYPHOID FEVER CONDITIONS. Visited November 5, 1913. Eleven cases of typhoid fever were investigated. They were found to be for the most part secondary cases, probably due to direct contact infection. Several samples of water were collected from suspected private wells, all of which showed evidences of pollution.

POLO, WATER SUPPLY.—Visited October 9, 1913. The information obtained was embodied in a descriptive report of the waterworks, copy of which was sent to the local authorities.

Polo is a farming community, with a population of about 1,800. Waterworks were installed in 1891, with a well 2,100 feet deep and located in the north side of town, as the source of supply. In 1901 the increased consumption made it necessary to drill a second well. This well is 1,200 feet deep, 15 inches in diameter at the top and 8 inches in diameter at the bottom. The first well terminates in a 6-inch bore. Potsdam sandstone was encountered at a depth slightly over 1,000 feet and the supply comes from this stratum and the St. Peter sandstone above it. The water originally stood about 70 feet below the ground surface, but has receded to the 114-foot level.

Analyses indicate the water to be of good sanitary quality. The total mineral content is about 335 parts per million and practically all the hardness is in the form of carbonates.

The water is pumped from the wells into two collecting reservoirs of 25,800 and 47,700 gallons capacity, respectively, by two deep well pumps of 170,000 and 228,000 gallons capacity, respectively. From the reservoirs the water is pumped into the distribution system by two duplex pumps. The distribution system comprises about 7.2 miles of 4-inch and 8-inch pipe and connected with the system is a 30,500-gallon steel tank resting upon a brick tower. A rough estimate places the average daily consumption at 300,000 gallons per day.

PONTIAC, PUBLIC WATER SUPPLY.—Visited November 10, 1911, July 23, October 30 and 31 and November 19, 1913, for the purpose of obtaining information for a descriptive report of the public water supply and also to instruct the waterworks employes in the operation of the filter plant and the application of bleach. (See Bulletin 9, page 30.)

Pontiac is a city of about 7,000 population and is the county seat of Livingston county. Agricultural interests are most important, but several factories have also developed, the principal products being shoes, candy and agricultural tools. The State Reformatory is located in Pontiac. Flowing through the center of the city is the Vermilion river, which provides fairly good natural drainage. The city is quite completely sewered, with two outlets in a down stream direction from town. Sewage at times constitutes almost the entire flow below the mill dam, but no complaints due to this method of disposal are reported.

Waterworks were first installed in 1892, when a 20-year franchise was granted private interests. In 1912 the franchise was renewed. The property has changed hands three times and is now owned by the Public Service Company of Northern Illinois and operated in connection with electric, gas and heating plants. Water has always been obtained from the Vermilion river. In 1902 a mechanical filter plant was installed and in 1911, at the suggestion, of the State Water Survey, hypochlorite treatment was begun and a laboratory equipped. (See Bulletin No. 9.) It is understood that enlargement of the filter plant is now being considered.

The river at this point has a watershed area of about 470 square miles and below the intake is a 6-foot concrete dam, owned by a local milling company. In times of extremely dry weather shortages of water have been only narrowly avoided by paying the milling company to keep its gates closed and by endeavoring to reduce wasteful consumption. The daily pumpage averages about 1,000,000 gallons, equivalent to 1,100 gallons per service, or 143 gallons per capita.

The purification process involves coagulation with lime and sulphate of iron, sedimentation, hypochlorite treatment and filtration. Two 2,000-gallon wooden tanks are provided for lime water and from these the solution is pumped into the low lift discharge. The iron solution is prepared in two 800-gallon tanks and application to the raw water is controlled by a constant level orifice box. Sedimentation takes place in two circular wooden tanks, each 20 feet in diameter and 14 feet deep, providing together about 1½ hours' retention period on an average day. As water flows from these tanks it receives a dose of hypochlorite under control of a constant head orifice box. Two wooden tanks of 350 gallons each supply the solution. There are three filter units of the wooden tub type. Each of these is 15 feet in diameter and has a nominal capacity of 500,000 gallons per day. Revolving rakes are provided to agitate the sand during washing. No automatic controllers or loss of head gages are used. Beneath the filters is a concrete clear well of 125,000 gallons capacity, equal to an average of about three hours' supply.

Until a few months ago frequent bacterial tests were made by the superintendent, but these have recently been neglected. The tests showed rather variable results. Monthly analyses made by the State Water Survey during the past year have shown quite uniformly good results, with the water well clarified and gas formers seldom present.

Water is raised from the river to the settling tanks by two centrifugal pumps, one a 4-inch pump, driven by a 10-horsepower motor, and the other a 6-inch pump, driven by a 15-horsepower motor. High service pumps include two tandem compound, duplex pumps rated at 1,000,000 gallons per day each, and one triplex power pump of 1,000,000 gallons capacity, driven by a 15-horsepower motor. There are soon to be added two 6-inch, two-stage centrifugal pumps for high service. The plant seems to be efficiently operated and very complete records are kept.

The distribution system includes about 16 miles of mains in sizes of 4 to 12-inch. The system was originally made up of cement-lined pipe, but the greater part is now replaced with cast iron. The 874 customers indicate that about 60 per cent of the population uses the supply for domestic purposes. Eighty-two per cent of services are metered. A standpipe 16 feet in diameter and 120 feet high is connected with the system but is cut out at times of fire and the pressure is raised by direct pumping to 75 pounds.

PORTLAND, Proposed Water Supply.—Visited February 5, 1913. The information obtained was embodied in a report, copy of which was sent to the local authorities.

Portland (Oglesby post office) has a population of about 3,200. Cement manufacture and mining are the two principal industries of the city. The installation of a public water supply has been under consideration since early in 1911, but a suitable source has not yet been obtained.

Three possible sources have been considered, namely, Vermilion River, drift wells and deep rock wells. The Vermilion river would afford an ample supply of water of satisfactory mineral content, but it is highly turbid at times and polluted so that filtration would be necessary. The water from deep rock wells is often highly mineralized, but is otherwise satisfactory. Drift wells in town have only a limited yield and would not be sufficient for a public supply. Three test wells were sunk in the bottom lands of the Vermilion river, south and east of town, but only a limited yield was obtained. A test well was then put down about two miles north of town in the bottom lands of the Illinois river, but only a short distance from the base of the bluffs. Analysis of water from this well showed a high mineral content, namely, 1,622 parts per million over 1,000 parts of which were in the form of permanent hardness. As a result of this analysis further tests were not made on this well.

It was recommended that a test well be put down in the Illinois bottom lands farther removed from the bluffs than the above well, but the results of further developments have not been reported to the State Water Survey.

PRINCEVILLE, PROPOSED PUBLIC WATER SUPPLY.—Visited September 26, 1913, for the purpose of conferring with village authorities and making inquiry relative to their plans for installing a system of water works. Princeville has a slowly growing population of about 800 and has very few public improvements thus far. Bonds to the amount of $10,700 have been voted to raise funds to pay for a well drilled to the St. Peters sandstone, about 1,600 feet deep, for pumping equipment and an elevated tank. The system of mains will be paid for by special assessment. An engineer was employed shortly after the visit and contracts for the well and elevated tank were awarded before the end of the year.

QUINCY, QUALITY OF PUBLIC WATER SUPPLY.—Visited from January 24th to the 28th. The quality of the water supplied was investigated and a census was made of the existing typhoid fever conditions. (See also Bulletin No. 9, page 30.)

It was found that the quality of water being furnished was satisfactory. Typhoid fever however, was quite prevalent, there being at least 80 cases. A conference was held with the mayor and water company officials and it was recommended that a thorough epidemiological investigation be made. Professor E. O. Jordan was employed and after a careful study of all the data available he concluded that the infection was caused by the condition of the city water furnished on two days when, owing to damage to apparatus by freezing, use of bleach was temporarily discontinued.

QUINCY, PROPOSED WATER PURIFICATION.—During the early part of 1913, much attention was given to proposed water purification works for Quincy, which works are now under construction. Three visits in connection therewith were made, namely; to Quincy on February 3, for the purpose of making an examination on the ground and reviewing the plans in company with Mr. W. R. Gelston, superintendent of the water company; to Madison, Wisconsin, on April 22 for a conference with the consulting engineers, Messrs. Mead and Seastone with reference to details of plans; and again to Quincy on June 4 and 5 for the purpose of addressing the mayor and council regarding the relative merits of plans recommended by Messrs. Mead and Seastone, and another set of plans submitted with a bid by the Jewell Water Improvement Company.

The new filter plant is to be built of reinforced concrete throughout, modern in every respect, and of very substantial construction.

The capacity of the present installation will be 6,000,000 gallons per day and will comprise six 1,000,000-gallon filter units. There will be two coagulating basins, one twice as large as the other with a combined capacity of six hours' retention on the basis of the nominal capacity of the plant. Underneath the filters will be a clear water reservoir with a capacity of about 750,000 gallons. This small clear water storage is deemed permissible, due to the fact that there is a reservoir connected with the distribution system, which holds about 17 days' supply. At the end of 1913 construction was well under way and the plant will be completed some time during the latter half of 1914.

RANKIN, PROPOSED SEWERAGE.—Visited October 29, 1913, for the purpose of making inquiry relative to a proposed system of sewers. Conferences were later held in Urbana with local authorities and the engineer employed on the work.

Rankin is a village of about 900 population with very few public improvements. An effort was made in 1911 to install water works, but the project was defeated. The proposed sewerage system is desired primarily for removal of storm water at the present time, but will be used in the future to remove sanitary sewage also, and the plans will probably include a settling, tank at the outlet. The outlet is a small creek near town which goes practically dry at times of continued drought, and more elaborate treatment works may in time become necessary.

RANTOUL, EXISTING PUBLIC WATER SUPPLY.—See Bulletin No. 10, page 168.

REDDICK, PROPOSED WATER SUPPLY.—Visited August 2, 1913. The information obtained, together with recommendations, were embodied in a report, copy of which was sent to the Local authorities.

Reddick is a farming community with a population of about 300. The occurrence of so many fires in the last few years has aroused interest in securing a public water supply. An engineer was retained and plans and estimates prepared. The plans call for a 10-inch well from 100 to 400 feet deep.

No definite location for a well had been decided upon, but a site near the center of the town was favored. An analysis of water from a 268-foot well near the favored locality indicated that a suitable supply cannot be obtained there. The water is very highly mineralized, having 4,900 parts per million of residue and over 4,400 parts are common salt. Wells in the drift near the center of town have a very limited yield. A well at the school house in the southwest part of the village is 70 feet deep and encounters a water bearing sand and gravel stratum 13 feet thick at a depth of 53 feet. Analysis of this well water shows a total residue of 474 parts per million. A pumping test on this well was recommended.

Two estimates were prepared, one for a system including air pressure tanks and the other for a system including an elevated tank. The elevated tank system was recommended by the State Water Survey. The estimated total cost including distribution system is about $13,000.

RIVER FOREST, Existing Water Supply.—See Bulletin No. 10, page 169.

RIVERSIDE, Water Supply.—Visited September 13, 1913. Information was obtained for a descriptive report on the water works.

Riverside is a well improved and highly attractive residence suburb of about 2,000 population on the Des Plaines river west of Chicago. A complete System of combined sewers is provided with a single outlet to the river below town.

Water works have been in use since 1870 when the village drilled two wells 600 feet deep. These flowed at first, but eventually it became necessary to obtain an increase in supply and a 2,200-foot well was drilled. This gave a salty water and was plugged at the 2,000-foot level. About fifteen years ago two new 2,000-foot wells were drilled at another site in the central part of town and these have since been the source of supply. An attractive pumping station was built at the site of the wells and a large wooden tank was placed on a brick Support built adjoining the pumping station. On January 1, 1913, the roof of this tank caught fire and before it could be extinguished the tank failed and the whole station was practically demolished. An emergency supply was hurriedly provided through hose connections with hydrants in the neighboring town of Berwyn and, in the meantime, preliminary equipment was obtained for pumping water from the Riverside wells which had not been damaged. Engineering advice was at once obtained and by the end of 1913 the station was rebuilt and re-equipped.

The two wells are drilled about 65 feet apart and are 15 inches in diameter at the top finishing 6 inches at the bottom. They both pass through the St. Peters and Potsdam sandstones, but there is reason to believe that they do not draw equally from the same strata. The wells flowed slightly when first drilled in 1897, but in 1899 the water level is reported as having been 20 feet below the top. In 1912 the level was measured at 70 feet, which continued about constant until July, 1913. Then, in about one week's time, a decided drop occurred, the level in one well falling to 140 feet and that in the other to 110 feet. The level in the latter well subsequently rose to 44 feet, while that in the former has remained at 140. No satisfactory explanation has been made of this remarkable phenomenon. A similar drop in head was reported about the same time in wells at Argo, three miles south of Riverside, but none of the other numerous deep wells in that section of the state are known to have experienced any marked recession of water. No data on maximum yield of these wells is available, but one is known to be much stronger than the other. The wells now are each equipped with a double acting deep well pump with a capacity of about 500,000 gallons per day. The well in which the normal water level is 140 feet below the top is capable of supplying the pump with very little recession, but the pump in the other soon begins to draw air. The suctions are at a depth of 180 feet.

Water is pumped from the wells into a covered masonry reservoir with a storage capacity of about 150,000 gallons. The average daily pumpage is about 275,000 gallons, equivalent to about 690 gallons per service. All services are metered. Water is pumped from the reservoir into the mains by three 5-inch single stage centrifugal pumps, each direct connected to a 25-h. p. motor. The capacity of each pump is 1,000,000 gallons per day against a pressure of 60 pounds. Two of these are piped for operation in series. Both well pumps and service pumps are started and stopped automatically in such a way as to keep the reservoir and elevated tank practically full.

The distribution system includes about 19 miles of cast iron pipe, practically all of which is 4-inch. A steel elevated tank replaces the old wooden tank that burned.

The supply is quite popular and is in very general use. From a sanitary standpoint there seems no reason for questioning the quality of the water. The two wells supply water of quite different mineral characteristics, one having about 900 and the other about 640 parts per million of total solids. The softer of the two has a high iron content, while iron in the other is absent. The supply, as a whole, is quite hard and there is said to have been little objection to the iron.

ROANOKE, PROPOSED PUBLIC WATER SUPPLY.—On May 22, 1913, following preliminary correspondence with local authorities, Roanoke was visited for the purpose of making an examination on the ground in connection with locating a suitable source of public water supply. On September 9 a second visit was made to ascertain the facts about a well supply proposed by the engineer employed by the village and to collect samples for analysis and on December 29 to 31 a representative of the State Water Survey conducted a well test at Roanoke. Reports on all these visits were prepared and sent to local authorities.

Roanoke is a village of about 1,500 population, mainly residential in character, and the center of a productive agricultural region. The only industry of importance is a coal mine. About five years ago the village drilled a well 120 feet deep in drift near the center of town with the expectation of installing water works. A bond election authorizing funds for the improvement, however, was lost. In November, 1913, a bond issue carried and plans and specifications have been prepared. The well originally drilled yielded a water high in iron and with a corrosive action and was, therefore, abandoned. Instead, the supply is to be obtained from a system of tubular wells about 30 feet deep, in the south part of town. Water will be pumped from these to a 93,000-gallon collecting reservoir and from there into the distribution system and a 40,000-gallon elevated steel tank.

ROBINSON, EXISTING WATER SUPPLY.—See Bulletin No. 9, page 30.

ROCHELLE, PUBLIC WATER SUPPLY.—Visited October 27, 1913. Information was obtained for a descriptive report on the public water supply.

The city has had a very substantial growth in the past few years and now has a population of about 3,000. Industries include a machine shop, knitting mill and two canning factories.

Water works have been installed since 1876. The first supply was derived from an abandoned stone quarry south of town and was used but little for domestic purposes. In 1897 a deep well was drilled near the quarry and the old supply was abandoned. In 1907 the city adopted as a supply a new well 1,026 feet deep, drilled to St. Peters sandstone in the center of town. Water now stands in this well 25 feet below the top, when not being pumped. The well is pumped with air-lift, which discharges into a concrete reservoir of 200,000 gallons capacity. Two duplex steam pumps each of 750,000 gallons per day capacity, force the water into the distribution system. The water consumption averages about 600,000 gallons per day.

The supply is of good sanitary quality and not excessively hard. It is quite popular and is used by practically the entire population.

About 9 miles of mains have been laid, ranging from 4 to 8 inches in diameter. There are about 800 services. The city has recently ordered meters on all services. Considerable trouble with corrosion of meter parts has been experienced. A 42,000-gallon elevated tank is connected with the system and provides an average pressure of about 50 pounds.

ROCHELLE, SEWERAGE.—A complete system of sewers was installed in 1907. It is designed for sanitary sewage only and includes about 7 miles of 8 to 15-inch vitrified tile having an outlet through a septic tank to Kyte river, a very small stream half a mile south of town. The tank is about 60x20 feet in plan and 7 feet deep, is divided longitudinally into two compartments and has a brick superstructure. A slaughter house nearby also discharges refuse into the stream. Nuisances have not been complained of, probably due to the fact that there are no dwellings within considerable distance of either of these sources of pollution.

ROCKFORD, IMPROVEMENTS IN PUBLIC WATER SUPPLY.—See Bulletin No. 10, page 170.

ROCK ISLAND ARSENAL, FILTER PLANT.—Visited January 19, 1913. A memorandum report of the visit was prepared. The filter plant has a present capacity of 1,000,000 gallons and is arranged so that the ultimate capacity can be increased to 1,500,000 gallons. The design and construction of the plant is exceptionally well carried out and the equipment is very complete.

Up to the date of visit satisfactory results had not been obtained and investigation showed that this was probably due to the addition of insufficient coagulant. An excessive quantity of raw water was then being delivered by the low lift pumping station to the filter plant and the excess was being wasted by way of an overflow within the coagulating basin. The amount of this excess was great, while alum was applied on the basis of the quantity of water actually reaching the filters. An experiment showed that the sedimentation taking place was similar to that occurring in a control sample containing only 3 grains per gallon of alum whereas alum was being added on a supposed basis of 6 grains per gallon. Experiment also showed that approximately 9 grains per gallon were necessary at the time of the visit to secure proper floculation and sedimentation.

ROCK ISLAND, TYPHOID FEVER EPIDEMIC, EXISTING WATER SUPPLY AND NEW FILTER PLANT.—See Bulletin No. 9, page 30.

ROODHOUSE, PUBLIC WATER SUPPLY.—Visited January 11, 1913, for the purpose of obtaining a description of the water works. A report was prepared and a copy sent to the mayor with comments on various unsatisfactory features of the system and recommendations for their improvement.

Roodhouse is a city of about 2,200 population. It is a division point on the C. & A. Railroad, but is otherwise of little importance from an industrial standpoint. There is no sewerage system, other than a few private drains which discharge into a very small creek flowing through the center of town.

Water works have been installed at Roodhouse since 1906 when a dam was built across a ravine about 1½ miles south of town, thus forming a reservoir of about 30,000,000 gallons capacity. The dam is an earthen structure and as originally built was 380 feet long and 30 feet high at the maximum section. It was 12 feet wide on top and had an upstream slope of two to one and a downstream slope of one and one-half to one. In 1910, due to a threatened shortage, the dam was increased 4 feet in height. A concrete spillway is provided but the water level never quite reaches it, for a depression in the crest of the dam has been carelessly left through which excess water escapes and endangers the safety of the structure. The reservoir is estimated to cover about 6 acres when full and the watershed area is estimated at one square mile. Neither of these areas have ever been accurately determined. The drainage basin comprises farm land and on it are a number of dwellings and public highways. Little control is exercised to prevent contamination. The supply is very turbid much of the time.

The Chicago & Alton Railroad has constructed a reservoir on the creek that flows through the city in order to obtain water for boilers and fire protection for the company's buildings. A connection is provided between the two supplies so that either the city or the railroad may pump water into the other's mains. The railroad supply is dangerously polluted and failure of the city's pumping equipment has, at times, resulted in opening the connection to obtain water for city use.

City water is delivered by a triplex pump having a rated capacity of 300,000 gallons per day. It is belt-connected to a 15-h. p. gasoline engine. The discharge line to town is a 6-inch pipe about 1½ miles long. About 4 miles of cast iron mains are laid in town, the greater part of which is 4-inch. A 60,000-gallon elevated steel tank maintains a pressure of 40 to 47 pounds in the mains. The supply is quite completely distributed but the existence of but 147 services indicated that only about 30 per cent of the population use the water for domestic purposes.

ROSSVILLE, Existing Water Supply.—See Bulletin No. 10, page 172.

RUSHVILLE, Proposed Change in Public Water Supply.—See Bulletin No. 9, page 30.

SAINT ANNE, Proposed Sewerage.—Visited August 29, 1913. The information obtained, together with recommendations were embodied in a report, copy of which was sent to the local authorities.

Saint Anne is a farming community having a population of slightly over 1,000. The village has a public water supply which is used by about 700 people. The system comprises a well 6 inches in diameter and 180 feet deep, entering rock at 100 feet; a deep well pump; a triplex power pump; a 45,000-gallon storage reservoir; a 14,000-gallon compression storage tank with accessories and about two miles of mains.

The topography within and about the village is rather flat and the natural drainage is poor. In order to secure better drainage a combined system of sewers is proposed. An engineer has been retained and a system designed. The sewage is to be discharged into a dredged drainage ditch southeast of the village. The flow in the ditch is sufficient to dilute the sewage from Saint Anne to a degree that will render it inoffensive, but it would be advisable to add to the design a sedimentation tank to prevent the filling up of the drainage ditch with sludge. Additional recommendations were made regarding number of manholes, size of pipe and method of making joints.

ST. CHARLES, Existing Public Water Supply.—See Bulletin No. 9, page 30.

ST. ELMO, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 174.

SALEM, PROPOSED SEWERAGE AND SEWAGE TREATMENT.—visited January 19, 1913, for the purpose of conferring with the consulting engineer for the city, Mr. J. S. Spiker, and the mayor, Hon. R. D. Wyatt. During this visit proposed plans for sewerage and sewage treatment were reviewed and various recommendations were made for modifications, which recommendations were embodied in subsequent correspondence. At the end of 1913, final plans had not been filed for review and approval, but such plans will probably be received during 1914.

SALEM, WATER SUPPLY.—The question of the public water supply was also discussed while in Salem with special reference to the possibilities of pollution of an impounding reservoir from which the supply is drawn without filtration or other means of purification. Fortunately the watershed tributary to the reservoir is but sparsely inhabited and it is possible by suitable inspections to maintain the water in a reasonably pure condition, though its physical properties will not be all that is desirable. As a result of this conference, the mayor was furnished with a suggested ordinance laying down rules and regulations with reference to possible sources of contamination along the shores of the reservoir and tributary streams.

SANDWICH, EXISTING PUBLIC WATER SUPPLY.—See Bulletin No. 9, page 30.

SANGAMON COUNTY POOR FARM, PROPOSED SEWAGE DISPOSAL.—A visit was made to Springfield on February 19, 1913, for the purpose of ascertaining the plans of the board of county supervisors for disposing of the sewage at the county poor farm. Sewage from that institution with a population of about 200, had been previously discharged into a small creek flowing through the poor farm and land owners below had threatened damage suits unless proper steps were taken to overcome the pollution. Without expert advice the board appropriated $1,100 and called for bids on septic tanks that would be inoderous and remove all pathogenic and disease germs. A meeting for letting the contract was set for the day of the visit and two bids were submitted, one of which was within the appropriation. An effort was made to induce the committee to postpone action until the disposal problem could be studied more thoroughly, but the sweeping guarantee of success made by the low bidder was considered sufficient protection by the committee and the contract was awarded. The tank built is of the ordinary horizontal flow type, 5 feet by 36 feet in plan and 6 feet deep, with a small coke filter through which all effluent must pass before leaving the tank.

SAVANNA, Existing Public Water Supply.—Visited May 1, 1913. Information was obtained for a descriptive report on the public water supply. A copy of the report was sent to the mayor with comments and recommendations.

Savanna is a city of about 3,800 population, situated on the bank of the Mississipi river. From the river front, the town site rises quite rapidly to heights of about 200 feet above the river. Excellent natural drainage is thus afforded. About ten miles of storm water drains have been installed and there are about 5 miles of sanitary sewers with two 18-inch outlets to the river.

Water works were first installed in 1886 and are owned by the city. A 5-inch well was drilled into Potsdam sandstone at a depth of 1,435 feet in the south part of town and a pumping station erected. This well flowed sufficient to supply the town, and a circular brick reservoir of 88,000 gallons capacity was built to collect its discharge. Additional supply became necessary eventually and a second well, 8 inches in diameter and 1,500 feet deep, was drilled about six blocks to the north of the old well. A natural flow was obtained and 8-inch pipe was laid to conduct this water to the reservoir at the plant. The two wells now have a combined flow of about 1,000,000 gallons per day. The average daily consumption is about 550,000 gallons and the maximum is almost as great as the flow of the wells. No means is provided to conserve the flow from these wells, the excess being allowed to go to waste.

The supply is of good sanitary quality, as evidenced by several analyses made by the State Water Survey, and is only moderately hard compared with other Illinois ground waters. The water has proved very popular and is used by practically the entire population.

Water is pumped from the reservoir into the distribution system by one tandem compound duplex pump of 1,000,000 gallons per day capacity and a new cross-compound duplex, 2,000,000-gallon pump of the fly wheel type. Records of station operation show a station duty of about 35,000,000 foot pounds work per 100 pounds of coal.

The distribution system includes about 9 miles of mains, 4 to 8 inches in diameter, and connected with it is a 570,000-gallon masonry equalizing reservoir built on a hill about 200 feet above the station. There are about 1,000 water services of which 20 serving large consumers are metered.

The management is quite efficient. Complete records of operation are kept and finances of the department are kept separate from other city funds so that satisfactory analysis is possible. Operating and maintenance costs amounted to 2.84 cents per 1,000 gallons pumped in 1912.

SHAWNEETOWN, Flood Conditions on Ohio River.—Visited April 10, 1913. See Report on Work of the State Water Survey in Flooded Districts of Illinois, during, April, 1913, on page 432.

SHELBYVILLE, Existing Water Supply.—Visited February 5 and 6, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Shelbyville is primarily a farming center and has a population of about 3,600. Water works were installed in 1885 by a promoter and the stock of the water company was disposed of to foreign capital. The financial condition of the company was not sound and the plant has since changed hands, but is still owned by outside capital.

The original source of supply was the Kaskaskia river, but in 1899 wells were put down in the river bottom lands and river water has not since been used. There are 22 wells 6 inches in diameter and from 20 feet to 25 feet deep, arranged in two staggered rows along the north bank of the river on the eastern edge of town. The water comes from a sand and gravel stratum 14 to 24 feet thick, above which is silt and below which is indurated drift. Analyses show the water to be of excellent sanitary quality and to have a mineral content of about 408 parts per million. The water is fairly hard arid contains an objectionable quantity of iron, namely 1.2 parts per million, but this has not caused much popular complaint because it is partially removed as noted beyond.

In 1912 a 2,000,000-collecting reservoir was built and the water is now pumped from the wells into this reservoir by means of a two-stage centrifugal pump. The object of the reservoir was not only for storage, but also to permit aeration and sedimentation for the removal of iron which formerly settled in the standpipe and distribution system. The results obtained are apparently satisfactory.

From the reservoir the water is pumped by two compound duplex pumps of 1,000,000 and 1,500,000 gallons capacity respectively into a distribution system comprising about ten miles of 2-inch to 12-inch pipe. Connected with distribution system is a 106,000-gallon standpipe.

A very commendable feature of the water works management is the practice of keeping complete operation and financial records. The records show an average daily pumpage for 1912 of 321,000 gallons.

SHELDON, Water Supply.—Visited September 12, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Sheldon is a small farming community of about 1,200 population. About 1897 the city established a municipal water system. Two or more shallow wells were first tried, but these failing to yield enough water the present well was drilled. This well is 1,850 feet deep, 12 inches in diameter at the top and tapers to a smaller diameter at the bottom. The water is of good sanitary quality, but the mineral content is fairly high, namely about 800 parts per million. Of this about 500 parts are common salt and all the hardness is in the form of carbonates, namely about 60 parts per million. To one unused to the water it has a disagreeable odor of hydrogen sulfide and an objectionable taste, but appears to be satisfactory to the consumers.

From the well the water is pumped directly into a distribution system comprising 3¼ miles of 4-inch to 8-inch pipe. Connected with the system is a 31,000-gallon steel tank supported on a brick tower, thus affording a pressure of about 45 pounds. No means are provided for recording the consumption, but it is estimated to average about 40,000 gallons per day.

SILVIS, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 173.

SPRINGFIELD, WATER SUPPLY.—As a part of the "Springfield Survey," which is now being conducted, the State Water Survey undertook to examine and report upon the public water supply. (See Bulletin 9, page 31.) In connection with this work, some inquiries were made with reference to the sewerage system and general sanitary conditions. The work involved about one-half dozen visits to Springfield, extending over the. period from January to August, 1913, and the examination of reports printed or otherwise which have any bearing on this subject. Results of this work were embodied in a report which will be found on page 208 of this bulletin.

SPRING VALLEY, WATER SUPPLY.—Visited December 18, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Besides being a farming center, Spring Valley has two small factories and a large coal mine. The population is about 7,900. Water works were installed in 1892 with a deep flowing well located at the southern edge of the city as a source of supply. In 1905 a second well was drilled about 70 feet distant from the first. Both wells are about 1,480 feet deep and terminate with a 6-inch bore in St. Peter sandstone.

The water flows under natural pressure from the wells to an 80,000-gallon collecting reservoir. From the reservoir it is pumped by two compound duplex pumps into a distribution system comprising about 8 miles of 4-inch to 10-inch cast iron pipe. Connected with the distribution system is a 150,000-gallon elevated steel tank, affording a pressure within the city of about 41 to 106 pounds.

The water is of good sanitary quality, but has a fairly high mineral content, namely, 763 parts per million. The hardness is all in the form of carbonates, namely, 260 parts per million. No means are provided for recording the consumption, but it is estimated to average about 440,000 gallons per day.

SPRING VALLEY, POLLUTION OF ILLINOIS RIVER.—Visited December 9, 1913. An agent was employed to collect monthly samples of river water at this point during 1914.

STAUNTON, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 174.

STERLING, PUBLIC WATER SUPPLY.—Visited July 31, 1913, for the purpose of securing a general description of the public water supply. Sterling has a population of about 8,000 and is located on the Rock river. It is primarily an industrial community, but also has many agricultural interests. The water works were established in 1886 by the Sterling Water Company and have ever since been owned and operated by that concern.

The supply is obtained from four tubular wells penetrating the Potsdam sandstone. They have depths respectively of 1,435, 1,606, 1,625 and 1,826 feet. The wells are flowing and under ordinary circumstances furnish sufficient water without pumping. They are, however, equipped with air lift for occasions when the natural flow is not sufficient to meet the demands.

Storage is afforded by a collecting basin formed by earthen embankments and having a capacity of about 750,000 gallons. There is also a standpipe connected with the distribution system which has a total capacity of 235,000 gallons.

The pumping equipment comprises the following:

One air compressor having a nominal capacity of about 400 cu. ft. of free air per minute, used for pumping the wells when the artesian yield is not sufficient.

One duplex steam pump with a nominal capacity of 1,500,000 gallons per 24 hours.

One duplex steam pump having a nominal capacity of 2,500,000 gallons per 24 hours.

One cross compound, crank and fly-wheel, horizontal steam pump having a nominal capacity of 3,000,000 gallons per 24 hours.

The supply is of excellent quality from a sanitary point of view and is reasonably soft and free from any objectionable physical characteristics. The supply meets with general popular approval.

STOCKTON, WATER SUPPLY.—Visited June 6, 1913, for the purpose of making inquiry relative to water works and proposed improvements thereof, and proposed installation of a sewerage system. A report was prepared and sent to the mayor.

Stockton has had a very substantial growth during the past 20 years and now has a population of about 1,500. It is a division point on the Great Western Railway and a residence center of a prosperous farming district.

Water works were installed in Stockton about 15 years ago, when the city adopted as a source of supply a well that had previously been drilled by private interests. This well is 1,500 feet deep and terminates in the Potsdam sandstone. It is 12 inches in diameter at the top and finishes 5 inches in diameter at the bottom. A deep well pump, rated at about 200 gallons per minute running 45 strokes per minute, is placed in the well with the working barrel at a depth of 300 feet. Water normally stands 60 feet below the top and the well is capable of supplying the pump operating at full capacity. Power is supplied by a 30 H. P. electric motor. Heretofore the deep well pump has discharged directly into the system of mains against a total lift of about 360 feet. The work was excessive and frequent breakdowns have resulted in a plan to build a 500,000-gallon concrete reservoir at the station. The well pump will discharge into this basin and from there water will be delivered by new service pumps to the distribution system.

The distribution system comprises about 2.24 miles of cast iron pipe, 4 to 8 inches in diameter and on top of a hill at the edge of town connection is made with a 100,000-gallon masonry reservoir that provides a pressure of about 48 pounds in the mains.

The supply is of good quality from a sanitary point of view and not excessively hard. It has proved popular and is used for domestic purposes by at least 80 per cent of the population.

STOCKTON, SEWERAGE.—Very few sewers have thus far been installed, but wishing to pave certain streets, the question arose among the authorities as to whether sewers should first be laid in those streets. The State Water Survey advised that this be done and in accordance with designs for a comprehensive system laid out for the entire city.

STONINGTON, WATER SUPPLY.—Visited July 15 and August 12, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Stonington is both a farming and mining town with a population of about 1,100. Water works were installed in 1906 primarily for fire protection. The sources of supply are two 6-inch wells, each 40 feet deep? drilled through hardpan into water-bearing sand and gravel. A third well is proposed. The water is of good sanitary quality.

The water is pumped from the wells into the distribution system by a 105,000-gallon per day deep well pump. The distribution system comprises about ¾ miles of 4-inch and 6-inch cast iron pipe and connected with it is a 50,000-gallon elevated tank. About ¼ mile additional mains are to be laid. No means are provided for recording the consumption, but it is roughly estimated at 70,000 gallons per day.

STREATOR, WATER SUPPLY.—Visited November 17-18, 1913. Information was obtained for a descriptive report on the public water supply. In 1911 a representative spent some time at Streator installing a laboratory at the water works and teaching the engineer proper methods of analytical control of the purification process. (See Bulletin 9, page 31.)

Streator is a city of about 15,000 population with extensive coal mines, clay products works, glass works and several minor manufacturing establishments. Flowing through the city is the Vermilion river, which at this point is grossly contaminated with mine water. A sanitary survey of the stream was made in 1911 and described in Bulletin 9. The city is thoroughly sewered with outlets to the river. No public complaints relating to stream pollution have been made.

Water works were installed in 1886, when a 30-year franchise was granted the interests still in control. The first supply was obtained from Otter creek, which, however, proved inadequate. An attempt was made to make up the deficiency with well water, but this plan also failed. About 1889 the present source was chosen, namely, the Vermilion river, at a point 3 miles southeast of the center of town, above all mine and other local pollution. About 142,000,000 gallons are impounded by a timber dam 169 feet long and about 9.5 feet high with 2-foot flash boards. For the first few years pressure filters were used for treating the water, but unsatisfactory results caused the addition of settling basins and subsequent operation under low head. The filtering capacity has been twice increased, once in 1896 and again in 1909. Additional settling capacity was provided in 1912, and the plant now has a nominal capacity of about 3,500,000 gallons per day. The average daily pumpage is slightly over 2,000,000 gallons.

When the raw water is very muddy, it is pumped to a preliminary basin of 600,000 gallons' capacity, where it receives about 7 hours' plain sedimentation, after which it is coagulated with alum and further settled for about 4½ hours in a 400,000-gallon basin. When the water is only moderately turbid, preliminary sedimentation is dispensed with, because the preliminary basin is on a hill and its use necessitates pumping against an additional head of about 30 feet. The. settled water is treated with hypochlorite and flows to any or all of sixteen filter units. The filters are contained in ten closed steel shells, four vertical and 10 feet in diameter, the other six horizontal, 8 feet in diameter and 20 feet long. Each of the horizontal shells is divided by a central transverse wall and contains two filter units. Filtered water is collected in a covered masonry reservoir of 1,000,000 gallons' capacity and from there is pumped to the city. The operation of the plant seems to be very efficient. Daily test for bacteria and gas formation in raw and treated water are made and the results published in local newspapers. They show quite uniformly good results, as have also frequent analyses made by the State Water Survey.

Water is drawn from the river and delivered to the settling basins by two 8-inch centrifugal pumps, each belt connected to a 25 H. P. vertical high speed steam engine. For high service there are provided two compound duplex pumping engines of the fly-wheel type, one of 3,000,000 and the other of 5,000,000 gallons' capacity per day. Until recently the plant was unique in that fuel was obtained at the site from a mine owned by the water company. The mine is now flooded and abandoned. The pumping station and surrounding property are neatly maintained and quite complete records of operation are kept.

There are two 14-inch discharge lines to town. The distribution system comprises a total of nearly 40 miles of cast iron pipe from 4 to 16-inch in size, and about 9 miles of wrought iron pipe 2 inches and less in diameter. There are about 3,850 taps in use, serving practically the entire population. About 370 of the larger consumers are metered. This is practically the only supply available. Shallow drift wells have nearly all been drained by the mines and water from deep wells is excessively hard and often salty.

STRAWN, Typhoid Fever.—Visited December 10, 1913, to investigate a small outbreak of typhoid fever. The results of the investigation were embodied in a report, copy of which was sent to the local authorities.

Strawn is a small farming community with a population of about 285. Owing to the occurrence of five cases of typhoid fever, the local authorities became suspicious of the public water supply. The public water supply was installed in 1911. The installation comprises a 10-inch well 50 feet deep, a pump, an elevated tank and a limited distribution system. Suspicion was placed on the public supply because when first installed the water had had a bad odor and color. No possibility of contamination of the supply was apparent and the outbreak was not of the general nature characteristic of water-borne outbreaks. It was suggested that the coating on the cast iron pipes of the distribution system might have been responsible for the taste and color. Also it should be noted that before filling the tank for the first time it was not cleaned out, as evidenced by bits of tar paper and other matter that were at times taken from faucets and fire hydrants.

There were only five cases and these were spread over a period of nearly four months. Three cases were in the same family and all five cases were school children who frequently came together. The first case occurred two weeks previous to any of the other cases and no information obtained threw light on the source of infection of this case. Considering the time interval between cases and the fact that all cases associated with one another, it is most probable that the latter cases were due to contact.

SULLIVAN, Proposed Improved Water Supply.—Visited May 22, June 21 and August 19, 1913, for the purpose of investigating methods of increasing the yield of the public water supply. There are various possibilities, including three localities for securing water from wells and one locality for securing water from a surface stream. The local authorities were advised that it would be impossible to decide upon relative merits of these several sources until pumping tests have been made. To the end of 1913 two pumping tests had been conducted at two of the sites where it was believed water from wells might be available in sufficient quantity. One of these tests showed the absolute impossibility of securing a sufficient quantity of water in the northern part of the city and the other test indicated a moderate supply of water of good quality near the center of the city and at the site of an existing auxiliary supply well. Further tests will probably be made during the coming year under the general supervision of the State Water Survey. The Survey has advised the local authorities that upon completion of these tests the information should be placed in the hands of a competent consulting engineer with instructions to prepare plans and specifications under which the new water works may be developed.

SYCAMORE, Public Water Supply.—Visited June 7, 1913. An inspection was made of the public water supply and a descriptive report was prepared.

Sycamore is a city of about 4,000 population, well improved and presents an attractive appearance. A complete sewerage system is provided for removal of both sanitary sewage and storm water, with a single 18-inch outlet to Kishwaukee river about one mile northwest of town. A treatment plant was included in the original sewerage design, but this was never built. There is said to be no objection to the present method of disposal.

Water works were installed about 25 years ago, when the city bored several drift wells in the northern part of town. These wells flowed into a collecting reservoir, from which water was pumped into the distribution system. About 10 years ago the city contracted with the local electric company, now the Public Service Company of Northern Illinois, to supply water from deep rock wells at their plant in the center of town. The entire system is owned by the city except the wells and pumps. The old supply is still available for use, but considerable time would be required to put it into service.

The public service company has two wells drilled about 15 feet apart and 950 feet deep, entering the St. Peter's sandstone. One is 10 inches and the other 12 inches in diameter at the top and both are 8 inches in diameter below a depth of 244 feet, where rock was encountered, and to which depth the wells are cased. Water rises normally to within 34 feet of the top and recedes to 40 feet on pumping. One well is equipped with a steam-driven double-acting pump having a 9-inch x 36-inch cylinder, at a depth of 100 feet. In the other is a 7¾-inch x 18-inch pump, at a depth of 180 feet, driven by a 30 H. P. motor. The two pumps have a combined capacity of about 1,000,000 gallons per day and discharged directly into the distribution system The average daily pumpage is about 300,000 gallons, equivalent to 485 gallons per service and 75 gallons per capita. Water sold to the city is metered and meters are placed on all services. There are about 15 miles of mains, ranging in size from 4 to 12 inches, and in the north part of town is an elevated steel tank of 175,000 gallons' capacity that affords about 43 pounds' pressure.

The supply is of excellent sanitary quality and is not excessively hard. It is used for domestic purposes by about 75 per cent of the population.

TAYLORVILLE, PUBLIC WATER SUPPLY.—Visited March 20, 1913. Information was obtained which was embodied in a descriptive report. A copy of the report was sent to the mayor.

Taylorville has had a substantial growth during the past few years and now has a population of about 6,000. The town presents a prosperous appearance and is well improved. The principal industries are two coal mines and a paper mill. Taylorville is quite completely served with a system of separate sewers. Storm water drainage is said to be inadequate. The sanitary system has one 18-inch outlet to the South Fork of Sangamon river at the southeast edge of town. Dilution is not at all times adequate to properly care for the sewage that is discharged.

Water works have been in use for about 25 years and are municipally owned. The supply was originally obtained from a large dug well. The yield became inadequate after a few years, but was temporarily increased by driving two tubular drift wells in the bottom of the old well. Other wells were later bored and directly connected with the suctions of the service pumps. These supplied the city until about a year ago, when they became badly clogged with sand. They were pulled up and eight new wells put down.

The eight wells now furnishing the supply are 92 feet deep and are cased with 8-inch pipe. They are connected in two groups of four each, one to each of two service pumps. These are duplex pumps, one with a capacity of 500,000 and the other of 1,000,000 gallons per day. The yield of the wells has not been tested. The consumption runs as high as 800,000 gallons per day and the supply is thought to be wholly adequate.

The water is of good quality from a sanitary standpoint. It is rather hard and contains considerable iron, which is somewhat objectionable.

TISKILWA, EXISTING WATER SUPPLY.—See Bulletin 9, page 31, and Bulletin 10, page 175.

TOLUCA, PUBLIC WATER SUPPLY.—Visited February 6, 1913. The visit was made primarily in response to a request by a local coal mining company for an investigation of the source of a stream of water flowing into its mine. Toluca is a city of about 2,400 population. A decrease in the population of about 8 per cent has occurred during the past decade. A combined sewerage system was installed in 1909 with an outlet to Crow creek at a point half a mile southwest of town. The dry weather flow is passed through a septic tank.

Water works have been installed since 1908. The source of supply is a well 2,000 feet deep, 12 inches in diameter at the top and finishing 6 inches at the bottom. It is cased to a depth of 1,000 feet. Water rises to within about 135 feet of the top and is withdrawn with a steam head deep well pump, having its working barrel at a depth of 247 feet. The pump discharges into a covered brick reservoir of 11,000 gallons' capacity and from there water is delivered to the distribution system by a duplex steam pump of 360,000 gallons per day capacity.

About 1.5 miles of 4-inch main have been laid and connected with this is an elevated steel tank of 40,000 gallons' capacity which maintains a pressure of about 40 pounds.

The water is of good sanitary quality, but very highly mineralized with total solids of over 2,000 parts per million.

The shaft of the mining company is located about 500 feet from the city well and has a total depth of 530 feet. There is a coal vein at that level and a so-called middle vein at a depth of 390 feet. Workings in the middle vein were sealed off several years ago, but in 1911 water was discovered entering the shaft from behind the seal. On reopening the tunnel the workings were found to be entirely filled with water. It was suspected the water came from the city well, so in 1912 a tunnel was begun and in the late fall the well casing was reached. A steady stream of water was found to be flowing down from above along the outside of the pipe, and analyses made by the State Water Survey seemed to indicate that it was emerging from the well. This suggested that the casing had probably developed a leak between this level (390 feet) and that to which water rises in the well (135 feet). The company had asked the advisability of driving an inclined tunnel in an upward direction toward the pipe in an effort to discover the leak, but they were advised by the State Water Survey to simply clear away all soft material around the pipe, near the 390-foot level, and shut off the inflow to the tunnel with a plug of concrete.

TOULON, Public Water Supply.—Visited September 26, 1913. Information obtained was embodied in a report on the public water supply, copy of which was sent to the mayor.

Toulon is a residence center in a prosperous farming region and has a population of about 1,300. There is no sewerage system, but such an improvement is assured. Treatment of sewage would be necessary before it could be discharged into any neighboring stream.

Water works were installed in 1911. A supply was obtained by drilling a well 1,445 feet deep into the St. Peter's sandstone. The well is 10 inches in diameter at the top and finishes 6 inches at the bottom. It is located near the center of town beside the plant of the local electric company, which has the contract for pumping. Water rises in the well to within about 90 feet of the surface. The working barrel is placed at a depth of 225 feet and as much as 150 gallons per minute has been discharged. The depth to which the water recedes when pumping at this rate is not known. Water is pumped from the well into a concrete reservoir of 50,000 gallons' capacity, well covered and protected against contamination, and from there into the distribution system.

The well is equipped with a double-acting deep well pump with a capacity of about 300,000 gallons per day. It is gear connected to a 15 H. P. motor. The high service pump is a 6-inch two-stage centrifugal pump, direct connected to a 30 H. P. motor, rated at 500 gallons per minute against a pressure of 85 pounds.

The system of mains includes 4.3 miles of 4 to 8-inch cast iron pipe, 48 hydrants and 20 cut-off valves. Taps number about 165 and are being continually added. All services are being metered. The supply is of good sanitary quality and is proving very popular. Total solids analyze about 1,100 parts per million, but the hardness is all of the temporary variety, forming only a soft sludge in boilers.

UNITED STATES NAVAL TRAINING STATION, PROPOSED IMPROVEMENT IN WATER SUPPLY.—Visited March 4, 1913, for the purpose of conferring with the assistant engineer in charge relative to proposed improvement in the slow sand filter plant at that station by the use of preliminary chemical coagulation and sedimentation. (See Bulletin 9, page 28.) An effort had already been made to increase the runs between cleaning of the filters by the installation of a plain sedimentation basin with a capacity of about 12 hours' supply, based on the known capacity of the plant. This, however, failed to be of much benefit, owing to the extreme fineness of the turbidity which obtains in Lake Michigan waters at this point. Accordingly it is proposed to supplement this process by the installation of necessary devices for the application of coagulating chemicals. Recommendation was also made that a control laboratory be installed at the same time. All of these recommendations were accepted by the officials at the Naval Training Station, but it is learned that at the end of 1913 no funds were available for improvements proposed, and that it is not likely that funds can be obtained until late in 1914.

UTICA, WATER SUPPLY.—Visited December 16, 1913. The information obtained was embodied in a descriptive report of the water works, copy of which was sent to the local authorities.

Utica, besides being a farming center, has several small industries manufacturing brick and cement and dealing in sand. The population is about 1,000.

A public water supply system was first installed in 1883 when a flowing well was put down to the Potsdam sandstone. Since then four other similar wells have been put down at different points about town. All wells flow under natural pressure and are 6 inches in diameter and from 225 to 350 feet deep. At the time of sinking the first well the water had a static head of about 40 feet, but at present the head is barely 20 feet.

The water is of excellent sanitary quality and only moderately mineralized, namely, about 400 parts per million. The hardness is almost all in the form of carbonates, namely, about 300 parts per million.

A distribution system has been gradually built up from each of the five wells to supply the territory near each well and there is no connection between these five systems. The largest pipe used is 4-inch wrought iron pipe and most of the distributors are small-size galvanized iron pipe. The water flows by natural pressure directly into the distribution system and consequently water can be obtained only on the first floor of dwellings. It is the custom to allow the water to run continually in the houses and consequently the consumption is high and equal to all that the wells will yield under natural pressure as piped. It is stated the yield of the wells was originally 200,000 gallons per day each, or a total of 1,000,000 gallons per day, but the natural flow is probably less than that now.

The village is now planning to install an entirely new distribution system of cast iron pipe and so constructed that it will serve as a basis for a future system under pump pressure. The wells will at first be connected with the new system and only natural pressure maintained, but later as funds become available pumps and a standpipe will be installed.

VIRDEN.—Visited April 28, 1913, by the engineer for the purpose of delivering an address on the advantages of a public water supply before the local Commercial Club. This visit followed a visit in November, 1912, during which various possibilities for securing a water supply for Virden were reported upon.

The present population of Virden is in the neighborhood of 4,500 and a substantial growth in the future is anticipated. Conservative estimates place the population about 20 years hence at 10,000. Beyond this, the city is not likely to grow materially, inasmuch as it is primarily dependent upon coal mines, which in course of time will be worked out. There are no local conditions which would lead one to anticipate a marked industrial development in Virden. The best available source of supply seems to be Sugar creek, about one mile to the eastward of the town, which has an ample watershed to meet the requirements of the town and an excellent site for an impounding reservoir.

In the address above referred to special emphasis was placed upon the necessity of building a water works to meet not only the present requirements, but reasonable future requirements and the principle that a community should not be misled by false economy into making inadequate provision in the distribution system for effectively fighting fires.

Work was begun on surveys and preparation of plans by the city engineer, but to the end of 1913 no definite decision with reference to the installation of a water supply had been reached. The Sugar creek project has been held back on account of some interested parties wishing to supply the cities of Girard and Virden by water derived from shallow dug wells in the vicinity of Girard. The adequacy of this latter project is now under consideration.

WARREN, WATER SUPPLY.—Visited October 16, 1913. An inspection was made of the water works system and a descriptive report was prepared, copy of which was sent to local authorities. The city has a slowly growing population of about 1,400. The principal industry is a tin plate factory, employing about 50 people, but the town is primarily an agricultural center. There is no sewerage system. In order to do away with cesspools, householders have been required to build small septic tanks, but no suitable outlet has been provided. Several of these discharge their effluents into street gutters, resulting in very unsanitary conditions.

Water works have been in use since 1895. In that year a well was drilled, terminating in St. Peter's sandstone, and a second one was added in 1901. They are drilled 20 feet apart in a park near the center of town and over them is built the pumping station. The wells are both 10 inches in diameter and cased to rock at a depth of 20 feet. One is 875 feet deep and the other 700 feet. Water stands normally about 75 feet below the surface. The wells were once tested for ten hours by pumping from each at the rate of 150 gallons per minute and no noticeable recession of the water level occurred. The average daily pumpage is about 80,000 gallons.

The water is comparatively soft with total solids of about 360 parts per million. It is good from a sanitary point of view and is very popular.

Each well is equipped with a single-acting deep well pump with the working barrel at a depth of 160 feet. The pumps discharge directly into the distribution system, connected with which is an elevated wooden tank of 56,000 gallons' capacity. About 3.8 miles of mains have been laid, ranging in size from 6 to 10-inch. The services in use number about 415. Only three services are metered.

WARSAW, FILTER PLANT.—Visited February 4, 1913, for the purpose of advising the local officials with reference to the operation of a newly installed rapid sand filter plant. A general description of the Warsaw water works and filter plant is contained in Bulletin No. 10, page 176. The principal difficulties observed during the above visit related to mechanical defects and lack of knowledge on the part of the water works superintendent of the manner in which certain of the mechanical devices were intended to operate. These matters were all adjusted through the medium of instructions at the time of the visit and subsequent correspondence.

WATERLOO, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 178.

WATSEKA, EXISTING WATER SUPPLY.—See Bulletin No. 10, page 179.

WAUKEGAN, IMPROVEMENT IN WATER SUPPLY.—Visited January 24 and March 15, 1913. The object of the visits was to investigate water works difficulties and recommend, if possible, means of overcoming same. A report was prepared and sent to local authorities. (See Bulletin 9, page 31.) Later, on June 2, 1913, another visit was made to Waukegan and an address delivered before the city. commissioners, covering substantially the ground covered in the report. Improvements were thereafter begun as recommended. A descriptive report on the Waukegan water works was prepared in the latter part of 1911 (see Bulletin No. 9), and in 1912, on the recommendation of the State Water Survey, treatment with hpyochlorite of lime was instituted.

The water works difficulties resulted from three causes, namely, the impurity of the water as drawn from Lake Michigan, the insufficient capacity of the intake pipe, and clogging of the intake by anchor and frazil ice. The most immediate necessity was greater intake capacity and elimination of ice troubles, and it was recommended that an emergency 24-inch intake 600 feet long be extended into the harbor. Such an intake will not become clogged with ice, and water drawn from it will be no more polluted than that from the existing 4,000-foot intake in the lake. This emergency intake was built and placed in readiness for the winter of 1913-1914.

A rapid sand filter plant has been strongly recommended as necessary for the delivery of a water satisfactory in appearance and sanitary quality, and is being seriously considered by local authorities.

WEST DUNDEE, EXISTING PUBLIC WATER SUPPLY.—See Bulletin No. 9, page 32.

WEST FRANKFORT, PROPOSED WATER SUPPLY.—Visited October 17, 1913. The information obtained, together with recommendations, were embodied in a report, copy of which was sent to the local authorities.

West Frankfort is principally a mining community and has experienced a rapid growth lately, due to the opening of additional mines. The population is now estimated to be over 4,000. The city has neither a public water supply nor sewerage system and with the rapid growth the lack of such is being felt.

West Frankfort is not advantageously located with reference to good sources of water supply for public purposes. It appears to be impossible to obtain an adequate supply of water of good quality from the ground. Deep rock wells would invariably yield a water too highly mineralized to be suitable for domestic purposes, and water encountered within the drift deposits at shallower depths, while of good quality, is not present in sufficient abundance to meet the needs of a community of this size. A supply may be obtained by impounding neighboring water courses, but this will involve rather large expense because of the necessity of building dams, long pipe lines and water purification works. Moreover it seems from available data that there are no reservoir sites which have a sufficient tributary watershed to furnish the entire supply at all times and the reservoirs must be replenished by pumping from the Middle Fork of Big Muddy river.

The State Water Survey has advised the authorities to secure the services of a competent consulting engineer for the purpose of investigating, with the cooperation of the Survey, available sources of water supply, so that a feasible project may be formulated.

WHEATON, SEWAGE PURIFICATION.—See Bulletin No. 10, page 180.

WHITE HALL, WATER SUPPLY.—Visited January 10, 1913. Information was obtained as a basis for a descriptive report on the public water supply. A copy of the report was sent to the mayor with recommendations that the city take steps toward installing means for purifying its supply.

White Hall has had a healthy growth during the past few years and now has a population of about 3,000. The manufacture of clay products is an important industry and there is a large condensed milk factory.

Water works were first installed in 1897, when a dam was built across a ravine about 2 miles east of town and an impounding reservoir of about 93,000,000 gallons' capacity thus formed. The flooded area of about 23 acres is privately owned and for its use the city pays an annual rental of $100. A threatened shortage of water two years ago resulted in the city raising the dam 4 feet, and during 1913 the supply was again almost exhausted. The dam is of earthen construction about 200 feet long and 25 feet high. The watershed area is not definitely known, but is estimated at not more than 2 square miles. The drainage area is sparsely inhabited, but the supply is subject to some danger of pollution. Fishing in the reservoir is permitted to members of a local club, who employ a man to patrol the watershed in summer and protect the supply against unnecessary contamination. Three analyses made by the State Water Survey have shown the supply to be of good sanitary quality. At times of rain or high wind the water may become very turbid and decaying vegetable growth during summer months has frequently caused disagreeable odors. The installation of purification works has been agitated, but nothing definite has yet been done.

Water consumption averages about 200,000 gallons per day, but all but about 60,000 of this is used by factories and the railroad. A single triplex pump of 400,000 gallons per day capacity is provided for delivering water to the city. Power is furnished in duplicate by two 25 H. P. two-cylinder vertical gasoline engines. A 6-inch discharge line leads from the station to town. Within the city limits are about 7.6 miles of mains, ranging in size from 4 to 8 inches. About 200 service taps are in use, indicating that only about one-third the population uses the supply for domestic purposes. An elevated steel tank of 80,000 gallons' capacity maintains a pressure of about 40 pounds in the mains.

WHITE HALL, SEWERAGE.—Visited September 2, 1913, to make inquiry relative to a proposed system of sewers. Efforts to induce local authorities to submit plans to the State Water Survey for review had failed and a contract for the work was awarded a few days before the visit. Inspection of the plans indicated that the system was well designed, but the method of disposal is liable to result in a nuisance that may cause complaint. A septic tank of the common horizontal flow type is to be built, from which the effluent will discharge into a small creek that is totally dry during portions of the year. The creek parallels a much-traveled highway within a distance of about 200 feet. A descriptive report on the project was prepared and sent to the mayor, pointing out the probable future necessity of more elaborate treatment works.

WILMETTE, EXISTING PUBLIC WATER SUPPLY AND SEWAGE.— See Bulletin No. 9, page 31.

WINCHESTER, PROPOSED WATER SUPPLY.—Visited June 19 and 20, August 29 and 30, and September 4 to 6, 1913. Two reports were prepared embodying the data obtained, together with recommendations regarding future procedure. Copies of these reports were sent to the local authorities.

Winchester is a prosperous farming community with a population of about 1,600. The question of a public water supply has been voted on by the city three times in past years. The first two votes were favorable, but no actual steps were taken to secure a supply. In 1910 preliminary plans were prepared, but the proposition failed to pass by a few votes.

The installation of water works was again actively considered this year and it has been learned since the visits that the proposition has been favorably voted on. During the first visit a field investigation of possible sources of supply was made and the latter two visits were made in connection with pumping tests on a test well.

Three possible sources of supply were pointed out, namely, (1) Big Sandy creek, (2) springs about 3 miles south of town, and (3) wells penetrating a sand stratum about 1½ miles south of town. An adequate supply could be obtained from Big Sandy creek by means of an impounding reservoir, but filtration would be necessary and it was advised that other sources be investigated. The springs mentioned above have a yield of about 600,000 gallons per day of good water, but owing to length of force main necessary it was advised that the possibility of a well supply nearer town be investigated. After a study of the wells about town, it was decided that the only promising source was in a valley south of town. A sand and gravel layer 13 feet thick is here found below clay and a test well was put down to a depth of 42 feet. Owing to poor equipment, a satisfactory pumping test was not made, but the consulting engineers for the city decided that an adequate supply from wells can be obtained in that locality and water works are to be installed.

WINNETKA, TASTES AND ODORS IN CITY SUPPLY.—Visited on June 7, 1913. The supply is taken from Lake Michigan, treated with hypochlorite in quantities not exceeding 5 pounds per million gallons, immediately after which it is pumped into the mains. Samples of the water were collected and microscopic organisms, particular asterionella, were found to be present. The trouble, which disappeared shortly afterward, was ascribed to these organisms. It is very probable that the use of hypochlorite made the tastes and odors more noticeable than would have otherwise been the case. See Bulletin 10, page 184.

WITT, PROPOSED PUBLIC WATER SUPPLY.—Visited March 19, 1913, in response to a request by local authorities, who desired advice as to procedure in obtaining a public water supply.

Witt is a mining town that has sprung up within the past few years and now has a population of about 2,500. The population is largely foreign and practically no public improvements have been made. The town is apparently unfortunately situated as regards securing an abundant water supply. Shallow wells in the vicinity are of but limited yield. The mine shafts have all been practically dry and the mining companies ship in large quantities of water for boiler use. Deep rock wells would in all probability supply very hard and otherwise highly mineralized water, even if found in adequate quantity. The country surrounding is very flat and offers no suitable site for a reservoir. Certain wells in the neighboring country are reported to have abundant yields and it was recommended that these and test wells at various other points be pumped as a first step toward locating a supply.

WOODSTOCK, EXISTING PUBLIC WATER SUPPLY.—See Bulletin No. 9, page 32.

YORKVILLE, Proposed Sewerage.—Visited October 23, 1913, relative to the location of a proposed sewer outlet. A report covering the investigation was prepared and a copy sent to the local authorities.

Yorkville is a residential and farming community with a population of about 430. The city has a public water supply (see Bulletin 9, page 32), but not a public sewer system. Private sewers have been built at different times with outlets to the Fox river.

The proposed sewerage system comprises about 3,900 feet of pipe with necessary appurtenances. The sewers are to be built on the combined plan and an outlet has already been built to the Fox river at the foot of a residential street. Objections have been raised because of the method of assessment and because of the location of the outlet. The river at the point of discharge is readily accessible and hitherto it has been the custom to drive vehicles into the water to be cleaned, and the stream has been used more or less by children for wading purposes. The nearest dwelling is 150 feet from the outlet. The presence of the outlet seriously interferes with the customary use of the stream as above indicated, and it is conceivable that under certain conditions there may be odors in the vicinity.

Yorkville will not probably have a population for many years to come which will produce a quantity of sewage that will cause a nuisance in the Fox river below Yorkville if discharged into the river in an untreated condition. Such being the case, it would seem that for all practical purposes suitable final disposal may be obtained by merely intercepting the present sewer and carrying the outlet in a direction further downstream. This conclusion was made as a recommendation to the local officials and to the Rivers and Lakes Commission.

ZION CITY, Water Supply and Sewage Conditions.—See Bulletin 9, page 32.

THE COMPARATIVE VALUE OF A CALCIUM LIME AND A MAGNESIUM-CALCIUM LIME FOR WATER SOFTENING*

On the market there are limes made from calcium limestones and limes made from magnesium-calcium limestones. The latter are favored by masons because they think it has a smoother plasticity. The claim has been that magnesium-calcium lime is as good as calcium lime for water softening. While we believed that the claim for magnesium-calcium lime was unwarranted, we were glad to make some laboratory experiments to settle definitely the question for ourselves.

We could find but little data concerning the effect of a magnesium-calcium lime for water softening. We found a record† of a sawdust filter impregnated with magnesia used for the removal of calcium salts.

In a paper on the efficiency of lime,‡ Mr. W. F. Monfort states that only the available lime (CaO) should be considered in lime purchasing.

Removal of magnesium from water is mentioned frequently in the literature and a better "floc" is obtained when magnesium is present in solution. This, however, has nothing to do with the effect of magnesium present in lime.

We used for our experiments the water from the University of Illinois water supply. This water is typical of deep drift well waters of central Illinois. An analysis shows that it contains 22 parts per million of carbon dioxide, CO_2; 128 parts per million of calcium carbonate, $CaCO_3$; 90 parts per million of magnesium carbonate, $MgCO_3$; and 86.8 parts per million of sodium carbonate, Na_2CO_3. Previous experiments¶ have shown that 276 parts per million (equal to 16.0 grains per gallon, 2.3 pounds per thousand gallons) are required to soften the water.

The limes used were furnished by the Ohio and Western Lime Company from their plants at Bedford and Huntington, Indiana. The

*Abstract of thesis prepared by Clarence Scholl under the direction of Prof. Edward Bartow and submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Chemistry. See also J. Ind. and Eng. Chem., 6.189.

†Soc. Chem. Ind., 1, 176.

‡Engineering News, 68, 889.

¶Univ of Ill. Bulletin, State Water Survey Series 7, 98; Ill. Soc. Eng. & Surv., 24, 213.

Bedford lime, the oxide, is a calcium lime containing very little magnesium. The Huntington limes, one oxide and one hydrate, are magnesium-calcium limes containing a large quantity of magnesium. The analyses of the limes are given below:

THE ANALYSES OF LIMES

Substance	Formula	Calcium Lime (Bedford) Per cent.	Magnesium-Calcium Lime (Huntington) Hydrated Per cent	Magnesium-Calcium Lime (Huntington) Oxide Per cent.
Calcium oxide	CaO	95.60	47.42	53.71
Magnesium oxide	MgO	0.84	33.20	37.60
Ferric Oxide	Fe_2O_3	0.02	0.15	0.09
Aluminum oxide	Al_2O_3	0.85	0.55	0.86
Silica	SiO_2	0.29	0.03	0.00
Carbon dioxide	CO_2	0.18	3.44	0.65
Water	H_2O	2.24	15.20	7.08
Total		100.02	99.99	99.99

Method of Procedure.—A number of portions of water of one liter each were treated with emulsions made from the three limes. The emulsions were of such strength that 1 cc. contained available calcium oxide, equivalent to 5 mg. $CaCO_3$. The available calcium oxide was determined by subtracting from the total calcium oxide the amount of calcium oxide necessary to combine with the carbon dioxide, CO_2, in the lime. Fifteen portions of water were softened to different degrees by adding amounts of the emulsion varying by 10 cc. each from 10 to 150 cc. Two portions were softened by adding amounts less than 10 cc. After adding the emulsion the portions were thoroughly shaken and allowed to stand over night. Each solution after filtration was analyzed. The alkalinity to phenolphthalein and methyl orange, calcium, and magnesium were determined. Results are expressed in terms of calcium carbonate ($CaCO_3$), to simplify calculation. Corrections were made for volume increase due to water added with the emulsion.

A study of the analytical data obtained shows the action of the two limes in softening water. (Compare Tables I and II, and the figure.) All the comparisons are based on the calcium oxide content of the limes. Both limes react first with the free carbon dioxide and there is an increase in the calcium content of the water. After the carbon dioxide is used up there is a decrease in the calcium content, the decrease being much more marked in the case of the magnesium calcium lime. While the calcium is more rapidly removed by the magnesium calcium lime, an equivalent of magnesium goes into solution.

There is a more rapid decrease in the methyl orange alkalinity when calcium lime is used, the interchanging of calcium for magensium leaving the methyl orange alkalinity nearly constant. The phenolphthalein alkalinity increases more rapidly with the magnesium calcium lime,

TABLE I.—EXPERIMENT WITH CALCIUM LIME.

Results Are Expressed in Parts Per Million Equivalent to $CaCO_3$.

		Alkalinity			
No.	CaO added	Phenol-phthalein	Methyl orange	Calcium	Magnesium
0	0	0	332.0	128.8	108.3
1	12.5	12.1	342.0	152.7	....
2	25	14.1	340.0	141.0	....
3	50	14.1	315.1	129.1	123.3
4	100	14.3	297.8	102.7	124.5
5	150	30.9	263.9	70.5	119.5
6	200	41.6	239.2	43.7	116.5
7	250	50.4	199.5	29.7	110.0
8	300	63.5	197.2	18.1	98.2
9	350	66.4	199.0	25.2	96.8
10	400	71.1	192.2	31.6	86.3
11	450	72.0	163.5	21.4	54.0
12	500	70.0	147.4	22.3	38.5
13	550	73.3	128.8	22.2	25.1
14	600	105.7	141.1	43.6	11.3
15	650	138.1	158.2	74.3	12.8
16	700	182.8	205.2	140.5	11.5
17	750	....	....	178.9	11.0

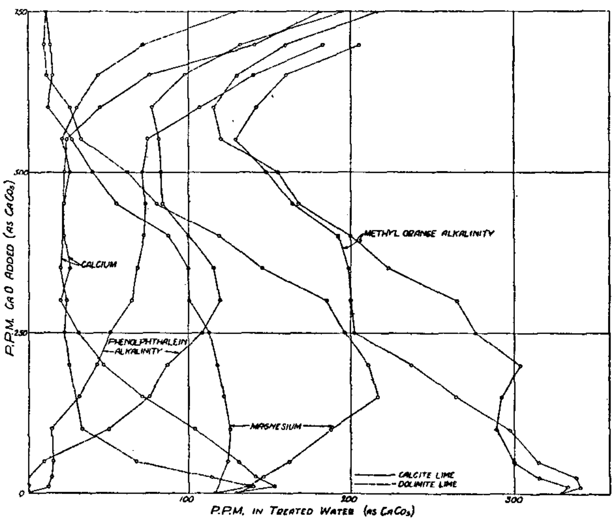
TABLE II.—EXPERIMENT WITH MAGNESIUM-CALCIUM LIME.

Results Are Expressed in Parts Per Million Equivalent to $CaCO_3$.

		Alkalinity			
No.	CaO added	Phenol-phthalein	Methyl orange	Calcium	Magnesium
0	0	0	332.0	128.8	108.3
1	12.5	0	335	139.6	138.0
2	25.0	0	318	113.9	144.3
3	50	8.1	301.0	65.7	160.3
4	100	49.0	289.7	34.0	186.0
5	150	72.1	292.5	....	216.0
6	200	85.3	303.7	24.4	210.3
7	250	109.2	277.2	21.1	195.8
8	300	118.7	265.0	21.3	184.3
9	350	113.4	224.7	17.5	144.8
10	400	99.4	200.9	21.3	117.8
11	450	80.7	165.7	21.4	79.0
12	500	81.4	154.0	25.1	61.0
13	550	79.9	119.9	21.1	32.3
14	600	76.2	114.2	26.8	29.0
15	650	97.2	128.8	42.5	11.5
16	700	132.2	159.6	70.9	10.3
17	750	193.2	216.2	126.8	10.3

due to the additional magnesium hydrate added. The magnesium reaches a maximum of 216 parts per million (as $CaCO_3$) when the calcium content approaches the minimum. The magnesium after reaching a maximum rapidly decreases in amount until the minimum is reached at the point of complete softening. At the point of complete softening the methyl orange alkalinity also reaches the minimum, while the phenolphthalein alkalinity is increasing. From the point of maximum softening, all the constituents except the magnesium increase. The magnesium does not increase, none being added with the calcium lime and that present in the magnesium-calcium lime is not dissolved.

Summary.—The difference between the action of calcium and magnesium-calcium limes is that magnesium replaces the calcium until a minimum of calcium carbonate is reached. It also reacts with magnesium acid carbonate, forming magnesium carbonate. With the addition of more lime all of the magnesium is precipitated as hydroxide.



Water Softening by Calcium and Magnesium—Calcium (Dolomite) Lime.

The softening of water is evidently dependent on the content of available calcium oxide and therefore all lime used for water softening should be bought on the basis of the quantity of available calcium oxide. Moreover, it is not advisable to purchase lime containing magnesium because the magnesium is without value for softening and increases the amount of sludge to be handled.

THE RELATION OF THE ELECTRICAL CONDUCTIVITY OF WATER TO THE SOLUBLE MINERAL MATTER*

Waters containing electrolytes, such as sodium chloride and magnesium sulfate, will conduct a current of electricity. The greater the quantity of these electrolytes dissolved in a given quantity of water, the greater will be the conductance. The conductance of such a solution is not directly proportional to the amount of substance dissolved. The conductance of a solution does not increase as rapidly as the concentration of the substance, nor is the conductance of solutions of different substances, at the same concentraion, equal. They may vary widely from each other, especially in concentrated solutions.

In dilute solutions, however, this variation is not so great. Natural waters are usually dilute solutions. Their concentration usually lies between 0.01N** and 0.001N, dilutions at which the conductance does not vary greatly, even though the composition of the mineral content varies. There is thus a general relation existing between electrical conductance. of a water and the quantity of dissolved mineral matter which it contains. Organic compounds in solution in natural waters, as a rule, do not conduct the electric current and consequently their effect in comparison with the conductance of the mineral matter is negligible.

Kohlrausch† in a study of the relation of the conductivity to the mineral content discovered a nearly constant relation. Using this relation, he proposed the following formula, by which the number of mg. per liter can be calculated: Multiply the specific conductance (L) in mhos‡ by 75,000, or mg. per liter=$0.75 \times L \times 10^6$.

Our experience indicates that the proposed constant factor .75 may be high for waters of one type or low for waters of another type, but by its use the concentration may be determined with a fair degree of accuracy. An accurate factor may be determined for a water from a given source, such as a lake, stream or well. After a factor has been determined for a supply, any variation in the total amount of

*A paper by H. L. Huenink, M. S., prepared under the general direction of Prof. Edward Bartow.

**N is used to denote a normal solution which is equal to one gram equivalent dissolved in one liter of solution.

†Leitnermögen der Elektrolyte. Kohlrausch und Holborn. p. 131.

‡The mho is the unit of conductance (*L*) and is equal to the reciprocal of the ohm, the unit of resistance.

dissolved substances can be readily measured and pollution detected.

P. S. Meerburg† at the Central Public Health Laboratory, Netherlands, has made a comparison of the conductance and residue. He found a fair agreement between the residue calculated from the conductance and that obtained by the usual evaporation method.

To determine the accuracy of this method and to determine whether it has practical utility for determining the residue of Illinois waters, a series of determinations was made in this laboratory. The measurements were made by the Wheatstone bridge and alternating current method. The cell was suspended in water in a battery jar, which was placed in a 20° C. incubator. The temperature of the water remained constant within .5° C. The residues were determined by evaporating 100 cc. of the water in a platinum dish and drying for one hour at 180° C.

The values for residues obtained by both methods are given in Table I.

TABLE I

Lab. No.	$L \times 10^6$	$75 \times L \times 10^6$	Residue on Evaporation	Error	Per cent error
24589	520	390	344	+ 46	+ 13.3
24590	206	154	140	+ 6	+ 4.2
24602	453	339	366	— 27	— 7.3
24618	4,700	3,520*	2,844	+ 676	+ 23.7
24620	510	382	356	+ 26	+ 7.3
24720	458	343	371	— 28	— 7.8
24723	1,613	1,109	1,023	— 14	— 1.3
24726	242	181*	313	—132	—42.1
24737	899	674	619	+ 55	+ 9.0
24750	515	386	358	+ 28	+ 7.8
24755	612	459	423	+ 36	+ 8.5
24756	888	656	651	+ 5	+ .7
24835	1.156	867	769	+ 98	+ 12.6
24836	593	444*	335	+ 109	+ 32.5
25205	178	133	137	— 4	— 2.9
25206	174	130	122	+ 8	+ 6.0
25208	1,070	802	862	— 60	— 6.9
25210	480	360	336	+ 24	+ 7.1
25213	1,150	862	825	+ 37	+ 4.4
25214	225	169	193	— 24	—12.4
25215	290	218	187	+ 31	+ 16.5
25216	270	202	191	+ 11	+ 5.7
25217	280	210	197	+ 13	+ 6.6
25220	780	585	540	+ 45	+ 8.3
25221	740	555	600	— 45	— 7.0
25222	1,125	843	1,006	—163	—16.2
25224	450	336	299	+ 37	+ 12.3
25225	440	330	316	+ 14	+ 4.4
25226	557	417	353	+ 64	+ 18.0
25227	1,050	787	873	— 86	— 9.8
25228	575	430*	353	+ 87	+ 24.3
25229	700	525	513	+ 12	+ 2.3

†Chemisch Weekblad. VIII, 977 (1911).

The agreement in most cases is fair. The four determinations marked (*) show that in some cases the deviation is considerable and therefore the method cannot be depended upon to give accurate results when the waters come from a variety of sources. Out of the remaining twenty-eight determinations, twenty-one show an error below 10 per cent and seven slightly over 10 per cent. The above samples comprised waters from rivers, wells, lakes and springs.

Measurements of the University supply were made daily for three weeks and practically no change in the conductance was observed. This indicates that no change in the mineral content had taken place.

Suspended matter does not interfere with the determination of conductance and therefore filtration is unnecessary.

The following table gives the values of the filtered and unfiltered water:

TABLE II

Lab. No.	Turbidity	$L\times10^6$ (unfiltered)	$L\times10^6$ (filtered)
24602	35	453	453
24618	25	4,700	4,780
24620	35	510	510
24835		1,156	1,184

The applicability of this method is dependent on the fact that equivalent conductance and the equivalent weight of the salts in natural waters are constant or nearly so. This will be seen from the relationship between conductance and concentration.

$$A = \frac{1{,}000\ L}{C}$$

where A = equivalent conductance
L = specific conductance
C = conc, in gram equivalents per liter

and since $C = \dfrac{W : \text{weight in grams}}{E : \text{equivalent weight}}$

the formula may be written

$$W = 1{,}000\ L\frac{E}{A}$$

E and A are constant, L can be measured and therefore W can be calculated. The constant 0.75 in the Kohlrausch and Holborn formula is $\frac{E}{A} \times 1{,}000$.

There is on the market an apparatus manufactured by Evershed and Vignoles of London known as the "Dionic Water Tester." The cell consists of a U tube, in which are placed two platinum electrodes. Direct current at 100 volts is furnished by a hand-driven dynamo, and the conductance is read directly from a conductivity meter in units of mhos $\times 10^6$. The error introduced by polarization is corrected on the scale. A table of corrections for temperature is furnished with the instrument. The conductance cannot be read from the scale with a great degree of accuracy, especially when the value is high.

One of the claims for this instrument is that the correct quantity of lime necessary to soften a hard water may be ascertained by adding lime in different proportions to the water and determining the conductance after each addition, the minimum indicating the quantity of lime necessary to soften.

C. C. Young* has shown that the value indicated by the minimum is not correct when Mg. is present, but when $Ca(HCO_3)_2$ is present alone the value is approximately correct.

The reaction between $Ca(HCO_3)_2$ and lime is slow when there is no agitation, and a long time is necessary after each addition of lime, before the conductance is constant. This method, therefore, at best is not very satisfactory for determining the lime value of a water.

*Ill. Water Supply Assn. (1913), p. 63.

THE PERCHLORIC METHOD OF DETERMINING POTASSIUM, AS APPLIED TO WATER ANALYSIS

BY CLARENCE SCHOLL.†

Potassium is determined gravimetrically as potassium platinic chloride (K_2PtCl_6), as potassium cobalti-nitrite ($K_3CO(NO_2)_6$), and as potassium perchlorate ($KClO_4$).

The potassium platinic chloride method is most commonly used. It is accurate, but there are difficulties because of the solubility of K_2PtCl_6 in alcohol, the non-uniformity of the precipitate, the loss by ignition, and the cost of material. The cost of platinic chloride equivalent to one gram of potassium in the precipitate K_2PtCl_6 amounts to $4.90. While this material can be recovered, the cost of recovery is considerable.

The determination as potassium cobalti-nitrite‡ in its present form is not satisfactory. The results are unreliable.

The potassium perchlorate method, more commonly called the Wense*-Caspari** method, has been applied to the analysis of fertilizers and similar material containing alkalies, alkaline earths, iron aluminum, magnesium and phosphates. The chief difficulty in this method has been the obtaining of the perchloric acid. The danger in preparing the pure acid, as was attempted, is very great. For this reason the method has not been available to many chemists. Recently a 20 per cent solution at $3.00 a kilo, a 30 per cent solution at $4.80 a kilo, and even stronger solutions of perchloric acid have been placed on the market.

The quantity of perchloric acid necessary to combine with one gram of potassium costs 3.8 cents. The cost of an equivalent amount of platinic chloride is $4.90. The cost of perchloric acid in the perchlorate method is not only lower than the cost of platinum in the platinic chloride method, but is much lower than the cost of recovering the platinum. The precipitate, $KClO_4$, is of constant composition, its solubility in 96 per cent alcohol containing 0.2 per cent $HClO_4$ is almost zero, and the loss by ignition is eliminated. The fertilizer

‡H. B. McDonnel, Bur. Chem. Bull. 162, 19 (1912).

*W. Wense, Z. Angew. Chem. (1891); 691; (1892) 233.

**R. Caspari, Ibid (1893), 68.

†An original investigation made while studying for the degree of Master of Science at the University of Illinois.

chemists* of Germany have tested the method and have obtained such accurate results that they have placed it on an equal basis with the platinic chloride method by adopting it as an official method.**

This method has been modified by the author as follows: Precipitate the sulphates in a strong hydrochloric acid solution, avoiding a large excess of $BaCl_2$. Evaporate the resulting solution with only a slight excess of $HClO_4$ without stirring. Dissolve the residue and again evaporate with $HClO_4$. Wash the precipitate only with alcohol containing 0.2 per cent $HClO_4$ before drying.

The revised method as applied to the determination of potassium in water is as follows: Evaporate an aliquot portion of the water to about 150 cc. Acidify with 10 cc. of concentrated HCl. Heat to boiling. To the boiling solution add drop by drop a 10 per cent solution of $BaCl_2$ until all the sulphates are precipitated. Avoid a large excess of $BaCl_2$. Boil for fifteen minutes. Filter. If no precipitate forms, filtration may be omitted.

Evaporate the filtrate to dryness. Heat until all the ammonium salts are driven off. Dissolve in 20 cc. of hot water and add a quantity of a 20 per cent solution of $HClO_4$, slightly in excess of that required to combine with nearly all bases present. One cc. $HClO_4$ is equivalent to 90 mg. of potassium (K). Evaporate to dryness. Add 10 cc. of hot water and a small amount of perchloric acid. Again evaporate to dryness. If white fumes do not appear, take up with 10 cc. of water, add more $HClO_4$ and evaporate to dryness. Repeat until white fumes do appear. Take up with 25 cc. of 96-97 per cent alcohol, containing 0.2 per cent perchloric acid (1 cc. of 20 per cent $HClO_4$ per 100 cc. of 97-98 per cent alcohol). Break up the residue with a stirring rod. Decant the supernatant liquid through a Gooch crucible containing a mat that has been washed with 0.2 per cent $HClO_4$ in alcohol. If there is an unusually large precipitate, dissolve it in hot water and repeat the evaporation with $HClO_4$. (Large quantities of $BaCl_2$ are difficult to change to the perchlorate.) Wash once by decantation with 0.2 per cent $HClO_4$ in alcohol and transfer the precipitate to the crucible. Wash several times with 0.2 per cent $HClO_4$ in alcohol. Dry the crucible in an oven at 120°-130° for an hour. Remove, cool and weigh. The increase in the weight of the crucible is $KClO_4$. (In using the Gooch crucibles do not disturb the mat after analysis. Dissolve the $KClO_4$ with hot water, leaving the mat intact. Using the crucible repeatedly in this manner eliminates the errors due to the action of $HClO_4$ on fresh asbestos.)

If both sodium and potassium are to be determined, obtain the combined chlorides by the usual methods and estimate the potassium as $KClO_4$, as described, omitting the precipitation of the sulphates with barium chloride.

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*Landw. Vers. Sta, *59,* 313 (1903); *67,* 145 (1907).

**V. International Congress fur Angew. Chem. *1,* 216 (1903); *4,* 940 (1903).

It is of advantage to evaporate to dryness with only a slight excess of $HClO_4$, and to repeat the process a second and possibly third time in order to insure the removal of nearly all volatile acids and in order to make stirring while evaporating unnecessary.

The recommendation of 97 per cent alcohol for washing is due to the solubility of $KClO_4$ in alcoholic solutions of $HClO_4$ containing 95 per cent or less alcohol. The difference between the efficiency of 97 per cent and 100 per cent alcohol is immaterial.

It is undesirable to wash the crucible with ether or alcohol just before drying. A slight amount of $KClO_4$ would be dissolved. Dry as much as possible with air suction and then dry in an oven. The small amount of $HClO_4$ left in the asbestos will be volatilized without causing any error, especially if the same asbestos mat is used repeatedly.

A series of analyses was first made using pure potassium chloride. (See Table I.)

TABLE I

ANALYSES OF SOLUTIONS CONTAINING ONLY POTASSIUM CHLORIDE

No.	Potassium added gm.	$KClO_4$ obtained gm.	Potassium obtained gm.	Error gm.
1	.0050	.0174	.0049	—.0001
2	.0100	.0353	.0100	....
3	.0150	.0530	.0150	....
4	.0200	.0701	.0198	—.0002
5	.0300	.1049	.0296	—.0004
6	.0350	.1241	.0350	....
7	.0500	.1769	.0499	—.0001

Since the amount of potassium found agreed with the amount taken, a second series was analyzed, using comparatively large quantities of sodium chloride in addition to the potassium. (See Table II.)

TABLE II

ANALYSES OF SOLUTIONS CONTAINING LARGE QUANTITIES OF SODIUM CHLORIDE

No.	Potassium added gm.	Sodium chloride in solution gm.	$KClO_4$ obtained gm.	Potassium obtained gm.	Error gm.	Error Per cent.
1	.0050	.0500	.0181	.0051	+.0001	+0.2
2	.0100	.1000	.0350	.0099	—.0001	— 0.1
3	.0200	.2000	.0712	.0201	+.0001	+ 0.05
4	.0300	.3000	.1073	.0302	+.0002	+ 0.07
5	.0400	.4000	.1423	.0401	+.0001	+0.02
6	.0500	.5000	.1783	.0503	+.0003	+0.05
7	.0600	.6000	.2129	.0600	.0000	0.00
8	.0700	.7000	.2471	.0697	—.0003	—0.04
9	.0800	.8000	.2830	.0799	—.0001	—0.01
10	.1000	1.000	.3534	.0997	—.0003	—0.03
11	.2000	1.0000	.7090	.2001	+.0001	+0.01
12	.3000	1.0000	1.0626	.2999	—.0001	—0.01
13	.4000	1.0000	1.4171	.3999	—.0001	—0.01
14	.5000	1.0000	1.7686	.4991	—.0009	—0.05
15	1.0000	1.0000	3.5438	1.0000	.0000	0.00

The variations are small and lie within the limits of the experimental error. The largest is —0.9 milligram; the smallest is zero. The average for the fifteen analyses is 0.07 milligram (0.04 per cent) less than the theoretical amount. The balance used is not capable of weighing less than 0.1 of a milligram. The error, in percentage, is large with small quantities of potassium (amounting to as much as 0.2 per cent), Increasing the quantity of potassium decreases the error in percentage.

An artificial mineralized water was then made by adding the following constituents to distilled water: $CaCO_3$, $MgCO_3$, $MgCl_2$, Na_2CO_3, NaCl, and $NaNO_3$. The insoluble constituents were dissolved with a small amount of hydrochloric acid. Portions of the solution containing 0.1 gram of each substance were measured out. Known amounts of potassium were then added to each portion and determined without removing any of the ions. The results are shown in Table III. In this series most of the errors, although not large, are minus in character.

TABLE III

ANALYSES OF WATERS OF HIGH MINERAL CONTENT

No.	Potassium added	Mineral Content	$KClO_4$ obtained	Potassium obtained	Error	
	gm.	gm.	gm.	gm.	gm.	Per cent.
1	.0500	.6000	.1757	.0496	—.0004	—0.06
2	.1500	.6000	.5301	.1497	—.0003	—0.03
3	.2500	.6000	.8887	.2508	+.0008	+0.07
4	.3000	.6000	1.0612	.2995	—.0005	—0.04
5	.3500	.6000	1.2378	.3493	—.0007	—0.05

To each of several portions of the same artificial water 0.1 gram of Na_3PO_4 was added, and the potassium determined as above, with results as shown in Table IV.

TABLE IV

ANALYSES OF HIGHLY MINERALIZED WATER CONTAINING PHOSPHATE

No.	Potassium added	Mineral Content	$KClO_4$ obtained	Potassium obtained	Error	
	gm.	gm.	gm.	gm.	gm.	Per cent.
1	.0500	.7000	.1784	.0503	+.0003	+0.04
2	.1000	.7000	.3540	.0999	—.0001	—0.01
3	.1500	.7000	.5323	.1502	+.0002	+0.02
4	.2500	.7000	.8867	.2501	+.0001	+0.01
5	.3500	.7000	1.2383	.3494	—.0006	—0.04

Sodium phosphate is insoluble in alcohol, but sodium phosphate does not produce an error in the determination of potassium (see Table IV). When sodium phosphate is evaporated with $HClO_4$ the following reaction takes place:

$$Na_3PO_4 + 3HClO_4 = 3NaClO_4 + H_3PO_4$$

Sodium perchlorate and phosphoric acid are soluble in alcohol and can not cause an error in the determination of potassium.

The sulphate and ammonium ions were found to produce an error, but the error caused by the sulphate was not equivalent to all the sulphate ion that was present. It is necessary to remove all of the ammonium salts and most of the sulphates.

SUMMARY.

The method of determining potassium as the perchlorate is accurate.

Sulphate and ammonium ions produce an error and must be removed. Precipitate the sulphate with $BaCl_2$ in a strongly acid solution, avoiding a large excess of $BaCl_2$. Expel the ammonia with heat.

The phosphate ion does not produce an error and need not be removed.

Evaporate the solution containing chlorides to dryness with a slight excess of $HClO_4$ without stirring.

Wash the precipitate only with alcohol containing 0.2 per cent $HClO_4$.

The time of making an analysis is short. The manipulations are simple. The cost is almost negligible.

The method can be recommended for use in water analyses and in other analytical work where the content of potassium is desired.

THE COMPOSITION OF SLUDGE AND BOTTOM DEPOSITS OF THE ILLINOIS RIVER

As a part of the investigation of the extent of pollution of the Illinois river by the Chicago Drainage Canal,* analyses of sludge and bottom sediment taken from representative points along the stream have been made.

The determinations made include specific gravity, water, loss on ignition, total nitrogen and ether soluble matter.

The results of these analyses (see table) show conditions which are in good agreement with the other data obtained in the Illinois river investigations.

The composition of the sludge in the Drainage Canal and the upper Illinois river resembles somewhat that of a sewage sludge. Marked improvement occurs between Marseilles and Henry, while below Peoria, the sediment seems to be that of a nominal relatively unpolluted stream.

TABLE SHOWING COMPOSITION OF BOTTOM DEPOSITS FROM THE ILLINOIS RIVER.

Date collected 1913	Source, water temperature, odor			Specific Gravity	Moisture	Per cent, in terms of dry matter			
						Nitrogen	Loss on Ignition	Fixed Matter	Ether Soluble
March 18	Lockport	37° F	fecal	1.20	71.2	.55	22.2	77.8	2.67
17	Morris	36° F	fecal	1.35	53.6	.51	16.2	83.8	1.12
19	Marseilles	40° F	fecal	1.24	44.3	.67**	10.	90.	1.07
20	Henry	41° F	disagreeable	1.28	63.	.39	12.1	87.9	.40
26	Chillicothe	39° F	disagreeable	1.38	48.3	.39	11.6	88.4	.36
April 5†	Peoria Narrows			1.69	32.1	.14	6.8	93.2	.28
March 25	Copperas Creek	43° F	earthy	1.58	40.2	.15	4.8	95.2	.11
24	La Grange	43° F	earthy	1.57	37.4	.20	5.3	94.8	.11
22	Pearl	41° F	earthy	1.77	29.8	.12	3.2	96.8	.18

*Effect of Chicago Sewage on the Illinois river. Univ. of Ill. Bul., State Water Survey, Series No. 10.

**Large numbers of sewage worms in this sample account for the high nitrogen content.

†Date received at laboratory.

THE RELATION OF THE MINERAL CONTENT OF BOILER WATERS TO THE SCALE FORMED*

Where steam power is used, the problem of obtaining a suitable supply of boiler water is very important. Especially is this true in the Middle-West where there are few waters, either surface or underground, which do not have some bad qualities, causing, for example, corrosion, formation of scale and foaming. A corrosive water is probably the most objectionable. Scale-forming waters are the most common, for practically every water except rain water and distilled water will form a scale in a greater or lesser degree when used in a boiler.

Ever since the invention of the steam engine, the evil effects of boiler scale have been noticed and studied. When marine engines did not use surface condensers "the evil effects of incrustation made themselves felt with multiplied force, because of the great rapidity with which the crusts formed, due to the large quantity of solids contained in the water. Sea water contains about 41,900 parts per million (2,450 grains per gallon) of dissolved solids, and it has been shown by J. R. Napier (Proc. Phil. Soc. Glasgow, Vol. IV, p. 281), that sulfate of lime begins to deposit before one-half of the water is evaporated."**

Not only were the evil effects of scale noticeable in marine boilers, but also in land boilers using natural fresh water. The formation of scale led to a considerable waste of fuel, and in some cases, to the explosion of the boiler.

The waste of fuel due to the poor conductivity of the scale has been the subject of extensive investigation. J. G. Rogers† makes the claim that a scale of $\frac{1}{16}$ of an inch thick requires an extra expenditure of 15 per cent more fuel; ¼ inch, 60 per cent, and ½ inch thick, 150 per cent.

Later, however, Schmidt and Snodgrass‡ showed that a scale ⅛ inch thick caused a heat loss of 10.5 per cent; ¼ inch little more, a loss of 20 per cent being considered very high. They found that the mechanical structure of the scale is of as much or more importance in producing the loss than is the thickness, and that the chemical composition has no direct influence on the heat transmitting properties.

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*Abstract of thesis prepared by F. W. Mohlman, under direction of Professor Edward Bartow, and submitted in partial fulfillment of requirements for the degree of Bachelor of Science in Chemistry, June, 1912.

**Rowan, Modern Steam Boiler, p. 611.

†Rowan, Modern Steam Boiler, p. 606.

‡U. of I., Eng. Exp. Sta., April, 1907.

The character of the scale must, however, be dependent on the properties of the substance in solution. Sulfates and carbonates of calcium and magnesium are the most abundant. Water containing more than 170 parts per million (10 grains per gallon) of these substances is usually classed as hard, and may form troublesome scale.

"Calcium bicarbonate ($Ca(HCO_3)_2$) is the most common scale forming salt. Calcium carbonate ($CaCO_3$) seldom exists in water in greater quantity than 34 parts per million (2 grains per gallon). Calcium carbonate is more soluble in cold water than in hot, and the presence of NaCl dissolved in the water increases its solubility to about 85 parts per million (5 grains per gallon). $CaCO_3$ is soluble in water saturated with CO_2, and thus we find the bicarbonate in solution. A saturated solution of CO_2 can dissolve 700 parts per million (41 grains per gallon) of $CaCO_3$ at 0°C and 880 parts per million (51.5 grains per gallon) 10°C, the solubility increasing with the temperature."* When such a solution is heated, CO_2 is driven off and the normal carbonate is formed and precipitated. The precipitation is practically complete at 143°C, or 43 lbs. gage pressure.

Calcium sulfate ($CaSO_4$) is also a common impurity. Calcium sulfate exists in nature with different amounts of water of crystallization, as anhydrite ($CaSO_4$), but more commonly hydrated, as gypsum ($CaSO_4 .2H_2O$). When gypsum is heated to a point between 110° and 120°, it loses three-quarters of its water rather quickly, and becomes the well known "plaster of Paris." The anhydrous sulfate is nearly insoluble, but the hydrated is soluble in water at 35°C. to the extent of 2,531 parts per million (148 grains per gallon). According to Regnault, water dissolves the greatest quantity of $CaSO_4$ at 35°, a liter of water at that temperature dissolving 2,570 parts per million (150.3 grains per gallon). The presence of certain salts increases the solubility. According to Anthon,** one liter of a cold saturated NaCl solution dissolves 8.18 gms. of $CaSO_4 .2H_2O$, probably through partial formation of Na_2SO_4 and $CaCl_2$. Under boiler conditions anhydrite ordinarily is precipitated. Evidently both a high temperature and a concentrated salt solution, which may form in a boiler, cause precipitation of $CaSO_4$.

The form in which calcium sulfate deposits from a solution† depends upon the temperature at which the evaporation takes place. Below 120° C. as soon as the solubility product is reached, $CaSO_4 .2H_2O$ separates out. From 120° C. to about 140° C., crystals of $CaSO_4 H_2O$ are deposited. Above 140° C. anhydrite ($CaSO_4$) is precipitated.

Magnesium bicarbonate ($Mg(HCO_3)_2$) is a common constituent of natural waters. Magnesium carbonate ($MgCO_3$) is formed when CO_2 is expelled, but unlike calcium carbonate ($CaCO_3$) it is appre-

*L'Eau dans L'Industrie, p. 31.

**Polytechnisches Journal, 1874, 210.

†Sci. Am. Supp., 1892, 14020.

ciably soluble in water at ordinary temperatures. At 100°C. it is practically all converted into $Mg(OH)_2$ and CO_2, a reaction which does not take place with the similar calcium salt and only very slowly with magnesium. Appreciably $Mg(OH)_2$ is soluble to about 8 parts per million (.5 grain per gallon).

Magnesium sulfate ($MgSO_4$) is sometimes present in troublesome quantities. It is readily soluble in cold water and still more soluble in hot water to about 122°C., above which temperature its solubility decreases. At about 200°C. it begins to decompose with precipitation of $Mg(OH)_2$ and formation of H_2SO_4, which is corrosive. If calcium carbonate is present, magnesium carbonate and calcium sulfate may be formed. Similarly in the presence of sodium chloride, magnesium chloride and sodium sulfate may be formed.

Silica (SiO_2) is present in almost all waters, but usually not in excess of 30-50 parts per million (2/3 grains per gallon), and it makes up but a small percentage of a scale.

Iron and aluminum are present in most waters only to a slight extent, and hence form but a small percentage of a scale.

The four salts first considered, calcium carbonate, calcium sulfate, magnesium carbonate and magnesium sulfate, are the most important in scale formation. Other salts, for example, the chlorides, nitrates, sulfates and carbonates of the alkalis, and the chlorides and nitrates of calcium and magnesium, do not cause scale formation. By double decomposition the cholorides and nitrates of calcium and magnesium may be converted into insoluble forms. The salts of the alkalis are all more soluble in hot water than in cold, and the only way they can enter scale is by supersaturation or by occlusion by some other salt.

Natural waters are complex solutions. Nearly every water contains all of the salts mentioned, and it is evident that the solubility of any salt will be affected to a great extent by the other salts in solution.

Numerous opinions have been expressed concerning scale formation. Fischer* says, "Little agreement exists betwen the chemical composition of the scale and the mineral content of the water, from which the scale was formed."

M. Cousti** states that the chemical composition of a scale varies in the different parts of a boiler, due to the unequal temperature of the walls of the boiler, and that the physical properties and not the chemical properties of the salts are the controlling factors, since the precipitation is caused by physical changes.

According to Cary,† "When several impurities occur in a boiler water, the kind of material precipitated depends mostly upon the temperature or degree of concentration. Thus, should we fill a boiler

*Polytechnisches Journal, 1874, 208.

**Traite des Epuration des Aux, 1893, 132.

†Engineering Magazine, 1897, 232.

with water containing mechanically-suspended-matter, this matter will gradually settle to the bottom, forming one layer; next, if the water be heated to 212°, most of the carbonate will be deposited; and, if afterwards the temperature be raised to 300°, the sulfate of calcium will be precipitated. By neglecting to blow off a boiler, we may concentrate some one of the solutions of a very soluble salt beyond its point of saturation, when another precipitation takes place. During all of this time much floating matter will be held in suspension by the circulating currents, and, when we finally draw our fires and the water comes to a state of rest, this will settle, and another layer be formed."

According to J. C. Greth* the nature and amount of scale formed in a boiler depends largely on the rate at which the boiler operates. For instance, in a given time, in boilers operating below their rating with water containing as high as 513 parts per million (30 grains per gallon) of carbonate and sulfate scale forming salts, comparatively little scale is formed. In the same time in other boilers operating above rating with water containing only about 170 parts per million (10 grains per gallon) of these salts, a considerable deposit of hard, tenacious scale is formed.

The type of boiler also has a bearing on the hardness of the scale. The scale formed from water of the same character in a water tube boiler is generally harder than that formed in the return-tubular boiler, or in the old two-flue boiler.

Considering all of these facts, the formation of scale is generally a definite process. Calcium carbonate deposits in an amorphous mass, or under proper temperature conditions, in crystalline form as aragonite. Calcium sulfate deposits as anhydrite. Iron and magnesium carbonates hydrolyze and deposit hydroxides or oxides. Magnesium sulfate is hydrolyzed at about 200°C. and deposits hydroxide. The soluble silica and alumina are forced out of solution, but most of the silica and alumina in the scale comes from suspended sand and clay in the feed water, and is carried down mechanically by the other incrustants. Salts of sodium and potassium are rarely if ever present in a scale. Analyses of numerous boiler scales have shown many anomalies, as the following statement of Greth** indicates. "Such general statements that waters containing only the carbonates of calcium and magnesium will form a soft scale, and that calcium sulfate will form a hard scale should be made with caution, for there are hundreds of instances where a hard scale is formed from waters containing only the carbonates of calcium and magnesium and also where the scale is quite soft in the presence of considerable calcium sulfate."

There is considerable disagreement as to which salt of magnesium is present in scales. The cause of the disagreement is seen in a statement by Stillman.† "When the scale-forming material is deposited, it

*Power, March 2, 1909.

**Power, March 2, 1909.

†Engineering Chemistry, p. 96.

is first in the form of carbonate and sulfate, but gradual heating expels some of the carbon dioxide, and the oxides of calcium and magnesium are formed. That portion of the scale next to the iron loses more of its CO_2, and becomes caustic as long as the fire continues. As soon, however, as the fires are drawn, the oxides of calcium and magnesium become hydrated by absorption of water. Thus the composition of the scale will depend, in a great measure, upon what portion of the boiler the deposit is made. Scale in which all the calcium exists as calcium sulfate and in which no magnesium carbonate is present, will be subject to but little variation."

The order of deposit was studied by Rothstein,* who observed the formation of scale from the following water under different conditions.

COMPOSITION OF THE WATER

	Pts. per mil.		Pts. per mil.
Total residue, 150°	3,640	Cl	167
CaO	450	N_2O_5	212
MgO	288	Total hardness	85°
SO_3	1,461	Permanent hardness	19°
CO_2	149	Temporary hardness	66°

The water was first heated in the condenser of a vacuum apparatus to 80°-90°, from here to a boiler with constant temperature of 140°; then to one at 130°, and finally at 94°. Scale was formed in all the boilers. Analysis gave the following results:

	I	II	III	IV
Thickness of scale	0.1-0.3 mm.	12.0 mm.	2 mm.	1.5-2 mm.
	Per cent.	Per cent.	Per cent.	Per cent.
Total loss on heating	43.66	8.87	5.22	7.37
CO_2	42.71	4.53	0	0
CaO	54.32	38.00	52.1	37.51
MgO	0	5.51	4.8	0
SO_3	0	46.08	36.21	53.6
SiO_2	0	1.08	.75	0
$Al_2O_3 + Fe_2O_3$	1.2	1.2	1.04	0
H_2O + Organic matter	.95	1.88	3.06	1.36

A calculation of probable salts present shows in I, $CaCO_3$, 97.03 per cent; in II, $CaCO_3$ 10.25 per cent; $Mg(OH)_2$, 7.59 per cent; $CaSO_4$, 78.33 per cent; in III, $Mg(OH)_2$, 6.96 per cent; $CaSO_4$, 87.97 per cent; in IV only $CaSO_4$, of the formula $CaSO_4 + \frac{1}{2}H_2O$.

$CaCO_3$ was deposited most easily. This scale was thin, brown, very hard and crystallized as calcite.

Not all the $CaSO_4$ separated at 140°; it was also found in boilers III and IV. One hundred and forty degrees is not high enough for its complete precipitation. Below 140°, without doubt, concentration plays the most important role in its precipitation.

*Zeit. Angew. Chem., April, 1905, p. 541.

Magnesium salts separated as $Mg(OH)_2$ with difficulty, and only above 100°. A large quantity of $MgSO_4$ was found in solution in the water from No. IV.

EXPERIMENTAL.

It was our hope to find some definite empirical relation between the mineral content of the feed water, and the chemical composition of the scale formed. We have studied the experiences of others, and have obtained by experiment some information ourselves. Waters from a number of towns in Illinois were selected for examination because of their specific character. We tried to obtain samples of scale and the corresponding waters. This has been a difficult matter because of the almost universal use of boiler compounds. Scales from untreated waters were procured from Urbana, Beardstown, Effingham and Freeport. These were analysed and the analyses compared with the analyses of the mineral content of the water from which they had been formed.

Water I was obtained from the Urbana city supply; water II, from the Illinois river at Beardstown; water III was Little Wabash river water at Effingham; water IV was the Freeport city water supply. Complete analyses of the mineral content of each water were made; the results are reported below:

PERCENTAGE COMPOSITION OF MINERAL CONTENT OF WATERS

IONS

	Water I, Urbana, City Supply	Water II, Beardstown, Illinois River	Water III, Effingham, City Supply	Water IV, Freeport, City Supply
CO_3	60.31	39.41	33.43	51.13
Ca	16.20	18.08	18.08	19.86
Mg	7.33	7.75	7.85	10.37
SO_4	.73	16.97	16.41	5.76
SiO_2	4.61	4.43	15.14	3.78
$Fe_2O_3 + Al_2O_3$	2.35	.10	6.91	.56
Na + K	7.16	6.27	5.24	3.19
NH_4, Cl, NO_3	1.41	7.00	4.32	5.37

HYPOTHETICAL COMBINATIONS

	Water I	Water II	Water III	Water IV
$CaCO_3$	43.67	45.46	28.01	49.68
$MgCO_3$	27.40	16.50	17.36	30.34
$MgSO_4$	...	15.24	15.54	7.23
$FeCO_3 + Al_2O_3$	2.75	.07	8.98	.63
Na + K salts	21.21	18.26	14.36	7.66

Scales I and II were formed from the Urbana water supply; III and VI from Illinois river water; IV and V from the Effingham water supply and VII from the Freeport water supply. The usual method for carbonate rock analysis was used; CO_2 was determined by means of the Parr CO_2 apparatus.* H_2O was determined by the Penfield method.** Analyses and descriptions follow:

PERCENTAGE COMPOSITION OF SCALES

IONS

	I	II	III	VI	IV	V	VII
CO_3	53.44	40.90	5.46	6.86	42.79	35.45	32.26
Ca	33.78	24.53	24.89	20.04	31.61	27.55	24.02
Mg	3.06	9.63	5.28	11.60	2.87	5.73	10.81
SO_4	.78	.32	51.04	34.36	3.86	7.81	1.63
SiO_2	1.70	8.79	2.05	2.56	6.56	8.13	5.68
$Fe_2O_3 + Al_2O_3$	3.11	2.89	2.14	6.52	5.45	4.25	8.06
Na + K	....	.71	....	....	.40	.14	....
$(OH)_2$	2.43	10.81	7.65	16.54	5.47	8.73	16.80
H_2O	2.28	1.37	2.03	1.58	2.01	2.63	1.50

HYPOTHETICAL COMBINATIONS

	I	II	III	VI	IV	V	VII
$CaCO_3$	83.62	61.22	9.06	11.38	71.03	58.85	53.55
$CaSO_4$	1.11	....	72.32	48.69	5.48	11.07	2.31
$MgCO_3$	4.58	5.92	....	2.20	3.23	1.64	3.79
$Mg(OH)_2$	4.18	18.76	12.63	27.76	6.86	3.71	25.87
$MgSO_4$	...	.40	....	....	....	....	....
$Fe_2O_3 + Al_2O_3$	3.11	2.87	2.14	6.52	5.45	4.25	8.06
H_2O	.06	....	2.03	1.58	2.01	.40	0.19
Na_2CO_3	...	1.46	....	....	.64	.18	....
SiO_2	1.70	8.79	2.05	2.56	6.56	8.17	5.68

DESCRIPTION OF SCALES.

I. A soft scale which had almost closed up a tube in a feed water heater at the Urbana water works. This scale was soft and crumbly, white, with thick red streaks of Fe_2O_3 through the mass, and with no crystalline structure. The pressure in the heater was 100 lbs. or 165°C., but as the water did not remain in contact with the tubes for any length of time, it is evident that the $CaSO_4$ found in the scale, even though insignificant in amount, must have been deposited through formation of anhydrite from the gypsum in the water at the high temperature, and not by concentration.

II. A soft, friable scale deposited from water I, in a teakettle. It was of uniform appearance, in color a light gray. Since the temperature of the water reached only 100°, no $CaSO_4$ was found in the scale. A higher magnesium content is found, however, the $Mg(OH)_2$ being four times as much as in scale I; the high silica would seem to show that SiO_2 is carried down mechanically rather than forced out of solution by heat.

III. Scale from a boiler in the C. B. & Q. pumping house on Illinois river at Beardstown, Illinois. Pressure, 110 lbs.; the boiler had not been washed out for about four weeks. A very hard, dark scale, in thin layers with the laminated appearance of a sulfate scale.

*Zeit fur anorg. Chem., VII, p. 22.

**8th Int. Congress App. Chem., 10, p. 217.

It contained the hightest percentage of SO_4 of any of the scales studied.

VI. Scale from the boiler in the C. B. & Q. shops at Beardstown using same water as scale III. It was also a hard, crystalline crust, but not so hard as scale III, and it did not contain as much carbonaceous matter. The pressure was 100 lbs., but this boiler was washed out every two weeks. In this scale the SO_4 is lower than in III, the percentages being 34.36 and 51.04, respectively. The pressure being approximately the same, and the water the same, the length of time before blow-off must have been the cause. In scale III, the concentration being allowed to proceed for almost twice as long as in scale VI, the water became stronger in alkali salts, which caused the separation of more sulfate, since $CaSO_4$ can be changed to anhydrite and so precipitated at as low a temperature as 130° in a saturated NaCl solution. Also $CaCO_3$ is more soluble in an alkaline solution than in pure water.

IV and V. Scales from the boiler of a meat block factory at Effingham. This scale as received was of two kinds; one a soft, rather amorphous gray crust, about 4/5 mm. in thickness, the other a harder, more crystalline scale, about 1 mm. thick and having about the same appearance as scales III and VI, although not so decidedly crystalline. No. IV, the soft scale, contained less $CaSO_4$ than No. V, the percentages being 5.5 and 11.0 respectively, less $Mg(OH)_2$, the percentages being 6.86 and 13.71 respectively, but more $CaCO_3$, the percentages being 71.0 and 58.9 respectively. It is seen that scale No. V, even though hard and crystalline, and of about the same appearance as No. VI, contains much more $CaCO_3$. The difference in composition of Nos. IV and V, and III and VI can only be explained as difference in boiler conditions, as the waters from which they are formed are similar. In fact, the Effingham water contains less $CaCO_3$ and Na salts and more SiO_2 and Fe_2O_3 and Al_2O_3, conditions which are considered as producers of a harder, higher sulfate scale. The boiler conditions in the Effingham scale were: pressure, 80 lbs.; washed out every 15 days.

Scale VII was from the High School at Freeport, Illinois. It was about 2 mm. thick, rather soft and amorphous, and of a pink tinge, due to a trace of manganese and a high iron content. This is about the usual scale formed from a water of the type of the Freeport city supply.

In sulfate waters, the composition of scale depends more upon the boiler, and the time of blowing off, than upon the composition of the mineral content of the water. The scale varies greatly even in the same boiler and unless uniform heating and feeding is possible, a uniform scale will not be formed. Hence, in practice, no numerical formulae can be derived or applied which will give the composition of the scale as a whole, even if the temperature and pressure in the boiler and the mineral content of the water are known.

METHOD FOR THE DETERMINATION OF HYDROGEN SULFIDE IN MINERAL WATERS

Our attention on several occasions has been called to the presence of hydrogen sulfide in specimens of water which have been received at this laboratory. Owing to the fact that there is considerable loss during shipment either because of escape of gas or because of its oxidation to sulfate, it is not deemed advisable to make examinations in the laboratory of such samples collected and shipped in the ordinary manner. Considerable time and expense is involved in making determinations in the field, and in order to overcome these objections a method of determination modeled on the method given by Treadwell and Hall (Analytical Chemistry, volume II, 636, second edition) has been devised.

A collection outfit containing three 250 c.c. glass stoppered bottles is used. These bottles are graduated at 175 c.c. by a mark extending around the outside. Into each bottle is placed a definite quantity (usually 25 c.c.) of N/100 iodine solution containing 2 grams of potassium iodide to the liter. The bottles are sent to the collector with instructions to fill each to the mark with representative samples of the water. At the time the bottles are sent out a fourth bottle is prepared for the standardization of the iodine solution. Twenty-five c.c. of the solution are introduced and it is filled to the mark with distilled water. This bottle is kept in the laboratory until the others containing the samples are returned. When the samples are received at the laboratory the contents of the four bottles are titrated with an accurately standardized sodium thiosulfate solution (N/100 or N/40, according to the amount of hydrogen sulfide present), using starch as an indicator. The number of c.c. of sodium thiosulfate used by the iodine solution in the distilled water, minus the mean of number of c.c. used in the three titrations of the water under examination, is equivalent to the amount of hydrogen sulfide or soluble sulfides which the water contained. This difference, multiplied by 2.55, if N/40 thiosulfate solution is used, and by 1.0, if N/100 solution is used, gives the H_2S content, in. parts per million. More accurate results would probably be obtained if the operation were carried out in its entirety in the field, but it is often impracticable to send a representative from the laboratory for this purpose.

It is believed that the method gives a fairly approximate value of the hydrogen sulfide content. Some of the results obtained are given in the table. It is proposed to test the accuracy of the method by the analysis of typical samples in the field and comparing the results obtained after shipment.

TABLE GIVING RESULTS OF H_2S DETERMINATIONS.

Lab. No.	Date	Location	Source	Hydrogen Sulfide pts. per mil.
22601	Oct. 31, 1911	Streator	640 ft. well	14.5
22603	Oct. 31, 1911	Streator	660 ft. well	15.0
22933	Jan. 29, 1912	Joliet	300 ft. well*	16.0
22964	Feb. 6, 1912	Fairbury	2,000 ft. well	12.5
23433	June 1, 1912	Buckley	172 ft. well*	4.7
24737	Feb. 9, 1913	Chicago	212 ft. well	13.3
24989	March 31, 1913	Chicago	150 ft. well	16.0
26252	Oct. 6, 1913	Morrisonville	Spring	.0

*Flowing.

WATER PURIFICATION IN ILLINOIS*

SOURCES OF WATER SUPPLY IN ILLINOIS.

All surface streams in Illinois are subject to pollution and yet many of them must serve as sources of public water supply for municipalities. Water purification, therefore, becomes necessary in order to secure water that is free from substances detrimental to the public health and acceptably free from suspended matter. Many communities in Illinois are fortunately able to obtain from wells good public water supplies sufficient for domestic purposes. Among these are some of the largest communities in the state outside of Chicago. A large number of cities are, however, forced to use surface supplies, either because a sufficient ground water supply is not available or because the ground water is not of acceptable quality.

The situation can be most readily understood by considering available sources of water supply throughout the state. For this purpose the state may be regarded as divided into three zones—northern, central and southern. In the northern zone is included the territory north of a line drawn from Quincy to the point where the Illinois-Indiana line reaches Lake Michigan. In this zone there is generally available an abundant quantity of excellent water from deep rock wells varying in depth from about 600 ft. to 2,400 ft.

In the central zone, which lies between the line above described and a second line extending from Danville to East St. Louis, many water supplies are obtained from deep drift wells.

The third zone, which includes the remainder of the state, contains very few wells yielding sufficient water for public water supplies. The glacial drift, where it exists at all, is too thin to produce wells with sufficient yield and the waters from rock wells are highly impregnated with mineral matter. The few exceptions to the rule are deep wells in the limestone on the southern slope of the Ozark uplift and a few deep wells in the alluvial deposits of the Ohio and Mississippi River bottoms, which form the southern tip of the state.

Communities in the southern part of the state must, therefore, as a rule use surface water. Along the Mississippi River, even north of Quincy, it is difficult to secure ground water sufficiently free from mineral matter to render it acceptable for public water supplies. The

*Presented October 20, 1913, at a meeting of the hydraulic, sanitary and municipal section of the Western Society of Engineers by Edward Bartow and. Paul Hansen.

Mississippi River cities, therefore, must use surface supplies, usually the Mississippi River itself.

The cities along the shore of Lake Michigan use the lake water because it is most convenient and most economical.

Numerous analyses have shown that the surface water supplies of Illinois, including Lake Michigan near shore, are unsafe as sources of public water supply. The opportunities for communities to own and control entire watersheds are very few and, moreover, even if water supplies could be protected in this manner, purification would still be desirable, owing to the presence of large quantities of suspended matter in nearly all of the streams of Illinois.

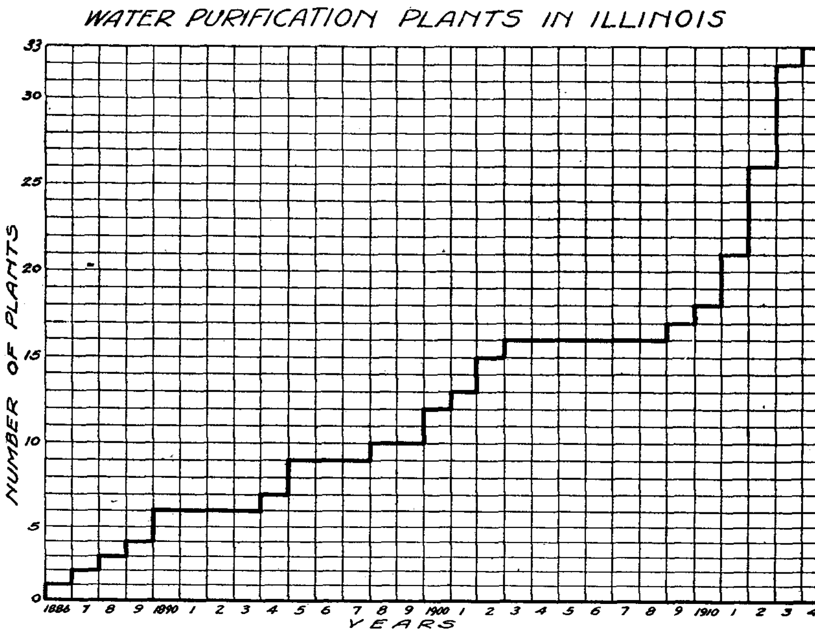


Diagram No. 1.

There are within the state of Illinois sixty-eight surface water supplies, of which thirty-three, including all the larger supplies, are now being subjected to some form of purification. Diagram No. 1 shows the progress of purification plant installation, and Diagram No. 2 shows the population served each year.

The first purification plant in Illinois was installed at Belleville in 1886. It consisted of two Hyatt pressure filters having a capacity of 300,000 gallons per day. This plant has since been abandoned. The first plant of this type in the United States was installed in 1874. A plant having a capacity of 1,350,000 gallons per day, consisting of six 10 ft. American filters, was installed at Elgin in 1888.

Two 8 ft. American pressure filters, having a capacity of 288,000 gallons per day, were installed at Streator in 1889. In the same year two 7 ft. American pressure filters, with a capacity of 220,000 gallons per day, were installed at Rogers Park. In the same year one 10 ft. American pressure filter, having a capacity of 226,000 gallons per day, was installed at Cairo.

The first gravity filter plant was installed at Quincy in 1892. It consisted of fourteen 12 ft. Jewell filters, having a total capacity of 4,000,000 gallons daily.

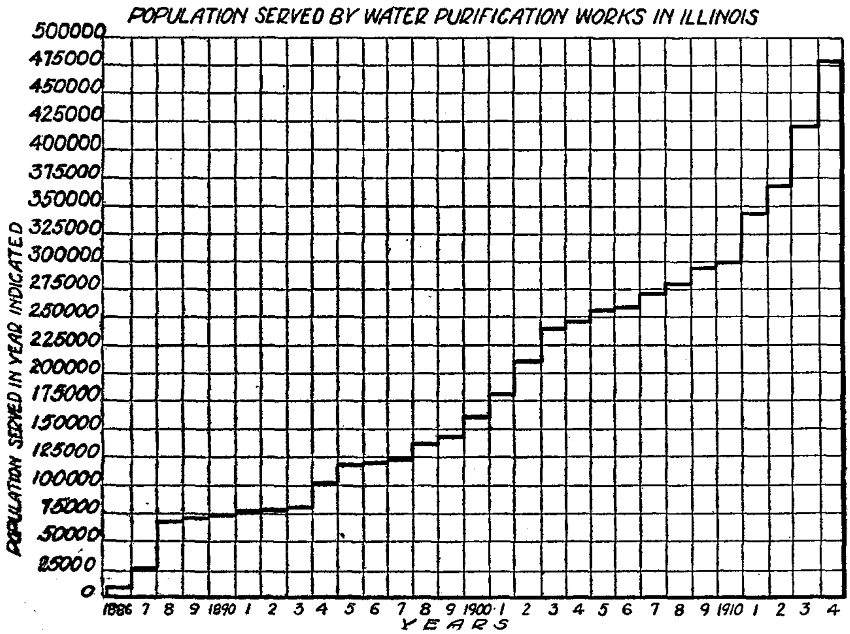


Diagram No. 2.

In 1903 the first concrete gravity filter plants were installed at Danville, with a capacity of 3,000,000 gallons per day, and at Moline, with a capacity of 4,000,000 gallons per day. To 1890 seven plants had been installed; to 1905 there were twelve; to 1910, seventeen; and since that time the increase has been rapid.

It is safe to predict that the growing recognition of the importance of having pure water supplies and the increasing demand for waters of good physical characteristics will result in the treatment of practically all surface waters within a few years.

PRESENT DISTRIBUTION OF WATER PURIFICATION WORKS.

At the end of 1914 there will be within the state thirty-six plants (see table) for the treatment of water and these will serve a population of about 490,000. This figure includes Rogers Park, but does not include a part of Chicago supplied with water sterilized by calcium hypochlorite.

Of the thirty-six plants, two, namely, Winnetka and Waukegan, are for sterilization with hypochlorite only, and will not be further considered; fourteen, including Rogers Park, are municipally owned

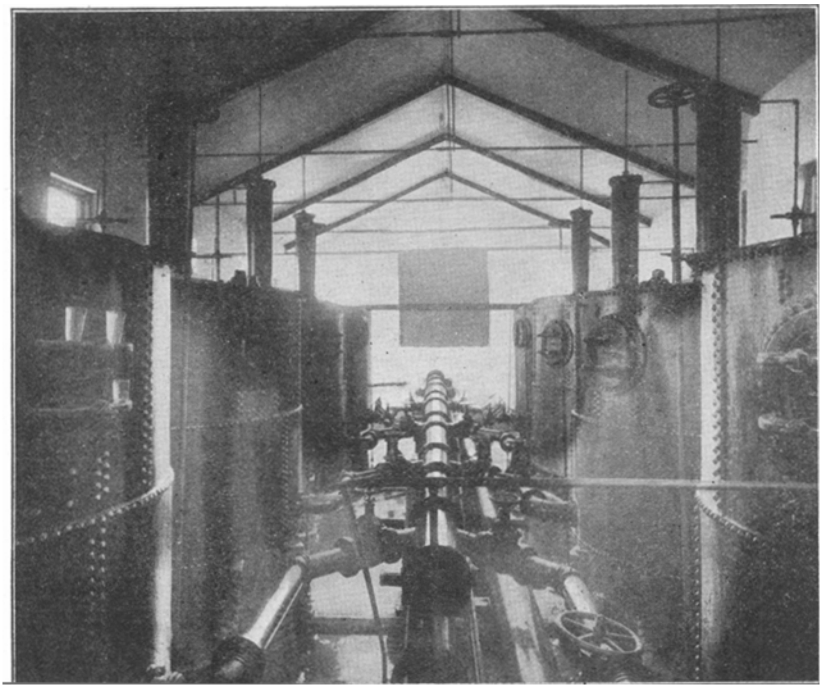


Fig. 1.—Pressure Filters, Installed at Elgin in 1888. The Hydraulic Cylinders Above the Filters Actuate Devices for Agitating the Sand Bed.

and have a combined capacity of 43.42 million gallons per day and serve a population of 167,400. Eighteen owned by companies have a combined capacity of 59.05 million gallons per day and serve a population of 293,700. Three owned by the United States Government have a combined capacity of 2.8 million gallons per day.

Considering purification plants with reference to type, there is one slow sand filter plant having a capacity of 300,000 gallons per 24 hours and serving a population of about 1,500. There are two

LIST OF WATER PURIFICATION PLANTS IN ILLINOIS, 1913

City	Population	Source of Supply	Ownership	Reaction Chambers — Minutes	Coag. Basins — Hours	Filters — M.G.P.D.	Clear Well Hours	Type of Plant	Chemicals Used	Cost of Plant per M. G. D.
R. I. Arsenal	1,000	Mississippi River	U. S.	...	4.5	1.0	1.5	Rapid Sand	A-H	...
Kenilworth	1,000	Lake Michigan	P	...	...	.5	...	Pressure Filters	A	...
Naval School	1,200	Lake Michigan	U. S.	...	12.0	.3	20.0	Slow Sand	A-H	...
Ft. Sheridan	1,500	Lake Michigan	U. S.	...	...	1.5	...	Pressure Filters	A-H	...
Hamilton	1,700	Mississippi River	M	0.3	3.0	1.5	2.5	Rapid Sand	A	...
McLeansboro	1,800	Reservoir	M	...	...	.24	...	Pressure Filters	A	...
Breese	2,200	Kaskaskia River	M	...	40.0	.2	24.0	Coagulation and settling	L-I	...
Warsaw	2,200	Mississippi River	M	...	4.0	.18	2.0	Rapid Sand	A-H	...
Winnetka	3,500	Lake Michigan	M	...	...	...	...	Sterilization	H	...
Carlinville	3,700	Macoupin Creek	P	...	5.0	.5	5.0	Rapid Sand	A	...
Lake Forest	4,000	Lake Michigan	P	...	...	1.0	...	Pressure Filters	A-H	...
Lawrenceville	4,000	Embarrass River	P	...	3.0	.65	5.0	Rapid Sand	A-H	...
Charleston	6,000	Embarrass River	M	8.0	2.8	1.0	3.0	Rapid Sand	A-H	...
Macomb	6,000	Crooked Creek	M	...	4.2	1.0	3.6	Rapid Sand	A	...
Pana	6,500	Reservoir	M	...	...	1.0	1.3	Rapid Sand	A-H	...
Pontiac	7,000	Vermilion	P	...	1.2	1.5	1.8	Rapid Sand	L-I-H	...
Mt. Carmel	8,000	Wabash	P	...	2.7	1.5	.75	Rapid Sand	A-H	$6,700
Murphysboro	8,000	Big Muddy River	P	...	8.4	2.0	4.0	Rapid Sand	L-I	...
Mt. Vernon	9,000	Reservoir	P	13.0	4.0	1.5	1.2	Rapid Sand	A-H	...
Rogers Pk.	10,000	Lake Michigan	M	...	...	3.0	...	Pressure Filters	A	...
Kankakee	14,000	Kankakee River	P	...	5.0	4.0	2.0	Rapid Sand	A-H	...
Cairo	15,000	Ohio River	P	...	3.8	3.0	.5	Rapid Sand	L-A-H	...
Granite City	15,000	Wells, Slough and Mississippi River	P	...	55.0		...	Coagulation Settling and softening	L-H	...
Streator	15,000	Vermilion River	P	...	...	2.5	...	Rapid Sand	A-H	...
Alton	18,000	Mississippi River	P	...	5.0	5.4	3.0	Rapid Sand	L-I-H	...
Freeport	18,000	Wells	P	...	1.4	2.0	2.3	Sedimentation and Filters—Iron Removal	L	...
Waukegan	18,000	Lake Michigan	M	...	...	...	...	Sterilization	H	$300
Urbana and Champaign	22,000	Wells	P	...	3.0	2.0	9.0	Aeration and rapid sand—Iron removal	...	...
Evanston	26,000	Lake Michigan	M	19.0	1.7	12.0	4.0	Rapid sand	A-H	...
Rock Island	26,000	Mississippi River	M	...	12.0	6.0	24.0	Rapid sand	A-H	$10,800
Elgin	27,000	Wells and Fox R	M	...	...	2.3	...	Pressure Filters	A	...
Moline	27,000	Mississippi River	M	...	2.5	6.0	3.0	Rapid Sand	A-H	...
Danville	30,000	Vermilion River	P	...	1.5	4.5	2.4	Rapid Sand	L-I-H	...
Decatur	35,000	Sangamon River	M	16.0	4.0	9.0	4.0	Rapid Sand	A-H	$15,400
Quincy	37,000	Mississippi River	P	16.5	4.6	6.0	.7	Rapid Sand	A-L-I-H	11,100
E. St. Louis	65,000	Mississippi River	P	...	18.0	16.5	3.4	Rapid Sand	A-L-I-H	...

LEGEND: A—Alum. L—Lime. I—Iron. H—Hypo. M—Municipal. P—Private. U. S.—U. S. Government plants utilizing sedimentation and coagulation only, which have a combined capacity of 3.7 million gallons per day and serve a population of 17,200. There are five plants with pressure filters having a combined capacity of 6.25 million gallons and serving a population of about 18,300. A sixth plant, at Elgin, now practically abandoned, owing to the availability of water from deep rock wells, may be added to this number. This plant would raise the combined capacity to 5,500,000 gallons per 24 hours and increase the population served to 45,300. There are two plants equipped with the pressure type of filter,

Fig. 2.—Exterior View of the Modern Mechanical Filter Plant at Rock Island. This Plant Is Built Within One of Four Abandoned Slow Sand Filter Units and Shows the Striking Contrast in Size.

but so installed that they act virtually as gravity filters. These plants have a combined capacity of 19,000,000 gallons per day and serve a population of 80,000. The most general type of filter is the open gravity, mechanical filter, and this type is used, or about to be used, at twenty-two plants having a combined capacity of 68.48 million gallons per day and serving a population of 291,100. Two iron-removal plants designed for the removal of iron from ground waters have a combined capacity of 6,000,000 gallons per day and serve a population of about 40,000.

PURIFICATION BY SLOW SAND FILTRATION.

The first effort to purify water in Illinois by slow sand filtration was made at Rock Island in 1898. The process soon proved totally unsuited for the highly turbid and often colored water of the Mississippi river at this point. In 1911 this plant was replaced by a modern mechanical gravity filter plant (Fig. 2). The only slow sand filter plant now in operation is at the United States Naval Training Station on the shore of Lake Michigan. The source of water supply is Lake Michigan, 1,200 feet from shore. The plant is of approved design and utilizes sand having an effective size of 0.32 mm. and

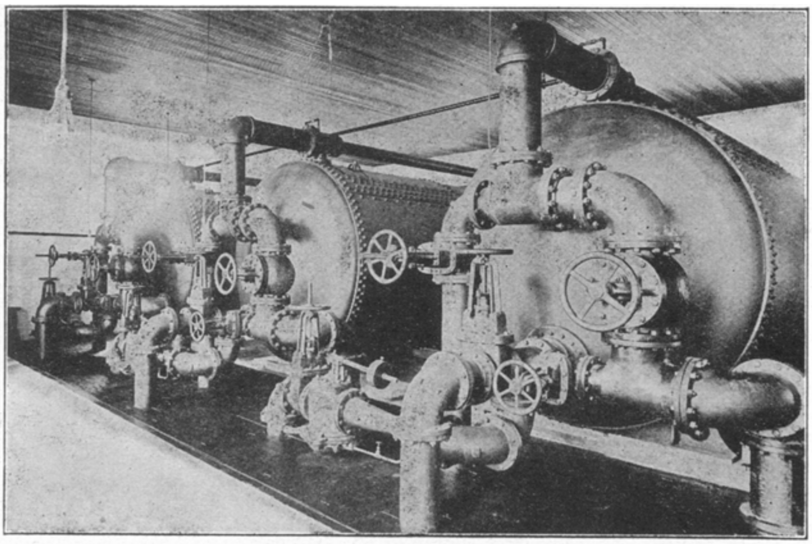


Fig. 3.—Pressure Filter Plant of Modern Construction at Fort Sheridan.

having a uniformity coefficient of 2.60. The ordinary rate of filtration is 4.6 million gallons per day. During the first few years of operation, the Lake Michigan water was pumped directly to the surface of the filters, but the frequent high turbidity placed such a burden on the filters that during the past year a sedimentation tank, having a twelve-hour period of retention, was installed. The preliminary treatment thus obtained failed to materially improve conditions and it is now proposed to assist sedimentation by means of the addition of a chemical coagulant.

PURIFICATION BY SEDIMENTATION ASSISTED BY COAGULATION.

The two plants for treating water by coagulation and sedimentation only are located at Breese and Granite City, respectively. The plant at Breese has a nominal capacity of about 200,000 gallons per 24 hours and a sedimentation period of about 40 hours. Lime and iron are used as coagulants. This plant has been in operation something less than a year, and up to date has proved very inefficient. Part of the inefficiency may be explained by certain defects in design, but even with these defects corrected and with intelligent and painstaking operation, there will still be difficulty in securing as good results as have-been obtained at the St. Louis water purification plant, after which this plant was modeled.

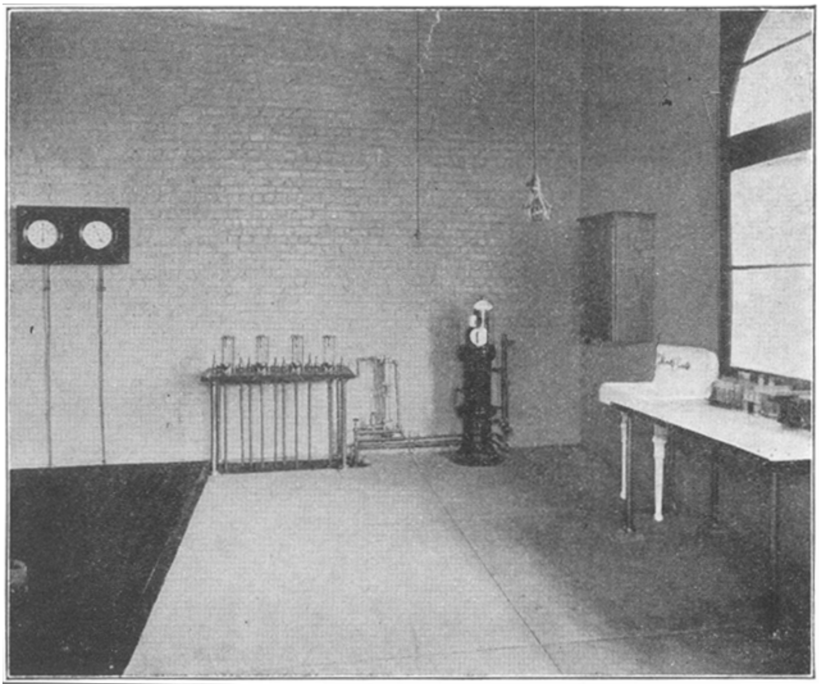


Fig. 4.—Ft. Sheridan Filter Plant—Sampling Taps in Center.

The other installation is at Granite City, where a most interesting treatment is adapted to the peculiarities of local conditions. The water supply is drawn partly from the Mississippi river, partly from a slough formed in an old channel of the Mississippi, and partly from tubular wells yielding water containing large quantities of iron. The Mississippi river or the slough water is mixed with the ground water in proportions found by experience to be suitable, and to the mixture is added a quantity of lime. The lime causes a rapid precipitation of ferric hydrate and also partially softens the water. The total sedimentation period is 55 hours.

MECHANICAL FILTRATION.

Filter Plants of the Pressure Type: The results obtained by means of pressure filters are more or less unsatisfactory. At McLeansboro, population. 1,800, there is a small pressure filter with a nominal capacity of 240,000 gallons per day, provided with neither coagulating basins nor clear-water storage. The water as it comes from the filters is generally turbid and the bacterial removal is very low. The plant could be improved by modifications in the coagu-

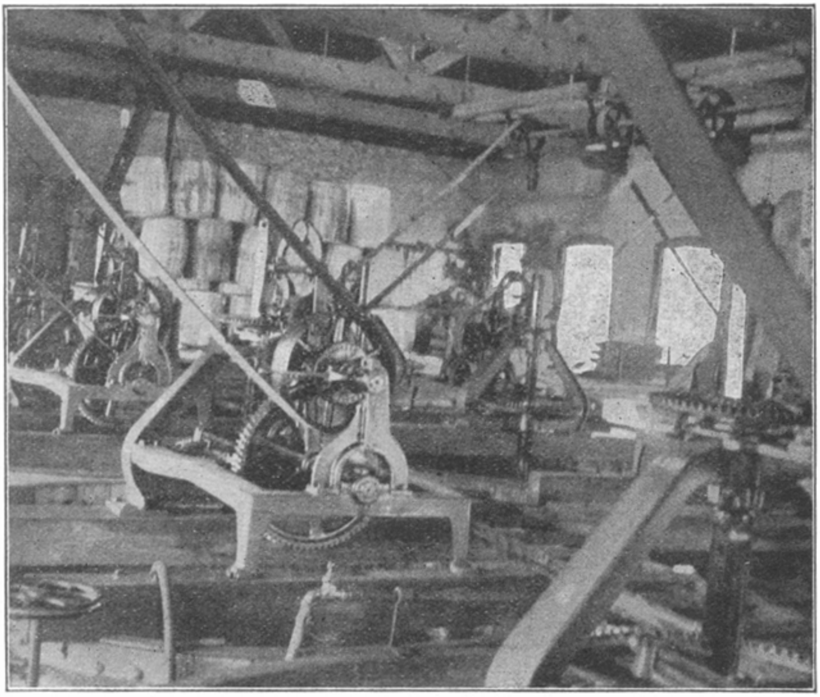


Fig. 5.—Interior View of Old Warren Filter Plant at Decatur. Note the Elaborate Machinery for Operating Sand Rakes.

lant preparation and feed devices, but it is not probable that it will give entire success.

There has been greater success at Kenilworth, where there are pressure filters having a nominal capacity greatly in excess of the consumption. At Lake Forest a safe water is obtained with pressure filters assisted by sterilization with hypochlorite, but at times the water in the mains has been turbid. The good results at Lake Forest must be in large part ascribed to the maintenance of systematic analytical control.

The new plant at Fort Sheridan (Fig. 3) has a capacity of 1,500,000 gallons, but it is rarely called upon to supply more than 500,000 gallons. It has not been under observation long enough to determine its success or non-success. In the absence of coagulating basins, much difficulty has been encountered in securing good coagulation of the water, especially in cold weather, and it is probable that some of the alum passes through into the filtered water. The bacterial results (Fig. 4) may be maintained reasonably low by the use of calcium hypochlorite, for which the plant is equipped. With the present small consumption, the plant, if properly operated, should

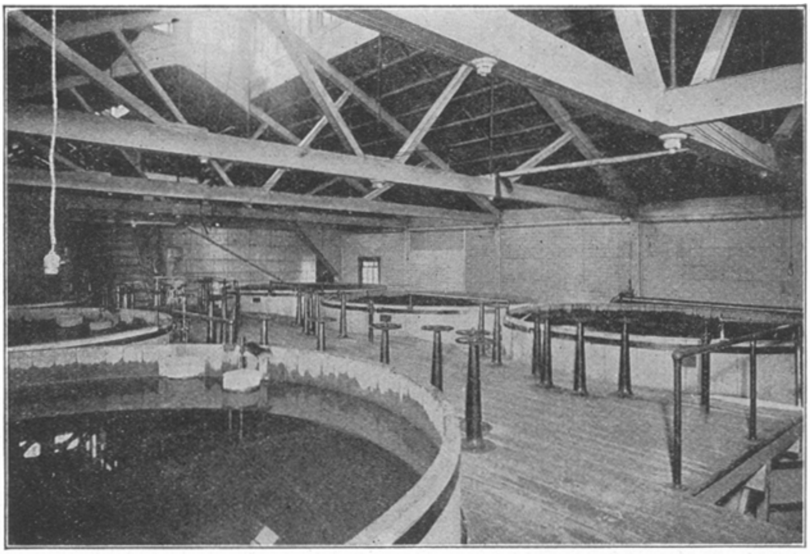


Fig. 6.—Operating Floor of Filter Plant at Cairo. Note Large Wooden Sedimentation Tanks in Left Background.

be capable of delivering a reasonably clear and safe water to the consumers.

Modified Pressure Filters: Filters of the pressure type, but operated as gravity filters, are used at East St. Louis and Streator. They are enclosed in steel shells just as are ordinary pressure filters, but otherwise they operate in the manner of gravity filters; that is to say, the water flows into them under a head of a few feet from the coagulation and sedimentation basins and the effluent passes into a clear-water reservoir. Thus the filters are not at all subject to the influence of the pumps. When such filters are properly designed and properly controlled, they give good results, but they have the serious disadvantage of relative inaccessibility. Both of these plants are under careful management, and available data indicate that they produce regularly acceptable results.

Mechanical Gravity Filters: The open gravity type of filter has come to be recognized as the standard installation, and, as will be observed in the table previously referred to, the great majority of plants are of this type. Within the state of Illinois may be found plants representative of almost every stage in the development of gravity filters. The old plants at Quincy and Decatur (Fig. 5), both now being replaced by new and larger plants of most modern construction, are examples of early practice. At Quincy in the nine-

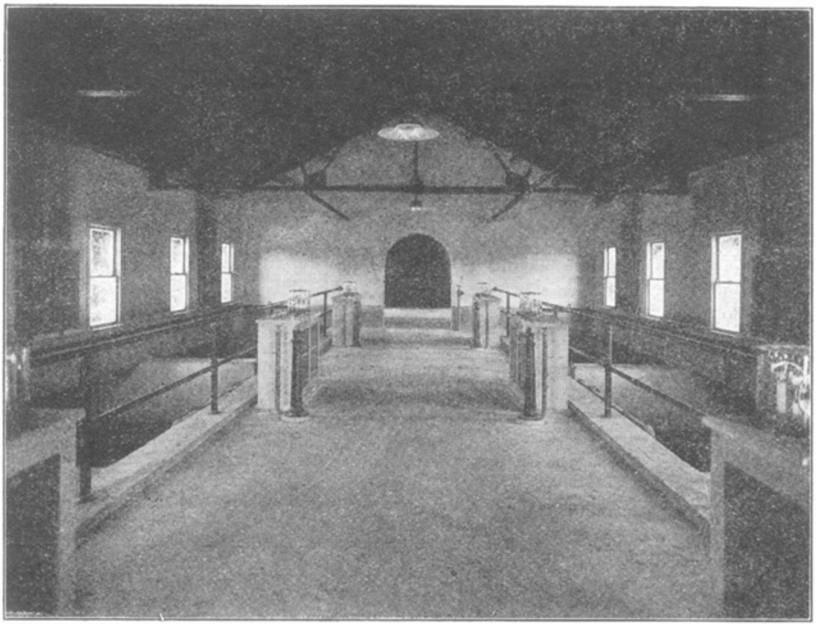


Fig. 7.—Operating Platform—Rock Island Filter Plant.

ties a series of important experiments were conducted which greatly increased our knowledge with reference to the use of lime and iron as coagulants. From these we pass through later developments at Cairo (Fig. 6), Pontiac, Alton, Danville, Moline, and finally reach the most up-to-date installations now in use at Rock Island (Fig. 7), and under construction at Quincy, Decatur and Evanston.

A group of the older plants, including the Cairo plant and the old plants at Quincy and Decatur, give poor results, primarily because they are now worked beyond their normal capacity. At the present time, however, these old plants are generally producing a safe water as a result of the addition of calcium hypochlorite as a sterilizing agent.

There are plants at Pontiac, Warsaw, and Lawrenceville of old design, but of comparatively recent installation. The Pontiac and Lawrenceville plants are faulty in design and operation, but hypochlorite is now maintaining the water safe in each instance.

Component Parts of Mechanical Filter Plants: Mechanical filtration in Illinois can be most advantageously discussed in a brief

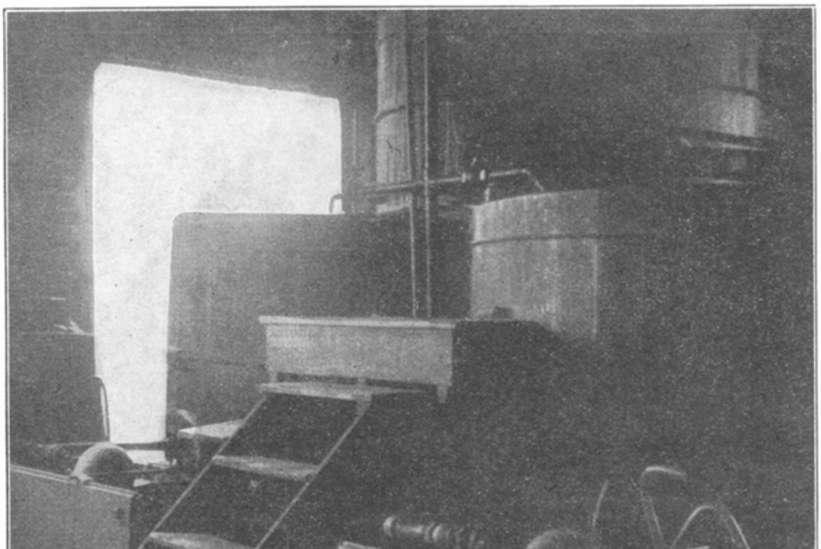


Fig. 8.—An Early Form of Proportional Chemical Feed of the Egyptian Water Wheel Type. Still Doing Satisfactory Work.

space by discussing the several component parts in the light of Illinois practice rather than by describing plant by plant.

Coagulant Preparation and Feed Devices: The chemical preparation and feed devices constitute a most important part of a mechanical filtration plant, though perhaps the least costly part. It is essential that the chemicals be added in the proper quantities and uniformly. But little real advance has been made in the design of the chemical preparation and feed devices. An early type, as exemplified in the Egyptian water wheel arrangement at Decatur

(Fig. 8), still gives very satisfactory results as compared with the more modern designs. This device consists of a dipper wheel made of bent piping, revolving partially submerged in a tank full of solution, the surface of which is maintained at a constant level. The wheel is actuated by a propeller placed in the raw water inlet pipe, so that it revolves and dips up solution at a rate approximately proportional to the volume of water entering the plant. The solution, which is made of a suitable strength to secure the requisite application to the raw water, flows out through the hollow hub of the dipper

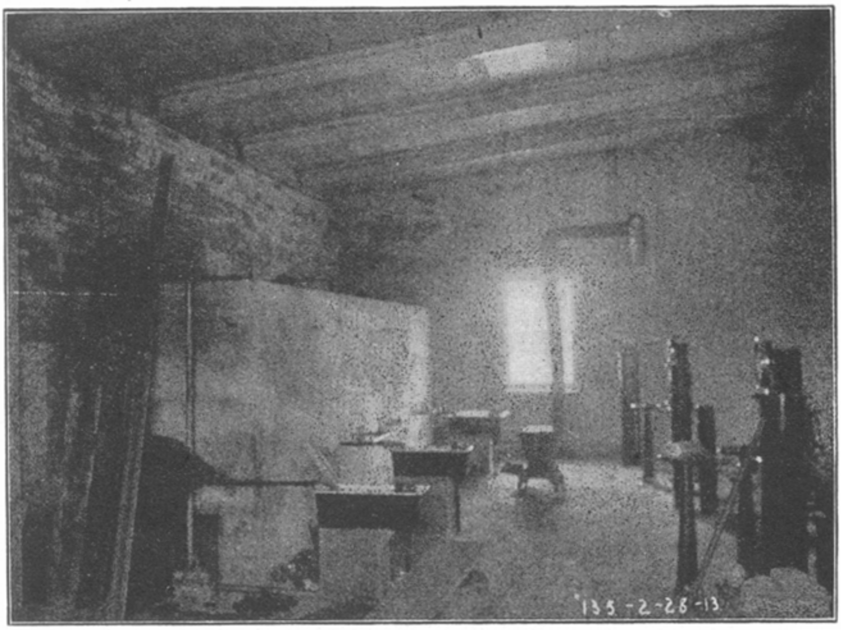


Fig. 9.—Chemical Storage Tanks of Concrete and Enamel Lined Orifice Boxes at Mt. Vernon. On Right Are Shown Loss of Head Gages and Valve Stands in Front of Filters.

wheel and is conveyed by suitable piping to the desired point of application.

A very common and generally satisfactory device for maintaining a uniform flow of coagulant is the so-called constant head orifice box (Figs. 9 and 10). In this device a constant head of solution is maintained over a free discharging orifice of sufficient size to deliver the requisite quantity of solution. In the more modern types the orifice is made adjustable so that the application of chemical may be varied without changing the strength of solution. A somewhat ingenious modification of the principle involved in this device is found at Alton. This apparatus is more compact than the ordinary constant head orifice box and is arranged for ready flushing out with clear water when desirable.

At Mt. Carmel is a simple form of apparatus (Fig. 11) which applies the chemical at a rate directly proportional to the volume of water entering the plant. It performs the same function as does the Eyptian water wheel above described, but somewhat more accurately. The water entering the plant is received in a small chamber with an orifice in the bottom. Within the chamber is a float connected

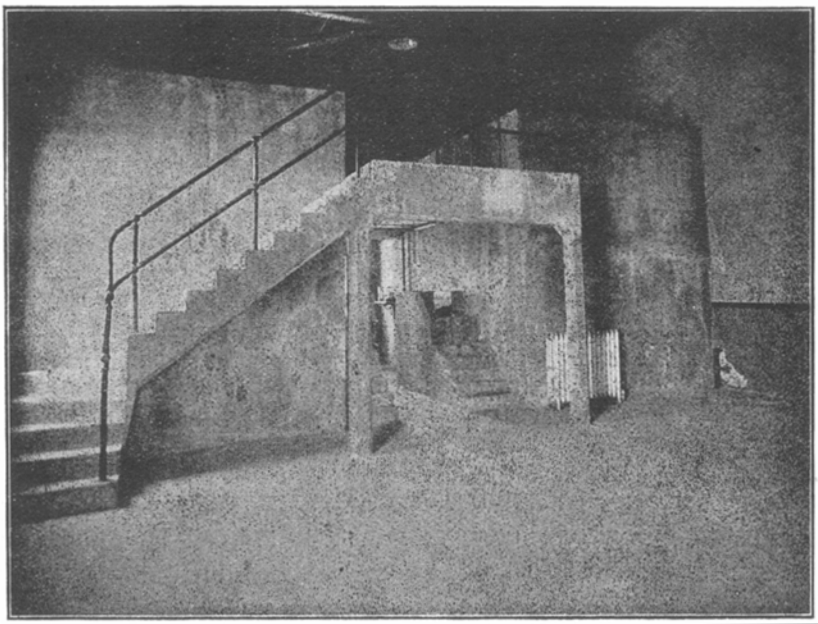


Fig. 10.—Chemical Solution Tanks and an Orifice Feed Box, All of Reinforced Concrete. In Use at Rock Island.

to one end of a lever arm, the other end of which is connected to an orifice attached at the end of a flexible pipe placed within a constant level solution tank. The apparatus is so adjusted that the head of water over the orifice in the inlet chamber to the plant is a fixed multiple of the head of solution over the orifice in the solution box.

At some of the plants in the state, notably at Cairo and at the new Evanston plant, solution pumps will be used to discharge the chemical into the raw water at the proper rate. The chemical pumps at Ft. Sheridan and Waukegan are actuated by the pulsations of the service pumps by means of water connections. Their rate of opera-

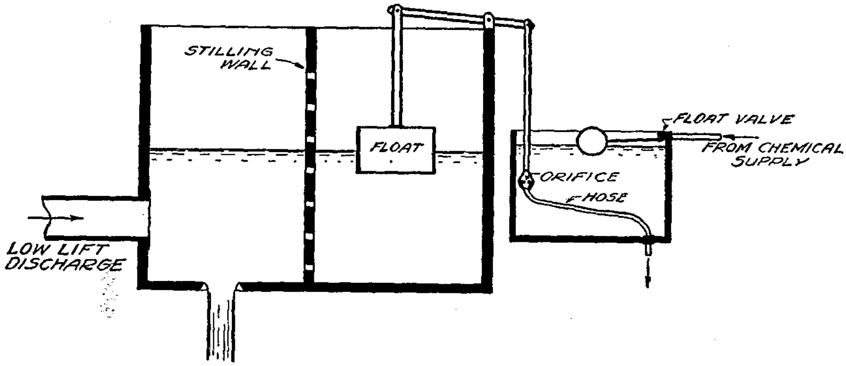


Fig. 11.—A Simple Device for Feeding Chemical Solution at a Rate Proportional to the Rate of Flow of Incoming Raw Water From Low Lift Pumps. In Use at Mt. Carmel, Ill.

tion is, therefore, proportional to the rate of operation of the service pumps.

Plain Sedimentation Basins: Plain sedimentation is an unusual preliminary to chemical coagulation and sedimentation and filtration, but appears to have considerable value in the treatment of waters carrying heavy turbidities in that it economizes on coagulant and produces a more uniform water to handle. Preliminary sedimentation is systematically used at East St. Louis (Figs. 12 and 13), where the retention period is approximately ten hours. At Rock Island

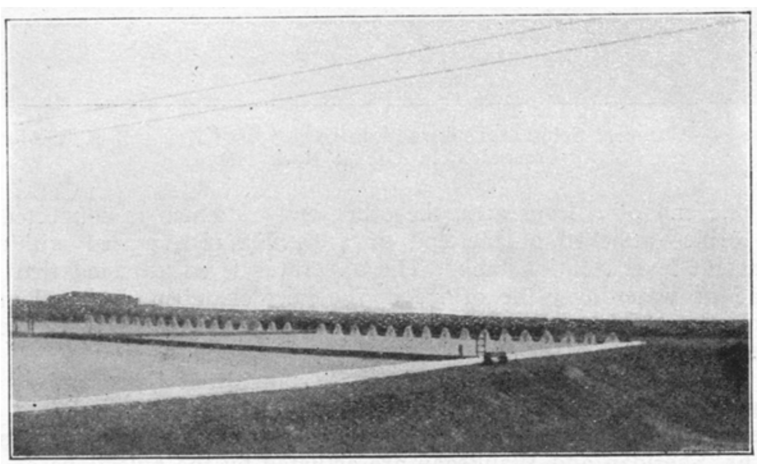


Fig. 12.—East St. Louis—Preliminary Settling Basin in Operation. Inlet End.

it is also used, the retention period being about twelve hours; the arrangement is such, however, that coagulant may be added at the entrance of this basin when desired. At Mt. Vernon and Pana a prolonged period of sedimentation is had in impounding reservoirs, but these cannot be regarded as parts of the filtration plant.

Reaction Chambers: Within the last few years the reaction chamber has come to be recognized as an important part of a mechanical filter plant. Its function is to maintain the water in gentle agitation after the coagulant is added until the reaction is complete. Five plants in Illinois include this feature, namely, those at Evanston, Decatur (new plant), Quincy (new plant), Charleston, and at Mt. Vernon. All these plants are now under construction or were com-

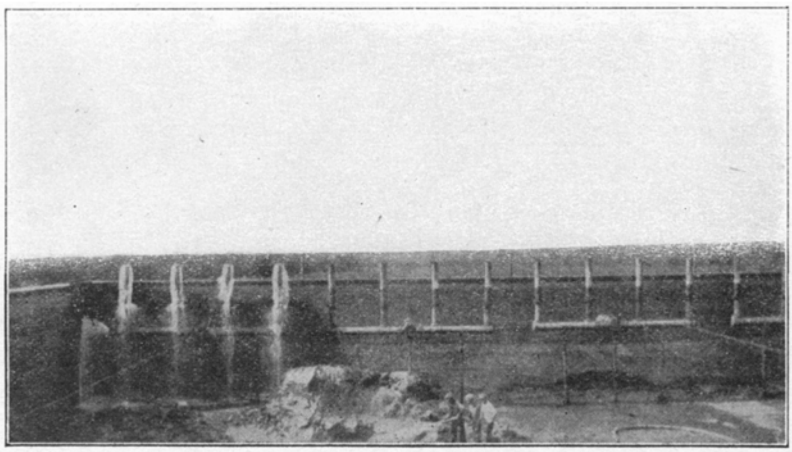


Fig. 13.—East St. Louis—Cleaning Preliminary Settling Basin.

pleted during the present year. Practice varies with respect to the retention period from eight minutes at Charleston to nineteen minutes at Evanston. The reaction chamber is generally a conveniently shaped compartment adjacent to the coagulating basins and highly baffled to produce a velocity of between ½ foot and 1½ feet per second. The baffles are generally of wood and so arranged that they may be moved from time to time to meet the requirements of varying quantities of water treated by the plant.

Coagulation and Sedimentation Basins: The general tendency in filtration practice in recent years in this state, as well as in others, has been to increase the retention period in the coagulation and sedimentation basins. These basins must, of course, be designed with special reference to the water to be handled and may vary within wide limits because of this consideration. On the other hand, the advent of the reaction chamber has probably checked greater increase in size because this adjunct now performs more efficiently and in less space what sedimentation basins were formerly counted upon to do.

Notwithstanding the fact that coagulating and sedimentation basins have been regarded as more and more of a necessity, and are counted upon to do more and more of the work of purification, thereby constituting filtration a final though very important finishing process, yet some of the latest designs include no coagulation and sedimentation; for instance, those at Pana, Ft. Sheridan, and McLeansboro. Aside from these exceptions, coagulating basins

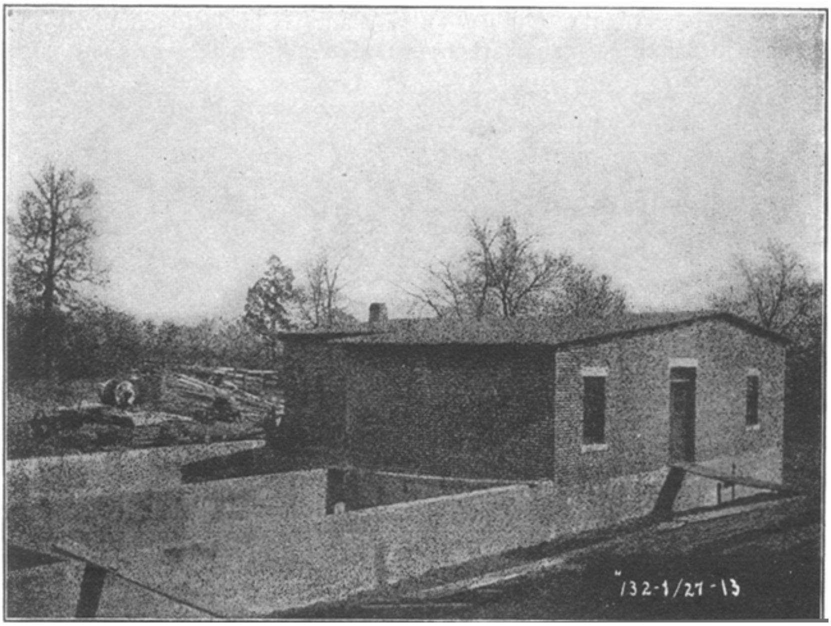


Fig. 14.—General View of Recently Completed Small but Modern Filter at Mt. Vernon. Coagulating and Sedimentation Basin in Foreground. Reaction Chamber Is Placed Under Projection to Building.

are used, and the periods of retention vary from 1½ hours at Danville to 18 hours at East St. Louis. The new plant at Evanston will have basins with a retention period of 1.7 hours. Here the turbidity will be only occasionally heavy and never difficult to handle. The new plant at Decatur will have basins of 4 hours' retention to handle the moderately troublesome water of the Sangamon. At Quincy 4.6 hours will be used, combined with much elasticity in operating arrangements, to meet the requirements of the very troublesome water of the Mississippi river.

Coagulation and sedimentation basins are generally provided in duplicate, and sometimes these basins are of different sizes to give greater range in the retention periods available. This latter arrangement obtains in the new plant at Quincy. In the larger and more modern plants, the basins are arranged so they can be operated in series or in parallel, with or without the reaction chamber, and sometimes still other combinations are provided. In the smaller plants, however, the tendency in the design of sedimentation and coagulation basins is toward simplicity. With the advent of the reaction

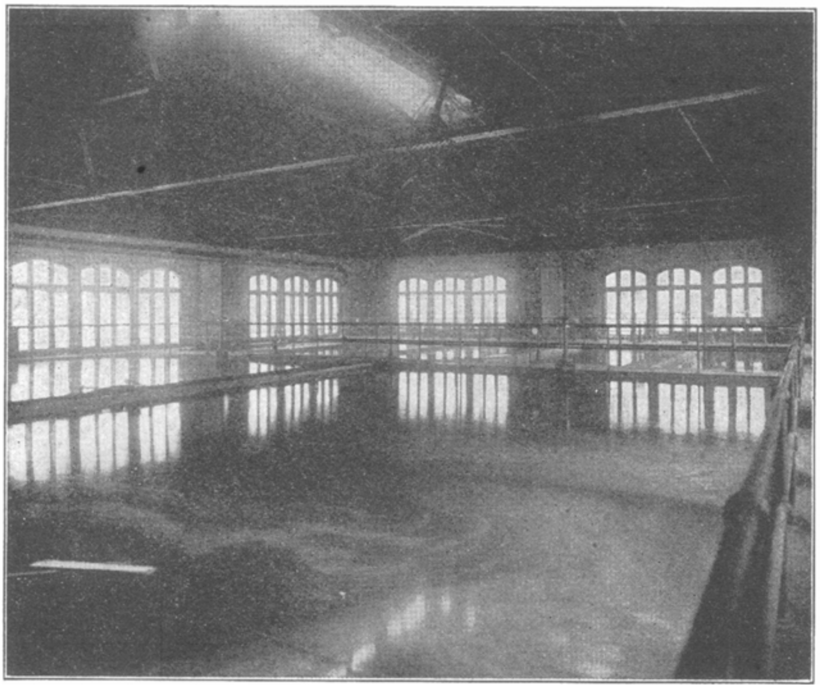


Fig. 15.—General Interior View of Moline Filter Plant. Coagulating and Sedimentation Basins in Foreground. Filters in Background.

chamber even the duplicate basin is omitted, as this will afford all necessary preliminary treatment during clear-water periods.

Filters: The filters proper vary greatly in appearance, ranging from the old Jewell high wooden tanks 12 feet in diameter and 12 feet high, installed in 1891 at Quincy, to the 36-foot by 23½-foot concrete units of the new Evanston plant. With the exception of the old Warren filters at Decatur installed in 1893, there is very little essential difference in the interior arrangements between the old and the new filters. The difference lies almost wholly in progressive improvements in details of design. All have in their bottoms a grid or system of conduits (Fig. 16) with perforated brass plates or strainer heads for collecting filtered water and distributing wash water. All have a sand bed of 30 inches to 3 feet in thickness. All have the usual connections for admitting raw water at the top, for drawing off filtered water at the bottom, for filtering to waste, for admitting clear wash water at the bottom and drawing off soiled wash water at the top. All operate with a range of filtering head up to 10 feet. The greatest differences lie in the method of agitating

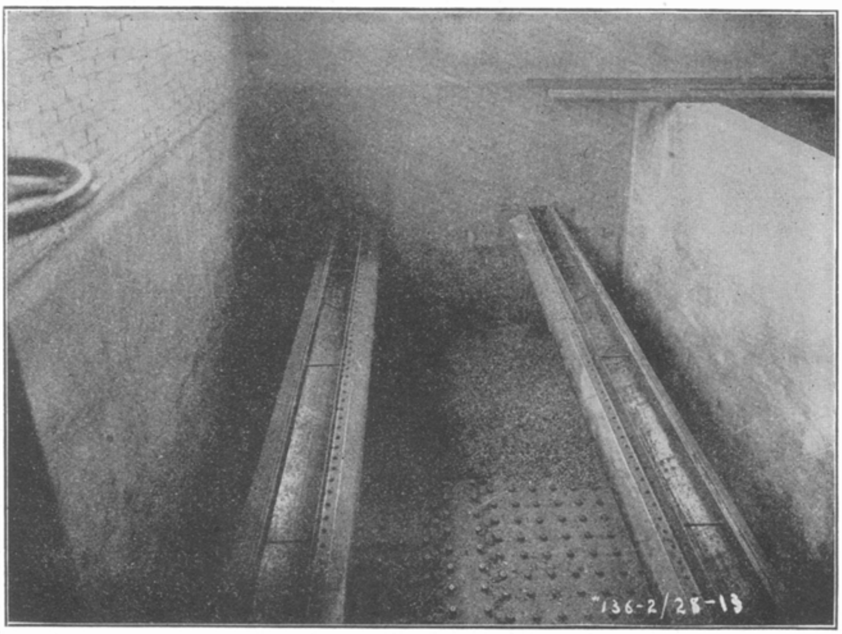


Fig. 16.—Interior View of a One Million Gallon Filter Unit at Mt. Vernon, Showing Central Manifold Casting, Strainer Heads, a Portion of Gravel in Place and Waste Water Troughs.

the sand. The older types have the cumbersome revolving rakes for agitating the sand bed, while the later designs are agitated by air blown in at the bottom, or rely entirely on the wash water when applied at a rapid rate. The old-fashioned rakes are not, however, regarded as obsolete and only during the past year a small plant at Warsaw was equipped with this agitating device.

The old Warren plant at Decatur represents a variation from the general type, in that the filters have double bottoms instead of grids or conduits, and there is a continuous perforated sheet of brass over the whole bottom of each filter instead of the small perforated strainer heads or plates. There is also a very thin bed of very coarse sand or crushed quartz not over 22 inches thick, and to offset the slight frictional resistance thereof, the filters are not permitted to operate under a head greater than 2 feet. There is also a difference in the relation of the several filters to each other, more particularly in the mode of control and washing. But as this type of filter is practically discarded and only of interest from an historical standpoint, further description will be omitted.

The most pronounced differences in design, aside from those already mentioned, between the old and new types of filters are:

First: The change from the circular to the rectangular form, which adds nothing to the efficiency, but greatly improves the general layout and is economical of space and material.

Second: The increase in size of units which likewise adds nothing to efficiency, but makes for economy of construction and facilitates operation.

Third: The introduction of a central gutter, an outgrowth of the increase in size of units which virtually divides a filter into two units, though still retaining a single set of inlet and outlet connections. This adds nothing to the efficiency and is a mere convenience of arrangement.

Fourth: The introduction of concrete collection and distribution systems, which cheapens cost of construction and permits of readily using larger conduits, thus reducing frictional resistance.

Fifth: The more careful design of troughs for carrying off soiled wash water so that the same may be carried off evenly and rapidly from all parts of the filter. This improvement was partly imposed by increased size of units, but also adds to the effectiveness of washing.

Filter Control: In the older plants the filters are always controlled by hand-operated valves, which renders the washing of filters a time-consuming and awkward operation. In the larger modern plants hydraulically-operated valves are the rule. This greatly simplifies the labor of cleaning a filter, permits of a simpler and better arrangement of the pipe gallery in front of the filters, and makes possible a neat-appearing operating floor. The main objection to hydraulically-operated valves is the annoyance of "sticking." This can, however, be largely overcome by using parallel-seated self-adjusting disk valves and by systematically cleaning the hydraulic cylinders at proper intervals.

The necessity for controlling the rate of filtration automatically is becoming more and more recognized. Even early filters had means of control, but until recently many filter operators held that an occasional partial turn of the effluént valve gave sufficiently close control. This is in large measure true, but this method places too great reliance on the watchfulness and reliability of the filter attendant. Most of the plants in the state are without automatic rate-controllers. There are three general types of filter rate-controllers in use, namely, the float type, the disk type, and the meter type. The float type in principle is simply a device for automatically maintaining a fixed head over an orifice of definite size or over a weir, generally the former. This type of controller is exemplified by those at Cairo, Pana, Moline (Fig. 17), and Danville. The disk type

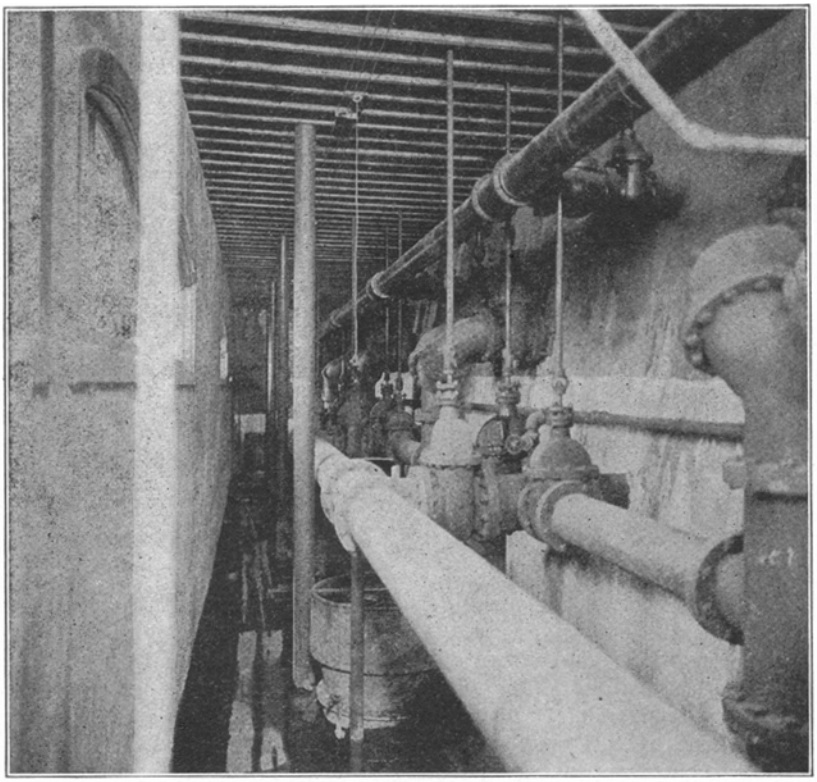


Fig. 17.—Pipe Gallery for Single Row of Filters at Moline. Note in Background Under Large Pipe a Rate Controller of the Float Type.

maintains a constant rate of flow by producing a constant head on a submerged orifice by means of properly weighted disk and balanced valve fastened to the same shaft. The dropping of the disk causes the valve to open wider and the raising thereof causes it to close. These controllers have a tendency to stick, but when carefully made and provided with properly designed valve ports, they give good results. Controllers of this type are installed at Rock Island (Fig. 18), Macomb, Alton, Mt. Vernon and Charleston. The meter type of controller depends for its operation on maintaining a constant difference of head between the throat and entrance to a Venturi tube. Any variation is transmitted to a diaphragm which actuates a pilot valve which in turn operates a gate valve. The variations in head may also be transmitted by electrical means to the gate valve. Controllers of this type are in use at Ft. Sheridan and are about to be used in connection with the two new plants at Quincy and Decatur.

Loss of head gages are devices for observing the loss of head suffered by the water in passing through a filter. Therefore, they indicate the condition of the filter sand beds and give the attendant a means whereby he can ascertain when a filter requires washing. The loss of head gages are of two types, namely, the indicating and the recording. The indicating are suitable for ordinary purposes, but there is a great advantage in having a record of the filter runs. Loss of head gages are not in as general use as they should be and in some plants they are permitted to become dismantled. Those plants having loss of head gages of the indicating type in use are Moline, Kankakee, Mt. Vernon, Macomb, Charleston, Warsaw, Hamilton and Ft. Sheridan, and Rock Island Arsenal. Rock Island has recording loss of head gages.

Clear-Water Storage: The provision made for clear-water storage varies greatly. In some plants it is scarcely more than a suction pit, while in others the storage is as much as 24 hours. The size of clear-water basins will depend largely on the storage available in distribution and equalizing reservoirs connected with the distribution system. For example, at Quincy the retention period is only 0.7 hour in the clear-water basin, but there is a reservoir holding about 14 days' supply on the distribution system. At Rock Island the clear-water basin, together with the filter plant, is at a high elevation and is directly connected with the distribution system. The storage period is 24 hours.

Generally speaking, there is a tendency to make the clear-water basin too small, when it is considered that the filters must operate at a uniform rate, no matter what the daily and hourly rate of consumption may be.

Accessories: Filter plants have a number of important accessories, the design and arrangement of which vary considerably in practice. As a rule, water from the source of supply must be raised to the filter plant ordinarily through a low lift. For this purpose electrically or steam-turbine driven centrifugal pumps are nearly always used because of their special adaptability to such service. The quantity of water pumped and the head pumped against are constant or nearly so and the total lift is not great. The water often contains grit and is often hard on piston and plunger pumps.

Wash water is supplied to filters in several ways, namely, (1) by drawing from the distribution system, (2) by installing low-lift centrifugal pumps taking suction from the clear well, each with a capacity sufficient to furnish wash water for one filter, and (3) by having an elevated storage tank supplied by small pumps starting and stopping automatically or by having a connection with the distribution system. In modern practice the storage tank is considered the most economical and desirable and is the method adopted for all of the new and larger plants now under construction. In all these cases small automatically-controlled pumps will be used, but there will be

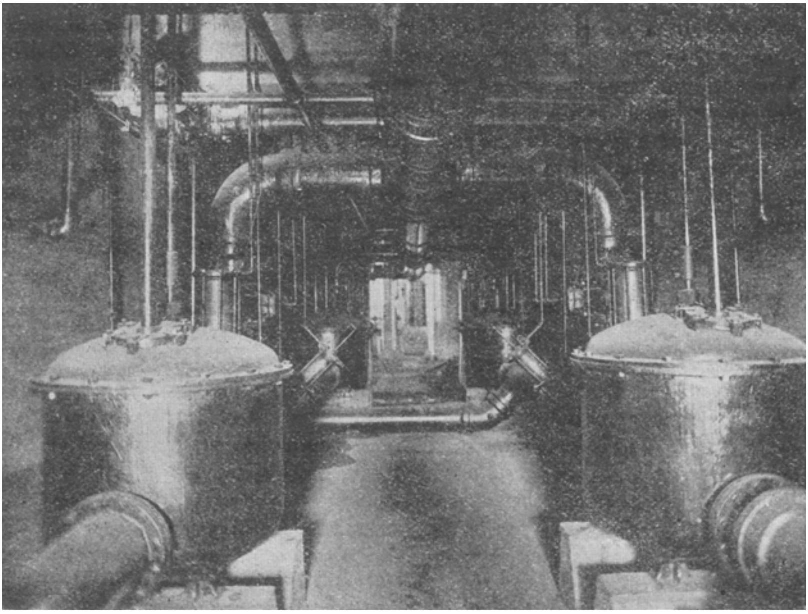


Fig. 18.—Pipe Gallery Between Two Rows of Filters at Rock Island. Illustrates Present Tendency to Secure a Clear Passageway and Ready Accessibility to All Parts. On Right and Left Foreground Are Shown Filter Rate Controllers of the Disk or Submerged Type.

in the case of the Quincy plant an emergency connection to the distribution system.

In all of the plants in this state where air agitation obtains, blowers are used, but in modern practice elsewhere compressors and air storage tanks are in favor.

Storage of chemicals is an important factor and often adequate provision is not made therefor. The storage space desirable will vary with local conditions, character of water to be treated, shipping facilities, etc., but even in small plants there should be sufficient storage available to permit of buying in carload lots. In the larger plants, large storage may be advisable in order to take advantage of market conditions.

Every filter plant should have some provision for office space, laboratory, toilet and locker rooms. Too often these matters are neglected in the smaller plants, and where proper conveniences are lacking the operation of the plant is almost certain to suffer.

A word may be said with reference to the appearance of super-

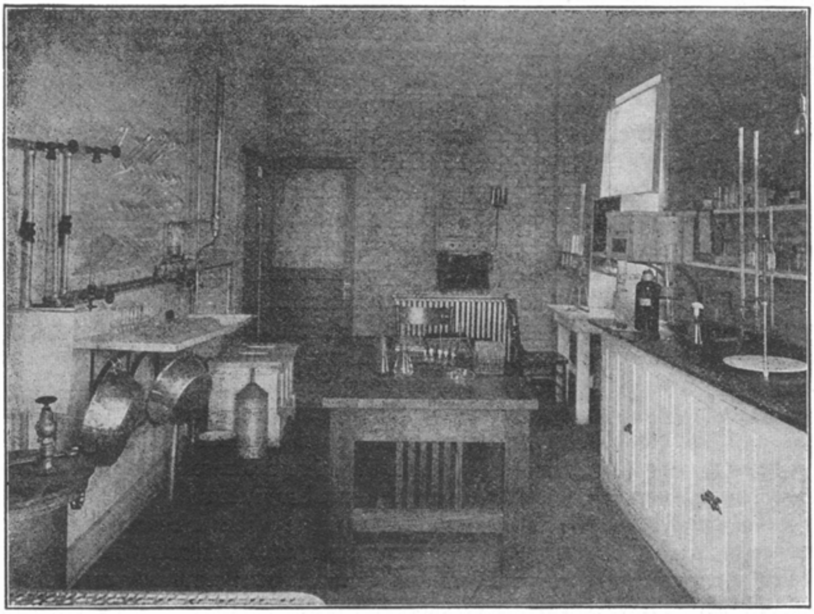


Fig. 19.—Control Laboratory at the Filter Plant of the Inter-State Water Co., Danville.

structures. Progress in this connection is being made, for it is unusual nowadays to see wooden or cheap brick barn-like structures built over large and important plants. But the superstructures for the smaller plants are still very crude in design. The additional expense for rendering these structures attractive is small compared with the cost of the whole plant, and it is eminently fitting that water-works buildings in general and filter buildings in particular should present a neat, clean and inviting appearance.

GENERAL ARRANGEMENT OF FILTER PLANTS.

The arrangement of mechanical filter plants varies greatly, depending on size of plant, local topography and other local requirements and depending on the ideas of the designing engineer. A plan that meets with general favor is what may be called the head house plan, in which the several parts of the plant are grouped about a more or less centrally located head house. The raw water is received at the head house, treated with chemicals, diverted to the reaction chambers and coagulating basins, then returned to the head house and diverted to the filters. The head house superstructure also houses chemical preparation and feed devices, machinery, laboratories, toilet rooms, locker rooms and offices. In some cases the head house is large enough for storage of chemicals also.

Frequently filter plants are not designed with a proper consideration for future extension and this in one or two instances has caused much awkwardness in making additions.

Laboratory Control: Laboratory control is feasible and necessary in even the smallest plants to secure best results. (Fig. 19.) Under actually existing conditions, laboratory control is especially necessary in the small plant because such plants are as a rule less perfect in design and construction than the larger ones. The tests required are very simply carried out and can, if necessary, be entrusted to a man of ordinary intelligence and industry, even though he has no scientific training. The determinations that should be made are turbidity, color, alkalinity, the number of bacteria and gas formers in the raw and filtered water. Solutions should also be tested, especially hypochlorite solutions. Should there be a municipal or industrial laboratory near by, it may perhaps be better in the case of small plants to have the bacterial work done there, but there is no reason why the simple physical and chemical tests above enumerated should not be made in even the smallest plants.

In conclusion, it is interesting to note that wherever reliable records can be obtained they show a marked reduction in typhoid fever even where the efficiency of the plant is not as great as it should be. At Decatur there have been no accurately-kept typhoid fever records, but the city has a reputation of being quite free from the disease. Much of this must be attributed to the old Warren filter plant, though its average efficiency, based on bacterial removal during late years, was only 90 per cent. At Moline and Rock Island the typhoid death rate has been low since the installation of filters. Shortly before placing the new plant at Rock Island in regular operation there was a serious epidemic of typhoid, showing the great danger that lurks in the use of the untreated river water.

It is unfortunate that there is not in Illinois a better system for the registration of vital statistics, since these form the best means whereby we may judge the efficiency of water purification works as well as estimate the need of such works.

Notwithstanding this lack of good vital statistics, the many advantages of having a clear, colorless water makes it safe to predict that within a few years we will see the purification of all muddy and colored surface-water supplies.

SURFACE WATER SUPPLIES OF ILLINOIS*

In Illinois there are about 332 municipal water works systems. About 79 per cent of the cities and villages of 1,000 or more population are provided with public water supplies. Not including Chicago, the aggregate population of these towns having water works is slightly over 1,630,000. The majority of these supplies are derived from wells, but over 40 per cent of this population is supplied with surface water. Chicago, which pumps its supply from Lake Michigan, is left out of consideration in compiling the accompanying data for the reason that its great size would tend toward distortion of general averages and conclusions relative to the numerous smaller supplies.

The character of the supply chosen by a town in Illinois depends largely upon the section of the state the town happens to occupy. In a general way, a good supply can most economically be obtained from wells, but in some regions ground water is to be had only in very limited quantities or is found to be of inferior quality from a mineral standpoint. Along the shores of Lake Michigan comparatively good well water is to be had in deep drillings, but in only one instance, namely, Lake Bluff, has a town chosen such a source of supply in preference to the lake.

In the northern quarter of the state good supplies are to be had from the St. Peter's and Potsdam sandstone. The former ranges in depth from about 600 to 1,500 feet, while the latter is usually at a depth of 300 to 500 feet below the St. Peter's. In the central part of the state wells drilled to these strata usually yield very highly mineralized water, frequently charged with hydrogen sulphide.

Central Illinois, however, is favored with having a heavy deposit of drift which yields an abundant supply of water in most localities. But these deposits of water-bearing gravel are also limited in extent. In a general way, to the south of a line running east and west through Champaign water is seldom obtainable in large quantities from either deep rock or drift wells and such ground water as is found is usually very hard. Exceptions to this rule exist near the southern extremity of the state, exemplified by Anna and Mounds, where excellent supplies are obtained from deep drillings in limestone. But it is frequently the case that there is practically no choice but to adopt a surface supply in southern Illinois.

All Illinois ground waters are comparatively hard, seldom having

*By Paul Hansen, Engineer, and Ralph Hilscher, Assistant Engineer.

less than 300 parts per million of dissolved solids. For small communities this water, when obtainable, is, however, often preferable to a surface supply. There is no surface water in the state, except Lake Michigan at a distance of five miles or over from shore, that is satisfactory for domestic uses at all times without purification. All surface supplies are subject to more or less pollution and there are hardly any that are not excessively turbid at times.

EXTENT OF SURFACE WATER CONSUMPTION.

Table I gives a comparison of the extent to which ground water and surface water are used for public supplies in various sections of the state. Tables II, III, IV and V list the towns using surface supplies of four different classes, namely, streams, impounding reservoirs, Lake Michigan and mixtures of surface water and ground water. In compiling Table I towns of the last-named class were considered as having surface supplies. Table VI summarizes the data in the four tables preceding.

TABLE I.
DISTRIBUTION OF WATER SUPPLIES.

Location of Cities	Number of Municipalities Supplied		Population Served			
	Ground Water	Surface Water	Total	With Ground Water Only	With Surface water in Part or Wholly	Per cent with surface water
Mississippi River banks	5	13	238,000	12,000	226,000	95.0
Mississippi River minor tributary water sheds	20	2	89,200	78,000	11,200	12.6
Rock River watershed	33	0	141,200	141,200	0	0.0
Illinois River watershed	164	12	787,000	599,300	187,700	23.8
Kaskaskia River watershed	11	12	67,400	22,300	45,100	67.0
Big Muddy River watershed	3	5	50,200	20,000	30,200	60.2
Wabash River watershed	17	13	145,400	67,600	77,800	53.5
Ohio River minor tributary watersheds	5	3	36,700	13,900	22,800	62.2
Lake Michigan (outside Chicago)	1	13	77,600	1,000	76,600	98.7
Total	250	73	1,632,700	955,300	677,400	41.5

It will be observed that out of about 332 cities and villages having public water supplies 41.5 per cent of their population is supplied with water of surface origin. About 73.4 per cent of the population using surface water is supplied with water treated in some manner for the purpose of clarifying or sterilizing the supply. The effectiveness of these treatment processes, of course, varies widely.

In a large number of towns using surface water the principal value of the supply is considered to lie in its use for fire protection. Most of the older towns of the state at some distance from Chicago began with a general use of private wells and they have been slow to give them up following the installation of municipal supplies. The unpurified surface supplies of southern Illinois seem to be very little used for drinking purposes and only to a limited extent for other domestic uses, which is not surprising considering their frequently high turbidity. The smaller communities on the

TABLE II.

CITIES HAVING SUPPLIES FROM STREAMS.

Name of City	Source of Supply	Population		Pumpage (Gals.)			Water Treatment
		Total	Per Water Service	Total	Per Capita	Per Service	
Alton	Mississippi River	18,000	8.2	2,400,000	133	1100	Mechanical filter—hypo
Belleville	East St. Louis	23,000	8.9	1,000,000	43	390	Mechanical filters—hypo
Breese	Shoal Creek	2,200	29.0	....	....	....	Coagulation & Sedimentation
Bridgeport	Lawrenceville	3,000	....	....	....	....	Mechanical filters—hypo
Cairo	Ohio River	15,000	....	....	....	....	Mechanical filters—hypo
Carlyle	Kaskaskia River	2,000	8.9	....	....	....	None
Carlinville	Macoupin Creek	3,700	9.2	370,000	100	925	Mechanical filters
Carmi	Little Wabash River	2,800	5.6	400,000	140	800	None
Charleston	Embarrass River	6,000	6.0	800,000	133	800	Mechanical filters—hypo
Chester	Mississippi River	2,800	....	70,000	25	875	None
Decatur	Sangamon River	33,000	6.7	3,000,000	91	600	Mechanical filters—hypo
East St. Louis	Mississippi River	65,000	6.5	10,000,000	143	1000	Mechanical filters—hypo
Effingham	Little Wabash R.	4,000	....	....	....	....	None
Grayville	Wabash River	2,000	12.0	200,000	100	1170	None
Greenup	Embarrass River	1,300	10.0	50,000	38	390	None
Hamilton	Mississippi River	2,000	....	....	....	....	Mechanical filters
Harrisburg	Saline River	6,000	....	....	....	....	None
Kankakee	Kankakee River	20,000	6.1	2,000,000	100	160	Mechanical filters
Lawrenceville	Embarrass River	4,000	6.2	300,000	75	460	Mechanical filters
Litchfield	Shoal Creek	3,000*	30.0	....	....	....	None
Macomb	Crooked Creek	6,000	11.0	350,000	58	530	Mechanical filters—hypo
Moline	Mississippi River	25,000	....	....	....	....	Mechanical filters—hypo
Mt. Carmel	Wabash River	7,000	6.4	1,000,000	143	900	Mechanical filters
Murphysboro	Big Muddy River	7,500	10.0	2,000,000	270	2700	Mechanical filters
Nauvoo	Mississippi River	1,000	....	....	....	....	None
New Athens	Kaskaskia River	1,200	....	....	....	....	None
Newton	Embarrass River	2,200	14.0	320,000	145	2000	None
Olney	Fox River	5,300	13.0	265,000	50	660	None
Pinckneyville	Beaucoup Creek	3,000	....	325,000	110	650	None
Pontiac	Illinois-Vermilion	6,500	7.5	900,000	138	1050	Mechanical filters—hypo
Quincy	Mississippi River	37,000	7.6	1,500,000	42	320	Mechanical filters—hypo
Rock Island	Mississippi River	25,000	....	....	....	....	Mechanical filters—hypo
Streator	Illinois-Vermilion	15,000	3.8	2,000,000	107	415	Mechanical filters—hypo
Vandalia	Kaskaskia River	3,100	11.0	140,000	47	400	None
Warsaw	Mississippi River	2,300	38.0	....	....	....	Mechanical filter
Wilmington	Kankakee River	1,500	....	....	....	....	None
		367,400					

* Population divided between stream and reservoir supply.

North Shore taking their supplies from Lake Michigan use the water very extensively, notwithstanding its unsatisfactory quality. This is probably largely due to the fact that these populations are made up of people who have always lived in cities and demand such conveniences as public water supplies and indoor plumbing. Moreover, North Shore people living in towns not having purified water have made quite general use of small house filters and also use large quantities of bottled water for drinking purposes.

Such data as are available indicate that the average population in southern Illinois towns using unpurified surface water is about 16.5 per water service, meaning that not more than one-third the people use the water in their homes. Compared with this is an ap-

TABLE III.

CITIES HAVING SUPPLIES FROM IMPOUNDING RESERVOIRS.

Name of City	Reservoir		Population		Pumpage (Gals.)			Water Treatment
	Capacity Mil. Gals.	Water-shed Area Sq. Miles	Total	Per Water Service	Total	Per Capita	Per Service	
Benton	....	....	2,700	38	....	....	....	None
Casey	....	1.	2,200	....	....	....	....	None
Centralia	950	8.	10,000	12	1,000,000	100	1,190	None
Freeburg	20	4.	1,400	17	10,000	7	120	None
Herrin	49	.57	8,000	....	....	....	....	None
Hillsboro	....	2.5	5,000	20	500,000	100	1,820	None
Litchfield	40	4.	3,000*	30	....	....	....	None
McLeansboro	75	....	1,800	30	40,000	22	670	Pressure filter
Mt. Olive	300	.38	4,000	10	500,000	125	1,250	None
Mt. Vernon	396	3.5	9,000	9	100,000	110	1,000	Mechanical filters
Pana	....	5.2	6,200	21	....	....	....	Mechanical filters
Paris	170	25.0	8,000	....	....	....	....	None
Roodhouse	....	1.0	2,000	14	65,000	33	440	None
St. Elmo	10	3.0	1,200	12	100,000	83	1,000	None
Salem	173	4.0	2,800	....	....	....	....	None
Sparta	....	.06	3,100	....	20,000	....	....	None
Staunton	....	1.6	6,000	30	....	....	....	None
Waterloo	40	....	2,100	14	700,000	330	3,000	None
White Hall	93	2.0	3,000	15	200,000	67	1,000	None
			81,500					

*Population divided between reservoir and stream supply.

TABLE IV.

CITIES TAKING SUPPLIES FROM LAKE MICHIGAN.

Name of City	Length of Intake	Population		Pumpage (Gals.)			Water Treatment
		Total	Per Water Service	Total	Per Capita	Per Service	
Evanston	5,600 ft.	26,000	5.7	6,000,000	230	1300	Hypo—new filters being built
Fort Sheridan	1,500 ft.	1,500	....	380,000	....	....	Pressure filters
Glencoe	Winnetka supply	2,000	3.7	214,000	102	397	Hypo
Highland Park	2080 ft. & 3650 ft.	5,000	5.3	545,000	110	574	Hypo
Highwood	Highland Park supply	1,200	....	160,000	133	....	Hypo
Kenilworth	1,400 ft.	1,000	5.0	100,000	100	500	Pressure filters
Lake Forest	1100 ft. 700 ft. & 30 ft.	4,000	6.0	600,000	150	900	Pressure filters and Hypo.
North Chicago	400 ft.	4,000	....	650,000	163	....	Hypo
Naval Training School	1,200 ft.	1,200	....	....	....	....	Sedimentation with slow sand filters
Waukegan	4,000 ft.	17,000	5.7	3,300,000	195	1100	Hypo
West Hammond	Hammond, Ind., supply	5,200	....	....	....	....	....
Winnetka	2200 ft. & 3000 ft.	3,500	3.7	466,000	133	490	Hypo
Wilmette	Evanston supply	5,000	3.6	400,000	80	350	Hypo
		76,600					

proximate average population of about 7 per service in towns having purified surface supplies and supplies of raw Lake Michigan water. This means that probably about two-thirds of the people use the water of better quality where it is available.

In southern Illinois, where most of the unpurified surface supplies exist, the most common source of drinking water is the private

TABLE V.

CITIES HAVING MIXED SUPPLIES OF GROUND WATER AND SURFACE WATER.

Name of City	Sources of Supply	Population		Pumpage			Water Treatment
		Total	Per Water Service	Total	Per Capita	Per Service	
Danville	Wabash-Vermilion River and wells.	30,000					Mechanical filters and hypo for river water only
Elgin	Fox River and wells	27,000	5.7	2,000,000	74	425	Pressure filters for whole supply when river is drawn from
Granite City, Madison and Venice	Mississippi River, pond and wells.	25,000	10.3	2,000,000	80	835	Coagulation, partial softening, sedimentation. & hypo
Jacksonville	Mauvaistaire Creek and wells.	16,000					None
Springfield	Sangamon River and wells.	54,000	8.9	5,300,000	98	877	None
		152,000					

TABLE VI.

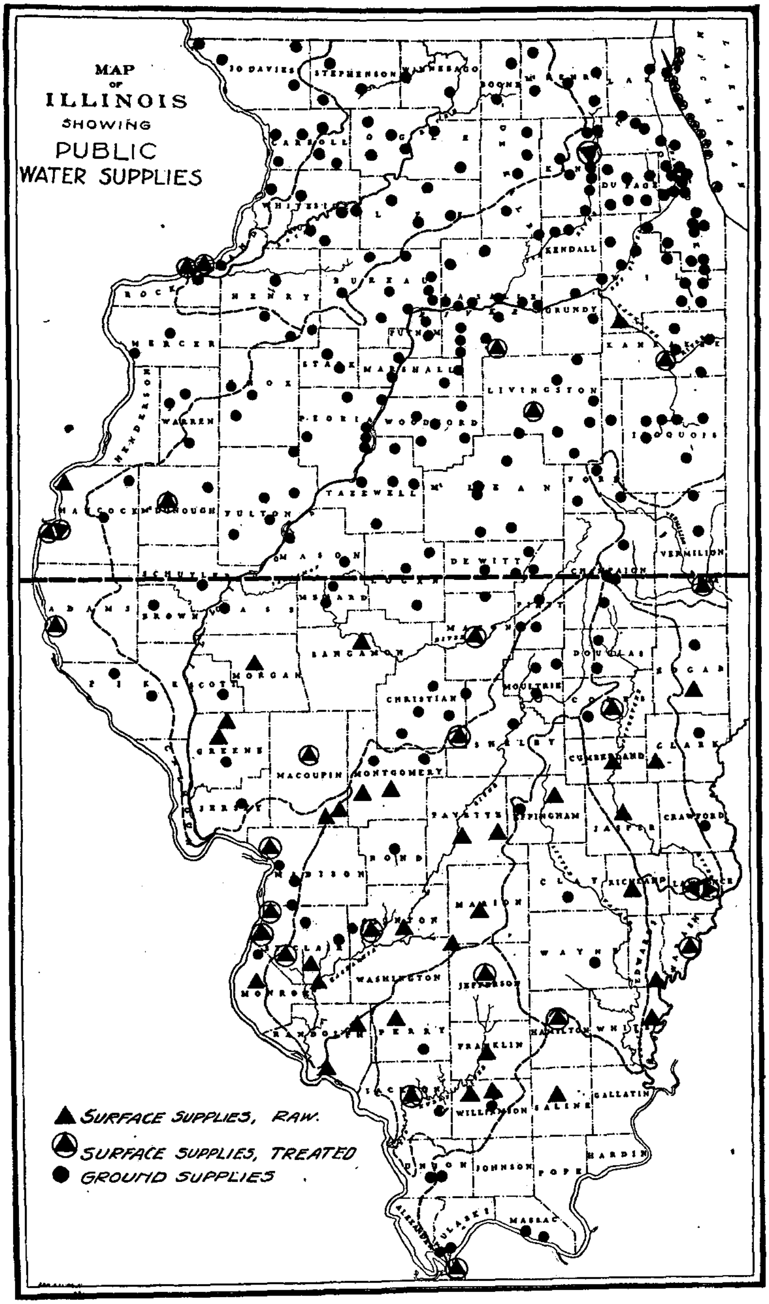
SUMMARY OF SURFACE SUPPLIES.

Sources of Supply	Number Cities Supplied	Number Cities Using Treated Water	Population Supplied			Average Population per Service	Average Consumption per Service
			Total	Using Treated Water	Per Cent Using Treated Water		
Streams	36	21	367,400	326,200	89.0	7.0	753
Reservoirs	19	3	81,500	17,000	20.8	15.0	1590
Lake Michigan	13	12	76,600	71,400	93.0	5.2	970
Mixture, ground water and surface water	5	3	152,000	82,000	54.0	8.1	806
Total	73	39	677,500	496,600	73.4		
Weighted Average						7.4	846

well. These wells are usually of the shallow, dug type, subject to various sources of pollution and very frequently furnish water of poor quality, as indicated by numerous analyses made in the laboratories of the State Water Survey.

The accompanying map of the state shows the towns having surface water supplies and the sources of supply.

As already intimated, a line east and west through Champaign divides the state into two parts typified by the characters of their



GEOGRAPHICAL DISTRIBUTION OF SURFACE SUPPLIES.

water supplies. To the south of this line 48 per cent of the existing supplies are of surface origin, while to the north only 11.5 per cent are surface supplies. In all that area of over half the state north of Champaign, but away from the shore of Lake Michigan, only about 5.5 per cent of the supplies are of surface origin.

TOPOGRAPHY AND WATERSHEDS OF ILLINOIS.

Illinois includes an area of about 56,650 square miles and has the lowest surface elevations of the North Central states, with a mean elevation of about 600 feet above sea level. Compared with this is Indiana with mean elevation 700, Michigan 900, Wisconsin 1,050, Iowa 1,100, and Missouri 800 feet above tide.

In a general way the elevations in Illinois decrease from north to south. This fact is indicated by the general southerly direction of flow of most of the principal streams. The average elevation across the north tier of counties is about 870 feet above tide. (This is figured as the mean of the highest and lowest elevations of the several counties.) The average elevation across the central part of the state, between Pike and Edgar counties, is about 625 feet. Across from Randolph to White county, near the southern end of the state, the average elevation is down to about 480. To the south of this rises the so-called Ozark uplift, a range of hills extending principally across Union, Johnson, Pope and Hardin counties and ranging in height up to 1,047 feet. The average elevation of this region is about 610 feet. Across the extreme southern end of the state the average elevation is about 415 feet. The highest point in the state is at elevation 1,257, in Jo Daviess county. The lowest is in Alexander county, elevation 279.

In the greater part of the state an impression of flatness is conveyed by the general absence of abrupt relief. Only in the Ozark uplift, at some points along the Illinois river and in the extreme northwestern part of the state does the country present in the slightest a rugged appearance.

Rock River: The Rock river has a length of about 300 miles and a drainage area of about 11,000 square miles. About 5,000 square miles of this watershed lies in Wisconsin and the remainder in Illinois. It drains a region covered almost entirely with drift, characterized in Wisconsin by extensive swamps and numerous small lakes. In Illinois the basin is generally undulating and well drained. However, extensive swamps occur along the Green river, an eastern tributary. The Pecatonica river, a tributary on the west, has its headwaters and a portion of its watershed in the unglaciated region in the northwestern corner of the state.

The average fall in the Rock river from source to mouth is about 1.2 feet per mile. The greatest fall in Illinois for any considerable distance is 1.31 feet per mile between Oregon and Sterling, a distance of about 36 miles. There are a number of power development plants along the stream. The flow in the river is regulated to a certain extent by tributary lakes in Wisconsin.

Illinois River: About 45 per cent of the area of Illinois is drained by the Illinois river. It has a total watershed of over 29,500 square miles, of which about 1,000 lie in Wisconsin and about 3,200 in Indiana. This area is divided as follows:

	Sq. miles		Sq. miles
Des Plaines river	1,392	Spoon river	1,870
Kankakee river	5,146	Sangamon river	5,670
Fox river	2,700	Crooked creek	1,385
Vermilion river	1,317	Macoupin creek	985
Mackinaw river	1,217	Minor tributaries	7,843
			29,525

In addition to these natural tributaries is the Chicago Drainage Canal, the discharge of which into the Des Plaines river is estimated by Cooley to be the equivalent of the runoff, under Illinois conditions, from a watershed of about 6,000 square miles. This discharge consists of Chicago's sewage and a large quantity of dilution water from Lake Michigan, and its flow is at a practically uniform rate.

The Illinois river basin is almost entirely covered with a heavy mantle of glacial drift. To the south and east of the main stream the country is generally quite flat and much of it poorly drained. West and north of the river and at the lower end of the watershed land is much more rolling. Much of the Kankakee basin in Indiana and the headwater portion of the Fox consist of large swamps. Extensive drainage by artificial water courses has been necessary throughout central and eastern Illinois.

The tributaries of the Illinois river have been utilized at a few places for power development. The stream most used for this purpose is the Fox, on which about fifteen power dams have been built within Illinois. The major part of these are still in use. There are three power dams in the Kankakee river. In the Vermilion there are two dams, one for power development at Pontiac and one at Streator, used for impounding the water supply. There is one power dam in the Illinois river at Marseilles. Power is developed on the Des Plaines at Joliet and the largest water power plant in the state is at the mouth of the Drainage Canal at Lockport. At the latter plant a head of about 30 feet is developed.

Kaskaskia River: This stream has a length of about 180 miles and drains an area of approximately 6,000 square miles. The headwater portion of the drainage basin is quite flat, characteristic of central Illinois, but as the lower end is approached land becomes more rolling. The descent of the river is generally gradual, its most marked downward grade being about 3 feet per mile in Moultrie county near the upper end. In one stretch of 20 miles in St. Clair county there is a fall of only 0.5 feet per mile.

The stream drains a region, the substratum of which is largely a compact clay. Thus the ground is quite unabsorptive, resulting in rapid rate of runoff and very great and rapid fluctuation in stream flow. A rise of 20 feet at the lower end is not unusual, but in time of drought the flow is small. This stream has never been used to any extent for power development.

Big Muddy River: Big Muddy river drains an area of about 2,400 square miles, lying to the north of the western part of the Ozark ridge. This is at the southern end of the glaciated region and in most places the drift is thin. Land slopes are generally quite pronounced and the drainage usually good. Like the Kaskaskia, this stream is subject to wide variation of flow. The main stream has but a slight descent and takes a decidedly crooked course through St. Clair, Washington and Randolph counties.

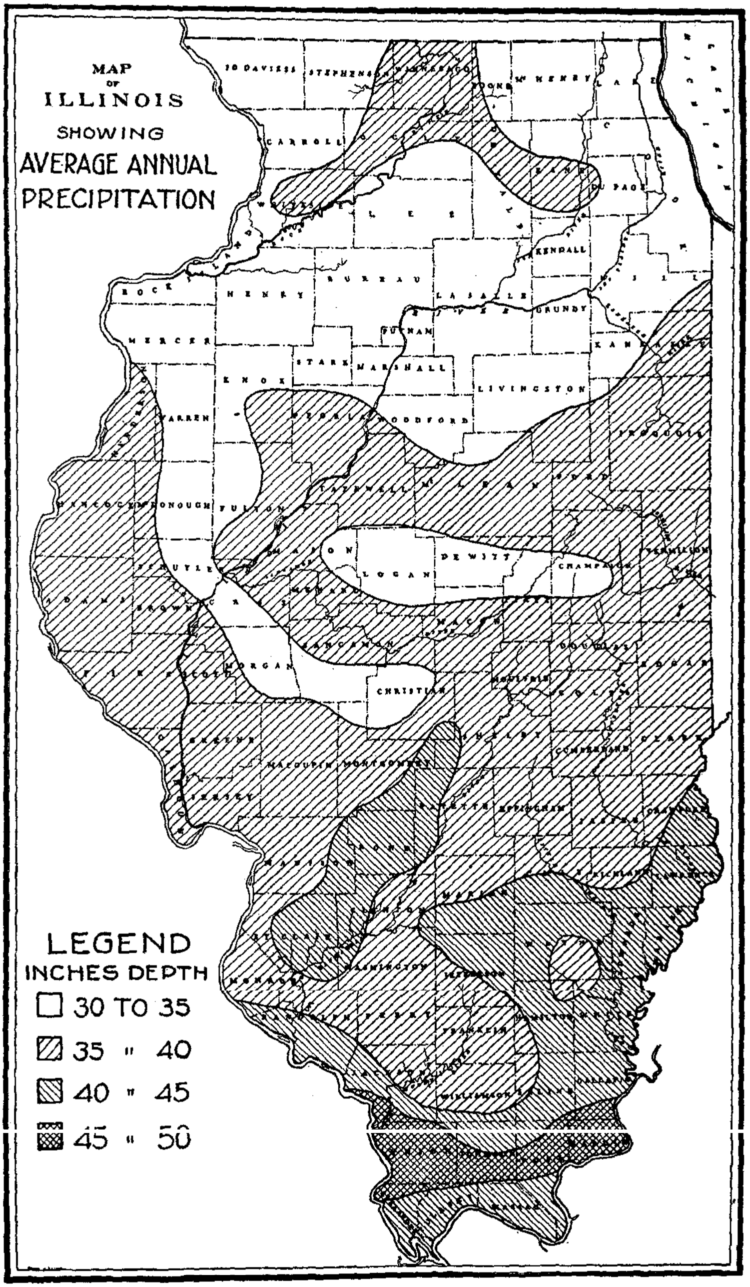
Wabash River: About 7,400 square miles along the southeastern border of Illinois drain to the Wabash river, the principal lines of flow being the Vermilion, Little Wabash and Embarrass rivers.

The northern part of this strip of country, including the Vermilion watershed, is covered with drift typical of central Illinois, more or less absorptive and poorly drained in many portions. As is the case in the western side of the state, land becomes more rolling to the south and the drift surface changes from loess to clay, which make rates of runoff very irregular.

Ohio River, Minor Tributaries: The extreme southern and southeastern parts of the state, along the Ohio river and lower Wabash, are quite low and large areas are subject to overflow. The Ohio drains directly the southern slopes of the Ozark ridge, and also the northern slopes at the east end. The most important of the minor tributaries is Saline river, with a watershed of about 800 square miles. This end of the state was largely beyond the influence of the glaciers. In the uplands are extensive exposures of rock and a rather rugged appearance is presented.

AVAILABILITY OF SURFACE WATER.

The average annual rainfall over the entire state is about 35 inches. The distribution of this precipitation is quite uneven, as shown by the accompanying map, on which are plotted the average iso-rainfall lines estimated from the United States Weather Bureau records of about 75 gaging stations. The rainfall usually increases from north to south. Dividing the state into three sections, the following average rates of annual rainfall in inches are found to prevail. Given also are maxima and minima during the past ten years.


MAP
OF
ILLINOIS
SHOWING
AVERAGE ANNUAL
PRECIPITATION
LEGEND
INCHES DEPTH
30 TO 35
35 " 40
40 " 45
45 " 50

	Northern Illinois	Central Illinois	Southern Illinois	Entire State
Maximum	50.70	43.82	48.83	43.45
Minimum	24.35	32.22	33.34	32.09
Mean	33.76	36.27	40.37	35.89

Runoff records in Illinois are rather meager. A few gaging stations have been established by government and state authorities, but the longest period for which data on any one of these stations are available is about five and one-half years. Most of the gagings were begun in 1908.

TABLE VII.
SUMMARY OF RAINFALL AND RUNOFF DATA IN ILLINOIS.

Stream and Location of Gaging Station	Watershed Area Square Miles	Dates of Gagings	Duration of Gagings—Months	Rainfall—(Monthly Avg.)				Runoff.				
				During Gaging Period.—Inches	Normal for the Period—Inches	PerCent Departure From Normal	Avg. Sec. Ft. on Watershed	Max. Sec. Ft.	Min. Sec. Ft.	Mean Sec. Ft.	Avg. Sec. Ft. per Square Mile	Per Cent of Rainfall
Rock River at Rockton	6150	1903–09	67	3.01	2.85	+ 5.6	16550	27100	950	4790	.78	28.9
Fox River at Sheridan.	2170	1905–06	9	2.97	3.02	— 1.65	5700	9780	240	1810	.83	31.8
Kankakee River at Momence.....................	2430	1905–06	17	3.12	2.96	+ 5.4	6780	6960	360	1980	.81	29.2
Big Muddy River at Cambon.................	735	1908–11	37	3.48	3.37	+ 3.27	2290	11000	0	536	.73	23.4
Beaucoup Creek at Pinckneyville	227	1908–11	37	3.37	3.11	+ 8.4	685	2170	0	98	.43	14.3
Embarrass River at Oakland...................	535	1909–11	21	3.08	2.99	+ 3.0	1470	3650	3	458	.86	31.0
Embarrass River at St. Marie	1540	1909–11	21	3.18	3.25	— 2.2	4390	6210	100	1290	.84	29.4
Kaskaskia River at Arcola	390	1908–11	39	3.08	2.99	+ 3.0	1070	3870	0	378	.97	35.3
Kaskaskia River at Shelbyville	1030	1908–11	41	3.37	3.27	+ 3.1	3100	10600	5.5	948	.92	30.6
Kaskaskia River at Vandalia	1980	1908–11	40	3.40	3.22	+ 5.6	6030	17720	3.5	1357	.69	22.5
Kaskaskia River at Carlyle.......................	2630	1908–11	40	3.49	3.26	+ 7.1	8380	19900	23	2213	.83	26.6
Kaskaskia River at New Athens	5220	1907–11	54	3.75	3.39	+ 10.0	17500	54400	162	5650	1.08	32.3
Shoal Creek at Breese.	760	1909–11	20	3.48	3.52	— 1.1	2370	6.20	48	641	.84	27.0
Silver Creek at Lebanon	335	1908–11	36	3.75	3.39	+ 10.1	1100	4030	0	293	.88	26.6
Skillet Fork, Little Wabash at Wayne City.	481	1908–11	35	3.26	3.47	— 6.1	1400	7760	.2	357	.75	25.6
Sangamon River at Monticello	550	1908–11	41	2.98	3.05	— 2.3	1470	9280	1.6	482	.88	32.8
Sangamon River at Riverton	2560	1908–11	41	3.17	3.21	— 1.3	7250	19200	60	2040	.80	28.1
Sangamon River at Oakford	5000	1909–11	16	2.97	3.09	— 3.9	13300	11000	432	3240	.65	24.4
South Fork Sangamon River at Taylorville.	427	1908–11	41	3.27	3.37	— 2.96	1250	4140	5	340	.80	27.2
Salt Creek at Kenney. .	459	1908–11	40	2.94	3.01	— 2.3	1210	5840	1	334	.73	27.6
Total	35659	....	.....	....	....	....	103295	....	....	29235	......	.....
Average	......	....	.....	....	......	....	......	....	....	....	0.82	28.8

In Table VII is given a summary of all available runoff data, together with rainfall data on the particular watersheds during the times covered by the gagings.

A weighted average runoff is obtained by dividing the sum of the mean rates of discharge by the sum of the watershed areas and equals 0.82 second feet per square mile. Likewise, the average ratio of runoff to rainfall over the entire state equals approximately 28.8 per cent.

The watersheds represented by these gagings are all fairly large, but it is apparent from the data that a drainage area of several hundred square miles may yield very little or even no flow at times. Small watersheds of impounding reservoirs used by a number of cities yield in some years no water for several months at a time.

PHYSICAL CHARACTERISTICS OF SURFACE WATER SOURCES.

Lake Michigan: Lake Michigan has a sandy beach, having, as a rule, only a gradual slope away from shore toward the center of the lake. At distances of 2,000 feet from shore the water is usually not more than about 25 feet deep. The sand on the lake bottom has a tendency to shift its position at some points along the shore, but only at Fort Sheridan has this action caused any particular inconvenience. The first intake, 1,400 feet long, at that point became completely covered with sand and a new and longer intake was added mainly on this account.

Usually the lake water a short distance from shore is quite clear, but in stormy weather water pumped from points even a mile or more from shore is often very turbid. To remove the heavier suspended matter and grit from the water, settling wells are built at the shore end of practically all the lake intakes. With these in use, however, many pumps show plunger rods rather badly cut by the sand.

The lake level along the Illinois shore is not subject to variations of more than a few feet and this slight variation introduces no difficulties in water works problems.

The average distance from shore at which water is obtained along the "North Shore" is about 4,500 feet. This is a weighted average based on the rates of pumpage at the various intakes. The longest of these intakes is at Evanston, where water is drawn from a point about 5,600 feet from shore. The shortest one regularly used is that at North Chicago, 400 feet long. A short emergency intake only 30 feet long is provided at Lake Forest.

Anchor ice troubles along the North Shore are more or less common and various intake devices have been tried in attempting to minimize the tendency of the intakes to become clogged. In the majority of cases a connection is made with the intake in such a way that water may be forced back into the pipe by the pumps, thus providing means of freeing the intake of large masses of small ice crystals that accumulate over the outer end. This remedy is expensive, however, as considerable water is thus wasted, and the inconvenience of having to frequently reverse operations at the plant is a disadvantage. In one instance a large wheel with deflecting veins was attached to the end of the intake pipe in such a way that the inflow of water would cause it to rotate rapidly. It was believed that this device would act to keep the ice broken up, but the wheel itself soon became coated with ice and ceased to revolve. It is apparently most essential that the velocity of flow into the end of the intake be reduced as much as possible, and thus avoid creation of a strong vortical current which may draw ice from a considerable distance to this opening. At Evanston this reduction of velocity is accomplished by having thirteen 42-inch openings scattered along the outer end of the intake. A number of other places have large iron cribs at the ends of the intakes, consisting essentially of a box, one side of which is covered only by a grating. At Rogers Park a large cylinder, perforated with numerous holes, is attached to the end of the intake and has satisfactorily eliminated ice troubles.

Streams: The majority of streams in Illinois have only a very gradual descent and during a large part of the time are of comparatively sluggish flow. Many of the streams are extremely variable, however, and are subject to extraordinary flood stages. Artificial drainage of farm lands has been extensively practiced in many parts of the state, and this undoubtedly affects more or less the rates of runoff, tending to make them more variable.

The stream beds are usually muddy and insecure. Extremely heavy loads of suspended matter are carried by the runoff from the drift area of Illinois, and much of this, of course, is deposited, at least temporarily, in the stream beds. A few streams, such as the Embarrass and Kaskaskia, have beds of gravel or sand and it is not uncommon to see the plungers of pumps drawing water from these rivers badly cut. In a number of cases it has been necessary to lay the suction pipe directly on the stream bed in order to keep it submerged at low stages. This arrangement increases the likelihood of drawing in gritty suspended matter and at Newton pebbles half an inch in diameter were seen embedded in the pump valves. Such difficulties could very likely be much reduced by constructing low dams below the intakes or by reducing the velocity of intake in ways similar to those adopted in avoiding anchor ice troubles. Mud and sand in untreated river water has in a number of cases made the use of meters impracticable.

Different types of surface soil on various watersheds seem to produce quite different physical characteristics in river waters. The Kankakee river, for instance, the greater part of whose watershed is swamp land in Indiana, delivers at Kankakee a water which is ordinarily not difficult to purify. But when high water occurs in the Iroquois river, a tributary entering a few miles above, an extremely fine sediment has to be handled and is very difficult to remove completely. A small tributary of the Vermilion river is responsible for similar difficulties at Streator. The stage of the Missouri river influences materially the purification of Mississippi river water below the confluence of these two streams. Missouri river is usually the muddier of the two, but its suspended matter settles out quite readily as compared with that of the upper Mississippi.

Stream beds tend to shift more or less under the action of flowing water, but the only difficulties reported from this source in Illinois are confined to the Mississippi. At Granite City water was originally drawn from one of two channels separated by a long, narrow island in the middle of the river. Each of these channels was nearly half a mile wide and river shipping was equally extensive in both. But the channel on the Granite City side began to fill in with sand about the year 1903 and by 1907 only a narrow strip of water near the water works remained. Later this water was entirely cut off, except during high stages, and a new source of supply had to be sought.

At Alton an alteration of the river bed has only recently occurred. About 1903 the government built a number of wing dams out into the river in an effort to straighten what was then a very crooked channel. The original channel passed very near the Alton water works and the intake pipe was always washed with a strong current. One of these wing dams was built about a quarter of a mile upstream from this intake and extends from the bank several hundred feet into the river. No serious trouble resulted from this, however, until 1913, when sand began to deposit below the dam opposite the Alton water works. In a few weeks the intake, which was originally six feet off the bottom, was resting on a sand bank throughout its length, and the city was in imminent danger of having its supply entirely cut off. The difficulty was met by hurriedly building an embankment wing dam over the intake, so arranged as to cause a scouring current to pass across the end of the intake pipe. At East St. Louis accumulations of mud on the intake during high water have caused difficulties in securing water, but none that could not be satisfactorily dealt with.

Reservoirs: Several cities have found it necessary to impound the runoff of small watersheds as sources of public supply. In all such instances the dams have been built of earth. These dams are all in southern Illinois, where a fairly compact clay suitable for such construction is usually available on the site. The dams all have either concrete cores or clay puddled walls. The upstream slopes range between 2:1 and 3:1 and the downstream slopes between 1½:1 and 3:1. So far as is known, none of the dams of this type in the state has ever failed.

The dam of greatest height is at Staunton. This rises to a height of about 50 feet above the original bottom of the ravine. At Mt. Olive the dam is 40 feet high, but most of the others range between 15 and 30 feet. That at St. Elmo is only about 10 feet high.

The spillways are usually of concrete, 15 to 30 feet long. That at Litchfield is of wooden construction, while those at Mt. Olive and Staunton are merely earthen channels around the ends of the dams. At Roodhouse a depression in the top of the embankment itself serves as an overflow and materially endangers the stability of the structure.

The impounding capacities and watershed areas for those places for which such data are available are given in Table III. The greatest impounding capacity per 1,000 population served is 95,000,000 at Centralia and the smallest is 8,300,000 at St. Elmo. In designing reservoirs of this character in Illinois it is safe to assume that there will occasionally occur years when the runoff from watersheds of only a few square miles' area will be zero for a period as long as six months. This means that a reservoir should be large enough to hold at least half a year's supply. The possibilities of shortage have apparently not been given proper consideration in some instances and cities such as Litchfield, Hillsboro, Sparta, and White Hall are finding additional supply necessary, even though the populations have not increased over what might have reasonably been expected.

The most common form of intake used with reservoir supplies in this state is a pipe leading out to the deepest part of the reservoir, where is attached a section of pipe on a flexible joint, so that water may be drawn from any depth. At Roodhouse a 6-inch hose on the end of the intake pipe answers this purpose. A cable attached to the shore or a framework in the reservoir usually serves to hold the end of the intake at the desired level. It seems to be the practice to draw water at a depth of about 3 to 4 feet below the surface.

Three of the newer reservoirs, at Centralia, Herrin, and Salem, are provided with intake towers from which water is drawn by the pumps. These are concrete structures about 6 feet square in plan and rising above high water level in the deepest part of the reservoir. Inlet gates are placed at various depths on the side of the tower, any one of which may be opened to admit water to the suction line.

It has not been the practice in building reservoirs to clear the land any further than to remove trees and shrubs. At Herrin about one-half the flooded area was stripped to a depth of about 6 inches, but this work was not completed, due to interference by heavy rains.

The majority of reservoir supplies in the state develop objectionable odors during the summer months, due usually to the decay of heavy moss growths. In a few instances copper sulphate has been applied to prevent these growths. This treatment was successfully used at Waterloo. It is understood that at Granite City an effort was made to eliminate taste due to algae in the water of a slough, but with little effect.

QUALITY OF ILLINOIS SURFACE WATER.

Table VIII contains a partial summary of results of analyses made in the laboratories of the State Water Survey of certain typical sources of surface water. The analyses were made at infrequent intervals and in all probability do not represent the greatest range

TABLE VIII.
QUALITY OF SOME SURFACE WATERS IN ILLINOIS.

Source	Parts per Million							
	Turbidity		Color		Alkalinity		Total Solids	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Lake Michigan at Waukegan, 4000 feet from shore	110	0	40	0	120	106	241	134
Reservoir at Centralia	225	0	160	10	68	20	172	111
Embarrass River at Charleston	800	8	15	0	278	194	362	212
Kankakee River at Kankakee	280	10	120	0.5	210	106	506	187
Illinois-Vermilion River at Streator	560	20	40	0	252	116	668	240
Wabash-Vermilion River at Danville	1500	0	60	0	295	100	1336	216
Big Muddy River at Murphysboro	1200	30	80	20	98	14	464	115
Sangamon River at Decatur	1000	0	160	0	316	138	1125	253
Fox River at Elgin	110	0	110	0	360	124	436	167
Mississippi River at Moline	600	0	140	0	174	49	608	118

that actually exists, but the results are sufficient to show that these waters are of extremely variable quality.

Lake Michigan is probably the best source of surface water supply in the state when drawn from distances of half a mile or more from shore. At that distance marked turbidity occasionally develops at times of stormy weather, while nearer shore the water is frequently roily. Reservoir waters are usually quite soft, but are subject to high turbidities in the majority of cases. These reservoirs, as noted, are in the southern part of the state, where the drainage areas are largely of clayey soil that is easily picked up by running water and held in suspension for comparatively long periods. Rivers in southern Illinois likewise carry very large quantities of finely divided suspended matter at high stages, turbidities frequently ranging over 1,000 parts per million. River waters in the northern half of the state are frequently very turbid, but, as a rule, this suspended matter is more readily removed by sedimentation.

The normal mineral contents of certain streams in the state have been materially altered by sanitary and industrial developments. The discharge of sewage from any town in Illinois having a public water supply derived from wells into a stream of relatively soft water must necessarily tend to harden the water in that stream, but there are probably no cases where such a change is of much importance. The large volume of Lake Michigan water coming through the Chicago Drainage Canal to the Illinois river has, by dilution, undoubtedly had a softening effect upon the water flowing in that stream. Big Muddy river drains an area on which are a large number of coal mines and the acid waste water pumped from these mines finds its way eventually to the river. The effect on the river water is marked. Sulphates are sometimes very high and bicarbonates abnormally low. Very likely the water in the stream itself is at times acid. The Illinois-Vermilion river likewise is highly contaminated with mine wastes below the city of Streator.

Pollution: With possibly very few exceptions there are no sources of surface water supply in Illinois that are entirely free from possible contamination of a dangerous character. All running streams are in danger of pollution and none of the various reservoirs from which municipal supplies are obtained is adequately protected against contamination by the public which is attracted to reservoir banks by the alluring picturesqueness of these bodies of water in a prairie country. The majority of towns having reservoir supplies make practically no effort to protect them, and in one instance several private sewers were until recently permitted an outlet in the city reservoir. Along the shore of Lake Michigan north of Chicago there are 23 sewer outlets scattered at distances apart averaging about 1.2 miles. Interspersed between these outlets are ten waterworks intakes, drawing water at distances of from 400 feet to about one mile from shore. The frequent outbreaks of typhoid fever along the north shore have made very apparent the dangerous character of this pollution.

Water Purification: Tables II, III, IV, V and VI give figures showing the extent to which water purification methods are applied in Illinois. There are 38 cities and villages in the state, representing about 72 per cent of the population using surface supplies that are being served with water which has been treated in some manner or other. Seven of these, all taking water from Lake Michigan, have provided hypochlorite treatment alone. Two cities provide coagulation and sedimentation and the remaining 29 are provided with filtered water.

REPORT ON THE PUBLIC WATER SUPPLY OF SPRINGFIELD, ILLINOIS*

SCOPE OF WORK AND ACKNOWLEDGMENTS.

As a portion of the "Springfield Survey," which is now being conducted under the general direction of the Russell Sage Foundation, the State Water Survey agreed to examine and report upon the public water supply. In connection with this work some inquiries were made with reference to the sewerage system and general sanitary conditions in Springfield.

The work involved about half a dozen visits to Springfield, extending over the period from December, 1912, to May, 1913, and the examination of all accessible reports and other data printed or otherwise which would have any bearing upon the matter in hand. The results of this work are embodied in the following report. The report is not to be taken as thoroughly comprehensive, inasmuch as there are various features of water works operation, construction and management that could not be treated adequately without an expenditure of time and consumption of space that would have been prohibitive. Therefore the report is devoted primarily to a discussion of the sources of supply and the quality of the water furnished, though brief statements relating to other matters are included.

The work of preparing this report could not have been accomplished but for the generous assistance rendered by Mr. W. J. Spaulding, commissioner of public property; Mr. W. D. Seeley, engineer; Mr. Walter Reid, superintendent of the distribution system; Mr. J. W. Curren, chief engineer at the pumping station, and Mr. Paul L. Scoog, inspector for the City Board of Health. Acknowledgment must also be made to Dr. George T. Palmer for valuable data secured as a result of his most efficient and painstaking investigation of the condition of private wells in Springfield.

For the purpose of presenting the main substance of the report in limited space for easy reference the following summary was prepared. This in turn will be followed by the main body of the report comprising various matters discussed in considerable detail.

SUMMARY REPORT.

DEVELOPMENT OF SOURCES OF SUPPLY.

The public water supply of Springfield was first established in 1868, at a time when the relation of public water supply to public

*Prepared by Paul Hansen, Engineer, and W. G. Stromquist, Asst. Engineer.

health was little understood or ignored; quantity not quality was then considered the main desideratum. Accordingly the most obvious source of supply, namely, the Sangamon river, to the northward of the city, was selected.

The waters of the Sangamon, however, proved so turbid and generally unsatisfactory for public water supply purposes that in 1884 the city undertook to install a well supply. To this end a large well 60 feet in diameter and 53 feet deep was built adjacent to the old pumping station on the south bank of the Sangamon. Though this well produced what seemed to be a large yield of water, it soon failed to meet the increasing demands of the city, and in 1888 we find the well supply being supplemented by the construction of a so-called infiltration gallery. This gallery was placed at a depth of about 26 feet (where a large water-bearing stratum had been encountered in sinking the well) and consisted of a wooden box 4 feet wide, 5 feet high and about 1,000 feet long, surrounded by broken stone. This gallery did not materially increase the supply, so that additional galleries were added from time to time until a total length of 2,753 feet was in use in 1900.

The moderate increase of water brought about by the construction of galleries led to a feeling that an adequate ground water supply could not be obtained and in 1890 a direct connection between the river and the end of one of the galleries was made, so that the ground water might be supplemented by river water. During the next twelve years an admixture of river water was used most of the time. Toward the last the effect of the turbid river water was so pronounced that the authorities were stimulated in 1902 to seek a greater quantity of ground water by the use of tubular wells. Accordingly four wells were drilled to the westward of the pumping station, but were never thoroughly tested until 1910 or 1911 under the present management. This tardy test was a result probably of an engineering investigation, which tended to discredit ground water sources and to favor using the Sangamon river after purification by sedimentation and filtration.

During the past three years the development of a ground water supply by means of tubular wells has been revived and numerous test borings and pumping tests have been made. This work has been rewarded by two additional groups of wells, which are capable of producing a sufficient quantity of water to meet the present needs of the town. Moreover, there are good indications that additional wells may be secured from which a sufficient quantity of ground water may be drawn to furnish the city of Springfield for a great many years to come.

ADVANTAGES OF PRESENT GROUND WATER SUPPLY AND NEED OF ABOLISHING RIVER INTAKE.

There are comparatively few cities in the country with populations as large as that of Springfield so favorably situated as to secure an ample public supply of pure ground water, and should the studies now under way demonstrate the presence of a sufficient quantity of ground water to meet reasonable future needs, Springfield is indeed fortunate.

To advocates of a surface supply it may be granted that it is perfectly practicable by means thoroughly understood by sanitary engineers of the present day to render a polluted surface water clear and colorless and safe for human consumption, but the works necessary for carrying out such a process are very costly and, moreover, their continued successful operation depends upon the intelligence and vigilance of the men who are placed in charge. Under conditions prevailing at Springfield a system of wells can be developed at roughly one-fifth the cost of purification works and the superiority of the well supply over a purified surface supply fully warrants liberal expenditures on the part of the city authorities for the purpose of thoroughly and exhaustively studying the extent of Springfield's ground water resources.

Since this paragraph was written new borings have developed a quantity of water equal to almost double the average daily consumption, and greatest confidence is expressed by the commissioner of public property in the availability of an ample quantity of water to meet reasonable future needs.

While the city now has a sufficient ground water supply to meet all present demands, there is still a very narrow margin of safety and practically no provision for future development. It may, therefore, become necessary in case of breakdown to machinery or because of an unprecedented dry spell accompanied by an excessive water consumption to again use the intake to the river. Strenuous efforts should, therefore, be made to further develop the well system, including the sinking of more wells and the building of storage reservoirs until any emergency likely to occur may be fully coped with by using water from the wells alone, thus making it possible to abolish the direct intake altogether.

The necessity for removing the direct intake is emphasized by a long series of analyses made in the laboratories of the State Water Survey. These analyses show that when the intake is in service the water as drawn from the mains is dangerously contaminated. The mere fact that the water drawn direct from the river constitutes only a small percentage of the total water consumption does not greatly minimize this danger for the reason that if disease germs are present in the water at all they will be present in enormous numbers; enough, in fact, to infect every man, woman and child in the entire city. Moreover, there is abundant opportunity for disease germs to be present in the water of the Sangamon river, inasmuch as this stream receives the entire unpurified sewage discharged from the city of Decatur, about 50 miles above. In times of flood this contamination may be swept down the river at the rate of 5 miles per hour, thus bringing it to the intake of the Springfield waterworks in something like 10 hours. Since the germs of typhoid fever (the principal water-borne disease) may exist for weeks and even months in the waters of a stream, it is manifest that the city would be in grave danger should there be an epidemic of typhoid fever in Decatur coincident with the use of river water at Springfield.

There is another important reason why the direct intake should be abolished, namely, the insecurity of depending upon a gate valve, as is now the case, to separate the pure from the impure water. The valve may be leaky or clogged, so that it will not close tightly, and again it may be left partially open through carelessness. Indeed, there is evidence of pollution in some of the analyses made when the direct intake was not supposed to have been in use.

Through the investigations of Dr. Palmer and numerous analyses made in the laboratories of the State Water Survey, the citizens of Springfield have been made well acquainted with the dangerous condition of many of the private wells throughout the city. But it may be pertinent to say a few words with reference to the relation of the private well to the public water supply. There is a strong tendency among persons uninformed with reference to sanitary matters to feel the utmost confidence in an old private well, possibly in a built-up portion of the town and surrounded by sewers and privy vaults, and these wells are often used in preference to the public water supply. In Springfield many of the worst wells have been filled in and the public water supply has been offered as a substitute by liberal extensions of the mains. It should, therefore, be incumbent upon the city to see to it that the public water supply is at all times beyond reproach as regards its sanitary quality. This, then, affords an additional reason why the city should extend and thoroughly study its ground water resources and abolish the intake to the river.

PUMPING STATION.

Along with the development of the source of supply there has been also a development of the pumping equipment. In 1885 the original pumping station proved inadequate and a new station was built near the old and the old station was subsequently converted into a machine shop.

In 1911 the second station proved inadequate and the steps were taken to build a still larger station. For economical reasons the pump pit in the existing station was utilized, so that it was necessary to tear down the old station and build the new station upon the same site, all without interfering with the daily operation of the plant. This has been successfully accomplished and the city now possesses a pumping station which is strictly modern and up to date, with a spacious pump pit capable of accommodating pumps up to a combined capacity of about 40,000,000 gallons per 24 hours.

The present pumping equipment comprises two old pumps (which were not disturbed during the entire reconstruction), having a combined capacity of 12,000,000 gallons. To these is being added a new Holly vertical, triple expansion crank and flywheel high duty pump, having a capacity of 10,000,000 gallons per 24 hours. By the removal of the two original pumps it will be possible to install three new pumps of similar size and design to the Holly pump.

The new pumping station is equipped with all accessories for securing the most efficient and most economical operation, yet the structure is economically built, simple in design and neat in appearance. The engine room is provided with a traveling crane, which facilitates installing new pumping machinery and making repairs to pumping machinery already in place. The main discharge from the station is provided with a Venturi meter, so that accurate records of the water actually pumped may be kept. Various other measuring devices throughout the station permit of maintaining complete records from which daily computations may be made of the station duty. Perhaps the only omission in this connection is the absence of platform scales for weighing coal and ash near the boilers, but this will probably be taken care of at an early date.

WATER CONSUMPTION.

A very creditable showing has been made in Springfield with reference to reduction in the water consumption and this has been brought about by the universal metering of all services. This reduction in consumption means, of course, reduction in water waste and it is especially fortunate for Springfield that waste is at a minimum, for it will prolong the time during which the city may enjoy a pure and wholesome ground water supply.

In 1906 the average daily per capita consumption was 125 gallons. In 1912 the average daily per capita consumption was but 98, or a reduction of 21.6 per cent. This reduction is all the more noteworthy in view of the fact that the number of persons using the supply greatly increased during the period mentioned. More significant figures are those showing the consumption per person using. In 1906 the consumption per person was about 178 gallons and this was reduced to about 125 gallons in 1912, or a total reduction of 29.8 per cent. Still more striking is the fact that from 1891 to 1896, when the installation of meters first began, the per capita consumption was about 300 gallons and there has been a steady decline, up to the present day. During the early part of this period, however, the consumption per capita was on the increase, but, as noted above, both the consumption per person using and the consumption per capita have decreased since 1906.

MISCELLANEOUS CONSIDERATIONS.

No attempt has been made to analyze thoroughly the distribution system of the water works with reference to the adaptability for furnishing fire protection (since this is adequately handled by the National Board of Fire Underwriters), but it is understood that practically the entire city is served by the mains and that the fire protection facilities are for the most part reasonably satisfactory. A duplicate main from the pumping station should, however, be laid at the earliest practicable date.

The financial side of the water works has not been fully dealt with, though there are presented a number of interesting figures giving cost for original construction, cost of maintenance and operation, receipts and expenditures and various unit costs. The general indication of these figures is that the city of Springfield has secured a water supply at comparatively low cost for installation and that the unit costs for operation are moderate and are being gradually reduced year by year.

SEWERAGE CONDITIONS.

The sewerage conditions in Springfield are likely to give rise to difficulty at some time in the future. At present the sewage is discharged through numerous outlets into neighboring small streams, but principally into Spring creek. This stream is now polluted in a high degree and constitutes a nuisance in its vicinity. Recent investigations by the State Water Survey indicate that the Sangamon river is also becoming seriously affected. There can be no doubt but that if the present rapid growth of Springfield continues it will soon become necessary to install sewage treatment works. The establishment of sewage treatment works requires for most economical results that all sewage from the city be conducted to a suitable point for the location of such works and that as far as practicable domestic wastes be separated from storm water. With the present haphazard design of the sewerage system of Springfield this can be done only imperfectly and at great cost. It would be, therefore, a great advantage to the city of Springfield if at an early date a thorough engineering study were made of the sewerage system looking toward the establishment of a consistent policy in making future extension, so that treatment of the sewage may ultimately be accomplished in the most satisfactory manner and at least cost.

CONCLUSIONS.

In conclusion it may be freely said that the city of Springfield will probably never have what may be regarded as a serious water supply problem. There will always be available an ample supply of water within the immediate vicinity of Springfield and for years it may prove feasible to have a ground water supply of the highest sanitary quality.

With reference to sewerage, early engineering studies should be made looking toward the necessity of treating the sewage in the not distant future.

DETAIL REPORT.

GENERAL CONSIDERATIONS.

Springfield lies near the Sangamon river, about twenty miles west of the geographical center of the state. It is the state capital and the county seat of Sangamon county.

Population: The growth of Springfield is shown by the United States census figures given in Table I:

TABLE I.

Year	Population	Percentage Increase
1840	2,579	....
1850	4,533	75.8
1860	9,320	105.6
1870	17,364	86.3
1880	19,743	13.7
1890	24,963	26.4
1900	34,159	36.8
1910	51,678	51.3

The government estimates place the population of Springfield at 55,200 in 1912.

The area included within the corporation limits is about 7.6 square miles.

Transportation Facilities: Springfield is reached by six railroads, namely, the Illinois Central, the Chicago & Alton, the Baltimore & Ohio Southwestern, the Wabash, the Chicago, Peoria & St. Louis, the Cincinnati, Hamilton & Dayton, and also the electric interurban lines of the Illinois Traction System.

Topographical and Geological Features: Surrounding Springfield is a comparatively level region, which constitutes a portion of the great prairie plain of central Illinois. The city occupies territory lying between Sugar creek and Spring creek, tributaries to the Sangamon river. This territory is, for the most part, gently undulating, or nearly level, but along the stream valleys the topography is much diversified by erosion.

Both streams receive surface drainage and domestic sewage from the city. The drainage is partly carried southeast and east into Sugar creek, which empties into the Sangamon river about thirteen miles by water above the Springfield water works. Other drainage flows west and north into Spring creek or its tributaries, and is discharged into the Sangamon a short distance below the water works.

The Sangamon river flows in a general northwesterly direction past Springfield. About 4½ miles east of the eastern limit of the city it has a northward course. It then makes a turn and passes the city in a westward direction, about two miles from the northern corporation limits and then flows onward to the northwestward.

The highest point in the city is about 100 feet above the bed of the stream.

The glacial drift is of moderate depth and rock is generally encountered at a depth of 50 feet or less. The drift consists of two beds of boulder clay, generally spoken of as hardpan. These beds are in places separated by a layer of sand. The upper portion of the drift contains deposits of sand and gravel and is covered with a fine surface soil.

Where deposits of sand or gravel are found immediately below the surface soil they constitute important water-bearing strata. The loam readily absorbs the rainfall and the impervious clay beneath the sand holds the water near the surface.

The deeper wells of this region draw their supply from the stratum of sand separating the two beds of clay. Most wells are shallow and obtain water from sand and gravel deposits near the surface and above the boulder-bearing clay. Some water is found in the clay, but not in sufficient quantity to supply wells.

Wells of great depth have not been sunk, but from records of wells sunk at neighboring towns, such as Jacksonville and Petersburg, it is believed that a supply of water could be obtained at depths of from 2,000 to 3,000 feet in St. Peter's sandstone. The water obtained from such wells in the central part of the state is generally highly mineralized and not very satisfactory for boiler uses or for general purposes.

The rock found below the drift is that of the coal measures, consisting of alternating beds of shale and sandstone, with occasional narrow bands of limestone and thin seams of coal.

Private Wells: A large number of private wells are in use in Springfield, but as a result of recent activities of the city health department and ordinances passed requiring connections to be made with city water mains, where possible, the private wells are being abandoned.

Very little exact information could be obtained relative to strata penetrated by the wells. As far as could be learned, the hardpan is found at a depth of 35 to 40 feet or more in the higher parts of the city. In the valleys of the small streams it may be encountered at 10 or 12 feet below the surface. Water is usually obtained, as already noted, from a layer of sand and gravel near the surface.

A full description of the private wells of Springfield, including tables of analyses of waters from many of them, is published in pamphlet form by the local health department. A summary of the analyses is given in Table 2:

TABLE 2.

	Number of Analyses	Maximum	Minimum	Mean
Turbidity	98	175.	0	7.
Color	84	20.	0	2.
Residue	113	3400.	345.	1200.
Chlorine	113	605.	5.	79.
Oxygen consumed	113	5.9	.1	1.9
Nitrogen as: Free ammonia	113	.960	.000	.044
Albuminoid ammonia	113	.686	.008	.075
Nitrites	113	2.000	.000	.050
Nitrates	113	128.	.000	23.22
Alkalinity	113	652.	158.	292.
Bacteria per cc	109	66000.	10.	3100.
*Gas formers, 10 cc	114	66+	31—	17?
1.0 c.c	218	143+	64—	11?
0.1 c.c	215	99+	95—	21?
Indol	87	74+	13—	...
Depth of wells	78	60	27.6	12

Sewerage System: Springfieid is quite generally served by several systems of sewers built on the combined plan. There are twelve outlets, three discharging into tributaries of Sugar creek and the rest into Spring creek or its branches. The sewage discharged into Sugar creek enters the Sangamon river above the water works. The sewage is not treated in any manner.

Wastes Disposal: Springfield has no general plan of wastes disposal. Private collectors collect garbage and refuse, which is dumped in several places within or near the city limits: The city board of health has recommended the passing of an ordinance regulating the collection of garbage and the installation of an incinerator for the disposal of garbage and refuse.

Vital Statistics: Records of vital statistics have been kept in the form recommended by the United States Census Bureau, so that quite reliable vital statistics can be obtained for the period from 1901 to the present time. In Table 3 are given, for each year, the population as estimated by the census bureau, the total number of deaths, total death rate, deaths due to typhoid, the typhoid death rate, and the percentage of which the typhoid fever deaths are of all deaths. The typhoid death rate has varied from 25.8 per 100,000 in 1901 to 85.8 per 100,000 in 1907. These variations are shown graphically in Figure 1.

*The figures for gas formers in column headed "Maximum" represent number of positive tests; the figures under "Minimum" represent number of negative tests and under "Mean" are given the number of doubtful determinations.

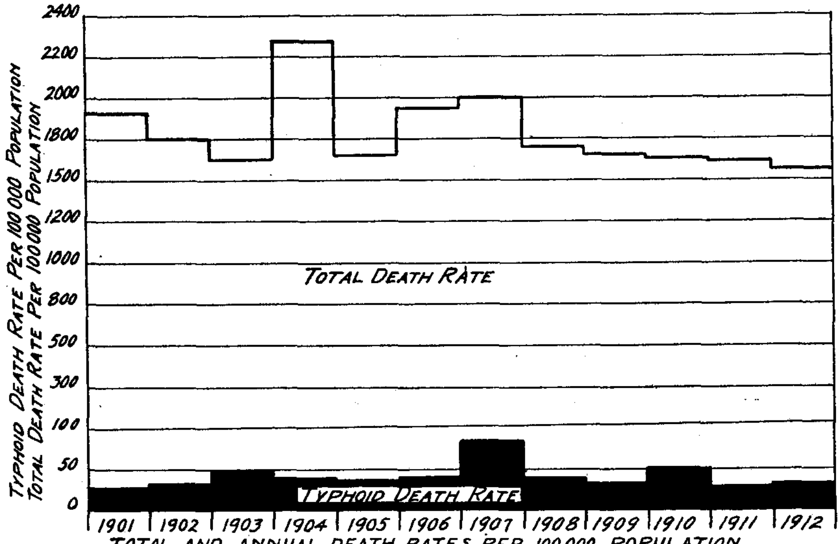


FIG. 1

Fig. 1.—Typhoid Death Rates at Springfield.

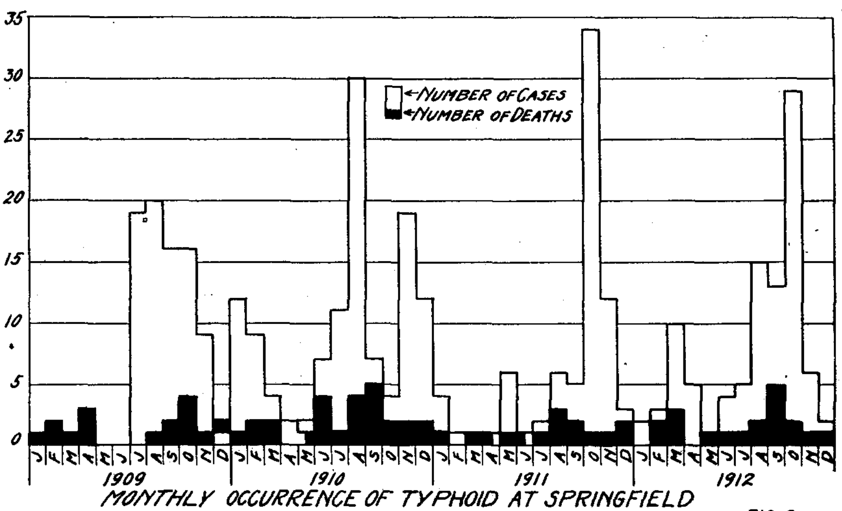


FIG. 2

Fig. 2.—Monthly Occurrence of Typhoid at Springfield.

In Table No. 4 are given, for the years 1909 to 1912, inclusive, the number, age, color and sex of victims of typhoid fever.

Table No. 5 contains the available statistics relative to the monthly number of cases and deaths. The number of deaths are given for each month for the years 1909 to 1912, inclusive, and the number of cases reported each month is given from July 1909, that being the first month for which records of the number of cases were kept. These data are also shown graphically in Figure 2.

These records show that out of 370 cases of typhoid reported from July, 1909, to December, 1912, 18.9 per cent proved fatal. This

TABLE NO. 3.

TYPHOID STATISTICS—SPRINGFIELD.

Year	Estimated Population	Total Deaths	Death Rate per 100,000	Deaths From Typhoid	Typhoid Death Rate per 100,000	Typhoid Per Cent of Total
1901	34,843	674	1,930	9	25.8	1.34
1902	35,527	640	1,800	11	31.1	1.72
1903	36,211	598	1,650	18	49.7	3.01
1904	37,495	801	2,280	15	40.0	1.87
1905	38,234	642	1,670	14	36.6	2.18
1906	38,933	750	1,950	16	41.1	2.13
1907	39,631	831	2,000	34	85.8	4.08
1908	44,075	764	1,730	17	38.6	2.22
1909	50,610	851	1,680	17	33.5	2.00
1910	51,678	860	1,660	26	52.0	3.02
1911	53,428	872	1,630	15	28.7	1.72
1912	55,200	876	1,570	19	34.4	2.19
Average			1.796		41.4	2.30

TABLE NO. 4.

CLASSIFIED TYPHOID DEATHS IN SPRINGFIELD, 1909 TO 1912.

Year	Total Deaths	Average Age	White	Colored	Male	Female
1909	17	38	13	4	12	5
1910	26	32	24	2	16	10
1911	15	34	11	4	10	5
1912	19	29	17	2	14	5
Total	77	33	65	12	52	25

TABLE NO. 5.

CASES AND DEATHS FROM TYPHOID—SPRINGFIELD.

Month	1909		1910		1911		1912	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
January	....	1	12	1	4	1	2	0
February	....	2	9	2	1	0	3	2
March	....	1	4	2	0	1	10	3
April	....	3	2	0	1	1	5	0
May	....	0	1	1	6	1	1	1
June	....	0	7	4	1	1	4	1
July	19	0	11	1	2	1	5	1
August	20	1	30	4	6	3	15	2
September	16	2	7	5	5	2	13	5
October	16	4	4	2	34	1	29	2
November	9	1	19	2	12	1	6	1
December	1	2	12	2	3	2	2	1
Total	82 6 mo.	17	118	26	75	15	95	19

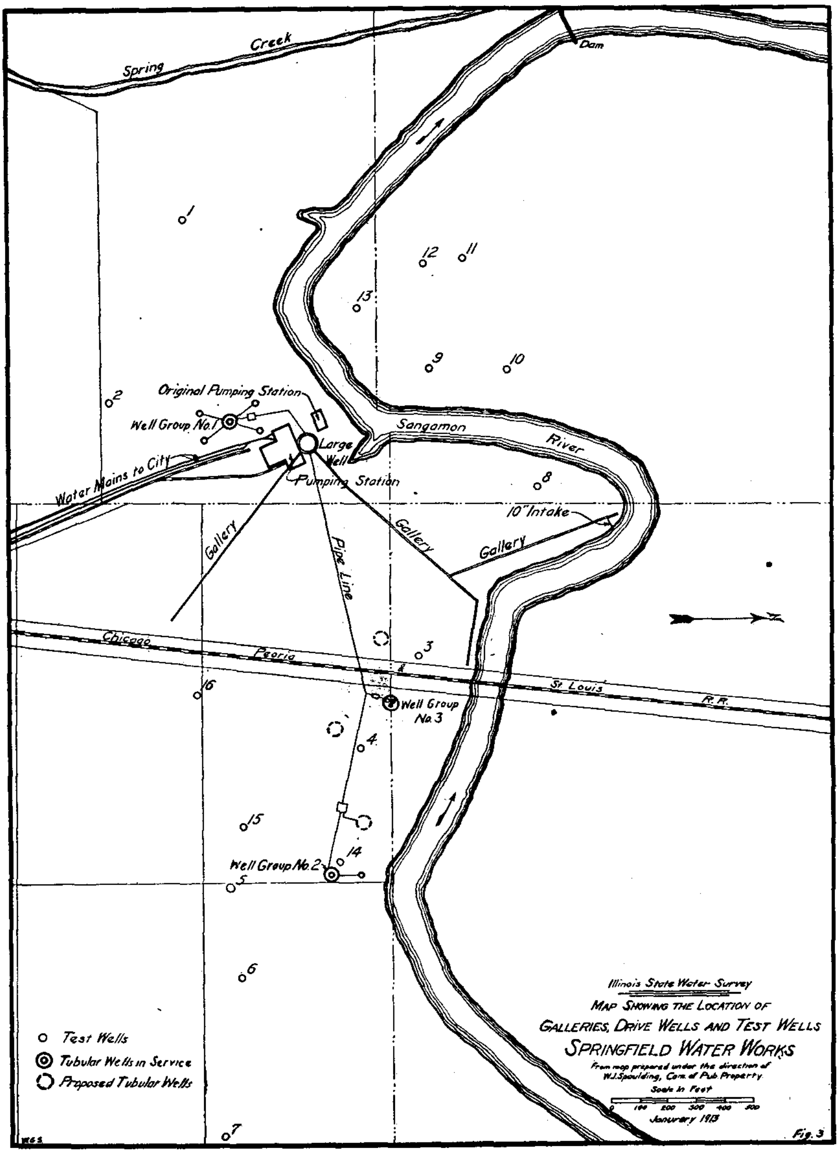


Fig. 3.—Location of Galleries, Drive Wells and Test Wells, Springfield.

high percentage indicates that all cases have not been reported to the board of health. The greatest number of cases are seen to occur in the late summer and fall.

SOURCES OF SUPPLY—GROUND WATER.

The city owns about 250 acres of land surrounding the pumping station, all but 45 of which was recently acquired. Figure 3 shows a portion of the land and also the relative location of the large well, infiltration galleries, tubular wells and test borings.

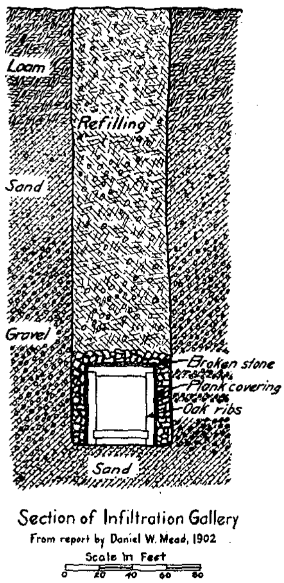


Fig. 4.

Large Well: The large well which was constructed in the first effort to secure a ground water supply and which is now used also as a collecting reservoir and suction pit, is 60 feet in diameter and 53 feet deep. The curbing is of brick, about 2½ feet thick and laid in mortar. Upon its top rests a conical roof supported by steel trusses and surfaced with shingles.

The infiltration galleries and the discharge pipes from the tubular wells discharge into the large well. The suction pipes of the service pumps extend through the wall and are turned down each with a foot valve near the bottom of the well.

The large well constitutes a rather unsatisfactory receiving basin, inasmuch as it is not watertight and permits much of the water pumped into it to seep away again into the ground. This difficulty will be remedied as soon as funds are available by the construction of a large concrete receiving reservoir. The plans for this reservoir have not yet been prepared. On the conduits between the tubular wells and the large well are placed concrete catch basins to retain the fine sand which is drawn through the strainers.

Infiltration Galleries: The first infiltration gallery was built in 1888, extending about 1,000 feet in a southeasterly direction from the pumping station and an additional gallery was later built, which ex-

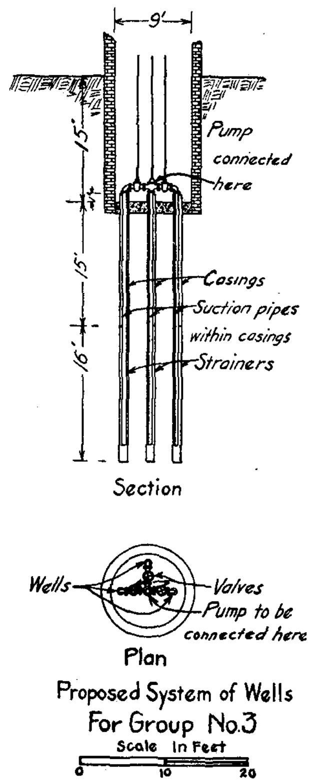


Fig. 5.

tends in a northeasterly direction. These galleries have been extended to a total length of 2,753 feet, as shown in Figure 3.

The method of constructing the first galleries is shown in Figure 4. A trench was dug to the bottom of a gravel stratum lying immediately above a sand layer at a depth of about 25 feet. In the bottom of the trench was built the gallery, about 4 feet wide and 5 feet high, walled and covered with 3-inch elm plank, supported by 3-inch by 5-inch oak ribs. Broken stone was placed between the walls of the wooden conduit and the sides of the trench, and also to a depth of from 6 inches to 1 foot over the gallery, after which the trench was refilled.

In the extensions made by the present management 36-inch circular concrete pipes were used.

Tubular Wells: In 1902 four wells were sunk near the pumping station. These wells have 10-inch casings with No. 8 Cook strainers (0.008 inch slots), 14 feet long and are 45 feet deep, extending to the hard pan. In 1911 a fifth well was sunk in the center of this group. The new well has a 12-inch casing with a No. 20 Cook strainer (0.020 inch slots), 24 feet long. An 8-foot shaft was sunk to a depth of about 20 feet and in this is placed a centrifugal pump. The suction of the pump is connected to 4-inch pipes leading to the outer wells and a 6-inch pipe in the center well. The location of these wells is shown in Figure 3 and is denoted "Well group No. 1." The arrangement is shown in Figure 5.

Two wells, the location of which is shown in Figure 3 (well group No. 2) were installed during the fall of 1912. The wells are 12 inches in diameter and 47 feet deep, with 12-inch No. 40 Cook strainers (0.040 inch slots). A centrifugal pump is placed in a shaft at one well and 8-inch suction pipes extend into the other wells.

An additional set of wells (well group No. 3 in Figure 3) is to be installed in the near future. It will consist of a central shaft 9 feet in diameter and about 15 feet deep. From the bottom of the shaft will be sunk three wells, as shown in Figure 6. A centrifugal pump will be placed at the bottom of the shaft, with its suction connected to each of the well casings.

EMERGENCY SUPPLY—SURFACE WATER.

When the yield of the galleries and wells is insufficient to supply the demand, water from the Sangamon River is admitted into the galleries. Records were available to show the periods when this was done from March 1, 1911, to December 31, 1912. According to these records river water was admitted during the following periods:

May 30 to June 26, 1911.
June 30 to September 8, 1911.
September 2 to November 8, 1912.
November 18 to December 31, 1912.

a total of 211 days, or about 31 per cent of the entire period. An effort will be made to develop the drive well system to such an extent that river water need not be used during the summer and fall of 1913.

A full description of the hydrography, geology, topography, population density and stream pollution of the Sangamon watershed may be found in the report on pollution of Sangamon River and tributary streams, page 253. The general deduction to be drawn from this report is that the Sangamon at Springfield is unfit for domestic water supply when unpurified, but that it may be rendered entirely acceptable by suitable methods of purification. On the other hand, sewage from Decatur and Taylorville should be treated both for the purpose

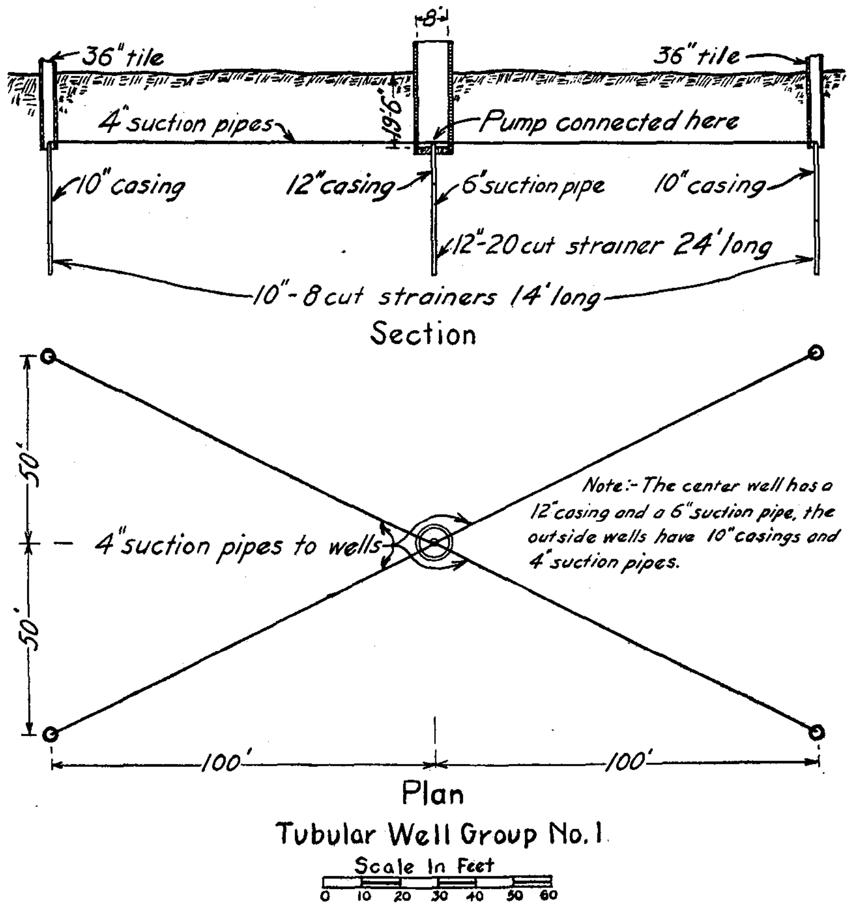


Fig. 6.—Plan Tubular Well, Group No. 1, Springfield.

of preventing nuisance and to avoid placing too great a burden on any water purification works that may be built.

Dam: A dam which was built at the site of the pumping stations at the time the waterworks were first installed was in 1908 replaced by a dam of reinforced concrete. The new dam was built about ¼ mile downstream from the pumping station. The object of the dam

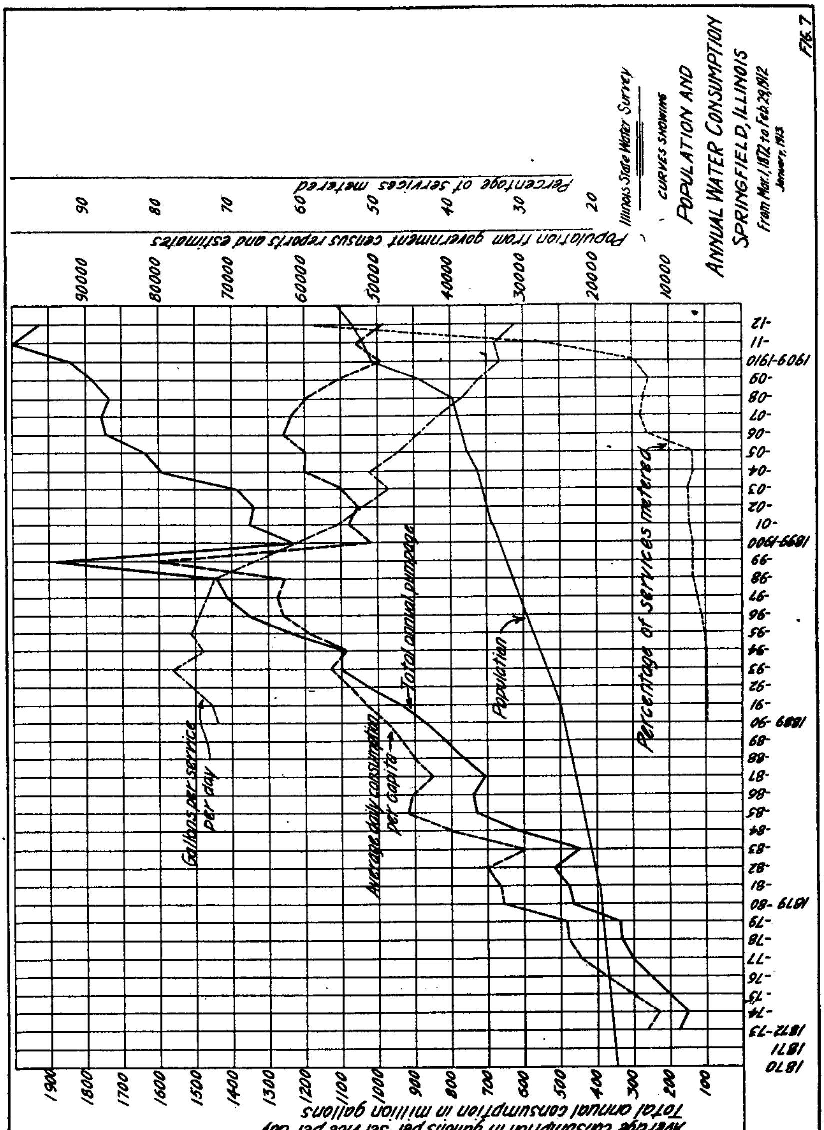


Fig. 7.—Curves Showing Population and Annual Water Consumption at Springfield.

was to maintain a higher level of water in the river during dry seasons on the assumption that this would retard the flow of the ground water toward the river and maintain a higher ground water level, as well as to impound an ample quantity of water for an emergency supply. The dam is 16 feet in height, but other dimensions or features of the design could not be obtained, as plans were not available.

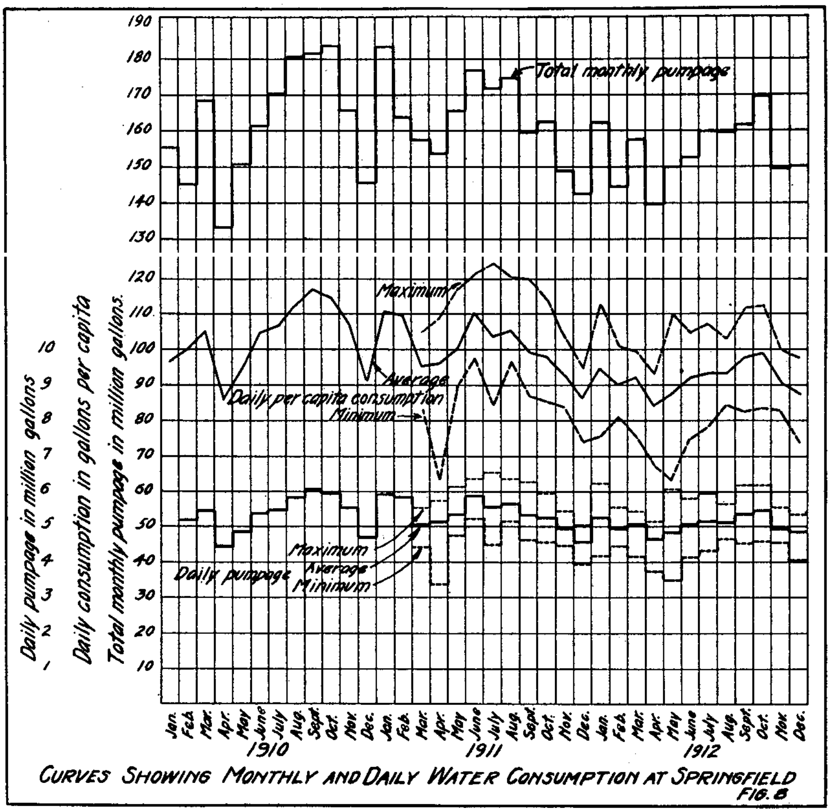


Fig. 8.—Curves Showing Monthly and Daily Water Consumption at Springfield.

CONSUMPTION OF WATER.

A study of the water consumption of Springfield is interesting and shows the effect of meters in reducing wasteful use of water. Pumping records have been kept and published in the annual reports of the waterworks superintendents, so that data on water consumption are available practically from the time of installation of the plant. The accuracy of the older records may be questioned, but they are, nevertheless, of some value as an indication of the growth of the waterworks.

In Figure 7 ark shown graphically the population, the total annual pumpage, the average daily consumption and the number of services for all years for which data are available from 1872 to 1912. These data for all years previous to 1902 had been compiled by Mr. Mead, consulting engineer, and incorporated in a report, and for the later years the data were given by Mr. W. J. Spaulding.

Figure 8 shows graphically the monthly consumption for the three years 1910-11-12. The maximum and minimum daily consumption for each month are given for all months for which these data were available.

The average daily per capita consumption increased steadily from about 25 gallons in 1872 to about 125 gallons in 1897. The exceptionally high rate of 159 gallons in 1898-99 is probably in error. The consumption then drops to about 105 gallons in 1900-1902 and increases to 125 gallons in 1905-1906, after which there has been a continuous decrease. Meters were used as early as 1880, and from 1902 to 1905 practically all commercial or industrial services were metered. In 1910 an ordinance was passed requiring all services to be metered, with the result that at the present time practically all services in use are metered. An explanation of the increase in the daily per capita consumption from 1900 to 1906, in spite of the metering of industrial services, can be found by a study of the following table:

TABLE NO. 6.
DEVELOPMENT OF WATER WORKS, 1897-1912.

Year	Population	Per cent increase	Average gal. per cap. per day	Number of services	Per cent increase	Per cent metered	Average gal. per service per day	Miles of mains	Per cent increase
1896–7	30,480	....	127.3	2660	....	6.2	1459	51*	....
1901–2	34,843	14.3	105.2	3600	35.3	7.3	1019	61	19.6
1906–7	38,933	11.7	123.5	5765	60.0	13.9	758	79	29.5
1911–12	53,424	37.2	98.4	8445	46.5	58.3	622	104	31.6

*Estimated

The significant figures in this table are in the columns showing per capita consumption and consumption per service. Between the fiscal years 1896-7 and 1901-2 there was a decrease in both columns, due in all probability to depletion of the ground water supply. Between the fiscal years 1901-2 and 1906-7 there was a marked per capita increase, but a marked decrease in the consumption per service, a figure which more nearly corresponds to the consumption by those actually using the supply. During the next five years there is a reduction in both the consumption per capita and the consumption per service, showing the effect of the extensive use of meters, which overbalances the effect of the material increase in the proportion of the population supplied as indicated by the extension of services and mains. Thus it is seen that throughout the past 15 years there has been a steady decrease in the water wasted.

In Table No. 7 is given the estimated distribution of the city water used during the past three years. These figures were taken from Mr. W. J. Spaulding's annual report and are based on records of pump revolution counters.

TABLE NO. 7.
ESTIMATED DISTRIBUTION OF WATER CONSUMPTION—SPRINGFIELD.

	Year Ending February 28th					
	1910		1911		1912	
	Gallons	%	Gallons	%	Gallons	%
Sold by meter, commercial.	654,340,876		689,007,895		828,555,499	
domestic	9,971,227		27,476,652		100,942,942	
Total	664,312,103	36	716,484,547	36	929,498,441	48
Sold on fixture rate (estimated).............	412,267,500	23	334,066,250	17	226,573,750	12
Free water (estimated)	191,644,000	10	183,644,000	9	162,504,000	8
Pump slip (estimated).........	91,807,797	5	99,383,246	5	95,980,000	5
Meter slip (estimated)	33,215,605	2	71,648,454	4	153,569,000	8
Unaccounted for............	442,918,947	24	582,438,424	29	351,497,850	19
Total..................	1,836,165,992	100	1,987,664,921	100	1,919,623,041	100

QUALITY OF WATER.

Results of analyses of samples of the public water supply of Springfield are given in Table 8. The records do not show whether river water was being used at the time the samples were collected, so the effect of admitting surface water cannot be ascertained. In some samples which were noted as being collected from the river the high bacterial count and the presence of gas formers would show that the water from the Sangamon is not satisfactory for domestic purposes, as may well be expected when the character of the stream and the sewage it receives is considered. The ground water supply is of good quality and if properly protected should be safe at all times. The difficulty, however, lies in securing an ample supply, so that the use of river water may be discontinued. The water from the galleries or wells has a total residue of about 300 and an alkalinity of about 200 parts per million. Typical mineral analyses are given in Table 9.

An examination of a number of analyses made when the river water was not supposed to be entering the filter gallery indicates some pollution and this suggests a leaky condition at times of the valve which controls the direct intake.

At the present time arrangements are being made for the installation of a hypochlorite treatment plant to safeguard the health of the city in case it should prove necessary because of inadequate supply

TABLE VIII

SPRINGFIELD ANALYSES—PUBLIC WATER SUPPLY.

Date	Lab. No.	Turbidity	Color	Odor	Residue	Chlorine	Oxygen consumed	Nitrogen as Free Ammonia	Nitrogen as Albuminoid Ammonia	Nitrogen as Nitrites	Nitrogen as Nitrates	Alkalinity	Bacteria per c. c.	Gas Formers 10 c. c.	Gas Formers 1.0 c. c.	Gas Formers 0.1 c. c.	Indol	Source	Location
2-14-'07	15714	0	0	0	272.	5.	2.1	.024	.048	.000	1.120	218.	660 Liq.	1 –	2 –	2–		Tap	707 S. 4th St.
2-27-'07	15772	Decid.	.6	0	389.	6.	3.4	.024	.112	.000	.880	227.	220	1 –	2 –	1+1– *		"	229 E. Capitol Ave.
3-18-'07	15838	Decid.	4	0	298.	6.	2.5	.016	.048	.000	.960	197.	1000 Liq	1 –	2 –	2–		"	625 Black Ave.
3-4-'07	15787	0	0	0	25.	1.	1.0	.256	.072	.013	.387	32.	20	1 –	2 –	2–		"	1119 S. 4th St.
3-25-'07	15862	0	0	0	250.	5.	2.0	.024	.096	.000	.720	183.	40	1 –	1+1–	2– *		" filtered	1150 Williams Blvd.
8-27-'07	16434	138	2	Earthy	361.	5.	7.5	.032	.224	.000	.320	233.	800	1 +	2 +	1+1–		"	
9- 9-'07	16467	.260	2	Sl.Musty	414.	5.	6.3	.000	.144	.003	.640	272.	Liq.	1 +	2 +	1+1–		"	229 E. Capitol Ave.
12- 9-'07	16842	0	0	0	380.	6.	1.5	.062	.044	.002	2.80	320.							
1- 27-'08	17051	5	0	0	288.	7.	1.7	.004	.030	.002	1.270	232.	190	1 +	1+1–	2 –	+	"	5th & Jackson St.
1- 27-'08	17052	0	0	0	300.	7.	2.2	.008	.026	.000	1.320	228.	130	1 +	1? 1–	2 –	–	"	" "
5- 25-'08	17462	30	30	0	281.	5.	3.1	.088	.256	.000	.400	193.	870	1?	1+1–	2 –	–		
8- 18-'08	17965	......	......	......	......	......	......	......	......	......	......	......	2000	1 +	2 +	2 –	+		
8- 19-'08	17971	20	30	0	281.	12.	3.5	.062	.158	.000	.320	236.	......	......	......	......	......		
12- 31-'08	18690	0	10	0	322.	13.	2.0	.008	.068	.000	.600	232.	390	1 –	2–	2 –	–	"	Executive Mansion
4- 29-'07	16004	80	4	1E	297.	8.	3.5	.072	.144	.008	2.40	223.	340	1?	1+1–	2 –		"	A.L.Ide & Sons'Shop
4- 29-'07	16005	15	2	0	154.	14.	2.7	.128	.096	.044	.480	76.	0	1 –	2–	2 –		" filtered	" "
1- 4-'09	18702	0	10	0	342.	18.	2.5	.028	.140	.002	.480	240.	450	2 +	1+3?	2+1?1–	2–	"	Executive Mansion
1- 4-'09	18703	5	20	Earthy	330.	18.	2.7	.036	.196	.010	.390	236.	2050	2 +	1+3?	2+2?	2+	"	5th and Monroe St.
5- 31-'09	19197	10	35	0	310.	10.	4.8	.016	.174	.000	1.200	190.	1600	1 +	2+	2+	+	"	City Hall
6- 8-'09	19257	40	15	0	309.	6.	3.5	.028	.146	.001	1.520	188.	280	1?	2?	1?1–	+	"	5th&Washington St.
6- 8-'09	19258	35	10	0	304.	6.	2.5	.026	.146	.003	1.280	188.	320	1?	2?	2?	+	"	5th & N. Grand Ave
6- 15-'09	19294	35	10	0	282.	5.	12.0	.038	.126	.001	1.200	188.	320	1 +	1+1–	† 2 –	+	"	1120 S. 7th St.
6- 22-'09	19316	15	10	0	280.	5.	1.4	.072	.240	.006	1.000	211.	Liq. 40	1 –	1+1–	2 –	+	"	300 S. 2nd St.
7- 6-'09	19379	20	30	Earthy	281.	5.	1.3	.094	.124	.001	.320	215.	30	1?	1+1–	2 –	+	"	1733 S. 4th St.
7- 13-'09	19411	40	15	0	303.	5.	2.8	.012	.144	.001	.960	207.	440	1 –	2+	1?1–	+	"	101 N. 5th St.
7- 19-'09	19449	0	0	Earthy	278.	4.	1.7	.008	.118	.010	.430	198.	250	1 +	1+	1 –	+	"	14 and Ash St.
8- 9-'09	19561	60	15	0	333.	6.	2.3	.048	.168	.010	.630	190.	1000	1 +	1+1?	1?1–	+	"	6th & S. Grand Ave.
8- 31-'09	19720	15	10	0	315.	10.	1.8	.092	.118	.001	.200	251.	2400	1 –	1–	1 –	–	"	302 W. Monroe
8- 31-'09	19721	20	40	Sweet	325.	8.	1.5	.126	.098	.001	.520	251.	3400	1 +	1?	1 –	+	S.gallery	Water Works
8- 31-'09	19722	60	25	0	322.	10.	2.8	.114	.112	.004	.240	240.	1900	1 +	1–	1 –	–	N. "	" "

*Not Iced
†Ice Melted

Table 1

SPRINGFIELD ANALYSES—PUBLIC WATER SUPPLY—CONTINUED

Date	Lab. No.	Turbidity	Color	Odor	Residue	Chlorine	Oxygen consumed	Nitrogen as				Alkalinity	Bacteria per c. c.	Gas Formers			Indol	Source	Location
								Free ammonia	Albuminoid ammonia	Nitrites	Nitrates			10. c. c.	1.0 c. c.	0.1 c. c.			
9-4-'09	19811	30	30	Musty	320.	11.	3.2	.012	.172	.000	.400	232.	3400	1 +	2 +	1+1? *	+	Tap	302 W. Monroe St.
9-20-'09	19846	50	30	Earthy	293.	9.	3.1	.064	.172	.000	.400	204.	230	1 +	1+1?	2 –	+	"	City Hall
10-4-'09	19950	60	20	0	289.	6.	3.8	.082	.198	.000	1.200	204.	380	1 +	2 +	2 +	+	"	302 W. Monroe St.
10-18-'09	20028	20	20	0	347.	12.	2.8	.048	.144	.120	.560	263.	240	1 +	1+1?	1+1–	+	"	" " "
11-1-'09	20099	20	10	0	311.	10.	2.6	.064	.080	.000	.400	253.	360	1?	2?	1? 1–	+	"	City Hall
11-15-'09	20184	10	0	0	338.	11.	2.1	.078	.086	.000	.400	251.	150	1 +	1+1–	2 –	+	"	302 W. Monroe St.
11-30-'09	20275	5	10	0	335.	11.	3.0	.080	.072	.006	.680	242.	120	1 +	2 +	2 –	+	"	City Hall
1-17-'10	20467	5	10	0	290.	15.	2.5	.044	.072	.000	.600	240.	6000	1 +	2 +	2 +	+	"	" "
2-1-'10	20554	20	20	0	333.	11.	1.4	.028	.066	.000	1.400	235.	90	1 –	2 –	2 –	+	"	" "
2-15-'10	20614	5	0	0	106.	9.	2.0	.106	.148	.000	.320	96.	4600	1 –	2 –	2 –	–	Reservoir	....
3-15-'10	20725	120	10	0	307.	5.	2.0	.004	.086	.000	1.040	199.	2800	1 +	1+1–	2 –	+	Tap	325 W. Washington St.
3-15-'10	20728	10	0	0	297.	7.	.7	.016	.066	.000	1.200	214.	30	1?	2 –	2 –	–	"	Lincoln Coal Mine
4-11-'10	20855	150	20	0	313.	6.	2.6	.022	.126	.000	.480	244.	1600	1 +	2?	2 –	+	"	325 W. Washington St.
4-11-'10	20856	30	10	Earthy	296.	6.	1.9	.022	.076	.000	.440	240.	180	1 +	2 –	2 –	+	"	City Hall
5-17-'10	21064	10	5	0	333.	6.	1.1	.016	.056	.000	.800	230.	112	1 +	1 –	1 –	+	"	" "
5-31-'10	21119	60	20	Slight	341.	6.	.9	.016	.080	.000	.760	220.	200	1 +	1+1–	2 –	+	"	" "
6-20-'10	21209	90	15	S.Earthy	317.	9.	1.7	.024	.112	.001	.880	248.	175	1 +	2?	2 –	+	"	....
7-5-'10	21299	30	15	Slight	307.	7.	1.3	.040	.024	.000	.800	246.	22	1 –	2 –	2 –	+	"	" "
7-18-'10	21378	35	10	S.Earthy	296.	9.	1 5	.064	.096	.004	.760	248.	21	1 –	1+1–	2 –	+	"	310 Monroe St.
2-1-'10	20555	30	20	0	250.	7.	1.5	.112	.200	.000	2.000	204.	3200	1 +	2 +	2 –	+		....
2-15-'10	20613	10	10	0	297.	12.	1.4	.022	.040	.000	.800	228.	550	1 –	2 –	2 –	–	"	City Hall
8-29-'10	21457	10	10	0	275.	7.	1.6	.092	.062	.000	.240	240.	28	1 +	2?	1+1?	+	"	....
12-6-'10	21666	5	0	0	298.	10.	1.6	.080	.096	.000	.240	250.	1800	1 +	2 +	2 +	+	"	128 N. Douglas Ave.
5-30-'11	22055	10	10	Slight	199.	7.	1.6	.042	.052	.000	.400	240.	1000	1 +	2 –	2 –	+	"	City Hall
6-6-'11	22062	5	10	0	253.	8.	1.7	.000	.056	.014	.200	240.	21	1 +	2 –	2 –	+	"	1549 S. Lowell St.
7-18-'11	22193	40	25	1E	332.	10.	1.5	.008	.096	.002	.240	224.	Liquefied	1 +	2 +	2 –	+	"	City Hall
7-26-'11	22229	30	20	1E	317.	11.	1.2	.016	.108	.006	4.000	234.	66	1 +	1+1–	2 –	+	"	" "
7-26-'11	22230	30	20	3T	322.	11.	2.4	.038	.120	.006	2.400	236.	116	1 +	1+1–	1+1–	+	Well	Pumping Station
7-26-'11	22231	40	25	2E	330.	14.	3.4	.100	.308	.016	2.800	234.	108	1 +	2 –	2 –	+	River	" "
9-13-'11	22417	350	100	2E	343.	2.	12.3	.104	.480	.048	.920	78.	50000	1 +	2 +	2 +	+	"	" "

*Not Iced

SPRINGFIELD ANALYSES—PUBLIC WATER SUPPLY—CONTINUED.

te	Lab. No.	Turbidity	Color	Odor	Residue	Chlorine	Oxygen Consumed	Nitrogen as				Alkalinity	Bacteria Per c. c.	Gas Formers			Indol	Source	Location
								Free Ammonia	Albuminoid Ammonia	Nitrites	Nitrates			10. c. c.	1.0 c. c.	1.0 c. c.			
9-13-'11	22418	20	30	2e.	323.	11.	2.3	.160	.096	.002	.160	250.	140	1 +	2 +	2 –	+	Pump Well	Water Works
"	22419	4	15	1e.	318.	9.	1.1	.090	.078	.000	.000	248.	15	1 –	1 + 1 –	2 –	+	Tap	836 S. Glenwood St.
10-16-'11	22528	20	20	2v.	302.	6.	1.3	.120	.120	.003	.440	224.	21	1 +	1 + 1 –	2 –	+	Well	Water Works
"	22529	90	20	1e.	379.	4.	4.8	.080	.240	.011	1.680	224.	750	1 +	2 +	2 +	+	River	" "
"	22530	15	23	1e.	317.	5.	1.1	.120	.104	.000	.120	224.	8	1 –	1 + 1 –	2 –	+	Tap	801 S. 8th St.
12-12-'11	22796	20	30	1e.	290.	5.	1.4	.068	.076	.002	.440	230.	1,500	1 +	2 –	2 –	+	Well	Water Works
"	22797	30	20	1e.	316.	5.	1.2	.056	.096	.025	1.840	230.	7,000	1 +		2 +	+	River	" "
"	22798	7	10	0	280.	5.	1.1	.072	.052	.002	.480	228.	13	1 +	2 –	2 –	+	Tap	City Hall
1-22-'12	22891	200	110	2e.	271.	5.	15.8	.194	.422	.012	1.120	76.	350,000	1 +	2 +	1 + 1 –	+	River	Water Works
"	22892	10	10	0	282.	6.	1.1	.034	.074	.001	.680	228.	650	1 +	2 –	2 –	+	Tap	527 S. 7th St.
3-20-'12	23121	35	22	1	287.	5.	1.5	.122	.126	.012	.680	200.	3,700	1 +	2 +	1 + 1 –	+	Well	Water Works
"	23122	5	7	1	273.	4.	.6	.024	.050	.000	.600	202.	650	1 +	2 –	2 –	–	Tap	1128 N. Douglas Ave.
4-15-'12	23232	2	5	2m.	263.	5.	.7	.018	.050	.005	.720	194.	7,800	1 –	2 –	2 –	–	"	1520 S. 6th St.
5-14-'12	23380	5	10	1	258.	4.	1.1	.000	.050	.000	2.200	194.	120	1 +	2 +	2 –	+	"	121 N. State St.
"	23381	7	10	1m.	248.	4.	1.1	.010	.050	.004	.630	194.	138	1 +	1 + 1 –	2 –	+	"	City Hall
6-10-'12	23480	24	0	1m.	290.	3.	1.0	.098	.080	.000	.32	222.	570	1 +	2 +	2 +	+	"	....
7-7-'12	23602	1	7	1m.	276.	3.	.7	.120	.086	.003	.12	236.	18	1 +	2 –	2 –	–	"	1401 Williams Blvd.
"	23603	1	10	1m.	282.	3.	.6	.316	.062	.002	.280	232.	110	1 +	2 +	2 –	+	"	City Hall
"	23604	1	6	1m.	275.	4.	.9	.032	.090	.000	.16	232.	31	1 +	1 + 1 –	2 –	–	"	2321 S. 10th St.
"	23605	15	40	1m.	294.	4.	.8	.250	.086	.002	.28	232.	27	1 +	1 + 1 –	2 –	+	Well	Water Works
9-23-'12	24031	10	10	0	308.	12.	2.9	.000	.050	Trace	.52	240.	3,260	1 +	2 –	2 –	–	Tap	220 E. Jackson St.
11-25-'12	24388	0	0	1e.	319.	7.	2.2	.000	.048	.000	.36	230.	40	1 +	2 –	2 –	+	"	1341 Bates Ave.
"	24389	30	0	1e.	340.	7.	2.2	.024	.068	.012	.92	236.	55	1 +	2 –	2 –	–	"	City Hall

SPRINGFIELD ANALYSES—PUBLIC WATER SUPPLY—Continued.

Date	Lab. No.	Turbidity	Color	Odor	Residue	Chlorine	Oxygen Cons.	Nitrogen as				Alkalinity	Bacteria per cc.		Gas Formers.			Indol	Source	Location
								Free Ammonia	Albuminoid Ammonia	Nitrites	Nitrates		Gelatine	Agar	10 cc.	1.0 cc.	0.1 cc.			
1-27-13	24665	25	0	0	333.	8.	1.3	.032	.064	.008	1.20	246.	154	146	1+	2 +	2 –	+	Well	City Hall.
1-27-13	24667	0	0	0	332.	8.	.7	.006	.040	.001	1.48	236.	310	50	1–	2 –	2 –	–	Tap	Leland Hotel
2- 4-13	24708	5	0	1e	328.	5.	.8	.010	.048	.006	1.12	228.	127	15	1–	2 –	2 –	–	Tap	818 N. 6th
2- 4-13	24709	0	0	0	371.	6.	.8	.000	.040	.000	.92	226.	112	20	1–	2 –	2 –	–	"	128 N. Douglas
2-10-13	24742	5	0	0	340.	8.	1.0	.016	.086	.002	.12	240.	....	.....	....	....	....	....	"	329 S. 5th
2-11-13	24757	2	0	0	318.	6.	1.1	.028	.052	.000	1.32	230.	55	100	1+	1 – 1 +	2 –	–	"	818 N. 6th
2-11-13	24758	0	0	0	320.	7.	.8	.018	.048	.000	.12	230.	45	1	1+	1 + 1 –	2 –	+	"	128 N. Douglas
2-18-13	24789	0	0	0	315.	6.	1.2	.006	.048	.000	.68	224.	75	5	1–	2 –	2 –	–	"	128 N. Douglas
2-18-13	24790	3	10	0	320.	7.	1.3	.022	.032	.007	.68	224.	60	20	1–	2 –	2 –	+	"	818 N. 6th
3-11-13	24878	7	0	0	281.	6.	1.3	.042	.038	.010	.64	218.	150	9	1–	1 + 1 –	2 –	–	"	818 N. 6th
3-11-13	24879	0	0	0	312.	6.	1.5	.000	.030	.000	.68	216.	32	1	1–	2 –	2 –	–	"	128 N. Douglas
4- 1-13	25008	40	20	0	300.	6.	1.9	.040	.130	.001	.56	180.	250	50	1+	1 + 1 –	2 –	–	"	Park Basin
4- 1-13	25009	5	0	0	294.	6.	1.6	.012	.044	.000	.80	196.	80	10	1+	1 + 1 –	2 –	–	"	128 N. Douglas
4- 1-13	25010	10	5	0	316.	7.	1.8	.024	.048	.002	1.00	192.	85	5	1+	2 –	2 –	+	"	818 N. 6th St.
4- 1-13	25011	10	5	0	318.	6.	1.6	.030	.048	.002	1.00	194.	600	70	1+	2 –	2 –	+	"	City Hall
4-22-13	25140	10	10	0	299.	5.	.8	.018	.044	.001	.80	182.	26	30	1–	2 –	2 –	–	"	818 N. 6th
4-22-13	25141	5	0	0	285.	7.	1.1	.004	.040	.002	.88	180.	20	5	1–	2 –	2 –	–	"	118 N. Douglas
5- 6-13	25224	8	10	0	299.	6.	2.1	.098	.088	.013	.72	208.	20	5	1+	2 –	2 –	–	"	818 N. 6th
5- 6-13	25225	5	10	0	286.	7.	1.5	.012	.062	.000	.56	208.	420	300	1+	2 +	1 – 1 +	+	"	128 N. Douglas
6-10-13	25428	10	20	0	301.	10.	1.2	.028	.058	.000	.44	226.	10	6	1+	2 –	2 –	–	"	818 N. 6th St.
6-10-13	25429	0	0	0	300.	8.	.8	.000	.060	.000	.44	226.	1	3	1+	2 –	2 –	–	"	128 N. Douglas
7-15-13	25659	35	15	0	295.	9.	1.5	.224	.080	.000	.40	218.	100	5	1–	2 –	2 –	–	Well No. 3	Pumping sta.
7-15-13	25657	20	35	1p	305.	9.	1.4	.216	.064	.000	.56	220.	lost	25	1–	1 + 1 –	2 –	–	Well No. 1	" "
7-15-13	25658	15	18	0	300.	9.	1.3	.000	.080	.001	.64	226.	31	48	1–	2 –	2 –	+	Tap	City Hall
8-26-13	25986	5	30	2s	317.	10.	1.5	.036	.052	.000	.80	226.	40	26	1–	1 – 1 +	2 –	+	"	" "
9-15-13	26110	35	0	0	304.	11.	2.9	.088	.100	.000	.56	230.	97	53	1+	2 +	2 –	–	"	" "
9-30-13	26209	3	15	0	368.	22.	2.8	.032	.130	.000	.48	226.	90	50	1+	2 –	2 –	+	"	Residence WJS
10-28-13	26384	30	0	2e	366.	15.	2.0	.058	.112	.040	.52	232.	880	217	1+	2 +	2 –	+	"	City Hall
10-28-13	26385	10	0	0	325.	17.	2.8	.006	.106	.005	.52	226.	223	68	1+	2 +	1 – 1 +	+	"	1130 W. Grand
12-22-13	26733	20	20	1e	319.	14.	1.9	.008	.074	.017	1.00	232.	131	73	1+	2 –	2 –	+	"	....
12-22-13	26734	5	10	1e	333.	15.	2.2	.000	.056	.000	.56	232.	97	37	1+	2 –	2 –	+	"	128 N. Douglas
No. of Analyses		113	113		113	113	113	113	113	113	113	113	108	30	113	219	221	103		
Maximum		350	110		414	22	15.8	.316	.422	.120	4.000	320	350000	300	75+	82+	32+	70+		
Minimum		0	0		25	1	.6	.000	.026	.000	.000	32	0	1	7?	23?	10?			
Mean		28	13		303	7.9	2.2	.054	.101	.005	.798	219	4240	48	31–	114–	179–	33–		

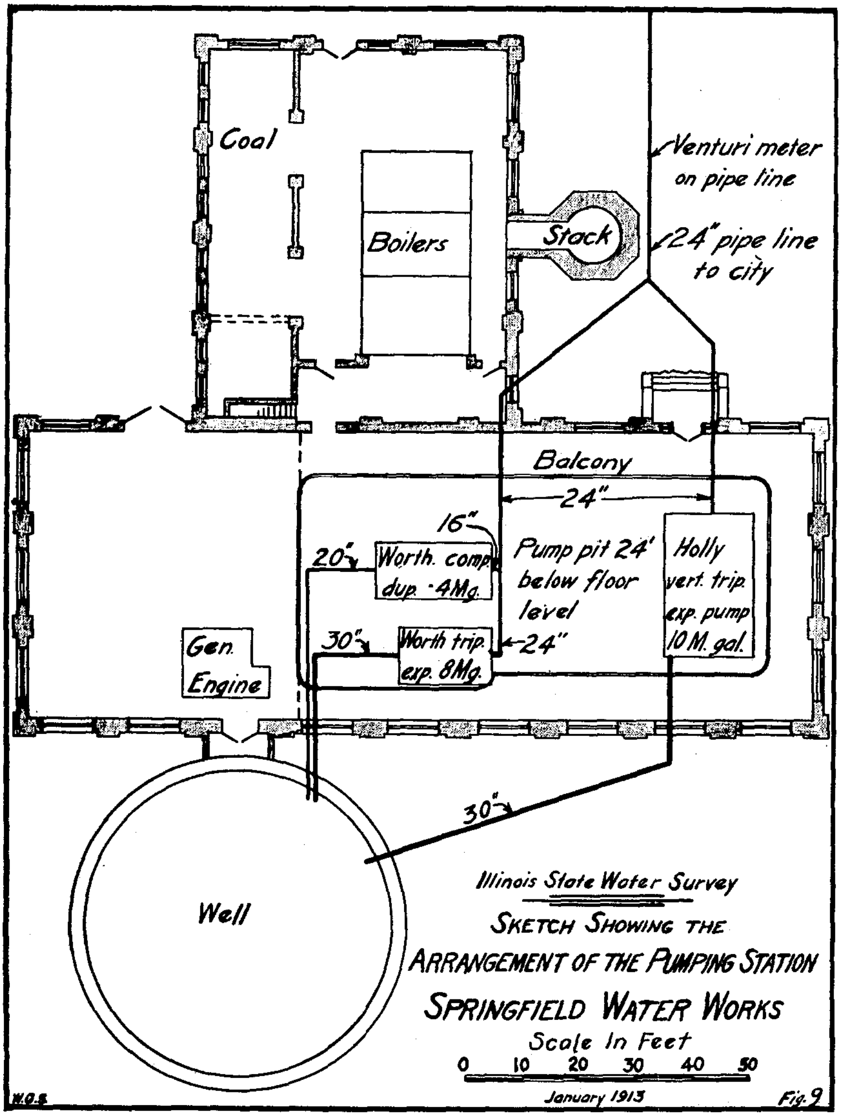


Fig. 9.—Arrangement of the Pumping Station, Springfield.

of well water or because of a breakdown in the low lift pumping machinery to use the river water.

PUMPING STATION AND MACHINERY.

The pumping station is located about two miles north of the northern limit of the corporation, or about four miles from the center of the city.

TABLE IX.

ANALYSES OF SPRINGFIELD CITY WATER.

Laboratory Number		19078		23121	
Date		April 29, 1909		Mar. 20, 1912	
Source		Pump Well		Pump Well	
IONS		Pts. per million	Grs. per gallon	Pts. per million	Grs. per gallon
Potassium	K	.....		7.4	
Sodium	Na	.....		7.3	
Ammonium	NH_4	.....		.2	
Magnesium	Mg	74.		17.4	
Calcium	Ca	.....		49.7	
Iron	Fe	.....		2.8	
Alumina	Al_2O_3	.....		10.	
Nitrite	NO_2	.....		.04	
Nitrate	NO_3	6.2		3.0	
Chlorine	Cl	11.0		5.	
Sulphate	SO_4	.....		36.	
Silica	SiO_2	.....		12.	
Alkalinity	......	180.		.....	
Soluble Residue	......	263.0		.....	
Total Residue	......	322.0		.....	
Incrustants	......	33.0		.....	
HYPOTHETICAL COMBINATIONS					
Potassium Nitrite	KNO_2	......	......	.1	.01
Potassium Nitrate	KNO_3	......	......	4.5	.26
Potassium Chloride	KCl	......	......	10.5	.61
Potassium Sulphate	K_2SO_4	......	......	.7	.04
Sodium Nitrate	$NaNO_3$	8.	.5	......	.....
Sodium Chloride	Na_2Cl	18.	1.0	......	.....
Sodium Sulphate	Na_2SO_4	......	......	22.5	1.31
Ammonium Sulphate	$(NH_4)_2SO_4$	......	......	.7	.04
Magnesium Sulphate	$MgSO_4$	40.	2.3	24.9	1.45
Magnesium Carbonate	$MgCO_3$	35.	2.0	42.9	2.50
Calcium Carbonate	$CaCO_3$	139.	8.1	124.1	7.23
Iron Carbonate	$FeCO_3$	......	......	5.8	.33
Alumina	Al_2O_3	......	......	10.0	.58
Silica	SiO_2	......	......	12.0	.69
Undetermined	......	23.	1.3	......	.....
Suspended Matter	......	59.	3.4	......	.....
Bases	......	......	......	2.6	.15
	Total	322.	18.6	261.3	15.20

The original pumping station is now being used as a workshop. A new building was erected in 1895 and rebuilt in 1912. The new building, which has just been completed, consists of an engine room about 50 feet by 140 feet, with an addition about 55 feet by 65 feet, containing the boilers and storage room for coal. About two-thirds of the main part of the building is taken up by the pump pit 24 feet deep below the floor level. The general arrangement is shown by the accompanying sketch, Figure 9.

The pumping equipment is given in Table No. 10.

TABLE NO. 10.
PUMPING EQUIPMENT.

No.	Maker	Type of pump	Nominal capacity	Diameter of Cylinders		Length of Stroke	Diameter of Pipes	
				Steam	Water		Suction	Discharge
1	Worthington	Vertical triple expansion, 2 plunger	8,000,000 gals. per day	18" 29" 46"	26.5"	36"	30"	24"
1	Worthington	Compound duplex	4,000,000 gals. per day	24" 43"	20"	36"	20"	16"
1	Holly	Vertical triple expansion, crank and fly wheel, single acting	10,000,000 gals. per day	26" 48" 72"	23"	42"	30"	24"

The Worthington triple expansion duplex pump was installed in 1898. The Holly pump had not been installed at the time of the investigation, but had been purchased and all arrangements made for its installation.

The pumps are placed in the pump pit, with the suction pipes extending into the large well and the discharge pipes connecting with the 24-inch pipe line to the city. The pumps operate against a head of about 240 feet, of which about 95 feet is due to the difference in elevation between the pumping station and the city. The pumps are equipped with pressure and vacuum gages and revolution counters. All pumps are operated condensing, a surface condenser being connected to the suction pipe of each.

The tubular wells are pumped by means of American Well Works centrifugal pumps. Well group No. 1 is equipped with an electrically driven pump, having a rated capacity of 750,000 gallons per day, with 6-inch suction and discharge pipes, and operated at a speed of 700 revolutions per minute. This pump was installed in 1910. At well group No. 2 there is an electrically driven pump with a nominal capacity of 1,500,000 gallons per day, 8-inch suction and discharge, operated at 1,120 revolutions per minute. It was installed in 1912.

A Clayton air compressor, 6x6x16 inches is used to supply compressed air for balancing the working parts of the Worthington vertical triple expansion pump.

The boiler equipment consists of three water tube boilers. One McNull boiler, 320 H. P., has recently been rebuilt. Two Heine boilers, 350 H. P. each, 48"x21'-9", were installed in 1911. A steam pressure of 150 pounds is maintained.

Among the auxiliary apparatus are the following:

1 Cochrane feed water heater.
1 Deane feed water pump, 7½"x4½"x12".
1 Worthington feed water pump, 9"x4"x6".
2 Worthington condenser pumps, 6"x8½"x6".
1 Worthington sump pump, 7½"x8½"x6".
1 Pulsometer pump.
1 Electric traveling crane in engine room, capacity 40,000 pounds.

For generating electric current there is a 125 k. w. Westinghouse generator, direct-connected with a 150 H. P. Ideal Corliss engine. As there is but one machine, a breakdown would prevent pumping from the wells and necessitate the use of river water.

A venturi meter has been placed on the main discharge pipe at the pumping station, but the installation of the recording apparatus will be deferred until the new pump is in place.

The work done at the pumping station is shown in Table No. 11, the data being taken from Mr. W. J. Spaulding's annual reports:

TABLE NO. 11.
WORK DONE AT PUMPING STATION.

	Year Ending		
	February 28, 1910	February 28, 1911	February 28, 1912
Average cost of coal per ton	$1.505	1.37	1,1975
Coal consumed, tons	7.070	5,557	5,891
Total pumpage, gallons	1,836,165,952	1,987,664,921	1,919,623,041
Average static head, feet	195	195	195
Average dynamic head, feet	232	232	240
Gallons pumped per pound of coal	130	178.8	162.8
Duty per 100 pounds of coal	25,125,606	34,604,352	32,609,268
Pumping station expense	$28,811.29	19,886.07	23,959.84
Cost of pumping per million gallons	$15.635	10.005	12.48
Cost per million gallons raised 1 foot	$0.0674	0.0431	0.0520

The coal used is a bituminous coal, 1¼-inch screenings and mine run.

DISTRIBUTION SYSTEM.

The development of the distribution system is shown by curves in Figure 10. For several years the mains have been extended in nearly the same proportions as the population has increased, but the relative number of services and fire hydrants has increased more rapidly.

The length of mains in place December 31, 1912, is shown in Table No. 12.

This includes the 24-inch and 15-inch pipe lines from the pumping station to the city. Additional statistics regarding the distribution system are given below in table No. 13.

Miles of main per 1,000 population	1.92
Miles of main per 1,000,000 gallons daily consumption	20.85

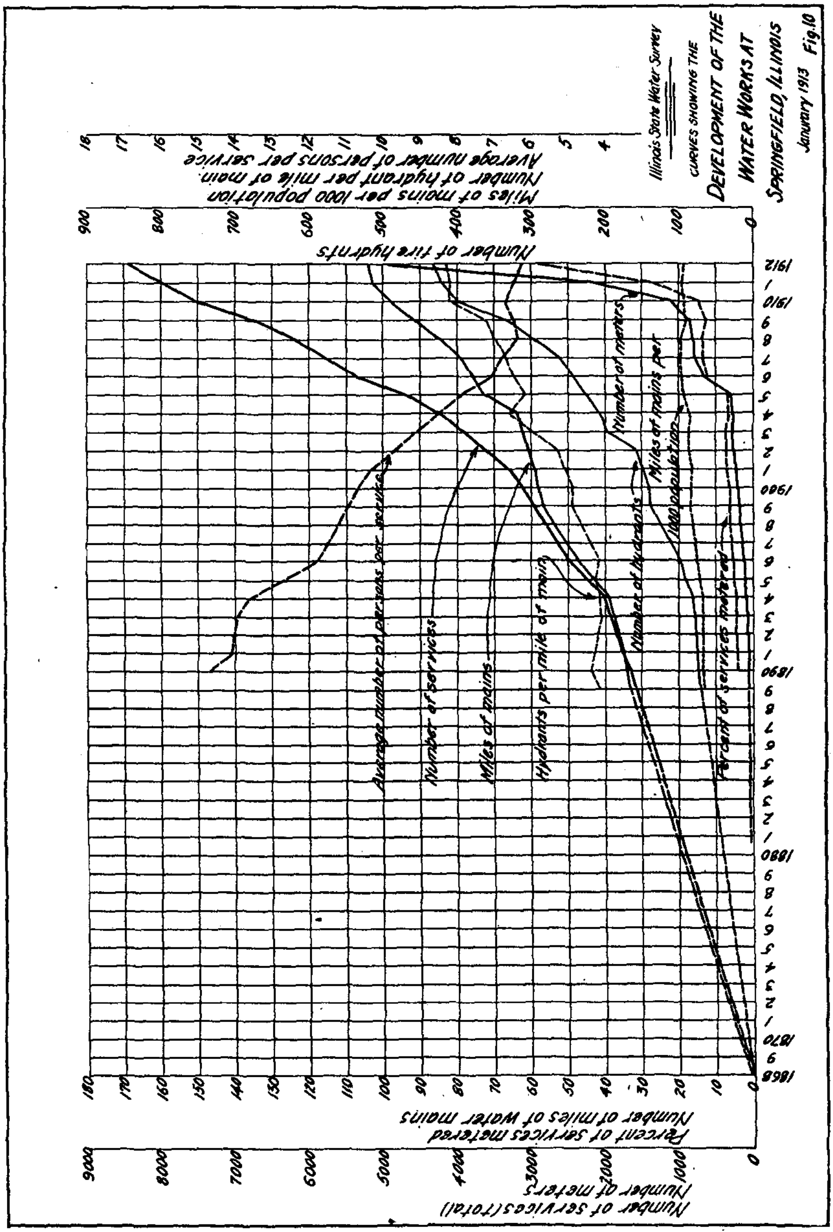


Fig. 10.—Development of the Waterworks at Springfield.

Number of valves 1,706
Number of valves per mile of main 16.1
Number of hydrants 868
Number of hydrants per mile of main.................... 8.2

TABLE NO. 12.

MAINS IN DISTRIBUTION SYSTEM.

Size	Length		Percent of total
	Feet	Miles	
24"	16,135	3.05	2.9
20"	9,649	1.82	1.7
15"	22,596	4.27	4.0
10"	76,714	14.52	13.8
8"	1,220	0.22	0.2
6"	317,138	60.13	56.9
4"	68,389	12.94	12.2
3"	1,046	0.20	0.2
3" - 8" private pipe	37,380	7.07	6.7
Hydrant connections	8,110	1.53	1.4
Total	558,377	105.75	100.0

The service connections are of lead and cast iron and range in size from ¾ inch to 6 inches. In the above statement the number of services is less than that given in Fig. 10. The number of services given above are those in actual use, while in the diagram the total number of services is given in order to be consistent with the data for previous years, for which only the total number of services could be obtained.

TABLE NO. 13.

	Year ending February 28		
	1910	1911	1912
Number of leaks per mile of main..................	....	0.370	0.759
Cost of repairs per mile of main.....................	....	2258	5.36
Number of service connections in use.............	5534	5667	6049
Average length of service connection...............	20¼	20¼	22
Average cost of service for year....................	13.38	11.29	13.34
Number of meters................................	1116	2206	4925
Percent of services in actual use metered...........	17.8	37.6	81.4
Percentage of receipts from metered water.......	51.3	63.6	79.0

The number of meters in use March 1, 1912, was 4,925, varying in size from ⅝ inch to 8 inches, and with practically all makes represented.

An ordinance now requires all services to be metered. Meters are furnished by the city, but for meters larger than 5/8 inch the consumer pays the difference in price between the larger size and a ⅝-inch meter. The meters are installed at cost by the city.

RESERVOIR.

When the water works were first installed a surface reservoir was built in the north part of the city. The city owns about 29 acres of land surrounding the reservoir, the tract being known as Reservoir Park. The reservoir is about 200 feet by 200 feet, with a capacity of 3,000,000 gallons. It is not used as a part of the system, as it is not located at a sufficient elevation to give pressure in the distribution system. It may, however, become available in a great fire, when the pressure in the mains is greatly reduced and when dependence must be placed on fire engines.

PRESSURE.

The general ground level at the pumping station has an elevation of about 510 feet above sea level, while the high point of the city is slightly over 600 feet above sea level.

The pressure ranges from 25 to 100 pounds, the latter being the pressure generally maintained at the pumping station. The pressure is not increased for fire service.

MANAGEMENT AND MISCELLANEOUS DATA.

Springfield has a commission form of government and the commissioner of public property has direct charge of the water works. The water works department is divided as follows: Pumping station, under the direction of the chief engineer; distribution system and meter departments, each supervised by its respective foreman; and an office force for handling the accounts.

IMPROVED MANAGEMENT OF WATER WORKS*

The object of this paper is to advocate the employment, on an annual basis, of consulting experts in connection with the operation of small water works installations for the purpose of improving the service, the equipment, and the economy of operation. This is by no means a new practice, but it is exceedingly rare, whereas it should be virtually universal.

The same method may be used for improving the operation of other public utilities such as electric lighting plants, sewage treatment plants, drainage districts, etc. The limits of a brief paper will not permit a broader discussion, and therefore will be confined to water works.

GENERAL METHODS USED BY EXPERTS IN SUPERVISING WATER WORKS.

The expert's services may be rendered by occasional visits, say, monthly or quarterly, by training the men locally employed, by periodic examination of records and accounts maintained in accordance with instructions furnished by the expert, and finally, by reports with recommendations, submitted at regular intervals. Not more than a few days per month would be occupied by the work involved, and the service may be rendered at what, comparatively speaking, is a nominal fee. For supervising water works in a small community $600 should yield a fair compensation. Perhaps a more satisfactory method would be to base the fee upon the gross receipts, making it a suitable percentage thereof.

NEED FOR EXPERT SUPERVISION.

It is hardly necessary to point out that there is a real need for improved management of water works, for the reason that most engineers who have had anything at all to do with water works are aware of the very general slipshod methods employed. During the past eight years the writer has had occasion to visit or receive reports upon about 200 small water works in the states of Ohio, Illinois and Kentucky, and but very few instances are recalled of small water works installations (that is to say, for towns having populations of 25,000 or less), where thoroughly effective methods of management were being employed. This does not infer that all these water works installations were not giving good service. As a matter of fact, some were

*Read before the Western Society of Engineers, March 3, 1913, by Paul Hansen. Reprinted from Journal W. S. of E.

giving good service, but generally at unnecessarily large expense, and without adequate records and accounts to show where economies might be instituted. The great majority, however, were giving very inferior service and showed every outward evidence of carelessness and neglect in management.

POSSIBLE OBJECTIONS TO EXPERT SUPERVISION.

The method of improving the management herein discussed is not advocated for the purpose of increasing the business of consulting engineers, but because it seems to be the only practicable method whereby the desired results can at present be accomplished. In large water works, of course, it is perfectly feasible to engage the entire time of an expert and designate him as general manager. In small water works, however, it is not possible to afford the continuous services of an expert. The men ordinarily employed, while they may be intelligent and conscientious, have not had opportunities to secure the necessary training and experience to render most effective service. Such men, backed by an expert, are as a rule capable of securing highly efficient results. Sometimes it is found that the water works has become a political football and is relegated to the mercies of very incompetent men. In such cases the consulting expert has a very difficult problem, but by tact and by appealing to the more enlightened sentiment of the community he may accomplish a great deal and because of the very fact that things are in a run-down condition the results of his efforts will be all the more striking.

There may exist the feeling that the supervision of water works should be entrusted to local engineers in general civil engineering practice. Such action would, as a matter of fact, be an injustice to these engineers for the reason that their numerous other duties and employments rarely permit them to acquire the necessary expertness in the restricted field of water works. It would appear, therefore, that no conflict of interest exists between the consulting expert and the local engineer. On the contrary, the local engineer should be the first to recognize the necessity for the services of an expert in water works operation.

Some persons lean to the belief that supervision over public water works should be maintained by some central state authority, and such supervision is certainly desirable, in so far as the sanitary quality of water supplies is concerned. But to enter into the economic phases of water works operation to the extent of giving the close supervision herein contemplated, would be altogether impracticable. It would involve the maintenance of an expensive and cumbersome state bureau engaged in performing functions which are primarily of local concern and, moreover, the mere fact that the services of such a bureau would be foisted on the local community would cause the local authorities to be generally antagonistic toward the bureau's requirements. It is not practicable for any central body to go further in this matter than the State Water Survey proposes to go, namely, to do just enough to demonstrate the value of expert services in water works operation and leave the rest to municipal and private enterprise.

RESULTS OBTAINABLE THROUGH EXPERT SUPERVISION.

Specifically, the results obtainable through expert supervision of a water works are:

1. Better service.
2. Reduction of cost of operation, which, of course, means increased earnings.
3. Anticipation of future requirements.
4. Improved design.
5. A professional and personal advantage to consulting engineers.

Better service means furnishing, throughout the community, an ample quantity of pure and clear water for domestic and industrial purposes, and providing a liberal safeguard against disastrous fires.

Decreased cost of operation means a supervision of all the details of operation in such manner that effective service will be rendered at minimum expense.

Anticipation of future requirements means that all necessary increases in the supply and equipment will be foreseen, so that they may be provided before the community is reminded of its needs by destructive fires, inadequate equipment, or disastrous epidemics due to the pollution of the water.

Improved design will result from a better knowledge of operating conditions than is ordinarily obtainable under present practice by those entrusted with the preparation of plans and specifications. The structural features can generally be readily taken care of, but a common fault is a failure to provide for contingencies encountered in operation. Under the present regime the consulting engineer's connection ceases at about the time that operation begins, and if he has any curiosity to learn if his designs are working out successfully he must satisfy his curiosity at his own expense.

A personal advantage accrues to the consulting engineer from supervision over operation by giving him continuous and regular employment, thus enabling him to maintain his organization intact. Further, it benefits him professionally by enabling him to concentrate his practice within a limited field, and thus he has the opportunity to increase his detailed knowledge along his chosen line; in short, he renders himself more expert. There are many men in consulting practice today who attempt to cover such a broad field that it may be frankly said they are not thoroughly competent in any one line.

MODUS OPERANDI OF EXPERT SUPERVISION.

For the purpose of illustration and not with any intention of giving a treatise on how to supervise water works operations, a brief description will be given of the manner in which expert supervision should work out. Three factors form the basis upon which this work is conducted:

1. Operation Records, relating to the physical facts connected with water works operation.
2. Financial Accounts, relating, of course, to the finances.
3. Technical Skill, which is required in obtaining and interpreting the operation records and financial accounts in such a way that all of the needs of the water works plant are fully revealed.

It will be of advantage to inquire a little more fully into these three items and consider them separately.

1. OPERATION RECORDS.

Records may be subdivided into several groups as follows:

(a) Source of supply.
(b) Purification works.
(c) Pumping station.
(d) Distribution system.

(*a*) *Records Relating to Source of Supply* comprise measurements of the quantity of water available, sources of possible pollution and analyses of the water.

The measurement of the quantity of water available may be made in a variety of ways, some simple, some elaborate, depending upon the character of the source of supply. At any rate, such records are exceedingly valuable in forecasting the adequacy of the source of supply for future requirements. In the southern part of Illinois are two communities each of which obtain their water supply from an impounding reservoir. During the past summer both of these reservoirs went practically dry and remained so for some months. In one case no emergency supply could be secured, the community suffered for want of water for ordinary domestic purposes and was left helpless in case of a conflagration.

In the case of surface-water supplies, the records relating to the condition of the watershed, particularly if the water is used in an unpurified condition, are exceedingly important. Inspections of the watershed, when intelligently made, are much more reliable than analyses in showing dangers to health. It is merely necessary to mention the Plymouth, Pennsylvania, epidemic of typhoid fever in 1885 to demonstrate the futility of analyses in detecting intermittent pollution, such as was responsible for that disastrous outbreak.

Analyses, however, should not be ignored, especially when it is possible to secure a long series of analyses, as they then become a measure of the pollution and give a record of the physical and mineral characteristics of the water. Where purification of the water is employed, such analyses are almost indispensable, as will be seen later.

It is much easier to give examples of the evil results of failure to maintain proper records regarding the source of supply than to give examples of water famines and other disasters that have been averted by the maintenance of such records. The latter instances are ordinarily not recorded and the danger is never realized by the general public.

(*b*) *Records Relating to Purification Works:* A volume might be written upon this subject alone. Experiences with small filter plants are most disheartening. Practically all of the small filter plants in Illinois, numbering half a dozen or more, are being ineffectively operated. The same is true in Ohio and Kentucky, and, no doubt, in other states. Some of the difficulty is due to bad design. Very small filter plants are apt to be built according to a bad design, whereas the conditions under which they are operated are such that they should be built according to the very best design.

Expert supervision over mechanical filter plants (those most generally used in the middle west) does not necessarily result in reduced cost because of the prevalent reprehensible custom of omitting the use of coagulant when the raw water is moderately clear, but within the limits of efficient purification the cost can undoubtedly be reduced. The average small purification works is placed in charge of a pumpman or fireman, having many other duties to attend to, and it is but natural that this, combined with his lack of knowledge of water purification, results in almost total neglect. In many instances such men, through ignorance of the danger of impure water to public health, have no hesitancy in by-passing the raw water into the mains when it becomes convenient to do so.

Records necessary for maintaining proper supervision over mechanical filter plants include analyses of the raw and filtered water, the quantity of water treated, quantity of chemicals used, the frequency of washing the filters, the quantity of wash water used, and numerous other details. For obtaining analytical data there should be established, in connection with every filter plant, however small, a suitably-equipped laboratory. It is an easy matter to train any ordinary water works employe of normal intelligence to make simple analytical determinations which will not only furnish the desired records, but will guide the filter attendant in his daily operation of the plant. If the expert has laboratories at his command, additional analytical control may be maintained on a somewhat more elaborate scale.

(*c*) *Records Relating to Pumping Station:* A small water works pumping station for which complete records are maintained, is a great rarity. Often it is impossible to get even an approximation of the quantity of water pumped, and generally the only records are from pump revolution counters without any allowance for slippage. It is a comparatively simple matter to weigh the coal and ash, to maintain pumping records both from revolution counters on the pumps and from a meter placed upon the main discharge from the station, and records of the discharge pressure, suction lift, quantity of boiler water used, etc. With such items as these it is possible to always know the condition of the pumps, figure accurately the station duty and find opportunities for improvement and cutting down the demands on the coal pile. The expert can also arrange, where conditions warrant, to purchase fuel and possibly other supplies on an analytical basis.

(*d*) *Records Relating to Distribution System:* Most deplorable of all are the records ordinarily maintained in connection with the distribution system. The data concerning the location of mains, valves and service connections is generally stored in the memory of ex-water works employes and local plumbers, who regard these facts more or less as stock in trade, and would consider it business suicide to record them. In many towns there is no vestige of a map of the distribution system to be found, and where such maps do exist it is only occasionally that they show mains laid since the original water works installation. It is not strange, therefore, that extensions to the distribution system are generally unwisely made, that fire pressure is often lowest where most needed, and that there are many undetected leaks and thefts of water. In the hands of an expert all of these difficulties may be easily overcome simply by making installations in accordance with complete maps and plans, by periodic inspections and by occasional tests for pressure, leakage and waste.

2. FINANCIAL ACCOUNTS.

Water works accounting, especially in municipally-owned establishments, is usually in a chaotic state. About all that is ordinarily recorded are the gross receipts and gross expenditures roughly itemized. Capital accounts are almost unheard of, and it is often impossible to get even approximately the cost of the plant. In many municipal plants large donations from public funds are calmly included as earnings. Such items as depreciation, allowances for taxes, interest on investment, sinking fund, rent, etc., are altogether ignored. If the gross receipts, no matter from what source, exceed the gross expenditures, no matter for what purpose, a profit is proudly proclaimed. In some instances, on the other hand, large numbers of free service connections make a water works appear as a losing proposition, whereas suitable compensation for such services would place the plant upon a sound financial basis.

Correctly-maintained accounts should display fully itemized capital accounts, maintenance accounts, repair accounts, replacement accounts, sinking fund accounts, depreciation accounts, interest accounts, and, in fact, every item that enters into water works construction, operation, and maintenance should be carefully recorded in its proper place. In addition, there should be maintained accounts showing unit costs for operation and construction. These latter are very valuable in making comparisons with other plants and with the same plant in different years. Accurately-maintained accounts are particularly serviceable in the adjustment of water rates. The establishment of water rates is, at the present time, on a most unscientific basis and it is common practice for small communities to adopt, parrot fashion, the rates established in some other community, regardless of the manner in which the water is obtained or the cost of delivering it to consumers.

3. TECHNICAL SKILL.

But little can be said with respect to technical skill. It is primarily a matter of natural aptitude and experience, and it is needless to say that no one should presume to enter this field of consulting practice unless his natural aptitude and experience have rendered him fitted therefor. Aside from the maintenance of records and financial accounts, it is necessary for the consulting expert to thoroughly instruct the men locally employed in their respective duties and this necessitates, of course, skill and a thorough knowledge of such duties on the part of the expert. The analytical mind of the expert also enables him to discover opportunities for modifying methods of operation which the more or less untrained man would fail to see.

SUMMARY.

To summarize: The employment of consulting experts to supervise the operation of public water supplies and other public utilities in small communities constitutes a simple and the only practicable method whereby the operation of such utilities may be rendered efficient, whereby the design may be improved, and whereby there will accrue a distinct professional and financial advantage to the experts. Once this system is fairly tried, it is hard to believe that it will not gain general favor. The Illinois State Water Survey hopes to promote its introduction by demonstrating, if possible, in a few specific cases the advantages that will result.

Note—The writer desires to acknowledge indebtedness to Messrs. Metcalf & Eddy, Mr. Robert Spurr Weston, Mr. Wynkoop Kiersted, Mr. F. A. Barbour, Dr. Edward Bartow and Mr. James M. Caird, for valuable suggestions.

DISCUSSION.

John W. Alvord: I am sure we should appreciate it, in every line of endeavor, if things could be prudently run with proper forethought, as Mr. Hansen has indicated he would like to have the small water works matters run. The picture which he draws of the average small water works is unfortunately all too true. I think perhaps there might be many instances cited which he has not mentioned which would make the condition of the average small water works even worse than he has pictured it.

There is a great deal of human nature in a small town and there is a great deal of human nature in the superintendent or owner of the small plant—ambitious human nature; and if there is any one thing in the world that the average man likes to believe, it is that he was born an expert at engineering.

I might illustrate this with a little incident that amused me the other day. A gentleman came into my office from a small suburb of Chicago, wherein resides one of the best water works engineers in this country, an honored past president of this Society. The gentleman said that the town trustees had asked this engineer for advice, and they had been told by him that they ought to have a new well which would cost, with its pump, about $14,000. "Now," he said, "some of us believe we ought to fight that proposition. We want you to overhaul his plans and tell us how to stop this thing. We may not get any water out of that well at all."

I asked for the name of the engineer and it was given me. I then said: "Well, I will tell you what you ought to do. You ought to go back and vote for those plans and say nothing more about it. He is a well-known engineer, that is, well known outside of the town where he lives."

He thanked me somewhat earnestly. I am not sure which was the greater surprise to him—that they had a widely-known engineer in their little town, or that I passed up a fee, all of which illustrates the old saying that "a prophet is not without honor save in his own country."

Benezette Williams: Mr. Hansen has covered the ground quite thoroughly on this small water works business. I will simply say that I have run across water works considerably larger where pumps were leaking 50 per cent of their recorded capacity—that is, their displacement capacity.

Burton J. Ashley: There seems to be springing up the necessity for another kind of an engineer, termed an efficiency engineer. The demand seems to come from industrial institutions. In thinking over the places into which he would fit, very naturally it has occurred to me that the field is broad and that this demand is going to increase as the necessity of knowing whether the various manufacturing plants, water works plants, sewage disposal plants, plants of any description, are being managed or run as efficiently as they should be.

At this time, but a few miles away from the city of Chicago there is employed an efficiency engineer from the East, who is testing and proving out the efficiency of all the mechanical and operating departments of a large and well-known industrial plant, and is paid a large sum for his labors. His labors and reports are expected to be of such interest that one of our well-known periodicals has its staff there watching the operations in order to publish an article upon the workings and usefulness of an efficiency engineer.

It seems to me that the time is likely to come when an expert of this character will fit into place and be of use under the conditions which have been recited by Mr. Hansen in his paper. It may not be in our day and it may.

F. E. Davidson: I have been much interested in listening to Mr. Hansen's paper. I think we have to consider that the situation in the small town today is a political one, and as long as we have a political form of government we are going to have conditions as described in the paper. It seems to me, however, that the idea of the commission form of government, which has proved so successful wherever it has been tried, might result in bettering conditions. We must take the managing body out of party politics before we can hope for a betterment of conditions in the management of water works in small towns. They are controlled today by politicians, absolutely regardless of the size of the city. If we can get small cities to adopt the commission form of government, put the government in the hands of three or five men—not a partisan body, but business men—and give them absolute control, then there is some hope for the engineer having control of the small water works.

Bion J. Arnold: I am not expected to speak on this subject, I suppose, tonight. The principal reason I have to give for speaking upon it is that I do not know much about it; but knowing that a man sometimes makes a better speech about something of which he knows little, I venture to make a few remarks.

It has been my fate to be one of the organizers of a society, or rather one of those drafted to be among the first directors of a society known as the Efficiency Society, and in that connection, of course, I have learned something about the qualifications of an efficiency engineer and the public opinion of efficiency engineers; at any rate, the opinion as formed by some parts of the public.

I believe, as one of the speakers has said, that there is a field for the qualified efficiency engineer in this country, and I want to say that I make no claims to belonging to the class known as efficiency engineers, because my field is an entirely different one.

It is a fact that the title of efficiency engineer is to a certain extent under suspicion from the fact that so many men have gone into the calling and called themselves efficiency engineers who have been unable, when given an opportunity, to effect economies—to produce efficient results. Therefore, they have been more or less discredited in certain directions. I know of some very efficient, able efficiency engineers. I have no doubt it is one of these gentlemen who is undertaking the task that has been outlined here tonight, although I do not happen to know which one it is.

I know there are men who are qualified for it or men who will go into this calling with the sincere purpose of qualifying themselves for the work before they undertake important work. There is no doubt in my mind but what they will prove a benefit to themselves and to the country, because there is a field and a large one.

As to the qualifications for such a position, I think too many of them have qualified—and evidence of this has been shown in the correspondence which has been received by this Efficiency Society—in a similar manner to a young man who grew up in my town. He was a lad in knee trousers when I left home, an ingenious lad, belonging to an ingenious family. He never stuck to anything very long, but he was ingenious enough to pick up almost anything and make a fair attempt at doing it, though he never did it very thoroughly or efficiently. The lad, as I say, was in knee trousers when I left home. Some years afterwards I was living in St. Paul and was at that time mechanical engineer of a steam railway. This lad came into my office to see me—a fine-looking fellow, dressed well, and apparently very prosperous. I said to him: "James," (his name was not James) "you seem to be doing well."

"Yes, sir, finely."

"And what are you doing now, James?"

"Oh," he said, "I am a plumber."

I said: "How did you happen to get to be a plumber?"

"Well," he said, "it was this way, B. J. I went out to ———— a couple of years ago and looked around, and I saw only two plumbers' shops in the town, and I thought it was a good place to start a plumbing shop, and I said to myself: 'By gosh, I am a plumber!' and I rented a vacant store and have been a plumber there ever since."

While his ambition was good, his execution was poor, and in order to make the anecdote teach a useful lesson, I am compelled to say that he went into bankruptcy two years afterwards. He, however, learned his lesson and is today an efficient and successful traveling salesman for one of the large plumbing establishments of the country.

Eugene A. Rummler: Mr. Hansen made a rather sweeping statement in regard to the inefficiency of small water plants. I presume the instance I am about to mention is an example of the kind of exception that proves the rule. I refer to the North Shore suburb of Winnetka. We have our own water and light plant. It started from a very small beginning, and has entirely paid for itself. It has no indebtedness and it clears for the village about $18,000 or $20,000 a year. I think it is managed on a very efficient basis. The managing engineer is well paid and the plant has, therefore, to some extent, become a source of temptations. They try from year to year to overturn the present management so as to be able to appoint some cheap politician in place of the present managing engineer. I presume that if that should ever happen, the only way we could have efficiency there would be to have an efficient consulting engineer.

It happens that tonight we have with us Mr. Frank E. Herdman, the managing engineer of this plant, and I wish the president would call on him.

Frank E. Herdman: There is not much to say about our water and light properties except that we have tried to operate them on a strictly business basis, and to do this we have kept politics absolutely out of them.

Our water property was put in operation in 1893, the money being raised by special assessment. Since that date all mains have been put in by special assessment, but all enlargements of the property and of the service have been paid for out of the earnings. In 1900 we put in operation our electric property, supplying our citizens as well as the street lighting. The first cost was cared for by time warrants, which were afterward paid for out of the earnings. In 1909 we took up the problem of rebuilding and enlarging these properties, which we have done on quite a large and permanent basis, without incurring any indebtedness other than for the new intake, the new building and machinery all being paid for out of the earnings. Our water rate is 15c per 1,000 gallons with a minimum of $1.00 per quarter, all consumption being metered. Our electric rates are 11c per kw. for light and 8c for power, with 50c minimum for light and 50c minimum per connected horse power per month for power. The village has had fire protection free from cost, and street lighting at a nominal cost.

We try to watch the little things and to maintain an efficient operation, and I think the results show that we have. We feel that in a small way we have demonstrated that a municipal property can be successful and a satisfaction and benefit to the community served. We have recognized the curse of politics and have kept free from it.

W. H. Finley: I think that the success of the water plant and electric light plant of Winnetka is due largely to the fact, as the last speaker said, that there has been no politics in it. It also bears out the remarks of a previous speaker, Mr. Davidson, as to the benefits that might be derived from the commission form of government.

Winnetka, you know, is a peculiar little North Shore village. Nearly everybody that lives in it has business here in Chicago. They have a feature in Winnetka that they have in very few other towns or villages, and that is, the old New England town meeting. They get together every once in a while as a sort of large family, and they keep Mr. Herdman and the others straight, whether they want to be or not.

Having lived in that village some eight years, I am fairly familiar with the growth of it, and I wish to endorse what Mr. Herdman said about it. I have always attributed the good state of things in Winnetka to the New England town meeting.

C. C. Saner: In regard to eliminating politics by changing to a commission form of government, I believe, to a certain extent, such a result might be accomplished—that is, the appearance of politics will be missing, but the same element that controls politics will still keep control of the situation. This element is the local business men, who aim to control such matters through an organization, which you find in almost all towns today. These organizations are the town trusts formed for the purpose of protecting home industries and thereby mulcting the population of the city at large. It is a condition that exists and controls today, and one for which I am not prepared to suggest a remedy unless some of our national laws control.

I agree with every word in Mr. Hansen's paper, but I believe that if an engineer would go into a city and really try to put a water works plant on an efficient basis, he would have a very hard battle on his hands. Should he try to buy coal on the B. t. u. system, he is in trouble with the local coal dealers. If he tries to buy tools on a competitive basis, he is in trouble with the hardware dealers. This is true all the way down the line. The matter would be taken up with the local "trust" and the necessary pressure brought to bear to remove the engineer who is disturbing the old antiquated method of conducting business.

W. W. DeBerard: Last summer when I was in the Rocky Mountains, about 50 miles from civilization, a long message was received, asking if I would name a young man who could "tune up" a filter plant. It seems that a plant of about 4,000,000 gallons' capacity had been purchased by a company owning in the same city the water and light works. A filter company had obtained the contract for filters through the purchasing agent, who had been ordered to go out and buy "one filter plant." On completion the filters had been turned over to the pumpman or to the electric light engineer, but the plant would not run efficiently. The operating company then went down the line of their force until they got to a hydraulic engineer, who came to me with a message, asking if I could suggest somebody to put the plant on its feet. I racked my head for some time and finally suggested a man they should have had on the job from the first. The other day he came into the office and told me the plant had been running for two months previous to his seeing it, and during all that time no floc, or precipitate, had ever been obtained from the coagulant. Somebody had dropped the remark that perhaps half a grain of alum was sufficient; therefore never more than half a grain went into the water. The new man immediately increased the applied alum to eight-tenths of a grain and got a beautiful floc. This plant had been running for two months' time, during which the company practically threw away all the money paid out for alum, simply because an intelligent operator was not in charge. The plant was a good commercial plant, but it needed a friend who understood its limitations. Many other things, such as loss of head gages, rate controllers, wash water regulation, and air application, were soon put into working order, while the original force was taught how to get service out of the installation.

Andrews Allen: I just want to say one thing, in very general terms, and that is, that *all engineers ought to be "efficiency engineers."* This line you try to draw between "construction" and "operation" engineering is, to my mind, dead wrong. The engineer must keep in touch with the operation of the plants he designs, or he cannot be a good designing engineer. He cannot design correctly unless he knows how to operate, and if he does know how to operate he ought to be an "efficiency engineer." Some of us may be "efficiency engineers" and some "inefficiency engineers," according to the results we accomplish, but you cannot tell to which class an engineer belongs by the sign on the door of his office.

Benezette Williams: I want to endorse what our past president, Mr. Allen, has said: I cannot conceive of an engineer being really competent to design and put into operation any plant, without his being the most competent person to conduct it for efficiency, other things being equal.

Of course, there are other qualifications than mere engineering ability requisite to efficiency in the management of a public utility, but this is paramount either for the manager or his assistants. The designer should be the one best qualified to bring about favorable results.

There are some things to be said about politics. Politics is made to carry many sins for which it is not responsible. It is too often made "the goat" for all of the shortcomings of human nature. Party politics is not a feature in the affairs of most of the small towns, or at least not in many of them. Elections are decided across political lines, but human nature comes into play just the same. Officeholders shrink from acknowledging any lack of qualifications for any duty however foreign to their experience and training, and their manifest delinquencies are not so much related to politics as to personal pride, or to personal likes or dislikes. Often the self-sufficient business man plays an important part, as suggested by one of the speakers this evening. Hence, it seems to me that politics is made to carry too great a burden—a burden often due to the shortcomings of human nature rather than to politics.

The Author: I purposely left out the term "efficiency engineer," because I did not contemplate that this kind of work was to be taken up by a separate class of engineers. In that connection, I wish to fully endorse Mr. Allen's remarks that it is the man who designs plants who is the man that ought to take up the matter of operating them, because the two go hand in hand. A man cannot design plants properly unless he can operate them properly.

I wish to make an apology in connection with Winnetka. I should have mentioned the Winnetka water works as one of the notable instances where a small water works plant is being properly operated, and that is due to the fact that they have a regularly employed expert to operate it. Winnetka, however, must be recognized as an exception to the general rule, inasmuch as it is a community of unusually intelligent and wealthy people and the conditions are unusually favorable for a broad-minded handling of municipal utilities. It is quite unlike the ordinary community and I do not think you can induce the ordinary small community to engage regularly the services of an expert. It seems like the expenditure of too much money. Yet small communities may have much benefit of expert advice for a comparatively small sum by employing an outside consulting engineer.

I would like to say a word or two with reference to municipal governments. It is true that the average municipal government is such that it is exceedingly difficult to introduce efficient methods, but that is a fact that is being universally recognized nowadays and these governments are being improved in many ways, and we may anticipate further improvements. Therefore, why not go ahead with our propaganda of advocating the employment of consulting engineers in connection with operation, and keep pace with our new opportunities?

REPORT ON THE POLLUTION OF THE SANGAMON RIVER AND TRIBUTARY STREAMS WITH SPECIAL REFERENCE TO CONDITIONS BELOW DECATUR*

CONCLUSIONS:

THE PROBLEM AT DECATUR.

The problem at Decatur, from a sanitary and engineering point of view, consists in preventing a nuisance in the Sangamon river under conditions imposed by the following important factors, which are stated and discussed at length in the body of the report:

1. A dry weather sewage flow of more than average strength with a present daily volume of about 3,000,000 gallons per 24 hours and with a probable volume ten years hence of approximately 4,400,000 gallons.

2. The presence in the sewage of waste from a corn products works, which wastes are roughly six to eight times as strong as normal domestic sewage and which amount in volume at the present time to about 1,000,000 gallons per day, with the probability that within the course of a few years the volume will be nearly doubled.

3. The presence in the sewage of small but very troublesome quantities of gas house wastes. The volume probably does not exceed 10,000 gallons per 24 hours.

4. A flow in the Sangamon river at Decatur which is incapable of disposing of the normal sewage from the city by dilution during about three to six months in the year and which at times is almost negligible as a dilution factor. Ten years hence dilution will be ineffective during three to seven months of the year, and twenty years hence dilution will not be available during four to seven and one-half months.

5. An objectionable influence of pollution extending during ordinary low water stages from ten to twenty miles below the main Decatur sewer outfall, causing bad odors for half a mile or more on either side of the stream and rendering the water unfit for cattle watering, recreation purposes, or any other legitimate uses.

6. The existence of a comprehensive system of sewers built on the combined plan, thereby preventing the separation of sewage and storm water for disposal purposes.

*A report by Paul Hansen, Engineer.

7. The existence of four sewer outlets at more or less widely separated points, necessitating intercepting sewers to convey the sewage requiring treatment to a suitable site (of which there are fortunately several) for treatment works.

8. The necessity, because of limited dilution available, of intercepting and treating in addition to the dry weather flow, a portion of the storm flow also.

RECOMMENDATIONS.

The result of studies made by the State Water Survey permit the following recommendations to be made:

1. Gas house wastes can and should be treated separately by sedimentation, possibly assisted by treatment with lime and supplemented by filtration through coke or coal.

2. Corn products wastes should, if practicable, be treated separately, because, though smaller in bulk than the domestic sewage, their greater concentration and their relatively great resistance to decomposition will cause them to be more difficult to treat by ordinary biological processes than the entire city sewage. Should, however, evaporation methods now under trial not prove applicable, then other methods, including biological methods, should be studied experimentally, which will occupy a period of at least twelve months.

3. Whatever the means chosen for treating the corn products wastes, the entire dry weather flow of sewage and wastes must be reduced to a nonputrescible effluent reasonably free from suspended matter, and treatment works should be designed to meet the needs of a population of at last 45,000.

4. A portion of the storm flow from the sewers must also be treated in a manner and to a degree that will prevent any nuisance in the Sangamon.

5. An acceptable and probably the most economical method of treating dry weather flow of sewage and a proper portion of the storm flow, assuming them to be free from corn products wastes and gas house wastes, consists of the following:

(a) Passage of three times the dry weather flow through screens, grit chambers, primary sedimentation tanks with separate sludge digestion chambers, sprinkling filters and finally through secondary sedimentation tanks similar in principle to the primary tanks.

(b) Passage of sewage and storm water flow in excess of three times the dry weather flow and up to a volume of about twenty-five times the dry weather flow through sedimentation tanks of short retention period (probably one-half hours' retention will be sufficient). These quantities are only roughly approximate and their final determination must rest upon further studies. The basis upon which and manner in which they must be ascertained is discussed at length in the body of the report.

(c) When the flow in the Sangamon river is equal to 250 cubic feet per second or more, it will be permissible to discharge the dry weather effluent from the primary tanks directly into the stream. This has an important bearing on the elevation at which the filters may be placed and may obviate pumping or at least lower the head to be pumped against and the quantity of sewage to be pumped.

6. In view of the lack of data at present available on the behavior of the Sangamon following rainfall during low water stages and hence the dilution which may be counted upon following storms, careful observations should be made during at least one dry season. Such observations to include:

(a) A continuous record of river water levels by means of an automatic recording water level gage.

(b) Enough stream measurements to give a reliable rating curve for all gage heights.

(c) Continuous measurements of sewage flow also to be accomplished by automatic recording gages.

(d) Complete rainfall records at Decatur and as many points on the watershed as practicable (some of these records are already available), and

(e) Frequent inspections of the Sangamon river below Decatur accompanied by analyses of the water.

7. The city should at once secure competent engineering and other expert assistance to plan and carry out the further studies herein recommended, and to prepare on the basis of their investigation complete plans, estimates, specifications, reports and other matter necessary to present the character of the project clearly before the people and to serve as a basis for spreading special assessments.

While the recommendations herein made call for preliminary investigations and studies that are necessarily time-consuming, yet the large sum of money to be expended (probably half a million dollars or more) warrants a most careful preliminary study. Such study will not only enable the designers to reduce to a minimum the cost of the necessary works, but will also insure a design that will effectively relieve present highly objectionable conditions.

DETAIL REPORT ON THE CONDITION OF STREAMS IN THE SANGAMON RIVER WATERSHED WITH SPECIAL REFERENCE TO THE MAIN STREAM BELOW DECATUR.

INTRODUCTORY.

The streams of the state of Illinois constitute its most important sources of water supply for various municipal and manufacturing purposes. They also serve to remove city drainage, sewage and industrial wastes. As the watershed becomes more and more densely

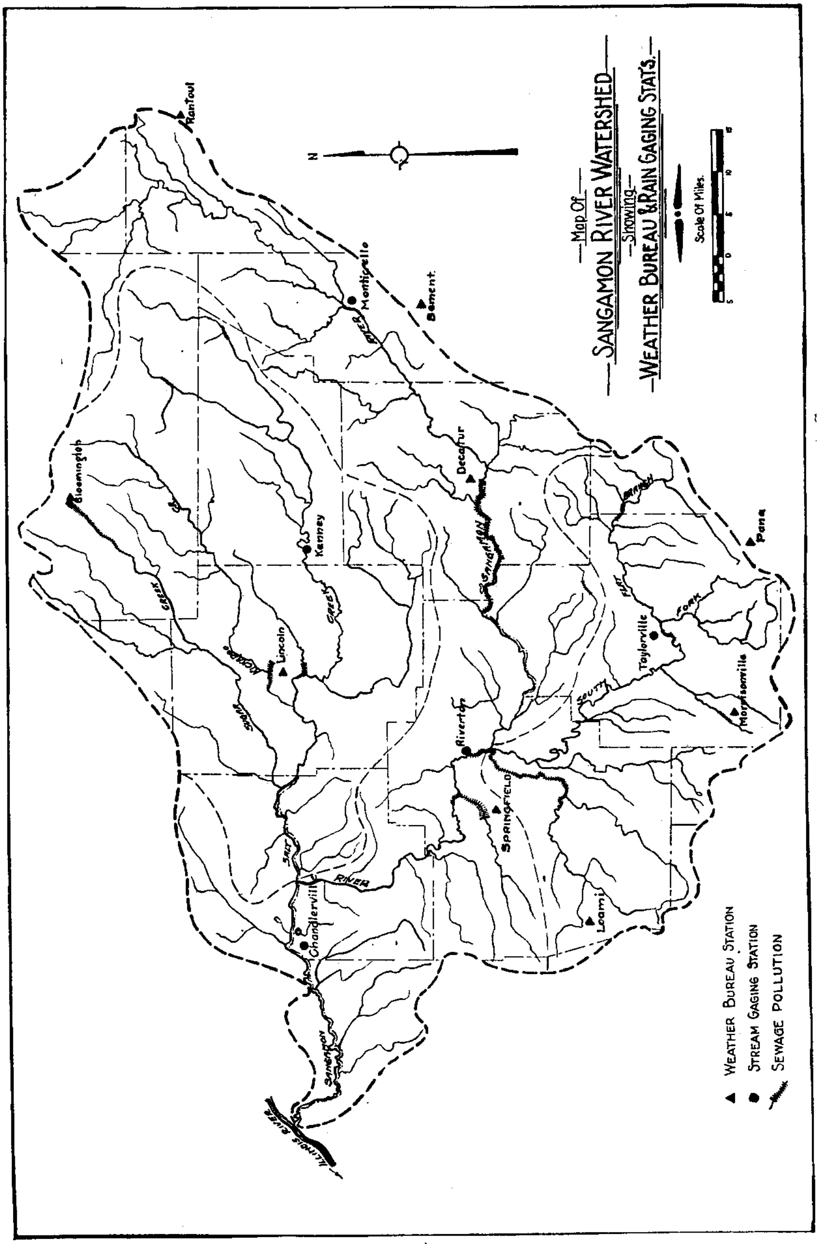


Fig. 1.—Description of Drainage Area and Stream.

populated, the streams tend to become more and more unfitted for water supply, more especially for domestic purposes. Both uses of streams, namely, as drainage courses and as source of water supply are legitimate uses and it, therefore, becomes the duty of the State Water Survey to periodically make an examination into the condition of the streams of the state with a view to establishing a mutually fair basis upon which communities, industries, and individuals may have the use of the streams for both drainage and water supply.

Nowadays there is a growing recognition of the importance of maintaining streams in a clean condition so that they may not be unsightly or malodorous, destroy fish life or render the stream unfit for boating and other recreation purposes. While these aspects of stream sanitation do not bear directly upon the use of streams as source of water supply, they necessarily enter into any study that is made of stream conditions and will ,therefore, be rather fully dealt with in this report.

With present appropriations the State Water Survey can investigate watershed conditions but slowly and not in complete detail. Therefore, in carrying out this work watersheds are selected that are in most immediate need of attention and those points at which pollution is most acute are given the more thorough study.

Thus far the stream investigation work of the State Water Survey has covered the watersheds of the Fox river and the Des Plaines river above Riverside, as these streams are most subject to objectionable contamination.

During the latter part of 1912 requests came to the office of the State Water Survey for investigations and advice relative to the pollution of the Sangamon river below Decatur. As this stream and some of its tributaries seemed to be in danger of objectionable pollution at other points, notably at Springfield and Bloomington, it was decided to extend the investigation to cover the entire Sangamon river watershed, but with special attention given to conditions at Decatur.

General Outline of Report: The following report will be divided into four main divisions, as follows:

1. Description of the watershed and streams.
2. Description of investigations with results obtained.
3. Discussion of the sewage disposal problem of Decatur.
   (a) Visual observations.
   (b) Results of stream analyses.
   (c) Composition and volume of Decatur sewage.
   (d) Summary discussion.

DESCRIPTION OF DRAINAGE AREA AND STREAMS.

Geographical: The drainage area of the Sangamon river (see Fig. 1), the largest tributary of the Illinois river, occupies an area of about 5,670 square miles near the geographic center of the state. This area has a maximum east and west dimension of 118 miles and a maximum north and south dimension of 86 miles. The watershed is divided into three important parts by the drainage areas of the main stream and its two most important tributaries, namely, Salt creek on the north and the South Fork of the Sangamon on the south. The drainage areas of Salt creek and South Fork are respectively 1,568 square miles and 946 square miles, leaving an area of 3,156 square miles draining directly or through minor tributaries into the main stream.

Topography: The area drained by the Sangamon river drainage system is for the most part rather flat prairie, though the topography is somewhat diversified in the eastern portion by low hills and undulating areas which constitute the terminal moraines of glaciers that traversed this territory. The valleys of the streams, more particularly the Sangamon itself, are bordered by more or less rugged land, and the main streams generally have broad and flat bottom lands. Elevations within the drainage area vary from about 420 feet to about 900 feet above sea level. These highest elevations are found in the northern part east of Bloomington.

Geology: The entire uplands of the Sangamon drainage area are covered with heavy glacial drift deposits. The eastern third of the area is covered by till plains crossed by narrow, sweeping zones marking the morainic belts of the last ice invasion from the north. The till deposits are of great depth and vary from 50 to 300 feet. The western two-thirds have the till covered with loess, a powdery soil of glacial origin. The glacial drift in this portion of the drainage area is much shallower than in the eastern portion and does not often exceed 50 feet.

In the valleys of the three main streams alluvial deposits are found and these are especially extensive along the lower reaches of the main stream and on Salt and Kickapoo creeks in the vicinity of Lincoln.

Throughout the eastern third of the watershed, where the glacial drift deposits are heavy, the water courses occupy channels of recent origin which bear no relation to pre-glacial drainage channels, while throughout the western part, covered by the area of comparatively shallow drift, the present streams follow with only minor variations the old pre-glacial drainage courses. This accounts in large measure for the more extensive alluvial deposits in the western area, which deposits are especially notable for large quantities of ground water yielded by them at Lincoln and Springfield.

The deep glacial deposits contain strata of sand and gravel at depths of 75 feet and more which are abundantly water-bearing and which furnish the public water supplies for a number of communities, notably Bloomington. In the western area of thinner drift water from the drift is not so abundant, but is present in sufficient quantity to furnish an ample supply for farm use and a few small supplies.

Hydrography: The main stream rises in the southern part of Ford county and the eastern part of McLean county, and flows in a general southwesterly direction to Decatur, a distance of about 95 miles. Thence it flows about 40 miles in a generally westerly direction as far as Springfield, where it is joined by the South Fork. From Springfield the river takes a northwesterly direction for 35 miles to the point of confluence with Salt creek about 8 miles north of Petersburg. From here on the river pursues a westerly direction for 35 miles to its confluence with the Illinois. The total length of the main stream is thus about 205 miles.

The elevation of the bed of the river at the source is about 850 feet above sea level, while at the mouth the low water elevation is about 419 feet. The total descent of the stream is thus about 430 feet or 2.1 feet per mile. The profile of the stream is not uniform. In the first ten miles the drop is as much as 120 feet or 12 feet per mile. During the next 73 miles, principally in Champaign and Piatt counties, the fall is about 130 feet or 1.73 feet per mile. Through Macon county the slope is slightly flatter, or 1.43 feet per mile. Through Sangamon county the slope is quite small, being but little over one foot per mile. Through Menard county the stream has a steeper gradient, namely, 2.23 feet per mile, which marks the descent from higher land into the valley carved by the Illinois river. As the river flows along the northern boundary of Cass county to its confluence with the Illinois, it passes for the most part through flat bottom land and has a fall of but one foot per mile. The characteristics of the stream gradient are more compactly shown in the following tabulation:

TABLE I. SHOWING SLOPE OF SANGAMON RIVER.

County	Distance in miles	Total fall feet	Fall per mile, feet
McLean	10	120	12.0
McLean Champaign Piatt	73	129	1.7
Macon	35	50	1.4
Sangamon	36	38	1.0
Menard	30	67	2.2
Cass Mason	26	26	1.0

The greater part of the Sangamon watershed is under cultivation. There are no forested areas and timber is limited to small groves scattered along river banks. The depth of the valley of the main stream below the general level of adjacent land is 20 to 30 feet for the first 60 miles of its course. The next 20 miles the river travels through a deeper cut of about 75 feet. This represents the descent of the stream from the newer glacial deposits to the older glacial deposits. For the remainder of its length the river flows through a valley about 50 feet in depth below the adjacent general level. There are exceptions to this general statement at Springfield and Petersburg, where local elevations cause the valley to have greater depth, reaching a maximum of about 100 feet.

TABLE II.

ANALYSES OF DECATUR WATER.

Date	Turbidity		Color		Gas Formers						Bacteria per cc.		
					Raw			Filt.					
Mo. Yr.	Raw	Filt.	Raw	Filt.	10.	1.0	0.1	10.	1.0	0.1	Raw	Filt.	Per c't removed
2-'06	Decid.	V. Sl.	0	0	1—	2—	2—	1—	2—	2—	335	240	28.3
3	Dist.	V. Dec.	.4	.1	1—	1—1+	2 +	1—	1—1+	2—	5700	1230	78.5
4	Decid.	Clear	Mud'y	0	1 +	2 +	2—	1 +	2—	2—	2500	840	66.5
5	Decid.	Clear	.3	0	1 +	1+1—	2—	1—	2—	2—	750	340	54.7
6	Decid.	Clear	.8	0	1 +	2 +	2—	1—	1—1+	2—	1180	110	90.7
8	Decid.	Distc.	.2	0	1 +	2 +	2 +	1 +	2 +	2 +	Lig.	Lig.	......
10	Decid.	Slight	.4	.2	1—	2 +	1—1+	1 +	2—	2—	510	260	49.0
12	V. Dec.	V. Dec.	Mud'y	Mud'y	1—	2—	2 +	1?	1—	2—	4000	Lig.	......
1-'07	Decid.	Clear	4.	0	1—	2 +	2—	1 +	2 +	2—	250	930	272.*
2	V. Sl.	V. Sl.	0	0	1—	2—	2 +	1—	1—1+	2—	490000	490	99.9
3	Decid.	Clear	Mud'y	0	1 +	2 +	2 +	1 +	2 +	1+1—	1700	290	83.0
4	35	20	.3	.2	1 +	1+1—	1+1—	1—	2—	2—	880	180	79.6
5	250	10	Mud'y	.2	1 +	2 +	2 +	1 +	1—1+	1—1+	8500	320	96.3
6	230	0	Mud'y	.3	1 +	2 +	2 +	1 +	2 +	2 +	31000	800	97.2
6	260	3	Mud'y	.1	1 +	2 +	2 +	1 +	1—1+	2?	5000	80	98.5
7	50	20	1.	.6	.....	2 +	2 +	.....	2 +	2 +	Lig.	12,500	......
8	208	20	Mud'y	.1	1 +	2 +	2 +	1 +	2 +	2 +	2500	Lig.	......
9	120	0	0	0	1?	1? 1+	2—	1 ?	1 ? 1 +	2?	800	600	25.0
11	30	0	.2	.2	1 +	2 +	1+1?	.....	2—	2—	2400	300	87.5
1-'08	30	5	0	0	1—	2—	2—	1 +	1—1+	2—	1200	740	38.4
3	100	0	0	0	1?	2 +	1—1+	1 +	1—1?	2—	2100	140	93.3
4	60	0	0	0	1 +	2 +	2—	1 +	1—1+	2—	1800	450	75.0
5	60	0	30	0	1 +	1+1?	2 +	1 +	1+1?	2 +	11500	1120	90.2
6	290	0	70	0	1 +	2 +	2 +	1 +	1+1?	1—1?	1500	65	95.8
7	60	0	50	0	1 +	1—1+	1—1+	1?	2—	2—	650	65	90.0
8	40	0	40	10	1 +	2 +	1—1?	2—	2—	2—	600	75	87.5
10	30	0	50	20	1 +	2 +	2?	1 +	1—1?	2—	560	15	97.4
10	35	0	50	10	1 +	2—	1? 1—	1 +	1+1?	2—	940	97	89.7
11	20	0	50	20	1?	2 +	2 +	1 +	2 +	2—	7200	560	92.1
12	30	0	30	10	1 +	2—	2—	1—	2—	2—	380	27	93.0
1-'09	35	0	50	20	1 +	2 +	1? 1—	1 +	2—	2—	12000	1400	91.7
2	300	0	100	0	1 +	2 +	2?	1 ?	2 +	2—	14000	900	93.6
3	30	0	10	0	1 +	1+1—	2 –	1—	2—	2—	2000	480	95.3
4	80	15	30	10	1 +	2 +	1? 1+	1?	1 ?1—	2—	4800	600	87.5
5	50	0	20	0	1 +	2 +	1+1?	1—	2—	2—	900	90	90.0
6	120	0	25	0	1 +	1—1?	1+1?	1 +	1+1—	2—	600	1000	66.7
8	240	0	30	0	1 +	1?	1 +	1 +	1 ?	1 +	3200	48	98.5
9	100	5	30	20	1 +	2 +	2 ?	1 +	2 +	1+1—	450	56	87.5
10	100	35	60	0	1 +	2 +	2 +	1 +	1+1?	2 +	42000	11000	73.9
11	40	0	0	0	1 +	2 +	2 +	1?	2 +	1? 1+	5400	1100	79.7
2–'10	0	10	0	0	1 +	2—	2—	1—	2—	2—	7400	1160	84.4
3	80	0	10	10	1 +	2?	1? 1+	1—	2—	2—	3600	450	87.5
5	200	10	10	10	1 +	2 +	2 +	1 +	2 +	1+1—	11000	700	93.7
5	810	15	20	10	1 +	2 +	2 +	1 +	2 +	2 +	60000	31000	48.3
7	70	3	35	5	1 +	2 +	1? 1—	1 +	1? 1+	2—	270	100	63.0
12-'11	20	12	25	15	1 +	2 +	1+ 1—	1 +	1? 1+	2 +	14000	3000	78.6

*Increase

Because of the general flatness of the area drained and because of certain topographical characteristics resulting from the area of glacial moraines, much of the tributary watershed has poor natural drainage and throughout considerable areas swamp conditions have prevailed. Drainage has been greatly improved by extensive use of farm drain tile and this has also largely eliminated swampy areas.

The Sangamon river has the characteristic flashiness of middle western streams, due in part to the unevenness in distribution of rainfall, in part to the absence of natural storage basins in the form of

TABLE II—CONTINUED

ANALYSES OF DECATUR WATER

Date	Turbidity		Color		Gas Formers						Bacteria per cc.		
	Raw	Filt.	Raw	Filt.	Raw			Filt.			Raw	Filt.	Perc't removed
					10.	1.0	0.1	10.	1.0	0.1			
1-12	15	20	30	18	1+	2+	2+	1+	1+1—	2—	12000	9700	19.2
3-12	20	3	25	10	1+	2+	1+1—	1+	2—	2—	1900	24	97.5
3-12	135	40	160	10	1+	2+	1+1—	1+	2—	2—	10000	750	92.5
4-12	340	160	35	5	1+	2+	2+	1—	2—	2—	16150	328	98.0
4-12	250	35	17	5	1+	2+	2+	1—	1+1—	2—	16500	330	98.0
5-12	......	45	33	0	1+	2+	2+	1+	2+	2+	25000	1200	99.2
5-12	200	10	20	20	1+	2+	2+	1+	1—	2—	12000	90	99.9+
5-12	140	8	22	10	1+	2+	2+	1+	2+	1+1—	17000	275	98.5
6-12	125	15	12	15	1+	2+	1+1—	1+	2—	2—	1300	57	95.6
6-12	200	20	20	30	1+	2+	1—1+	1—	2—	2—	1700	90	94.7
7-12	60	0	10	15	1+	2+	1—1+	1+	2+	2+	1000	Lig.	......
7-12	50	0	50	7	1+	2+	2+	1+	1—1+	2—	800	150	81.3
3-12	25	0	20	8	1+	2+	1+1—	1—	2—	2—	240	12	95.0
8-12	175	0	25	0	1+	2+	2+	1+	2+	2+	1500	225	85.0
9-12	85	10	30	20	1+	1+1—	2—	1+	2+	2+	7800	91	98.8
10-12	90	5	15	20	1+	2—	2—	1—	1+1—	2—	370	93	74.9
10-12	75	5	20	10	1—	2+	1+1—	1—	2—	2—	370	60	83.3
11-12	110	25	35	5	1+	2+	2+	1+	2—	2—	350	150	66.7
11-12	25	0	5	0	1—	2+	1+1—	1+	2—	2—	230	90	60.8
12-12	15	0	10	0	1—	1+1—	1+1—	1—	1+1—	2—	....	......	......
12-12	10	0	15	0	1+	2+	2—	1—	2—	2—	4500	2000	55.6
1-13	40	2	45	10	1+	2+	2+	1+	2—	2—	Lig.	50	......
1-13	70	20	15	0	1+	2+	2+	1—	2—	2—	2300	50	97.8
2-13	25	0	0	0	1+	2+	1+1—	1—	2—	2—	90	10	83.8
2-13	25	0	5	0	1+	1—1+	2—	1+	2—	2—	130	1	99.9+
3-13	20	2	10	5	1+	2+	1+1—	1+	1+1—	2—	3950	5	99.9+
3-13	1000	50	30	15	1+	2—	2—	1—	2—	2—	20000	150	99.3
4-13	60	20	10	5	1+	2+	1+1—	1—	2—	2—	1400	70	95.0
4-13	50	2	20	5	1+	2+	2—	1+	2—	2—	770	30	96.1
5-13	60	10	10	5	1+	1—1+	2—	1+	2+	1+1—	1000	151	94.9
5-13	90	5	10	10	1+	2+	2+	1—	2—	2—	890	38	95.8
6-13	70	20	20	10	1+	1—1+	2—	1—	2—	2—	95	8	91.6
6-13	75	10	18	6	1+	2+	2+	1—	2—	2—	550	130	76.4
7-13	50	10	10	10	1+	2+	1+1—	1+	1—1+	1—1+	310	150	51.6
7-13	65	40	25	10	1+	1+1—	2—	1+	2—	2—	770	210	72.7
8-13	40	20	20	20	1+	2+	2+	1+	2+	2+	560	210	62.5
9-13	25	15	20	20	1+	2+	2+	1+	2+	1—1+	290	212	26.9
10-13	5	5	10	10	1+	2+	1+1—	1+	2+	2—	460	2000	33.5 *
12-13	150	10	20	20	1+	2+	2+	1+	2+	2—	65000	115	99.9+
12-13	5	0	20	0	1+	2+	2+	1—	2—	2—	186	20	89.3
1-14	15	3	30	10	1+	2+	2+	1+	2+	1+1—	7000	3500	50

* Increase

lakes and ponds along the course of the stream and its tributaries and in part to the impervious character of the soil in wet seasons and its absorptive and holding power in dry seasons. Variations in stream flow are somewhat magnified by the extensive use of farm drain tile above referred to. The water of the main stream, as well as that of most of the tributaries, is rarely entirely free from turbidity, though at times the turbidity is so low that it would not be considered unobjectionable in a public water supply. The turbidity is greatly intensified after rainfall and at times becomes as much as about 1,000 parts per million. The water also has a distinct color, which varies with the turbidity and is obscured by it. During periods of low stream flow the water may be free from color. Ap-

TABLE III.
RAINFALL IN INCHES ON THE SANGAMON WATERSHED AT SPRINGFIELD.

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
1879	......	......	......	......	......	......	1.52	3.82	0.84	1.25	5.12	2.88	......
1880	2.70	2.89	2.37	3.23	5.76	2.47	1.82	1.80	3.15	2.04	1.60	1.10	30.93
1881	0.84	5.85	4.45	1.96	2.86	4.96	3.37	4.03	6.43	10.02	6.93	4.81	56.51
1882	2.48	7.92	4.92	3.85	10.59	12.71	1.89	3.13	1.21	3.76	2.60	3.15	58.21
1883	1.96	7.53	1.36	4.42	6.61	8.40	3.77	0.95	1.06	6.08	3.48	3.17	48.79
1884	1.51	4.24	3.70	2.49	3.79	6.20	3.62	1.54	6.86	2.74	1.30	5.19	43.18
1885	2.81	0.94	0.17	6.36	2.78	4.18	1.82	4.82	4.47	6.30	1.44	2.52	38.61
1886	2.19	1.86	2.45	2.98	3.56	3.83	0.05	4.19	7.24	0.80	1.74	0.80	31.69
1887	1.09	4.26	1.41	2.89	1.92	3.07	1.01	1.05	2.89	0.85	1.36	3.35	25.15
1888	3.03	2.03	3.48	1.41	8.61	5.50	4.59	1.43	1.70	3.61	3.41	1.99	40.79
1889	2.13	1.64	1.97	0.71	6.64	3.65	2.14	0.78	4.74	2.86	4.05	2.00	33.31
1890	5.72	2.01	2.20	2.94	4.33	4.50	2.14	1.03	0.96	1.30	1.29	0.26	28.68
1891	1.16	2.69	3.21	2.81	1.96	2.11	4.44	4.65	1.38	1.88	5.49	1.59	33.27
1892	1.14	3.41	2.69	7.19	7.51	2.51	5.63	1.89	3.48	1.05	4.19	1.78	42.47
1893	0.65	3.47	4.19	10.23	7.41	1.99	1.60	0.28	2.15	0.16	1.57	1.03	34.73
1894	2.51	2.58	3.09	3.36	2.8	1.56	2.06	1.86	2.94	0.85	1.63	3.10	28.34
1895	1.12	1.03	1.61	2.49	2.55	3.49	5.53	2.76	2.80	0.27	3.28	8.08	35.01
1896	1.77	2.11	1.25	1.91	2.49	6.45	8.51	1.87	5.42	1.76	1.88	0.31	35.73
1897	5.91	1.15	4.47	3.85	2.19	4.11	4.16	2.86	0.35	0.52	4.94	3.07	37.58
1898	5.81	2.70	9.65	3.76	5.12	4.76	2.34	4.40	6.82	6.15	2.94	1.83	56.28
1899	1.51	2.52	2.95	1.12	11.81	2.45	1.51	3.81	3.33	4.08	1.84	1.87	38.80
1900	0.88	4.85	1.50	1.06	2.49	1.45	2.89	4.44	5.15	2.63	2.61	0.41	30.36
1901	1.80	1.31	2.96	1.23	1.88	5.34	0.58	2.92	1.95	1.78	1.06	2.70	25.51
1902	1.01	1.01	3.73	3.03	1.80	10.10	1.41	5.12	2.30	2.15	2.82	2.23	36.71
1903	1.44	3.05	1.47	3.99	5.28	2.13	1.59	2.92	2.48	1.50	0.98	1.50	28.33
1904	1.98	1.49	4.73	4.81	3.74	2.34	4.25	2.63	3.96	0.11	0.02	0.57	30.63
1905	2.13	1.18	1.48	2.02	2.28	2.31	3.99	4.70	2.40	3.66	1.60	1.72	29.47
1906	2.99	2.18	4.02	2.26	3.70	3.03	0.93	4.88	3.77	1.46	3.13	3.14	35.49
1907	6.17	0.30	4.81	2.80	2.94	3.29	6.70	7.13	0.92	1.36	1.87	2.79	41.08
1908	1.77	4.28	2.21	4.48	7.27	1.38	1.37	2.62	1.22	0.29	1.17	1.62	29.68
1909	2.03	4.34	1.10	5.34	5.91	4.11	6.47	1.62	3.67	2.76	3.70	1.47	42.52
1910	1.68	0.94	0.18	2.81	4.39	4.58	2.63	0.78	4.34	1.74	1.57	0.86	27.50
1911	2.34	1.73	1.86	4.40	1.18	3.44	4.87	3.37	10.68	2.00	3.10	1.86	40.83
1912	1.08	1.56	4.21	5.39	4.40	3.13	4.47	2.87	1.42	3.49	1.48	0.31	33.81
1913	3.55	1.35	5.35	3.55	0.96	1.84	1.66	2.88	3.41	3.61	4.49	0.77	33.62
Mean	2.05	2.66	3.14	3.41	4.29	4.18	2.97	2.82	3.52	2.64	2.69	2.30	36.85
Maximum	6.17	7.92	9.65	10.23	11.81	12.71	8.51	7.13	7.24	10.02	6.93	8.08	58.21
Minimum	0.65	0.30	0.17	0.71	0.96	1.38	0.58	0.28	0.35	0.29	0.02	0.31	25.15

pended is a table (No. 2) showing the results of a series of analyses of the Decatur public water supply. The figures in the columns marked "raw" apply to the Sangamon river above local pollution and the figures in the columns marked "filt." apply to the water as delivered to consumers.

Rainfall and Stream Flow: In Table No. 3 are presented available rainfall records at Springfield. From these records it will appear that

TABLE IV.

RAINFALL AND RUNOFF AT RIVERTON, SANGAMON RIVER.

Watershed Area, 2,560 Square Miles.

Season	Rainfall Av. Sec. Ft. on Watershed			Run-off—Second Feet			
	Normal	Actual	Per Cent Departure	Maximum	Minimum	Mean	Per Cent of Rainfall
Spring—March-May, 1908	7,110	11,340	+59.5	13,100	1,830	5,867	51.7
Summer—June-August, 1908	8,420	8,040	— 4.5	3,320	101	526	6.5
Fall—September-November, 1908	6,120	3,110	—49.2	148	60	85	2.7
Winter—December, 1908-February, 1909	5,000	5,540	+10.8	179	101	785	14.2
Spring—March-May, 1909	7,110	9,590	+34.9	5,580	856	2,783	29.0
Summer—June-August, 1909	8,420	8,970	+ 6.5	10,600	148	2,285	25.4
Fall—September-November, 1909	6,120	6,340	+ 3.6	254	148	371	5.9
Winter—December, 1909-February, 1910	5,000	4,970	— 0.6	7,020	....	1,708	34.2
Spring—March-May, 1910	7,110	6,060	—14.7	6,020	344	1,970	32.5

Rainfall figured— Average at Morrisonville, Decatur and Rantoul.

the average rainfall is about 37 inches per annum and that it varies from 25 inches to 58 inches per annum. A number of stream gagings and gage height records have been maintained by the United States Geological Survey at Riverton and Monticello on the main stream and Taylorville on the South Fork. The results of these measure-

TABLE V.

RAINFALL AND RUNOFF AT MONTICELLO, SANGAMON RIVER.

Watershed Area, 550 Square Miles.

Season	Rainfall Av. Sec. Ft. on Watershed			Run-off-Second Feet			
	Normal	Actual	Per Cent Departure	Maximum	Minimum	Mean	Per Cent of Rainfall
Spring—March-May, 1908	1,700	2,635	+54.9	9,280	505	2,033	73.4
Summer—June-August, 1908	1,764	1,520	—13.8	756	8	111	7.3
Fall—September-November, 1908	1,158	571	—50.6	25	6	8.9	1.6
Winter—December, 1908-February, 1909	1,093	1,195	+ 9.3	3,120	11	321	27.0
Spring—March-May, 1909	1,700	2,220	+30.7	2,880	182	664	29.8
Summer—June-August, 1909	1,763	2,155	+22.2	8,720	11	517	24.0
Fall—September-November, 1909	1,158	1,326	+14.4	320	10	48	3.6
Winter—December, 1909-February, 1910	1,093	1,140	+ 4.3	2,120	128	536	47.0
Spring—March-May, 1910	1,700	1,080	—36.5	1,480	74	283	26.2

Rainfall figured—Average at Urbana and Bloomington.

TABLE VI.

RAINFALL AND RUNOFF AT KENNEY, SALT CREEK.

Watershed Area, 459 Square Miles.

Season	Rainfall Av. Sec. Ft. on Watershed			Run-off—Second Feet			
	Normal	Actual	Per Cent Departure	Maximum	Minimum	Mean	Per Cent of Rainfall
Spring—March-May, 1908.	1,418	2,195	+54.9	5,840	253	1,269	57.6
Summer—June-August, 1908	1,473	1,270	—13.8	645	14	127	10.0
Fall—September-November, 1908	968	477	—50.6	33	5	18	3.8
Winter—December, 1908-February, 1909	916	1,000	+ 9.3	7,140	14	333	33.5
Spring—March-May, 1909.	1,418	1,854	+30.7	1,810	96	429	23.2
Summer—June-August, 1909	1,473	1,800	+22.2	1,600	6	248	13.8
Fall—September-November, 1909	968	1,106	+14.4	722	5	67	6.1
Wineter—December, 1909-February, 1910	916	955	+ 4.3	....	....	185	19.4
Spring—March-May, 1910.	1,418	900	—36.5	933	43	157	17.4

Rainfall figured—Average at Urbana and Bloomington.

ments are presented in Figures 2, 3 and 4. Figure 5 represents the probable stream flow at Decatur and was obtained by interpolation between the records for Riverton and Monticello. The interpolation was made in proportion to the watershed areas above the respective points.

TABLE VII.

RAINFALL AND RUNOFF AT TAYLORVILLE, SOUTH FORK SANGAMON RIVER.

Watershed Area. 427 Square Miles.

Season	Rainfall Av. Sec. Ft. on Watershed			Run-off—Second Feet			
	Normal	Actual	Per Cent Departure	Maximum	Minimum	Mean	Per Cent of Rainfall
Spring—March-May, 1908.	1,270	1,850	+45.7	3,300	150	954	51.5
Summer-June-August, 1908	1,490	1,290	—13.4	238	5	31	2.4
Fall—September-November, 1908	1,080	505	—53.2	12	5	6	1.2
Winter—December, 1908. February, 1909	935	946	+ 1.2	1,430	6	193	20.4
Spring—March-May 1909.	1,270	1,570	+23.6	2	69	468	29.8
Summer-June-August, 1909.	1,490	1,760	+18.1	2,060	28	355	20.2
Fall—September-November, 1909.	1,080	1,150	+ 6.5	430	5	63	5.5
Winter—December, 1909-February, 1910	935	840	—10.2	1,600	74	298	35.5
Spring—March-May, 1910.	1,270	1,060	—16.5	1,600	52	583	55.0

Rainfall figured— Average at Morrisonville and Pana.

TABLE VIII.
STREAM GAGINGS OF SANGAMON RIVER AND TRIBUTARIES BY STATE WATER SURVEY.

	Nov. 30, 1912		Dec. 20, 1912		July 7-10, 1913		July 22-24, 1913		Aug. 5-7, 1913		Sept. 25, 1913	
	Sec. feet.	Gal. per day	Sec feet	Gal. per day	Sec. feet	Gal. per day	Sec. feet	Gal. per day	Sec. feet	Gal. per day	Sec. feet	Gal. per day
Monticello												
Sangamon below sewer outlet	......	......	......	......	22.0	14,277,000	......	......	5.2	3,331,000	......	......
Decatur												
Sangamon below dam	89.5	58,000,000	66.9	43,300,000	25.0	16,173,000	......	......	0.18	114,000	2.1	1,418,000
Stephens creek west of Decatur	......	......	......	......	not gaged	no flow	......	......	......	......	......	......
Springfield												
South fork near mouth	......	......	......	......	20.9	13,426,000	......	......	7.4	4,776,000	......	......
Sugar creek near mouth	......	......	......	......	2.0	1,284,000	......	......	0.25	162,000	......	......
Spring creek near mouth	......	......	......	......	6.9	4,456,000	......	......	4.4	2,833,000	......	......
Sangamon below Spring creek	......	......	......	......	99.7	64,410,000	......	......	23.9	21,918,000	......	......
Petersburg												
Salt creek at mouth	......	......	......	......	212.5	136,150,000	......	......	......	......	......	......
Sangamon above Salt creek	......	......	......	......	168.0	108,540,000	......	......	......	......	......	......
Taylorville												
South fork above paper mill outlet	......	......	......	......	......	......	2.1	1,334,000	......	......	......	......
South fork below all sewers	......	......	......	......	......	......	3.7	2,392,000	......	......	......	......
Bloomington												
Sugar creek below all sewers	......	......	......	......	......	......	5.9	3,787,000	......	......	......	......
Sugar creek 13½ miles below sewers	......	......	......	......	......	......	7.1	4,568,000	......	......	......	......
Lincoln												
Kickapoo creek n. w. of Lincoln	......	......	......	......	......	......	22.8	14,737,000	......	......	......	......
Salt creek above sewer outlets	......	......	......	......	......	......	49.1	31,713,000	......	......	......	......

Still incomplete studies of the relation between rainfall and run-off indicate an average runoff for a normal year to be about 30 per cent of the rainfall. The percentage runoff during different seasons, however, varies widely. While as yet no definite figures can be given, some tentative figures are presented in Tables IV, V, VI and VII. It appears that roughly the spring runoff (including the months of March, April and May), is in the neighborhood of 50 per cent of the rainfall and fluctuates somewhat roughly in proportion to the variations in the rainfall from the normal. The spring months are, therefore, periods of large stream flow, when there is usually ample dilution to prevent all nuisance or other objectionable conditions due to the discharge of sewage into streams. During the summer months of June, July and August, the percentage runoff is somewhat erratic. A wet season will give a high percentage run-off and a dry season a low percentage. The variation in runoff is generally greater than the variations in the rainfall. During the fall months

TABLE IX.

POPULATION OF SANGAMON RIVER WATERSHED—CLASSIFIED AND SHOWING VARIATIONS.

Census Year	1910	1900	1890
Urban (1,000 over	171,102	131,101	98,918
Rural in Watershed	161,152	178,885	188,690
Totals	332,254	309,956	280,608
Per cent Increase—Urban	30.5%	32.5%	....
Per cent Decrease—Rural	9.9%	1.5%	....
Per cent Increase—Total	7.2%	10.5%	....
Population per square mile rural	29.6	32.9	33.4
Population per square mile total	61.1	57.0	51.6

of September, October and November, the runoff is invariably small and rarely, so far as available data indicate, exceeds 6 per cent of the rainfall. This is undoubtedly due to the fact that during the summer and fall the rainfall is so small that the ground becomes dry and capable of absorbing large quantities of water. During the winter the precipitation and also the stream flow increases. It is difficult to trace any definite relation between the rainfall and runoff in the winter time for the reason that conditions are favorable to wide fluctuations. With a frozen ground for example and a heavy rain, the runoff will be large. Also in the late winter months the ground is likely to become fairly well saturated with water. During the early winter months, however, the rainfall may be low and the runoff correspondingly low.

For the purpose of indicating the periods during which objectionable stream pollution is likely to occur, brackets have been drawn on the diagrams showing stream flow at Riverton, (Fig. 2) Decatur, (Fig. 5) Monticello, (Fig. 3) and Taylorville, (Fig. 4) indicating periods during which the stream flow is inadequate to afford sufficient dilution to prevent nuisance. These periods are shown both for the present and ten and twenty years in the future. They will be referred to under the detailed discussion of the several towns.

Population: The populations on the entire watershed of the Sangamon river for the past three census years are given in Table IX. This tabulation divides the population into urban and rural. Every community over 1,000 population is considered as an urban population. This manner of classification differs from that used by the U. S. Census Bureau which places the lower limit of urban population at 2,500. In justification thereof, it may be pointed out that communities with 1,000 population or more are rapidly installing public water supplies and sewerage systems which give them all the characteristics of urban communities with reference to sanitation of waterways, which is the main subject of this report.

The table shows that there is a substantial growth of the entire population varying from 7.2 to 10.5 per cent in a decade. The urban

TABLE IXa.

POPULATION IN VARIOUS PARTS OF SANGAMON RIVER WATERSHED IN 1910.

	Area Square Miles	Population			Persons Per Square Mile		
		Rural	Urban	Total	Rural	Urban	Total
Main stream above mouth	4485	159,755	172,578	332,333	35.6	38.5	74.1
Salt creek above mouth . .	1568	48,700	54,280	102,980	31.0	34.6	65.6
South fork above mouth . .	946	16,998	12,913	29,911	18.0	13.7	31.7
Main stram above Riverton	2560	85,007	113,881	198,888	38.7	51.7	90.4
Main stream above Decatur	862	30,908	38,043	68,951	35.8	44.1	79.9

population is increasing rapidly, namely, from 30.5 per cent to 32.5 per cent in a decade, whereas the rural population has materially decreased. During the decade from 1890 to 1900, the decrease in the rural population was 1.5 per cent. During the decade from 1900 to 1910 the decrease was 9.9 per cent. The explanation of this decrease lies principally in the transfer of many small towns from the rural to the urban class and also in the tendency for farmers to live in communities, thus enabling them to enjoy many of the conveniences of urban life. This tendency is greatly fostered by improvement of transportation facilities including interurban railroads and the automobile. Another explanation of the decrease in rural population is the rapidly extending use of farm machinery which reduces the help required on farms.

It will be observed that the urban population during 1910 constituted about 51.5 per cent of the entire population on the watershed. The population per square mile for the rural population was only 29.6 in 1910, a material decrease over previous census years. This dispersion of rural population is so great that it can have no material effect

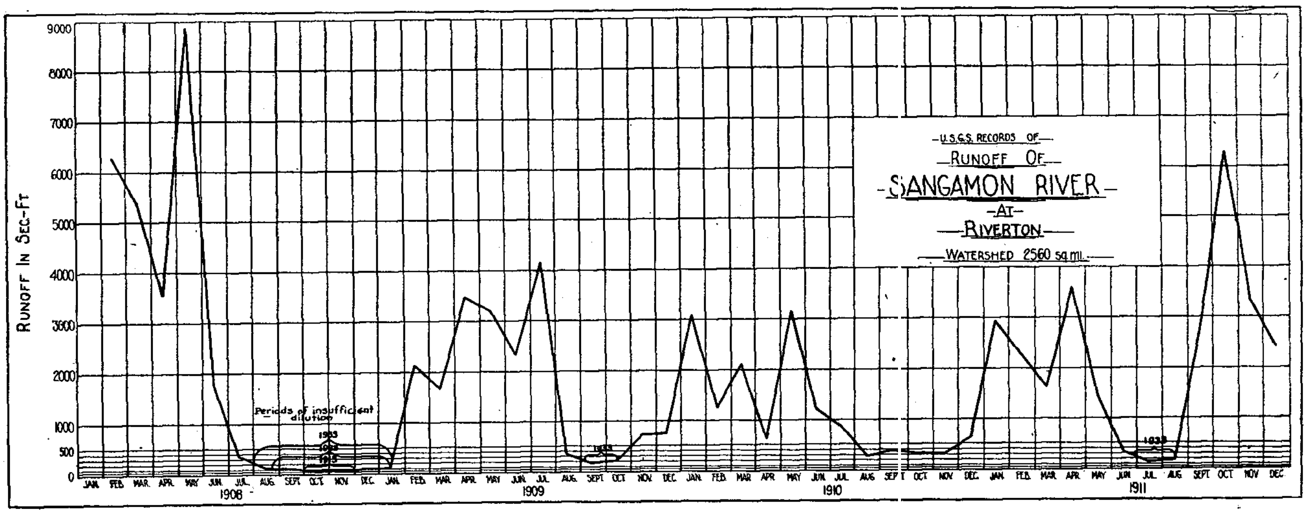


Fig. 2.—Runoff of Sangamon River at Riverton.

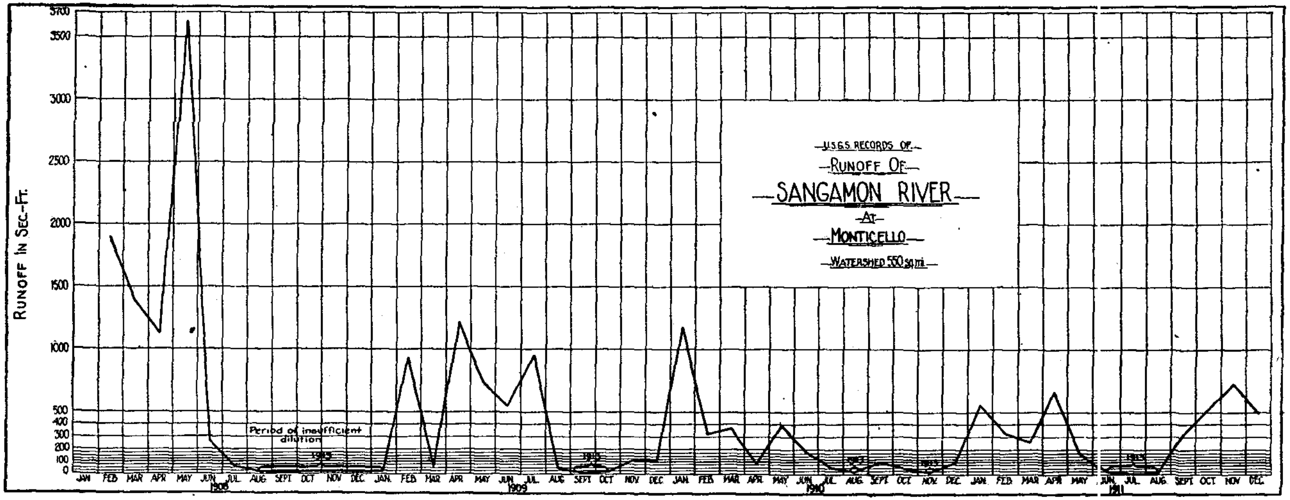


Fig. 3.—Runoff of Sangamon River at Monticello.

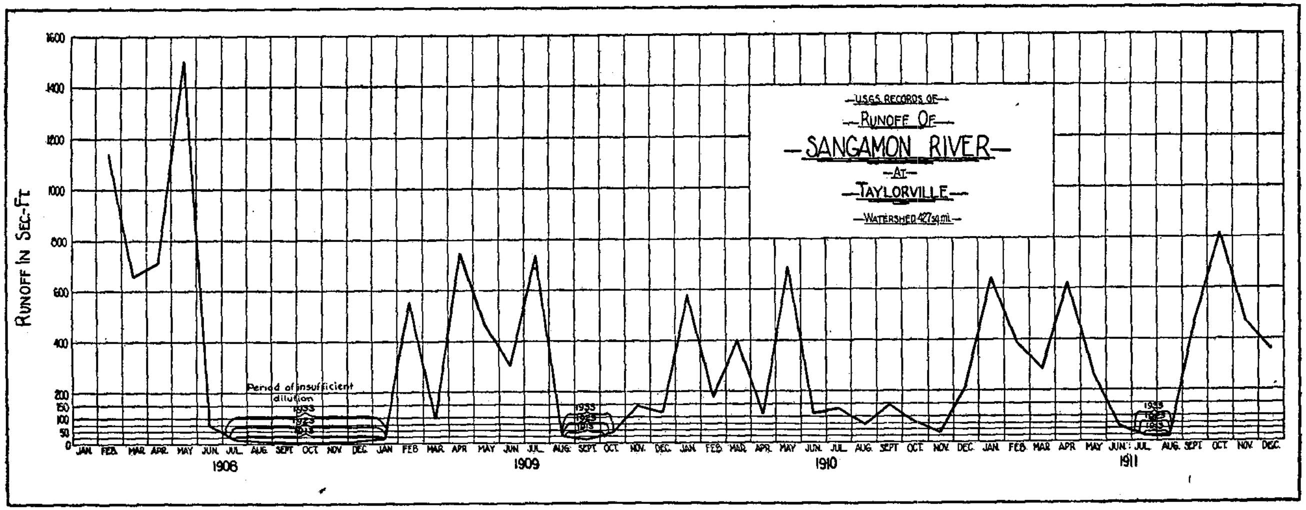


Fig. 4.—Runoff of Sangamon River at Taylorville.

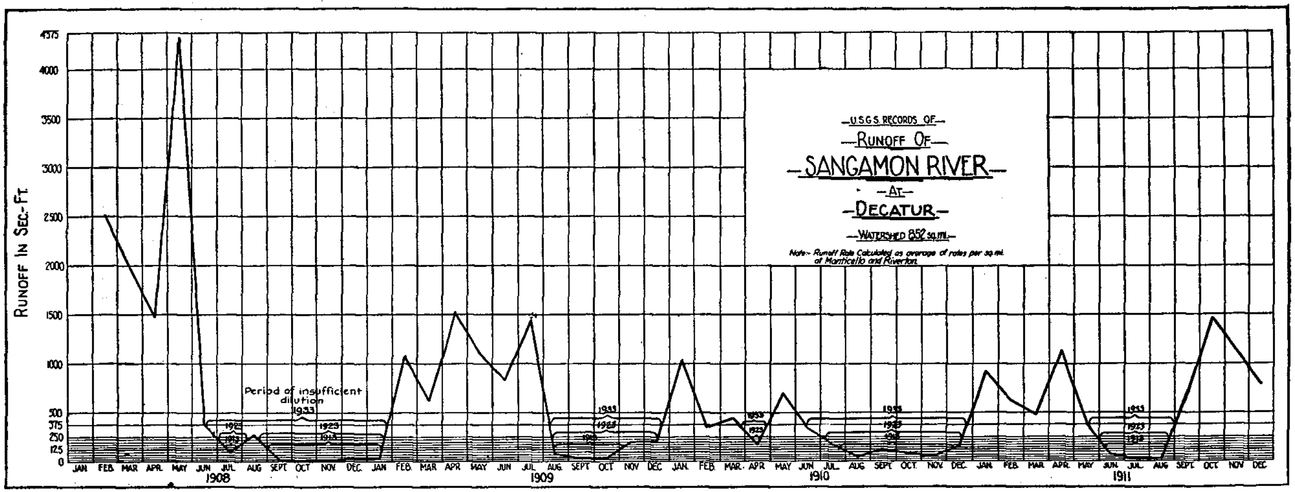


Fig. 5.—Runoff of Sangamon River at Decatur.

upon the contamination of waterways except to the extent of rendering a surface water unsuited for domestic purposes without purification. This is true, however, for any unprotected watershed, however, sparse the population. The urban population, therefore, constitutes the principal, and practically the only factor that needs to be considered in connection with objectionable stream pollution. For the purpose of showing the distribution of population in various portions of the watershed, Table No. IXa. has been prepared to show populations above the mouth of the main stream, above Springfield, above Decatur, above the mouth of Salt Creek and above the mouth of Salt Fork.

DESCRIPTION OF INVESTIGATIONS MADE.

The principal methods used for examining the sanitary condition of the Sangamon river watershed consisted of the following:

(1) Inspection trips during which samples were collected at various points for analysis and stream measurements were made.

(2) Special studies of sewage disposal conditions, including sewer gagings and sewage analysis.

(3) Studies of the sewerage conditions of all of the urban communities on the watershed.

General Remarks Regarding Inspection Trips.

A condensed statement of the various inspection trips and their purpose is contained in the following table (Table X.). In addition to those listed, numerous other visits were made to Decatur for the purpose of making inspections and consulting with the local authorities.

The year 1913 proved to be a most favorable year for making investigations relative to stream pollution. The protracted dry period occurring during the summer months caused the stream flow throughout the Sangamon watershed to fall below all records. The inspection and sampling trips were so timed as to secure a gradation of conditions with reference to stream flow from extreme low water to what may be termed a medium low stage. The latter is a stage that in ordinary times will persist throughout the summer season. The highest stage encountered was on November 30, 1912, when the total stream flow at Decatur was 89.5 second feet and represented a medium to low stage. At this time the dilution available was about 2½ cu. ft. per thousand of population at Decatur. On the basis of the rule which calls for a dilution of from 3 cu. ft. to 6 cu. ft. per 1,000 population, it is apparent that even at this stage of the river the dilution is far from sufficient for the Decatur sewage. On December 20, 1912, a somewhat lower stage was encountered, namely, a stage which provided a dilution of about 1.9 cu. ft. per 1,000 population. This trip was accompanied by extended analyses of the sewage, measurements of sewage flow, and analyses of the water in the river above and below Decatur. During the extended trip, covering the entire main stream, of July 7-10, an unusually low stage prevailed, during which there was available at Decatur but .72 cu. ft. of dilution water per 1,000 population. The extended trip of August 5-7 came at a time when the flow in the stream after the public water supply of Decatur had been removed, was almost a negligible factor, and consisted merely of something over 100,000

TABLE X.

SCHEDULE OF TRIPS ALONG THE WATERCOURSES OF THE SANGAMON WATERSHED.

Dates	Personnel	Purpose of Trip
September 23, 1912	H. P. Corson, Chemist	Inspection of Sangamon below Decatur and collection of samples at four points
October 15, 1912	Paul Hansen, Engineer	Inspection of Sangamon for 14 miles below Decatur
November 30, 1912	H. F. Ferguson, Assistant Engineer, A. L. Epstein, student	Visit preliminary to gaging sewers and obtaining weighted samples of sewage
December 21, 1912	R. Hilscher & H. F. Ferguson, Asst. Engineers, A. L. Epstein, student	With assistance of men employed by Decatur made sewer gagings and obtained samples of sewage and river water for analysis.
July 1 to 5, 1913	H. F. Ferguson, Assistant Engineer, V. R. Fleming, special Asst. Engineer	Preliminary trip covering entire watershed for purpose of selecting sampling points, selecting gaging stations and establishing schedule of operations.
July 7 to 10, 1913	H. F. Ferguson, Assistant Engineer, V. R. Fleming, special Asst. Engineer, F. G. Norbury and C. R. Newell, Eng. Assistants	Trip covering main stream during which 24 sets of samples were collected and seven stream measurements made.
July 22 to 24, 1913	H. F. Ferguson, Assistant Engineer, V. R. Fleming, special Asst. Engineer, F. G. Norbury and C. R. Newell, Eng. Assistants	Trip covering Salt creek and South fork of the Sangamon during which 17 sets of samples were collected and 6 stream measurements were made.
August 5 to 7, 1913	H. F. Ferguson, Assistant Engineer, V. R. Fleming, special Asst. Engineer, F. G. Norbury and C. R. Newell, Eng. Assistants	Trip covering main stream during which 24 sets of samples were collected and seven stream measurements made.
September 25, 1913	H. F. Ferguson, Assistant Engineer, F. W. Tanner, Bacteriologist, M. C. Sjoblom, Eng. Assistant, F. W. Mohlman, Asst. Chemist	Trip covering Sangamon River from Decatur to 17 miles below Decatur at which time 8 sets of samples were collected and one stream measurement was made.

gallons which passed through the fishway in the water works dam. The dilution at this time was only .005 of a cubic foot per 1,000 population.

Bloomington.

During the investigation, special attention was given to conditions at Decatur, but other stream pollution problems on the Sangamon watershed were also investigated. Most important among these is Bloomington on Sugar Creek, a tributary of Salt Creek. At this point an extremely low stream flow was encountered, the dilution available was negligible and amounted to not over 0.2 cu. ft. per 1,000 population at Bloomington. For several miles below the city Sugar Creek is virtually an open sewer, but under the dry weather condi-

TABLE XI.

SHOWING DILUTION AVAILABLE FOR SEWAGE DISPOSAL AT VARIOUS CITIES ON THE SANGAMON WATERSHED (BASED ON MEASUREMENTS MADE BY STATE WATER SURVEY).

Date	Decatur Population 35,000 Discharge			Bloomington Population 30,000 Discharge			Springfield Population 55,000 Discharge			Taylorville Population 6,000 Discharge			Monticello Population 2,500 Discharge			Lincoln Population 12,000 Discharge		
	Sec. Ft.	Gals. per day	Sec. Ft. per 1000 pop.	Sec. Ft.	Gals. per day	Sec. Ft. per 1000 pop.	Sec. Ft.	Gals. per day	Sec. Ft. per 1000 pop.	Sec. Ft.	Gals. per day	Sec. Ft. per 1000 pop.	Sec. Ft.	Gals. per day	Sec. Ft. per 1000 pop.	Sec. Ft.	Gals. per day	Sec. Ft. per 1000 pop.
Nov. 30, 1912	89.5	58,000,000	2.52	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Dec. 20, 1912	66.9	43,300,000	1.91	....	....	....	....	....	....	....	....	....	22.05	14,277,000	8.8	....	....	....
July 7-10, 1913	25.0	16,173,000	.72	....	....	....	99.7	64,410,000	1.8	....	....	....	....	....	....	....	....	....
July 22-24, 1913	....	....	....	5.9	3,787,000	0.2	....	....	....	2.1	1,334,000	0.35	....	....	....	22.8	14,737,000	1.9
Aug. 5-7, 1913	0.18	114,000	.005	....	....	....	23.9	21,918,000	0.43	....	....	....	5.2	3,331,000	2.1	....	....	....
Sept. 25, 1913	2.01	1,418,000	.06	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

tions prevailing, self-purification of the stream occurred in the remarkably short distance of 5 to 7 miles. This phenomenon results in part form the fact that the stream is well adapted to self-purification. It consists of a series of pools and riffles, but this is not the entire explanation of the phenomenon, and it is probable that further explanation may be had in the seepage of the sewage into the ground through the bed of the stream. Point is given to this theory by the testimony of persons living near the stream that in dry weather, the pollution beyond a distance of 5 or 6 miles below Bloomington is much less marked than it is after periods of considerable rainfall when the ground is too wet to permit soakage through the stream bed. Possibly increased rainfall washes the sludge accumulated in the bed of the stream farther down stream and thereby gives rise to the above noted objectionable conditions, but such cannot be entirely the case, for it seems that the most pronounced odors at points 10 to 12 miles in a down stream direction occur in the late spring or early summer when the stream bed is washed clean by spring freshets. The conditions at Bloomington, notwithstanding the rapid self-purification of Sugar creek, are very bad, and during the past summer gave rise to some complaint and the city is now contemplating a modification of its sewerage system that will have the effect of eliminating, to some extent at least, the nuisance now existing. That more complaint has not been made against the sewage disposal of Bloomington is no doubt due to the general remoteness of Sugar creek from habitations.

Springfield.

At Springfield, the investigations of July 8 and August 6, 1913, indicated the dilution in the main stream to be insufficient to prevent nuisance below the entrance of Spring creek, which receives the greater portion of the sewage discharge of the city. The stream flow on these dates was unusually low and afforded an available dilution as indicated by Table XI on the respective dates of but 1.8 cu. ft. and 0.43 cu. ft. per 1,000 population at Springfield. Until the present summer, there has been no marked pollution of the Sangamon river below Springfield, notwithstanding the fact that during almost every summer, the volume of flow in the stream is not sufficient to adequately dilute the sewage from so large a population. The explanation of this lies in the circumstance that the sewage from Springfield must travel anywhere from one to five miles before reaching the Sangamon and thus has opportunity for partial self-purification. There are local nuisances on both Sugar creek and Spring creek, more particularly on the latter at the National Guard Rifle Range, through which Spring creek flows.

Looking somewhat into the future, it may reasonably be expected that ten years hence there will be 65,000 persons tributary to the sewers in Springfield. Allowing for a degree of self-purification of the

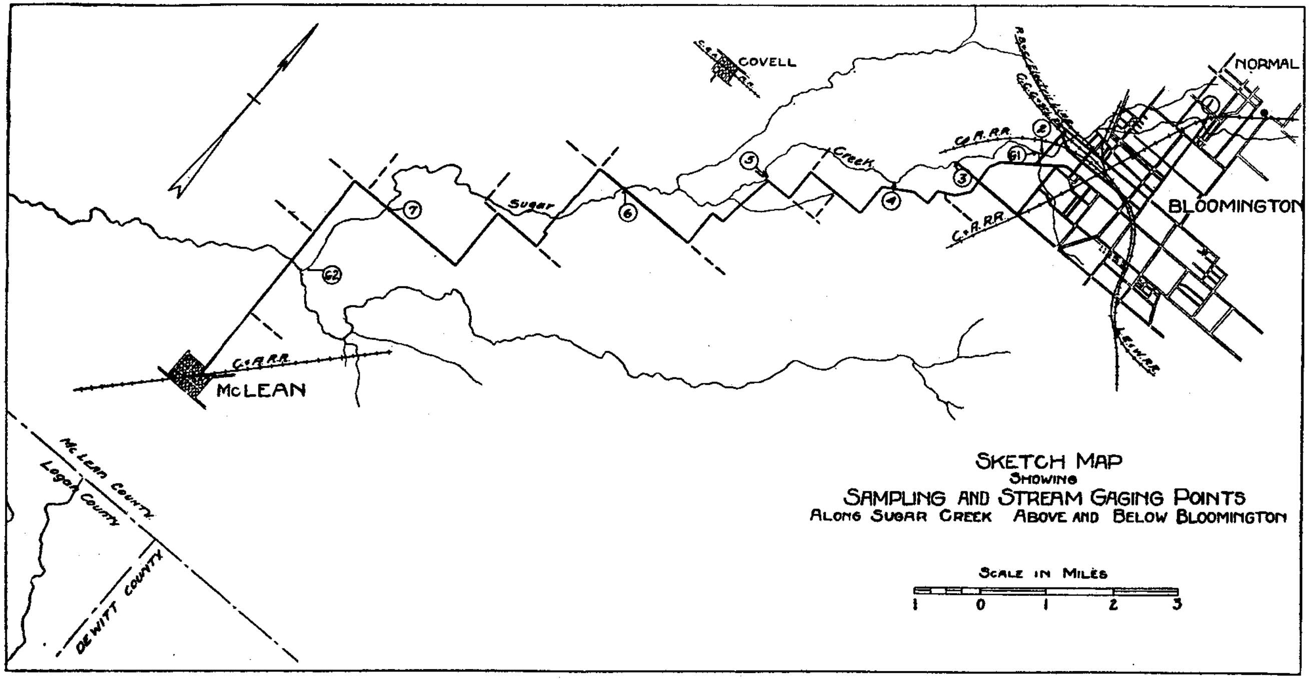


Fig. 6—Sampling and Stream Gaging points Along Sugar Creek Above and below Bloomington.

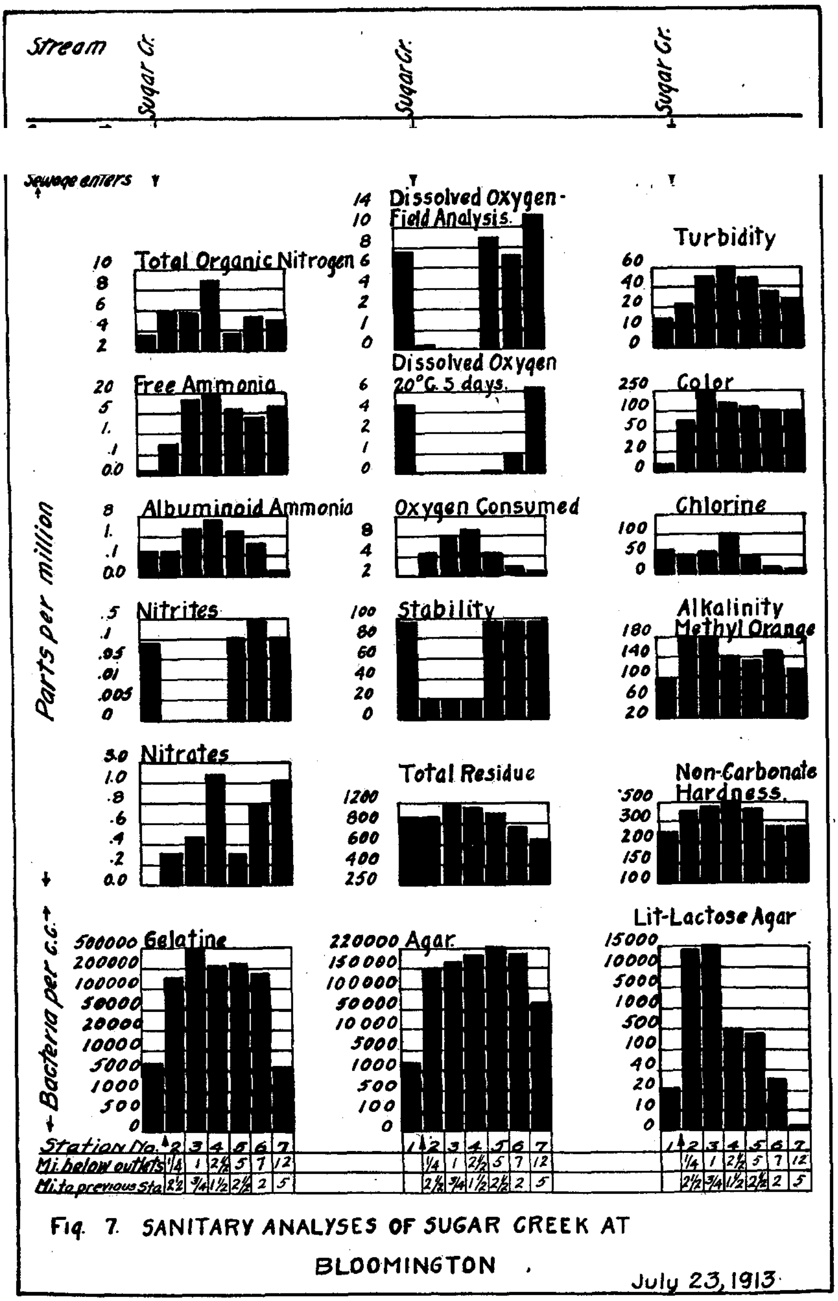


Fig. 7.—Sanitary Analyses of Sugar Creek at Bloomington.

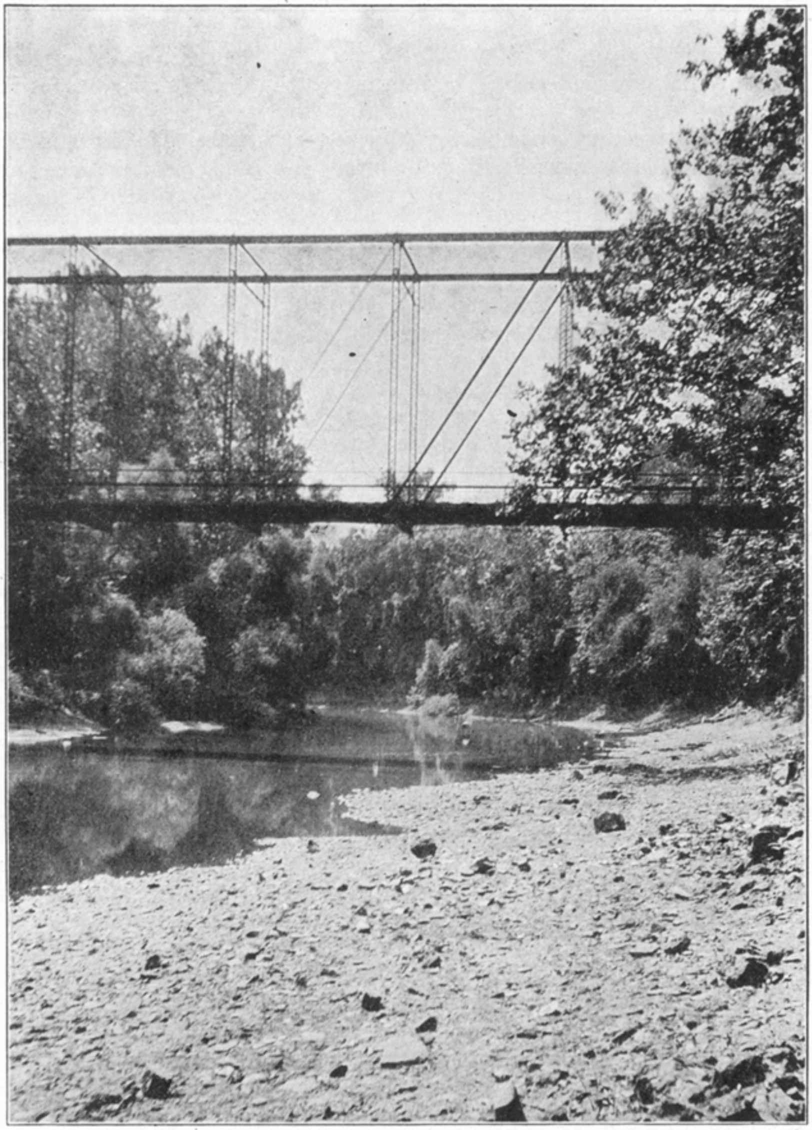
sewage before it reaches the Sangamon river, a conservative estimate of the diluting water required would be about 2 cu. ft. per 1,000 persons tributary to the sewers. This represents a flow in the river of 130 cu. ft. per second. According to run-off figures presented in Figure 2, there will be occasional years similar to 1908 and 1913, when the stream flow will be insufficient for periods of 4 months or more.

Twenty years hence, Springfield may reasonably be expected to have a population of 80,000 tributary to the sewers. Moreover, with the additional volume of sewage, the same degree of self-purfication, that now obtains cannot be expected in Spring creek and Sugar creek, and, therefore, it will be reasonable to assume a necessary flow in the Sangamon of at least 3 cu. ft. per second for each 1,000 persons tribu-

Below Waterworks Dam at Springfield, Looking Upstream.

tary, or a total of 240 cu. ft. per second. According to data presented in Figure 2, there will occur in almost every year a period of greater or less duration up to 6 months, when the dilution available will be inadequate.

In all probability the necessity for better final disposal of the sewage at Springfield both to avoid local nuisance within the limits of the city itself and for the purpose of protecting riparian owners along the Sangamon in a downstream direction, the city will in a few years be obliged to consider the problem of treating its sewage. As this will involve important modifications in the existing sewerage system, it would be well for Springfield to study the problem at once so that all future sewer construction can be done in conformity with a plan that will meet reasonable requirements as to final disposal.



Sangamon River Below Junction with South Fork and Sugar Creek, Springfield.

For sampling points and analyses at Springfield, see Figs. 14 and 16 to 21.

Taylorville.

Taylorville, on the South Fork of the Sangamon, is approaching the point where objectionable nuisance will be created due to the discharge of its sewage directly into the stream. During the extreme low water encountered during the investigations of the summer of 1913, the stream was visibly polluted below the city, but nuisance conditions had not reached a point likely to give rise to vigorous complaint. The dilution available was very low, namely, .35 cu. ft. per second per 1,000 population at Taylorville. The reason that a greater nuisance was not produced may be explained by the fact that only a small proportion of the population of Taylorville uses the sewerage system. There should be available in the South Fork a flow of about 30-35 cu. ft. per second to adequately take care of Taylorville's sewage, but as a matter of fact the stream flow falls below these quantities for periods, ranging from a few weeks to 6½ months or more. See Figure 4. No additional sewerage construction should be undertaken until a suitable plan has been developed for ultimately conducting all sewage to a proper locality for the installation of treatment works.

Lincoln.

The conditions at Lincoln with reference to the pollution of Salt creek are much the same as those that exist at Taylorville with reference to the pollution of the South Fork of the Sangamon, only the dilution available in the former instance is yet materially greater than that available in the latter. At Lincoln the dilution at extreme low water is about 2 cu. ft. per second per 1,000 population. Visible contamination existed, though a distinct nuisance was not apparent. The absence of nuisance is undoubtedly due to the fact that Lincoln sewage is discharged into several small water courses at some distance from the main stream, thus giving an opportunity for partial self-purification of the sewage before entering Salt creek. While the present arrangement protects Salt creek, it creates a very foul nuisance in the tributary water courses which has proved a serious inconvenience to the residents of Lincoln itself. Furthermore, the sewage from one of these small tributaries constitutes a menace to the public water supply, in that during high water the sewage is backed up and stands over the suction pipe from the infiltration galleries and wells which constitute the sources of supply. An agitation is now on foot in Lincoln to correct, not only the conditions above outlined, but to improve various features of the sewerage system proper which are defective. The State Water Survey has formally advised the local authorities to reconsider the entire plan of the sewerage system with a view to developing a comprehensive system which will serve all needs of the community and which will permit a final inoffensive disposal.

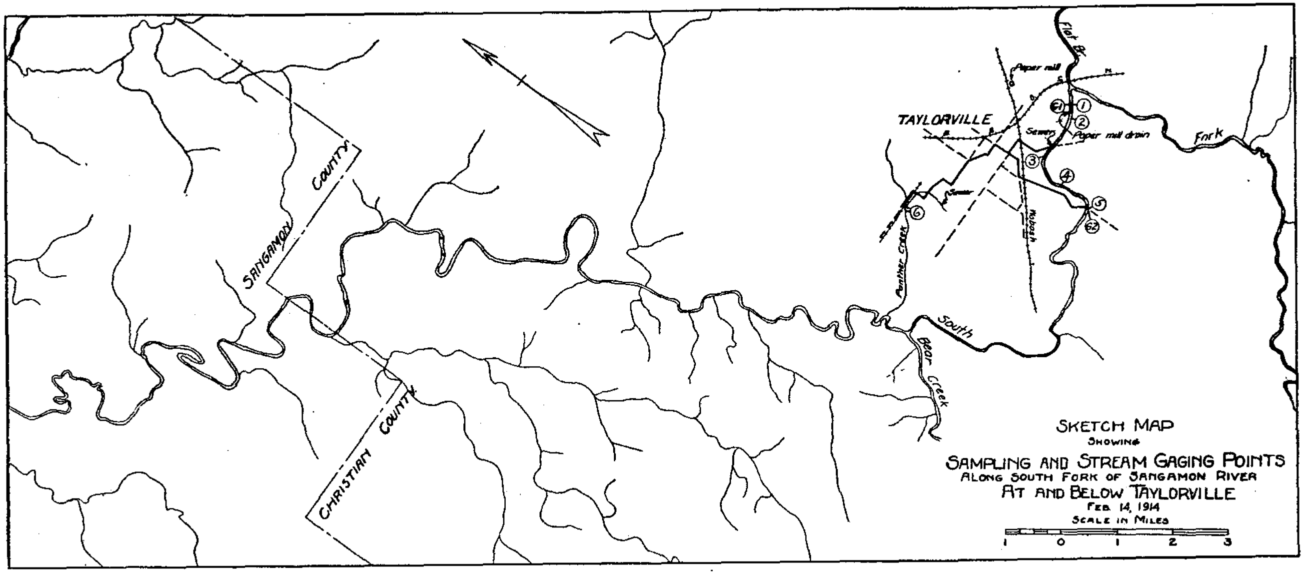


Fig. 8.—Sampling and Stream Gaging Points Along South Fork of Sangamon River at and Below Taylorville.

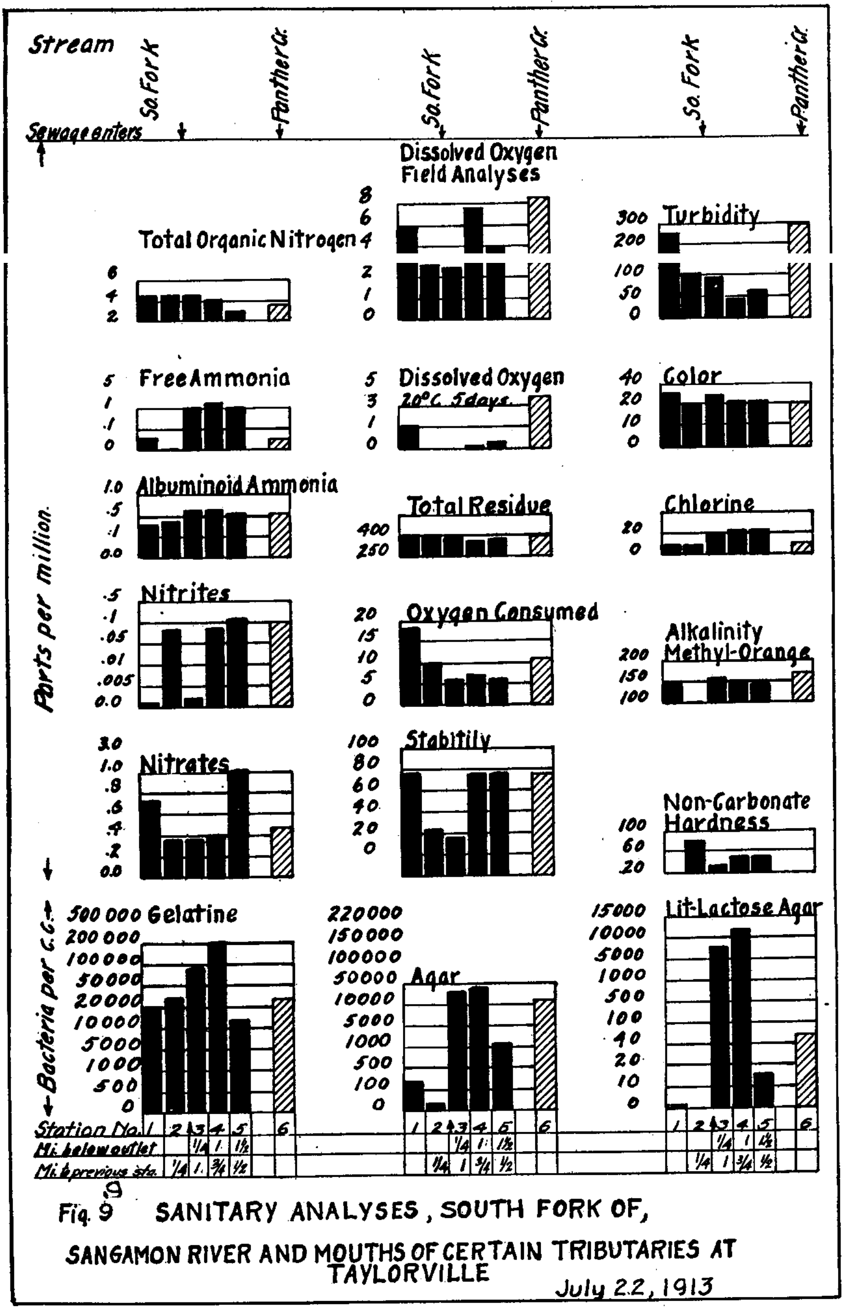


Fig. 9.—Sanitary Analyses South Fork of Sangamon River, Taylorville.

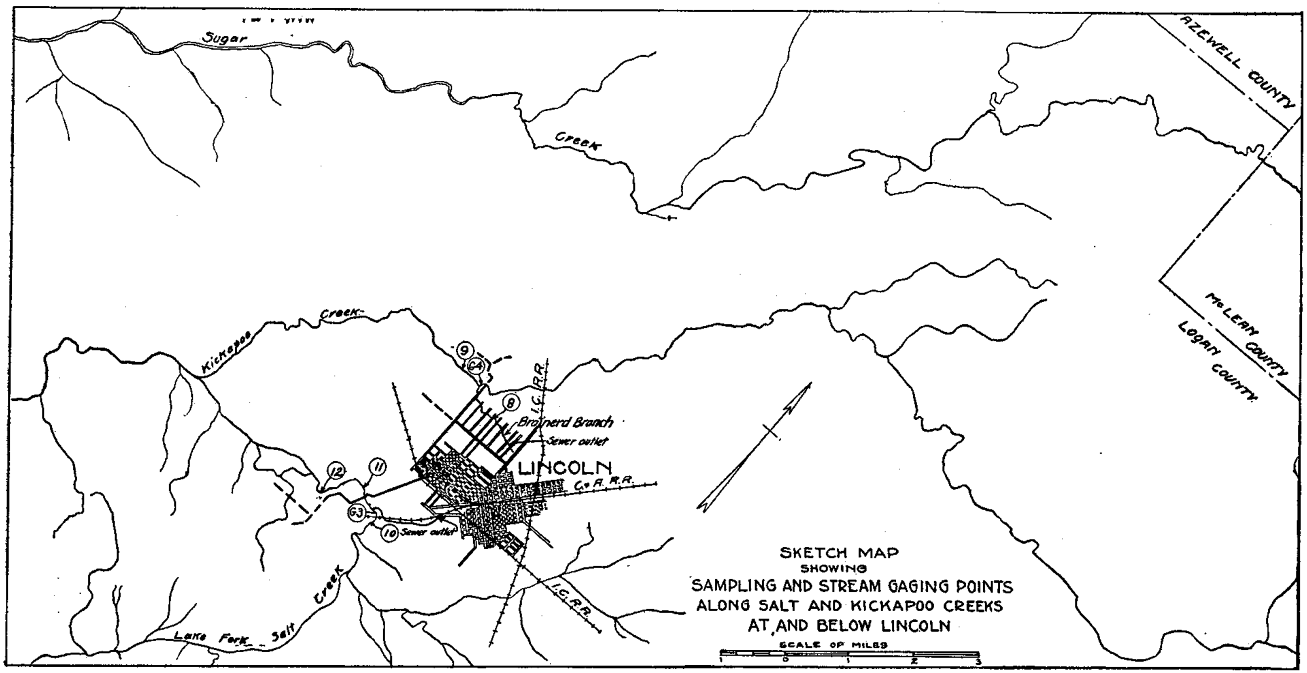


Fig. 10.—Sampling and Stream Gaging Points Along Salt and Kickapoo Creeks, Lincoln.

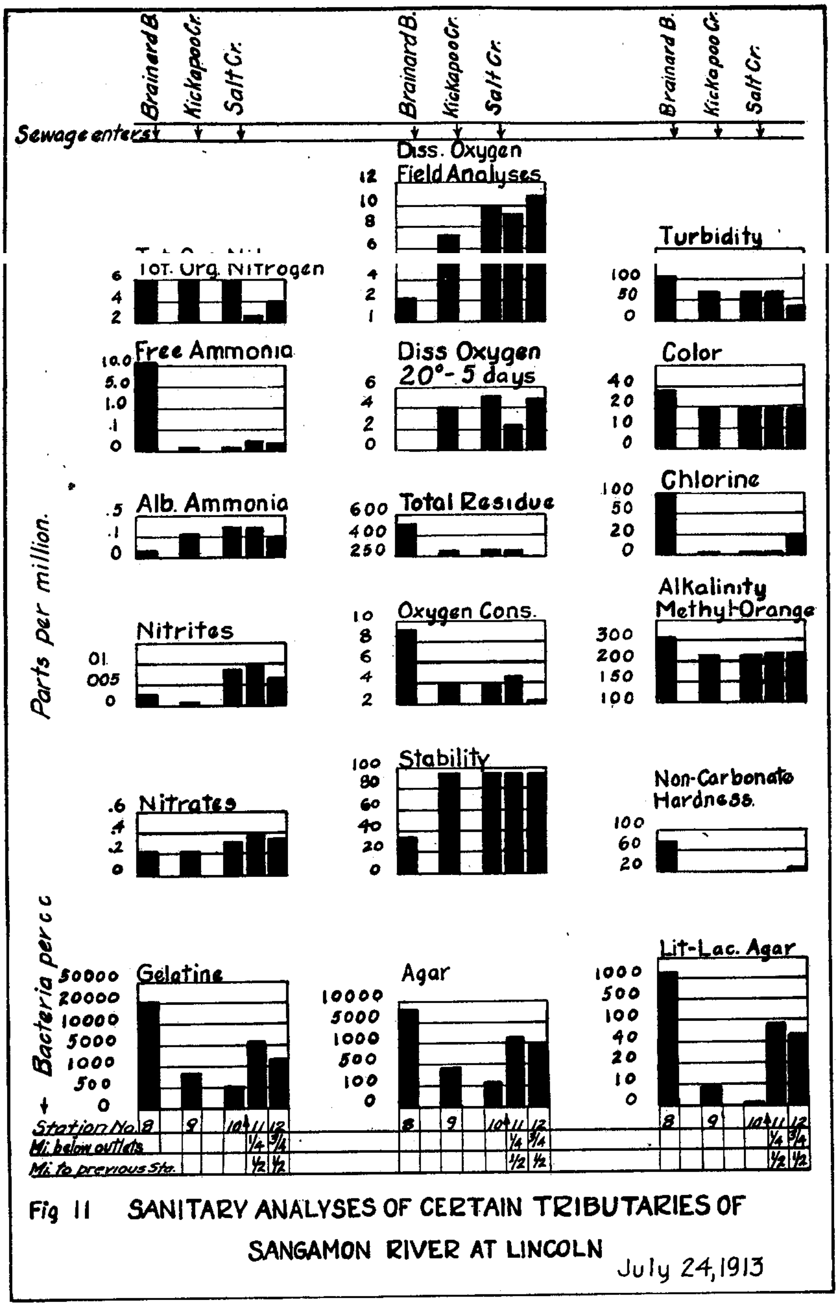


Fig. 11.—Sanitary Analyses of Certain Tributaries of Sangamon River at Lincoln.

Monticello.

Monticello, on the main stream about 30 miles above Decatur, is also approaching a condition where the matter of sewage treatment must be given consideration. As yet, the dilution available is inadequate only during extremely low water such as was encountered on August 5, 1913, when the dilution was about 2.1 cu. ft. per second per

TABLE XII.

DRAINAGE AREAS ABOVE CERTAIN TOWNS ON THE SANGAMON RIVER WATERSHED.

Municipality	Stream	Tributary to	Drainage area Area in sq. mi.
Assumption	Big George Creek	South Creek	11
Atlanta	Kickapoo Creek	Salt Creek	270
Bloomington	Sugar Creek	Salt Creek	18
Clinton	Ten Mile Creek	Salt Creek	23
Clinton	Coon Creek.	Salt Creek	10
Decatur	Sangamon	Illinois	862
Farmer City	Salt Creek	Sangamon	72
Kenny	Salt Creek	Sangamon	459
LeRoy	North Fork	Salt Creek	43
Lincoln	Kickapoo Creek	Salt Creek	310
Lincoln	Salt Creek	Sangamon	870
Maroa	Salt Creek	Sangamon	Practically none
Monticello	Sangamon	Illinois	550
Morrisonville	Bear Creek	South Fork	24
Mt. Pulaski	Salt Creek	South Fork	533
Moweaqua	Creek north of town	South Fork	53
Moweaqua	Flat branch including George Creek	South Fork	133
Petersburg	Sangamon	Illinois	3005
Riverton	Sangamon	Illinois	2560
Stonington	Buckhart Creek	Sangamon	9
Taylorville	South Fork at W. R. R	Sangamon	427
Taylorville	South Fork sewer outlet	Sangamon	408
Sangamon River above confluence with Salt Creek	....	....	3055

1,000 persons at Monticello. See Figure 3. At ordinary low stages, the dilution is ample to prevent nuisance. Notwithstanding the present absence of seriously objectionable conditions, no expensive sewerage improvements should be undertaken at Monticello without taking due cognizance of the ultimate necessity for installing treatment works.

For sampling points and analyses at and below Monticello, see figures 12 and figures 16 to 21.

Other Communities.

In addition to the foregoing communities, there are a number of other communities on the watershed, located on streams with very small drainage areas. By referring to table No. 12, it will be observed that the towns of Assumption, Clinton, Farmer City, Leroy, Morrisonville, Moweaqua and Stonington are all located on streams with drainage areas so small that there will be during the summer season no stream flow or at most a very small stream flow incapable of adequately diluting the sewage. Some of these communities such as Farmer City and Clinton have already met with complaints on account of inadequate sewage disposal. It is quite probable that the problem will become more acute in all these communities, as they increase in size or as the sewerage systems more completely serve their populations. None of them should be permitted to extend its sewerage system until it has adequately considered the matter of final disposal in an inoffensive manner, so that all future sewerage construction may be carried out economically in accordance with a plan that will now or ultimately permit of adequate treatment of the sewage.

DISCUSSION OF THE SEWAGE DISPOSAL PROBLEM AT DECATUR.

Decatur is the only city on the watershed where complaints against stream pollution have been persistent and where they have taken the form of threatened damage suits. The situation, in fact, is so acute that the city must do something to relieve the conditions at the earliest practicable date. Therefore, the remainder of the report will be devoted to a somewhat detailed description and discussion of the pollution of the Sangamon at Decatur.

As frequent reference will be made to various localities, Figures 12, 13, 14 and 15, showing all sampling and inspection points along the main stream, are inserted here.

Visual Observations.

The details of the situation at Decatur can best be described by first presenting the results of visual observations made during various trips for sampling and inspection. This will be followed by a presentation of analytical data with comments on the significance of same. Reference will be made to localities by station numbers shown on the accompanying map (Figure 13). The location of stations will be designated with reference to their distance in miles below the main Decatur sewer outlet. This main outlet is known as the Broadway sewer and discharges at a point immediately below the water works dam.

Station No. 6: Station No. 6 is just below the water works dam and just above the Broadway sewer outlet. The water in the stream at this point is practically a normal surface water. It receives pollution at various points above, notably at Monticello, and the shops of the Wabash railroad, but while this renders the water dangerous for domestic uses, it does not render the stream visibly polluted, or even polluted to an extent that can be readily detected by a chemical analysis. The principal evidence of pollution lies in the bacterial content. Except during freshet, the water is reasonably clear to the unaided eye, though upon analysis it shows a slight turbidity. During high water,

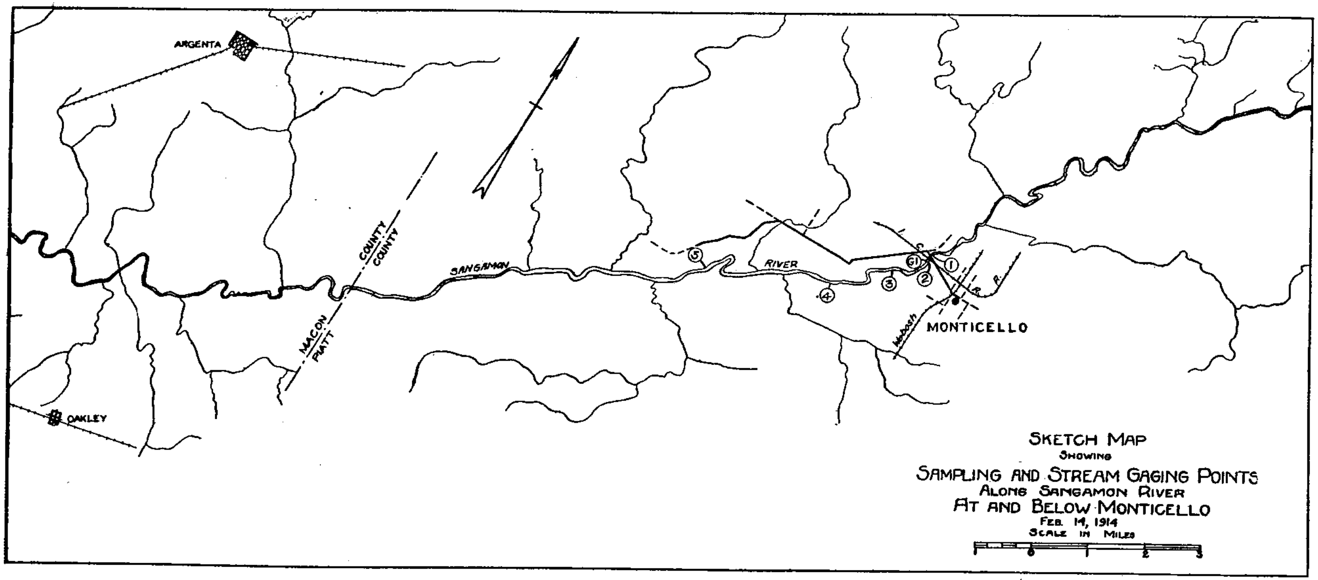


Fig. 12.—Sampling and Stream Gaging Points Along Sangamon River, Monticello.

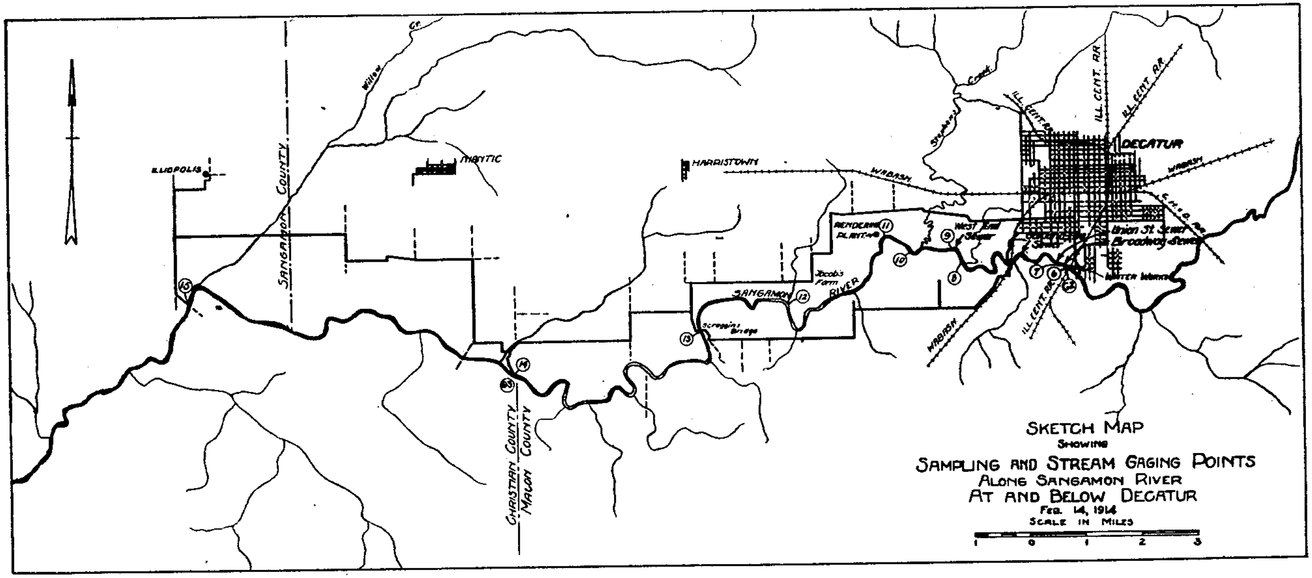


Fig. 13.—Sampling and Stream Gaging Points Along Sangamon River, Decatur.

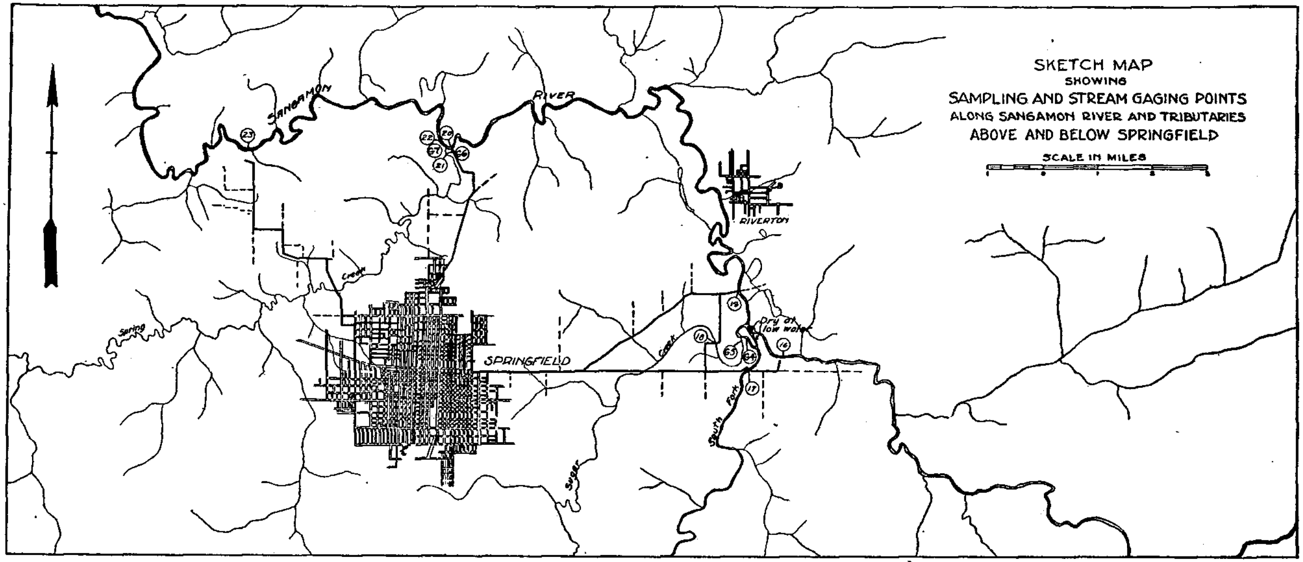


Fig. 14.—Sampling and Stream Gaging Points Along Sangamon River and Tributaries, Springfield.

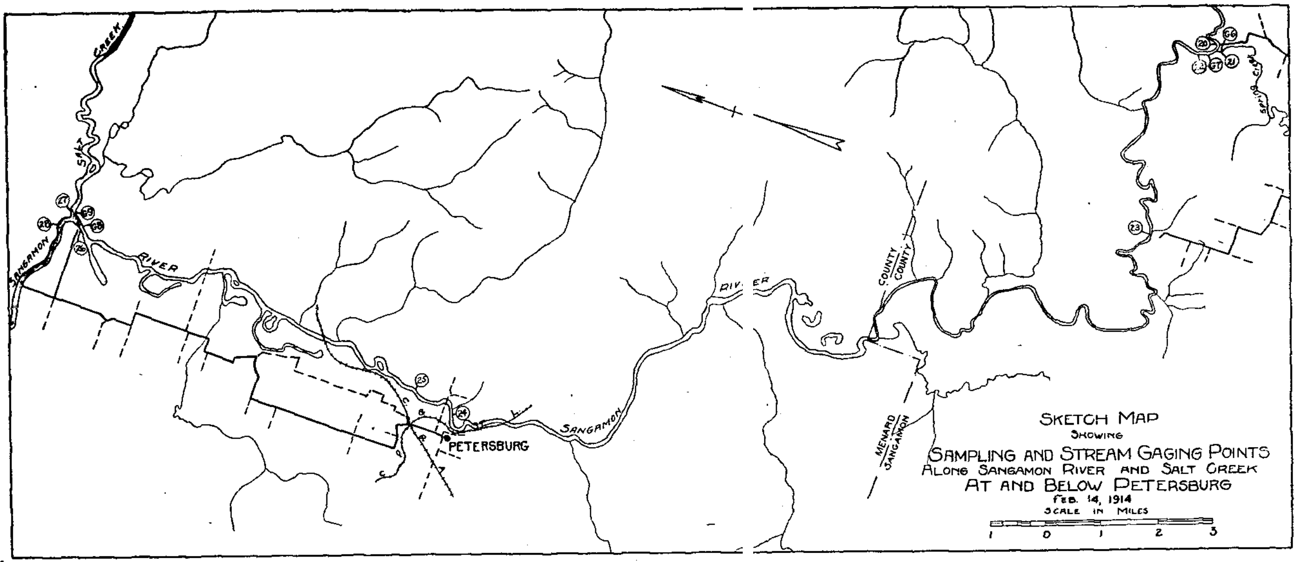
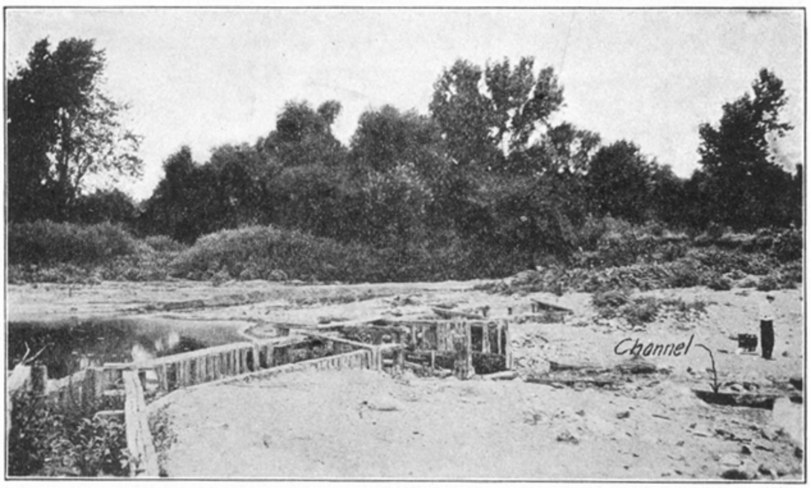


Fig. 15.—Sampling and Stream Gaging Points Along Sangamon River and Salt Creek, Petersburg.

however, the turbidity may become very great, reaching as much as 1,000 parts per million. The city takes its public water supply from the Sangamon river, but before delivering the water to the consumers, it is filtered and sterilized. A new water purification plant of modern design and construction and capable of meeting reasonable future needs of the community, is now being built.

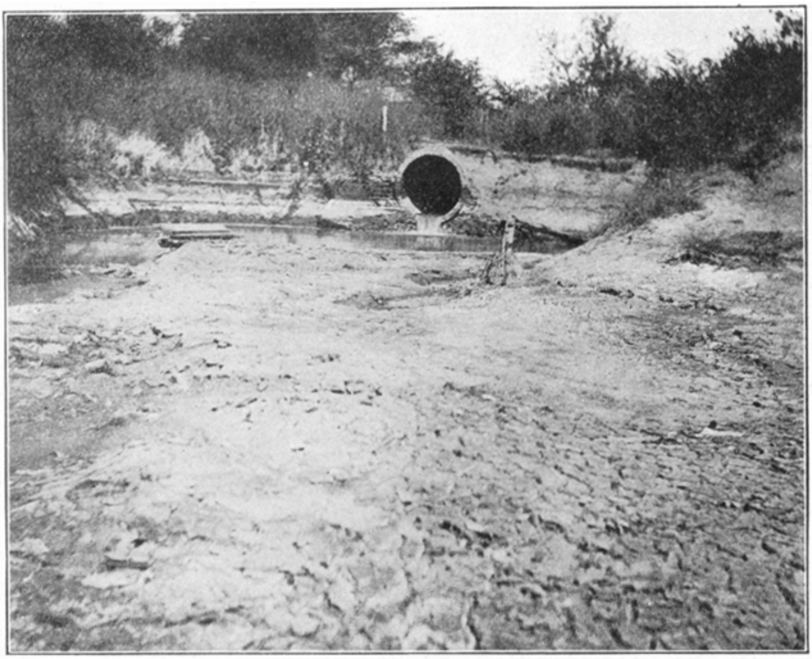
Broadway Sewer Outlet and Station 7: A marked change in the appearance of the river during ordinary stages occurs a few feet down stream from Station No. 6, at the outlet of the Broadway sewer, immediately below which is Station 7. This sewer, which is 6 feet in diameter, and serves a large territory, discharges into a small cove in which has formed a great pool of foul-smelling putrefying liquid. The



Immediately Below Waterworks Dam at Decatur During Extreme Low Water.

pool overflows into the river at the same rate at which sewage is received from the sewer and discolors the entire stream. The predominance of the sewage is so great, in fact, that the flow of water in the stream below the outlet cannot be distinguished in appearance from crude sewage.

The sewage from the Broadway sewer during dry weather conditions is visibly stronger than an average sewage. During certain hours of the day gas house wastes and wastes from the Corn Products Works are visibly present. The combination of gas house wastes and sewage produces a peculiarly disagreeable odor, of which the gas house wastes seem to be the predominant factor. These odors are recognizable not only at the sewer outlet, but also for several miles in a down stream direction, as will be observed later. Furthermore, the gas house wastes carry an oily substance which forms oily films on the surface of the water in the stream and tarry deposits along the bed of the stream. The Corn Products wastes, which were particularly observable at about 9:30 on December 21, 1912, the date that sewage measurements were made, are characteristically light colored in appearance, and this light color can be traced for many miles in a down stream direction. The remoteness of the Broadway sewer outlet from habitations has prevented it from becoming the object of serious complaint by residents of Decatur, and, furthermore, the river immedi-

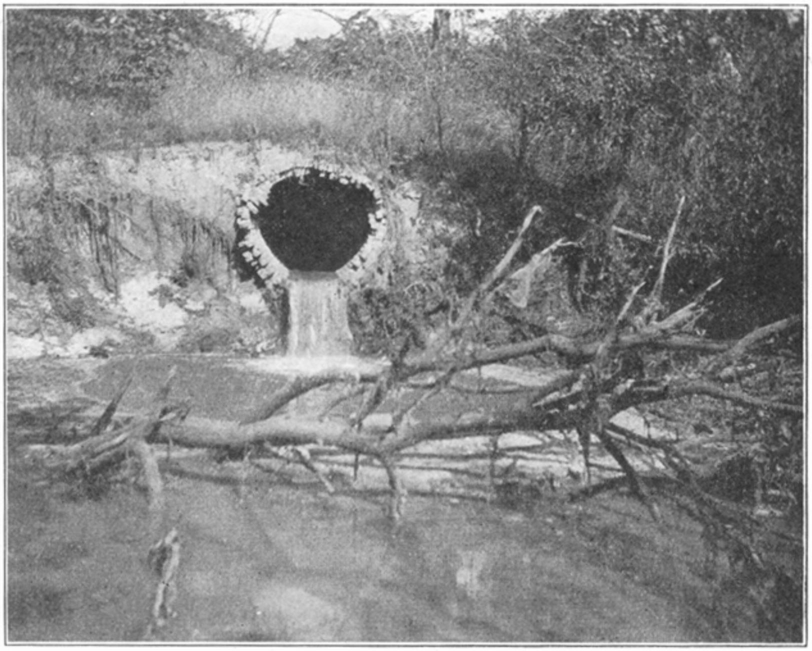


Broadway Sewer Outlet, Decatur. Note Heavy Sludge Deposits in the Foreground.

ately below the outlet passes through a territory that is little frequented:

At a distance of several hundred feet in a down stream direction, the river receives the discharge from the Union street outlet sewer. This sewer does not extend to the river bank, but discharges into an open ditch about 1,000 feet long. The volume of sewage is very much smaller than that from the Broadway outlet, and though the quantity is sufficient in itself to cause objectionable conditions in the stream, yet the influence of the Broadway sewer is so great that the effect of the addition of the sewage from the Union street outlet is scarcely perceptible.

About seven-eighths of a mile in a down stream direction from the Broadway outlet is the outlet from the Oakland avenue sewer. (See Map 13.) The outlet is submerged, and it is ordinarily not possible to note the influence of its discharge into the already grossly polluted stream. The stream at this point passes within a few hundred feet of a public highway, and near a residence addition that is now being developed. The stench which arises from the stream at certain hours



Monroe Street Sewer, Decatur.

of the day is sufficient to cause seriously objectionable conditions. These objectionable conditions constitute the best argument, of the self-interest variety, why the city of Decatur should adopt an improved method of sewage disposal.

Between the Broadway outlet and the Oakland avenue outlet; the river is exceedingly filthy; active putrefaction is plainly in progress as is revealed by numerous gas bubbles on the surface of the water; the bed of the stream is covered with a heavy black and slimy sludge deposit and the banks of the stream are rendered unsightly by dried sludge deposits remaining from previous high water. A measurement of the sludge deposits at the Oakland avenue sewer showed them to be 1½ feet to 2 feet in thickness.

Station No. 8: Station No. 8 is about 2⅜ miles in a down stream direction below the Broadway sewer outlet, and just above the so-called Seventh Ward sewer outlet, which is the last of the sewer outlets in Decatur. This sewer drains principally good residence districts and discharges through a long outfall sewer, possibly a mile in total length and 4 feet in diameter, directly into the channel of the stream. The outlet is remote from habitations and the stream at

Oakland Avenue Sewer Outfall, Decatur. Note Heavy Deposit in the Foreground.

this point is so enclosed with trees and weeds that the outlet is very difficult, to find for one who is not well acquainted with its location. The river at this point is still very foul from the influence of the sewers above, and due to septic action which takes place in the slowly moving current, the liquid takes on a blackish color which contrasts strongly with the fresher and lighter colored sewage from the Seventh Ward outlet. Sludge deposits were in evidence as usual, but of lesser thickness than those encountered at points above. Underlying the sludge deposits is a rather hard gravelly bed which is swept clean by high water. On the south side, and at a distance of about one-fourth mile, is a residence, the occupants of which complain greatly about the odors from the river, especially during the evening and at night, when the wind is from the northward.

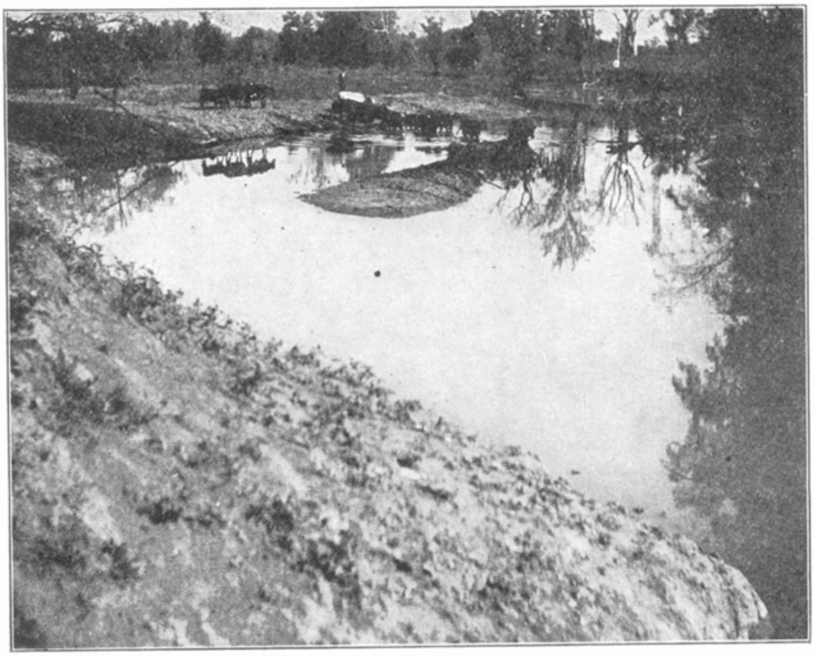
Station No. 9: Station No. 9 is 2¾ miles below the Broadway outlet and 200 feet below the outlet of the Seventh Ward sewer. The stream at this point and below is generally fringed with trees and heavy growth of weeds, but on either side the land is cultivated or used for pastureage. During all visits, the stream at this point was grossly polluted and generally showed the lighter sewage from the

Seventh Ward Sewer, Decatur.

Seventh Ward sewer outlet on the north and the black septic sewage from an upstream direction along the south bank. Heavy slimy growths began to appear and those that flanked the sides of the stream were dark gray or black.

Station No. 10: Station No. 10 is about 3½ miles below the main sewer outlet and just below the point where Stevens creek discharges into the Sangamon. It lies about 1 mile from the main road to the southward of the river and about ½ mile from the nearest dwelling house. The banks of the stream are fringed with trees and weeds while the bottom land to either side is cultivated. The water in the stream was very dark colored and a pronounced disagreeable odor was observed. This odor reaches the dwelling above referred to, much to the inconvenience of the occupants. These people also complained of odors from a rendering establishment about ¼mile further down stream (see Station No. 11), which odor is alleged to be worse and quite different from that from the sewage polluted river.

Station No. 11: Station No. 11 is about 4 miles below the Broadway outlet and about ½ mile from the main road to the northward. It is at this point that the above mentioned rendering establishment is located. Dead animals and butchers' offal are converted into fertilizer and grease and in the process a foul waste liquid is produced amount-



Sangamon River at Jacob's Farm. Cattle Entering Stream.

ing to about 1,400 to 2,000 gallons per week, and this is discharged directly into the river. The effect of these liquids on the river was not marked because of the gross pollution from above. Curiously enough, while the stench in the neighborhood of this plant seemed very disagreeable to the observers sent out by the State Water Survey, the workmen at the plant complained earnestly about the sewage odor from the stream. The banks and bottom of the stream at this point were covered with slimy deposits and the water was dark colored and undergoing active fermentation. During the visits covering the higher stream flows, patches of green scum floated upon the surface.

Jacob's Farm: This point is 6 miles below the Broadway sewer and was visited but twice, namely on September 23 and October 15, 1912. The portion of the farm bordering the stream is used primarily for pasturing cattle. The cattle are shown on an accompanying photograph wading in the stream and drinking of the water. As a result of this it is claimed by Mr. Jacobs that the animals sicken and die. No specific diseases have been observed, but it is claimed that the cattle do poorly for weeks or, perhaps months, and finally die as a result of wasting away. In one instance, however, it appears that an animal was seized with a violent disease and came to its death in the course of a very few days, When questioned as to the availability of other sources of water supply for cattle watering, Mr. Jacobs stated that there was a good spring on the farm, but that the cattle seemed to prefer the flavor of the sewage polluted stream.

That the stream is polluted at this point is visibly evident. It has the characteristic gray color of a polluted water devoid of oxygen. A stale sewage odor was quite marked and there was a thin deposit of sewage and mud in the bed of the stream. The claim is made that no fish have been caught in the stream at this point since 1910, and it has been further stated that previous to 1908, no objectionable pollution existed. Reference to run-off diagrams will show that stream flow in 1908 was very low. At present the odors are so strong that at times they are said to reach a road about ¾-mile distant. No habitation in this vicinity, however, are inconvenienced.

Station No. 12: Station No. 12 is about 7 miles below the main sewer outfall. The river is about ¼-mile from the road and about the same distance from the nearest habitation. A small spring-fed creek enters the river at this point, but during dry periods the discharge of the creek is very small. A number of cattle are pastured along the banks of the river, and the owner states that they drink from the small spring-fed creek in preference to the river, which experience is at variance with that of Mr. Jacobs. The difference in the mineral content of the spring waters may in a measure account for this. For example, it is said that a water heavily impregnated with iron is not relished by cattle.

The water in the river at this point was markedly polluted, turbid, and heavy growths of grayish organisms were present. At times large floating masses of greenish-black scum were observed.

Station No. 13: Station No. 13 is at Scroggins' bridge, a distance of about 9 miles below the Broadway sewer outlet. The stream is wide and shallow and has steep banks from 15 to 20 feet in height. The bottom is firm and underlaid with, rock. This point has been visited more than any other point on the stream. On each visit it showed marked evidences of pollution. On the first two occasions, the color of the water was distinctly whitish, not at all characteristic of sewage, but strongly suggestive of wastes from the Corn Products

Works. The white substance seems to be colloidal in character, and strongly resistant to the influences of decomposition. The bed of the stream is covered with a dark brown mud which shows the presence of considerable organic matter by the ebullition of much gas when probed with a stick. At certain times a greenish black vegetable growth is carried on the surface which, however, is more unsightly than malodorous. Much complaint is made due to the objectionable condition of the stream at this point by persons passing over the bridge. The odors also reach the house of Mr. Scroggins which is nearby. It is claimed that at times gas house wastes are distinctly in evidence and that the tarry character of these wastes produces serious difficulty in boilers at threshing time.

Station No. 14: Station No. 14 is at a river ford about 14¾ miles below the Broadway sewer outlet and about one-half mile off the main highway to the northward. The land on either side is cultivated or in timber. The river at this point is shallow, has a good current, and a gravelly bed. At close range, a slight odor could be detected. During the very low stages encountered in July, August, and September, 1913, the stream showed the effects of past pollution by a greenish hue due to the development of plant life which feeds on the decomposition products of sewage matter. On one occasion (October 15, 1912), an inspection was made at Niantic Bridge about one mile below Station 14 at a time when the stream was at ordinary low water stage. In contrast with inspections made at Station 14, the water was found to be rather dark colored, evil smelling, and contained many dead fish and slimy growths. A woman living near the stream, testified to objectionable odors and it was claimed that these odors carry for distances of ¾-mile.

Station No. 15: Station No. 15 is about 21¾ miles below the Broadway sewer and due south of Illiopolis. A bridge crosses the river at this point and the banks are fringed with a growth of trees and weeds. Station No. 15 was visited three times, namely, July 8, August 6 and September 25, 1913. On all occasions, the water was found comparatively clear and without odor. The stream bottom is of clean sand and could readily be seen through a foot or two of water. Small fishes were present and. the water gave every evidence of being inoffensive. Residents of Illiopolis, however, claim that at times the stream shows distinct evidences of pollution at the bridge, that fish die, and that in general the fishing is inferior to what it was in previous years. These observations, however, do not occur at times of extreme low water, but rather at medium low stages. This confirms the observations made one mile below Station No. 14 and appears to be explainable on the theory that the time element required for self-purification rather than the volume of sewage is the controlling factor during periods of low and extremely low stages. During extremely low stages such as those encountered on the three trips of July, August and September, 1913, the river, though excessively polluted at Decatur, had an opportunity, because of very sluggish movement of the water, to become self-purified, even before it reached Station No. 14. A moderate rise in the river, however, moves the polluting matter on so rapidly that it is not eliminated even by the time it reaches Station No. 15. A moderate rise in the stream during the summer time may also have the effect of scouring out and moving downstream large quantities of sludge that have been deposited below the sewer outfalls.

Summary of Visual Observations: The general results of the numerous' visual observations that have been made along the Sangamon below Decatur show that the river is grossly contaminated during low stages of water. It further shows that the volumes of water available for dilution purposes during the summer months are seldom sufficiently great to materially change the nuisance conditions below the city. Extremely low water conditions such as were encountered during 1913 tend to diminish the distance in a downstream direction within which a nuisance exists. The time factor required for self-purification then becomes the dominating factor and a quantity more or less of sewage does not materially affect the linear extent of the nuisance. It is probably because of this fact that during the extreme low water the extent of nuisance was about the same with and without the wastes from the corn products works flowing into the river. This does not mean that the corn products wastes are incapable of creating a nuisance and there is no doubt that if the sewage were removed and the corn products wastes remained a very serious nuisance would still exist. Furthermore, the nuisance will extend in a downstream direction in proportion to the extent that increased volumes of waste increase Stream flow.

An indication of the proportion of the year during which nuisance conditions may be expected to exist is obtained from an examination of Figure 5, upon, which is indicated the periods during which there is a deficiency of flow to adequately dilute the sewage at the present time, ten years hence and twenty years hence. In preparing the diagram, it was assumed that at the present time a volume of flow in the river of 5 cubic feet per second is required for every 1,000 persons tributary to the sewers. It was further estimated that there are at present about 30,000 tributary to the sewers. On this basis, a stream flow of at least 150 cubic feet per second is required, a requirement which is not met from three to six months during the year. Ten years hence the population tributary to the sewers will be in the neighborhood of 45,000, which will require a flow in the stream of 225 cubic feet per second. On this basis a deficiency. will exist for from three to seven months in the year. At the end of twenty years, with an estimated population of 70,000 tributary to

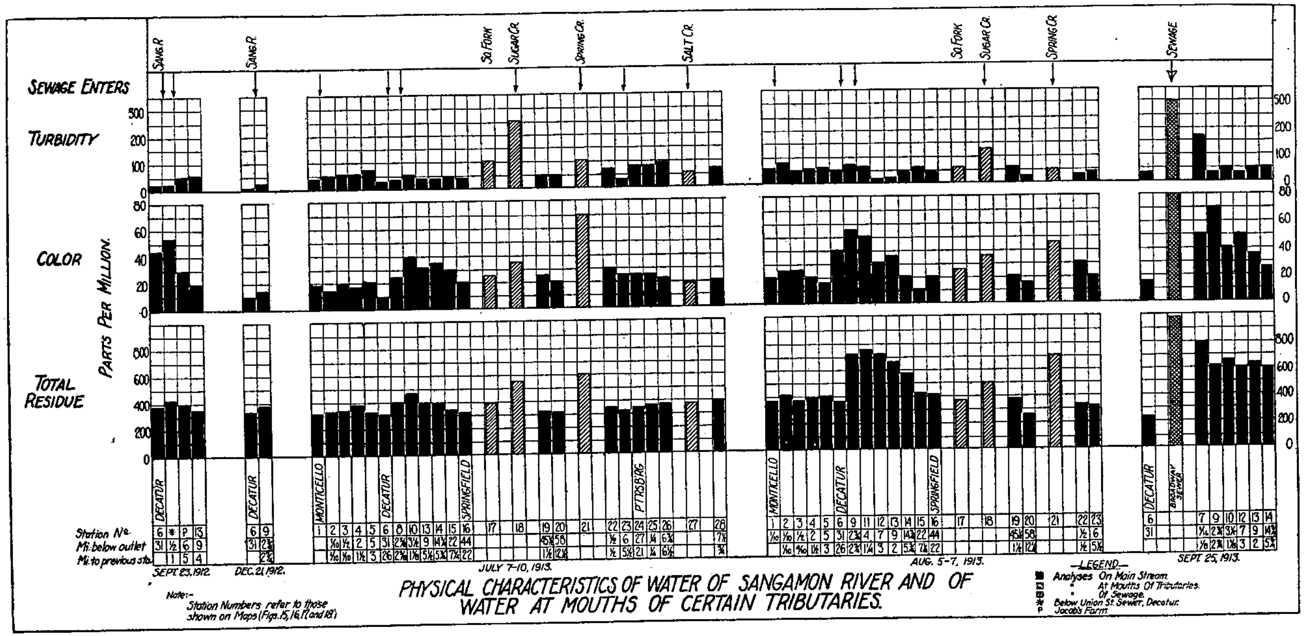


Fig. 16.—Physical Characteristics of Water of Sangamon River.

the sewers, a dilution of 350 cubic feet per second will be necessary. The period during which dilution will be unobtainable is estimated at from 4 to 7½ months.

The periods during which nuisance will persist will not increase rapidly in the future for the reason that the flashy character of the Sangamon river causes it to change from low water to flood and from flood back to low water in a comparatively short space of time.

RESULTS OF ANALYSES.

The results of analytical determinations of Sangamon river water are presented diagramatically in Figures 16 to 21.

Five sampling and inspection trips are included on these diagrams, namely:

September 23, 1912, when the first series of analyses were made as a result of complaints received from residents of Harristown.

December 21, 1912, which includes only two river samples collected at a time when sewage samples and sewage flow measurements were made. The stream flow on this date was medium low and measured 66.9 cubic feet per second.

July 7-10, 1913, when the first extensive river trip was made. The stream flow that was obtained on this trip may be regarded as the usual low late summer flow and measured 25 cubic feet per second.

August 5-7, 1913, when the second extensive river trip was made. An unprecedented low stream flow of but 0.18 cubic feet per second was encountered. It is also to be noted that the corn products works were shut down during this trip and had produced no liquid wastes since July 29:

September 25, 1913, when a trip was made to examine the river below Decatur, following a protracted dry period. The corn products works were still shut down. On this trip extreme low water was encountered which measured 2.01 cubic feet per second.

Certain physical characteristics (Figure 16) of water from the Sangamon and certain tributaries. The turbidity determinations are not of special interest other than that they show a tendency to increase below sewer outlets. As turbidity represents principally mineral substances, it does not appear in sewages except in the form of rather large flakes of organic matter, and this form of turbidity was not considered. The high turbidity just below the upper sewer outlet at Decatur on September 25, 1913, is probably due to stirring up sludge from the bottom.

Color determinations are of much greater significance and show pronounced increases below all sewer outlets and show an abnormal condition on the three last trips for distances of 14¾ to 22 miles below the Decatur main sewer outfall.

Total residue on evaporation gives a good index of pollution

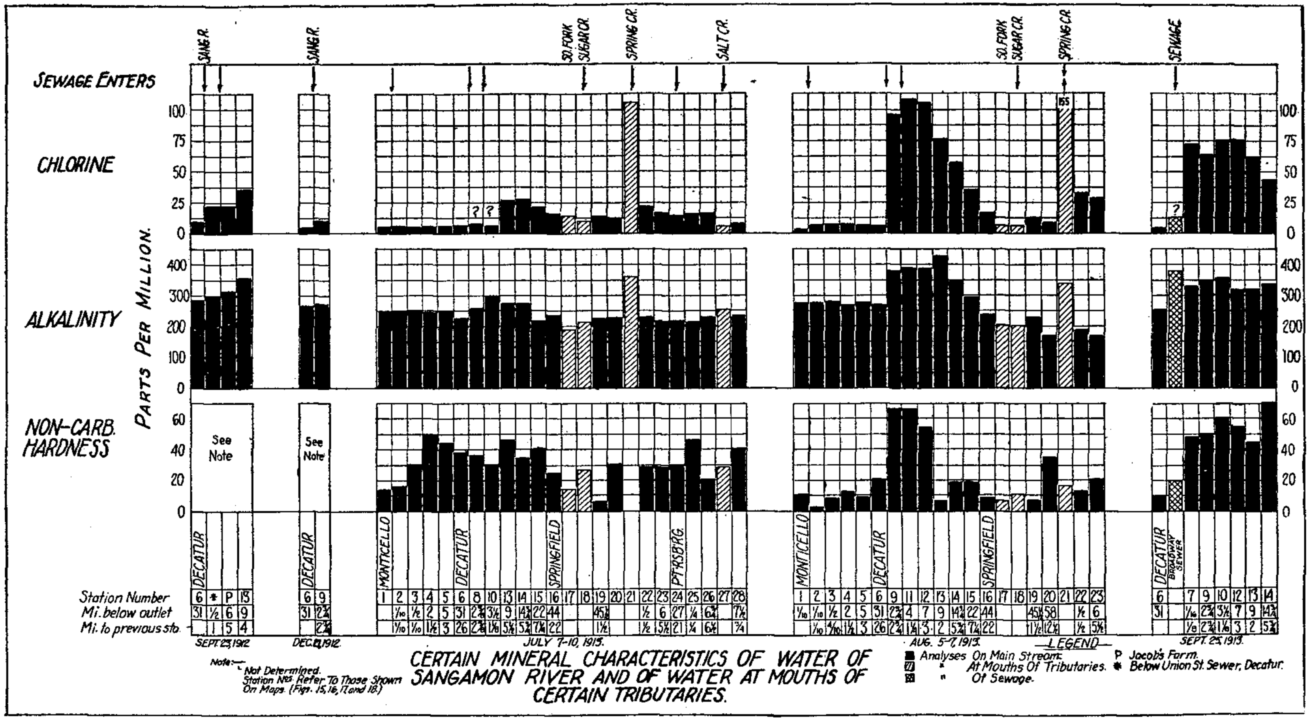


Fig. 17.—Certain Mineral Characteristics of Water of Sangamon River.

during the very low water periods encountered in August and September, 1913, but on previous occasions the increase in residue below sewer outfalls was less marked.

In Figure 17 are given certain mineral characteristics of the water of the Sangamon. The chlorine shows very clearly the influence of sewage and shows to some extent the dilution available. The two low chlorine determinations below the main Decatur sewer outlet for July 7-10 are probably in error.

Alkalinity determinations signify little, but it is interesting to note that the alkalinity is at times markedly increased by the entrance of sewage.

Non-carbonate hardness is very markedly increased below Decatur at extreme low water, which shows the influence of pickling liquors used in some of the metal-working establishments of Decatur.

Total Organic Nitrogen, see Figure 18, shows marked increases below the main Decatur sewer out-fall on all trips made. The increase was particularly striking on September 25, 1913. On this occasion the content of organic nitrogen was more than four times what it had been on any previous occasion, even including the low-water flows of July and August. The explanation of this very great content of organic nitrogen is that the trip of September 25 was made following a long period of extremely low water during which vast quantities of sludge had accumulated in the bed of the stream. These accumulations were in an active state of fermentation and, due to ebullition, quantities of sludge were being constantly mixed with the water above. Moreover, it was found exceedingly difficult in collecting samples to avoid stirring up the sludge, inasmuch as the slightest agitation would cause violent ebullition of gases.

Free Ammonia: The same conditions which are reflected by the total organic nitrogen are also reflected in the free ammonia, and the same explanation will apply. The free ammonia, in addition, gives an indication of the staleness of the sewage and it will be noted that at the extreme low water stages the sewage shows the greater staleness. There is a very high ammonia determination occurring about nine miles below the main Decatur outfall on the trip of August 5 to 9. This probably resulted from a local ebullition of sludge which was observed to occur at various points in a downstream direction.

Albuminoid Ammonia: The albuminoid ammonia also shows similar conditions to the total organic nitrogen, but in a somewhat less pronounced manner. It will be observed that a very high albuminoid ammonia determination was made immediately below the main sewer outfall on September 25, 1913. This can be in part attributed to the admixture of comparatively fresh suspended matter.

Nitrites and Nitrates: On Figure 19 the nitrites and nitrates throw some light upon the processes of decomposition that take place

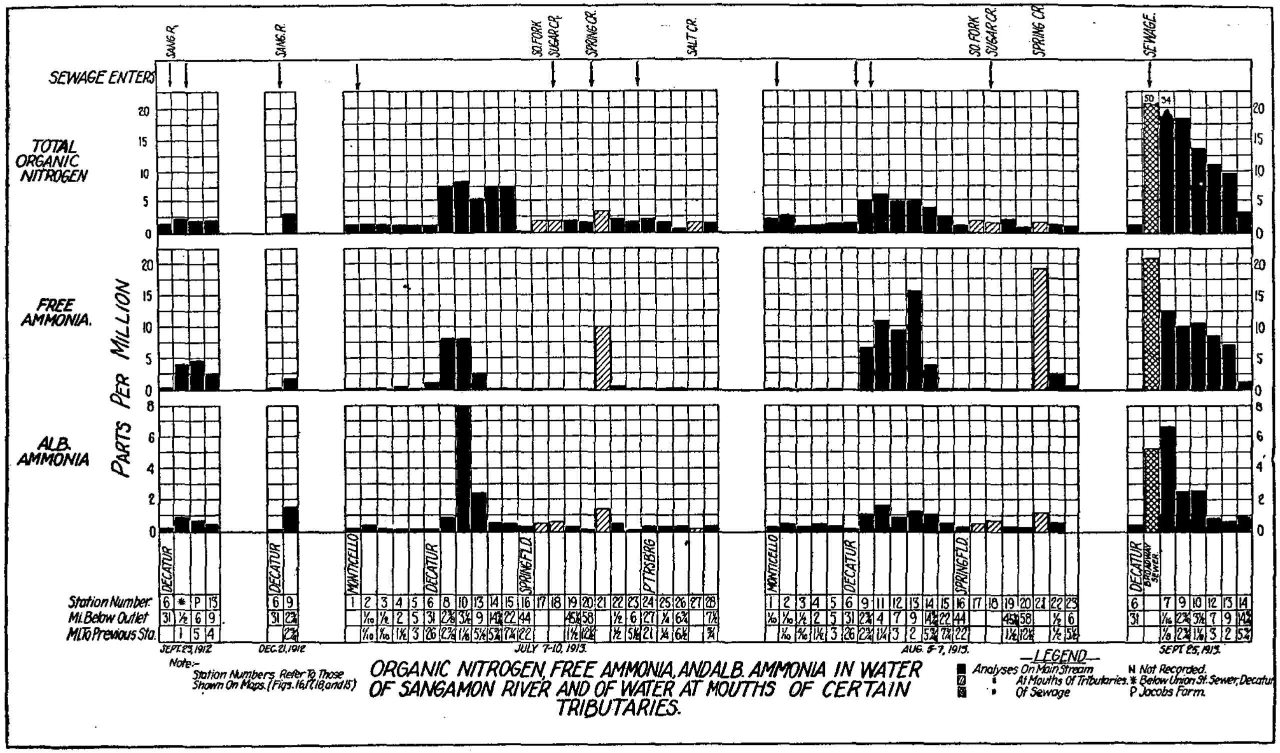


Fig. 18.—Organic Nitrogen, Free Ammonia, and Albuminoid Ammonia in Water of Sangamon River.

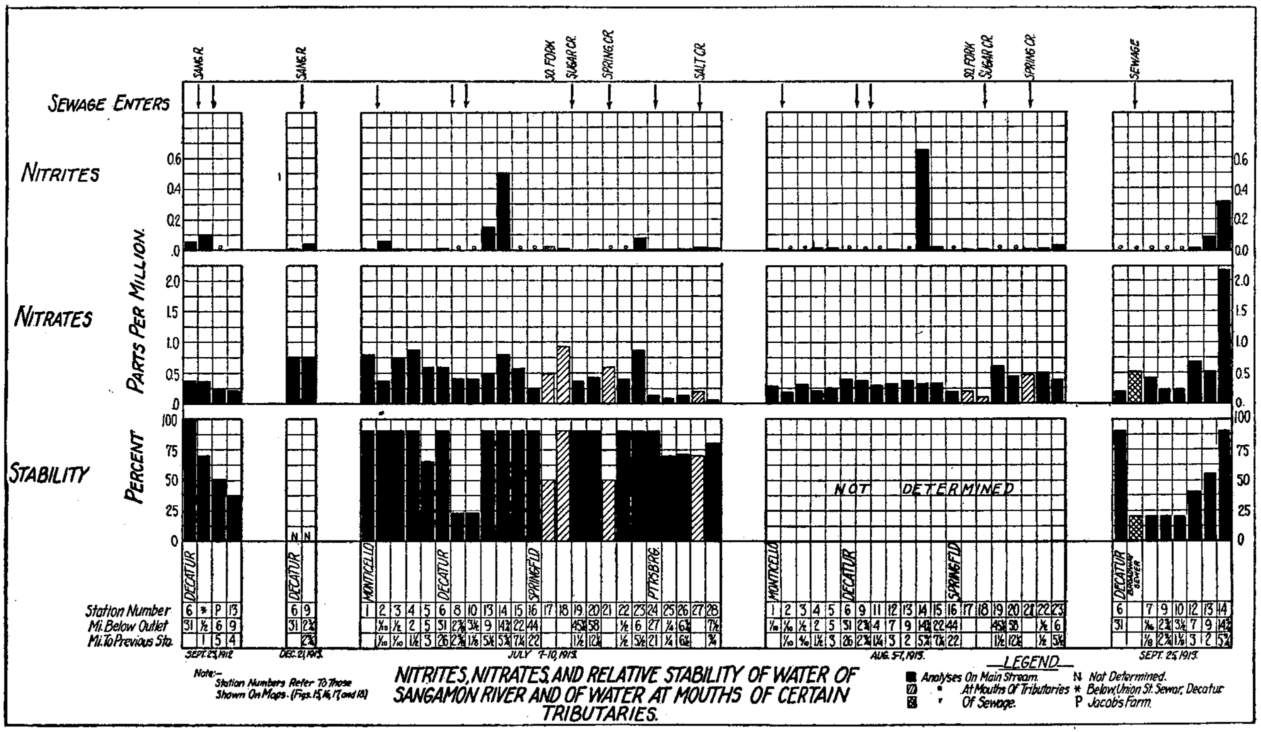


Fig. 19.—Nitrites, Nitrates, and Relative Stability of Water of Sangamon River.

in the river below Decatur. Immediately below the Decatur outlets the stream is generally devoid of nitrites, indicating a degree of freshness in the sewage, but nitrites appear in considerable quantities at distances of 9 to 14¾ miles below the sewer outfalls. Nitrates are present in practically all determinations and, generally 'speaking, attain their maximum at the same time that the nitrites obtain their maximum. This indicates that oxidation does not keep pace with nitrification. The character of decomposition is somewhat different than that which takes place under more intensive conditions in sewage treatment works when the nitrates are practically exhausted, while the nitrites are high. Generally speaking, the nitrate and nitrite determinations that have been made add little information regarding the condition of the stream, but it is probable that a greater number of determinations at more frequent intervals and at shorter distances apart would have given some further items of technical interest with regard to the decomposition processes taking place in the sewage.

Stability: The determinations for relative stability were not entirely satisfactory, but show in a general way a marked lowering in the relative stability below the Decatur sewer outlets. It was only on the last trip that the relative stability was reduced as much as might reasonably be expected by the appearance of the stream below Decatur.

Oxygen Consumed: Fig. No. 20 shows in the oxygen consumed figures, conditions very similar to those brought out by the determinations for total organic nitrogen. A rather marked rise in the oxygen consumed is shown at a distance of two miles below Monticello on July 7, 1913. This can probably best be accounted for by the presence of carbonaceous organic matter resulting from vegetable growth stimulated by the decomposition products of the sewage introduced at Monticello. This conclusion is confirmed by high nitrates encountered at this point and immediately above. On September 25, 1913, the oxygen consumed, like all the other determinations indicating pollution, was very high below the Decatur main sewer outlet.

Dissolved oxygen was determined in the field and also on samples incubated at 20° for five days following their collection. The field analyses show unexpectedly large quantities of dissolved oxygen at points below Decatur. In some instances, as on the trips of July, August and September, 1913, the oxygen content is abnormally high at distances of 14¾ to 22 miles in a downstream direction. This is undoubtedly due to the stimulus given by the decomposition products of the sewage pollution above to the growth of plant life, which gives off oxygen. The determinations for dissolved oxygen made in the laboratory after five days' incubation at 20° C. show greater reductions than those shown by the field determinations due. of course. to the further decomposition of the organic content of the water.

Determinations for Bacterial Content: The most consistent determinations that were made are those far bacterial content shown on

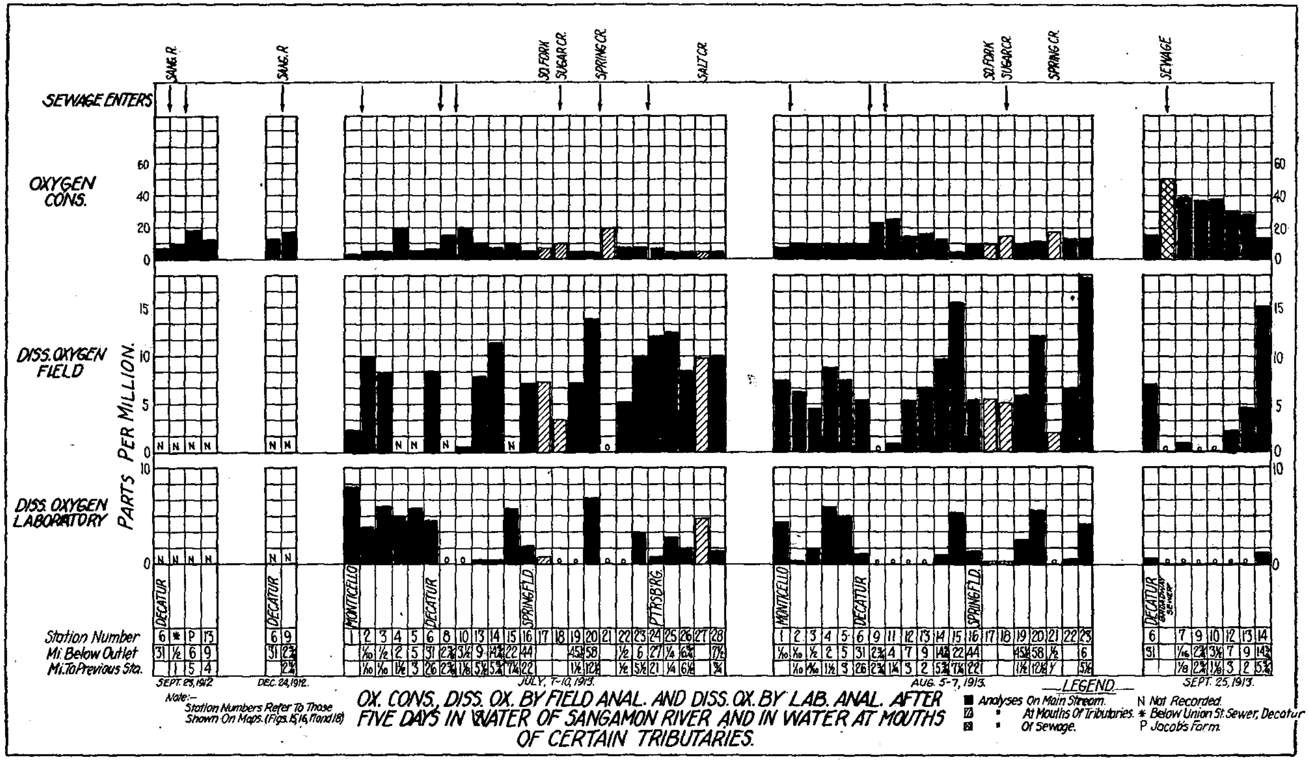


Fig. 20.—Oxygen Consumed. Dissolved Oxygen by Filed Analyses and Dissolved Oxygen by Laboratory Analyses of Water of the Sangamon River.

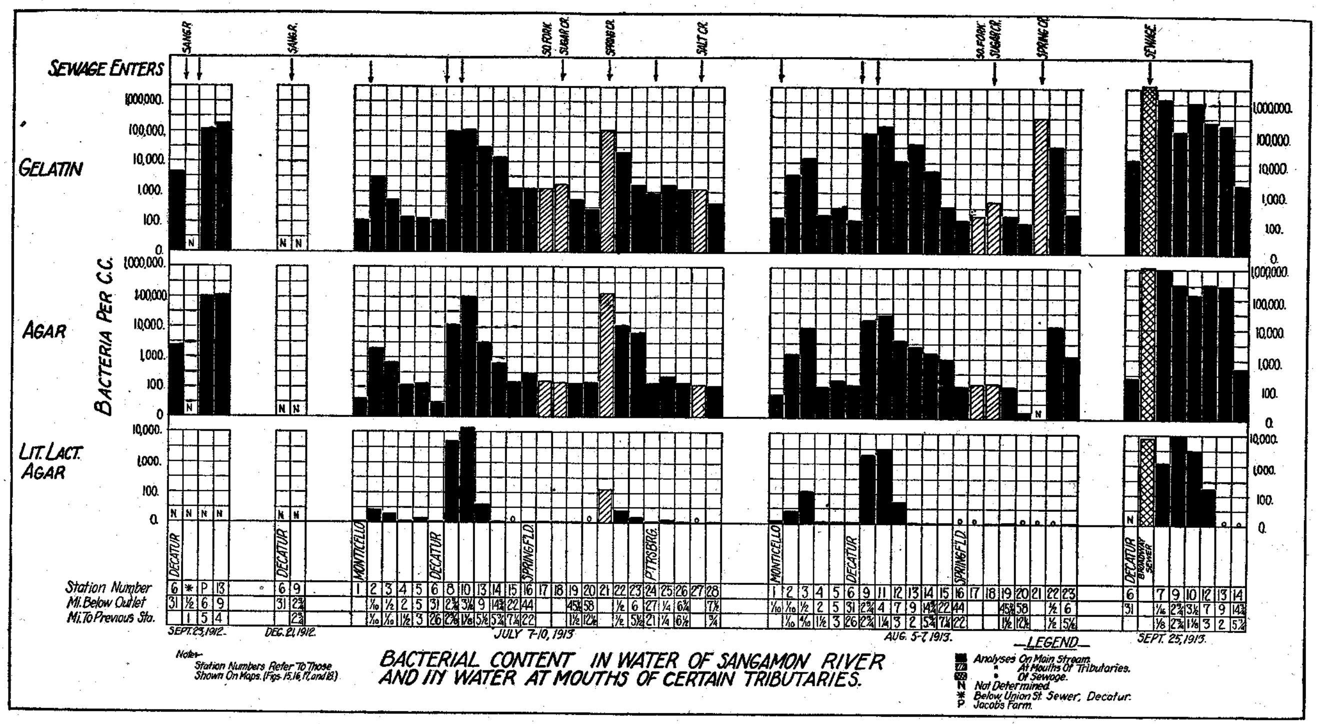


Fig. 21.—Bacterial Content in Water of Sangamon River.

Figure 21. The bacterial counts on gelatin and agar plates, particularly on the former, show strikingly the increased pollution at each city at which sewage is introduced. Also the bacterial content traces the existence of pollution for greater distances than do any other determinations. It will be observed that below Decatur the influence of pollution is observable in the bacterial content all the way to points immediately above the entrance of Springfield's sewage. The determination of the number of red colonies on litmus lactose agar gives in a rough way the content of bacteria of intestinal origin. These are strikingly large in number immediately below the various

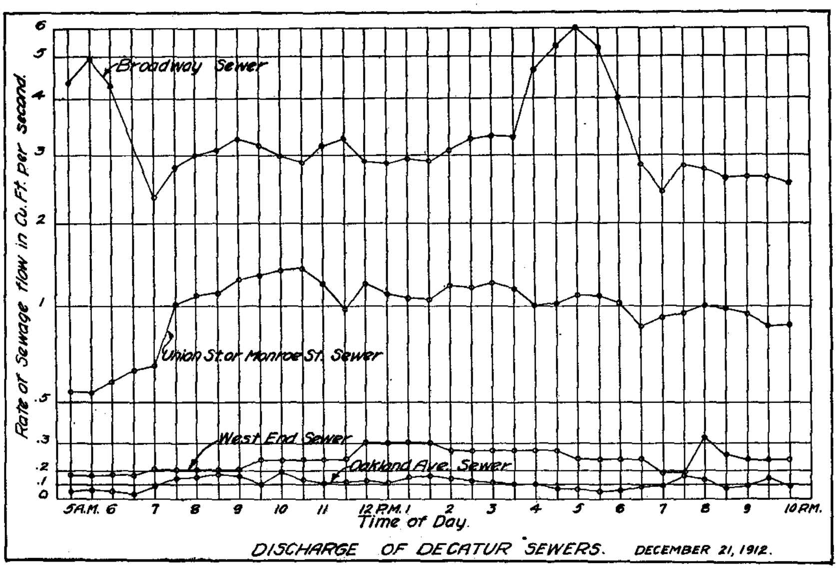


Fig. 22.—Discharge of Decatur Sewers.

sewer outlets, but, generally speaking, they do not persist for great distances in a downstream direction. Below the main Decatur sewer outfall they are observed only in very small numbers or not at all at distances beyond 7 to 9 miles.

Summary of Analytical Evidence: Summarizing the analytical evidence with reference to the polluted condition of the Sangamon river, it may be said that the pollution encountered below Decatur is far in excess of the pollution occurring at any other point. During periods of low water it seems to make but little difference with reference to offensiveness whether the stream contains a quantity more or a quantity less of sewage or industrial wastes. The stream flow is so small that very much less quantities of sewage than now enter the stream would cause its gross contamination, and moreover the extent of the pollution in a downstream direction, as noted under the discussion of visual observations, is limited by the time that it takes the sewage in its passage downstream rather than by the dilution available. Of course, increased quantities of sewage that increase the current velocity of the river will increase the distance in a downstream direction to which the nuisance may persist. The trip of September 25, 1913, shows in a striking manner the effect of long-continued low water. It appears that at such times heavy accumulations of sludge occur which in undergoing decomposition add greatly to the pollution of the water over and above that which would be caused by the discharge of sewage alone.

COMPOSITION AND VOLUME OF DECATUR SEWAGE.

The object of these studies was to ascertain approximately the character and quantity of sewage produced by the city of Decatur, and these factors will in turn throw some light on the design required for sewage treatment works and necessary connecting sewers. It is unfortunate that only one set of weighted samples of the sewage was secured. This resulted from the fact that the weirs built for measuring purposes were washed out during the floods of the spring of 1913.

Conditions Under Which Work Was Done: Collection of samples, sewer gagings and stream measurements were made on December 21, 1912, following a protracted period of dry weather during which the temperature was low. At the time of the measurements the ground was frozen to the depth of a few inches. The figures obtained may, therefore, be taken as typical of dry weather conditions. It was impracticable at the time to extend the measurements and collection of samples over the entire 24 hours. Accordingly measurements were made from 5 a. m. to 10 p. m. only, with the expectation that the principal fluctuations throughout the day would be obtainable in this way and that an indication of the volume and composition of the night sewage could be obtained by the 5 a. m. and the 10 p. m. measurements and samples.

Method of Sampling: In order to secure samples as nearly as possible representative of the sewage flowing, portions were collected at half-hour intervals and the size of each portion was made proportional to the sewage flow at that particular time. This was accomplished in the following manner: A table was prepared showing weir discharges and also small proportional quantities of sewage expressed in cubic centimeters for each one-sixteenth of an inch difference in head over the weir. The small proportional parts were measured out in a cylindrical graduate at each half-hourly weir reading and poured into a large receptacle. At the end of the day the contents of this receptacle were thoroughly mixed and a gallon of the liquid was placed in a bottle for shipment to the laboratory. To preserve the samples in transit, chloroform was added. To throw some light on the variation in the sewage composition, full samples were taken from each outlet sewer at 5 a. m. between 9:30 and 11 a. m. and at 10 p. m.

The results of sewage flow measurements are contained in Figure 22. Table 13 gives a condensed record of flow measurements, showing total for the day and maximum and minimum rates. The analyses are given in Table 14. In order to bring out some of the results of analyses more clearly, the determinations are presented graphically in Figure 23.

TABLE XIII.

SUMMARY OF SEWAGE FLOW MEASUREMENTS AT DECATUR ON DEC. 21, 1912.

Name of Sewer	Av. Discharge cu. ft. per second	Av. Discharge gals. per 24 hours	Minimum Rate gals. per 24 hours	Per Cent of Average	Maximum Rate gals. per 24 hours	Per Cent of Average
Broadway	3.15	2,040,000	1,580,000	87.3	3,880,000	190
Union or Monroe	0.787	510,000	378,000	74.1	942,000	185
Oakland Ave	0.0974	63,000	21,800	34.6	123,000	195
7th Ward or West End	0.248	161,000	115,000	71.6	205,000	127
Total	4.282	2,774,000				

Comparison of Sewage at Several Outlets: The analyses show that in general the sewage from the Broadway outlet is stronger than that from the other outlets, though but little stronger than the sewage from the Oakland avenue sewer. Sewage from the Union street sewer is somewhat weaker, and the sewage from the Seventh Ward sewer is rather dilute. The explanation of the low organic content of the sewage in the Seventh Ward sewer may be found in the fact that all of this sewage is of a domestic character from good residence districts where the water consumption is apt to be large and moreover the sewer probably receives considerable leakage of ground water inasmuch as it laid throughout a large portion of its length in alluvial deposits which are more or less saturated with water.

Determinations for Solids: The average sewage from the entire city is above normal strength. The total residue on evaporation is much greater than is encountered in what may be regarded as an average sewage, but large proportions of these solids are of mineral origin. The volatile solids are in the neighborhood of 490 parts per million which is somewhat over double what should be found in an average sewage. The explanation can be found in the very heavy content of solids in the Broadway sewer, especially at certain periods in the day as at 9 o'clock in the morning on the day of sampling, when there were 3,000 parts per million. These solids undoubtedly emanate from the Corn Products Works, a conclusion confirmed by visual observation and relatively low total organic nitrogen in contrast with the volatile residue on evaporation, for corn products wastes are poor in nitrogenous matter.

The total solids, as well as the volatile solids in the Union street and Oakland avenue sewage, are also above normal and it would appear that these sewers also receive some form of industrial wastes which tends to concentrate the sewage. The solids, both total and

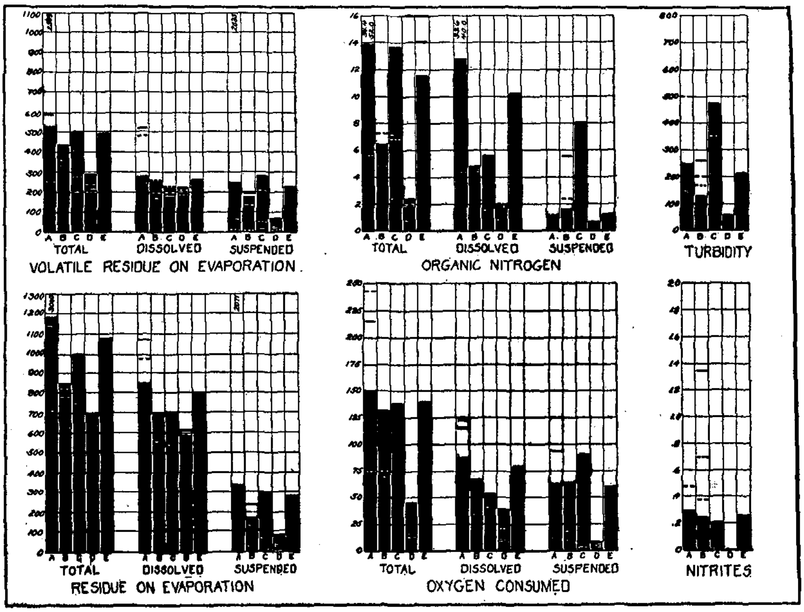
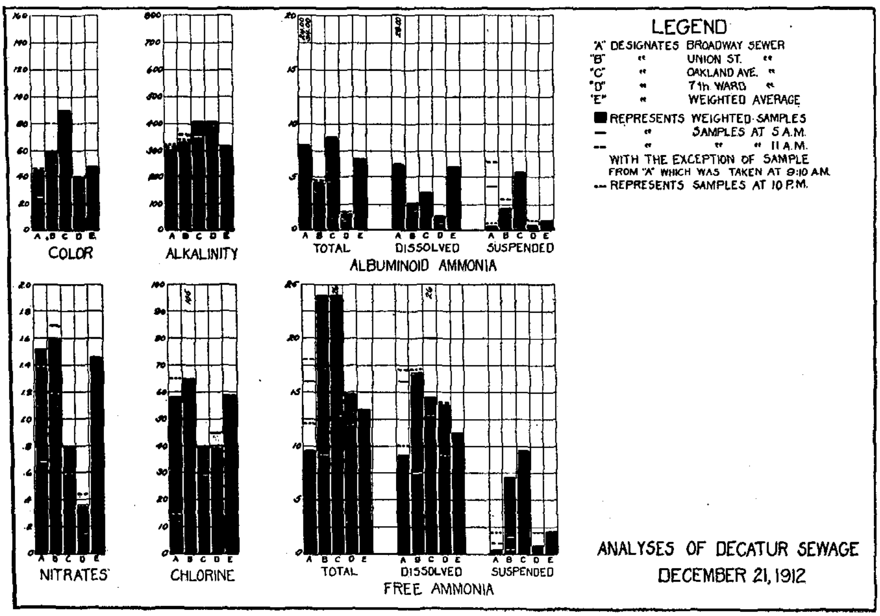


Fig. 23.—Analyses

volatile, in the Seventh Ward sewer are characteristic of those of an ordinary weak domestic sewage.

Referring to the suspended solids, these are relatively large in the Broadway sewer and the Oakland avenue sewer. In the Seventh Ward sewer and the Union street sewer the suspended solids show more or less of the characteristics of domestic sewage, but a surprisingly small proportion is in suspension, while a very large proportion of the volatile matter is in solution. The explanation is not altogether clear, but it is probable that some hydrolytic action takes place within the long outfall sewer, resulting in the decomposition and solution of the solid matter.

Nitrogen Content: In none of the determinations did the total organic nitrogen content indicate a very strong sewage and the weighted average nitrogen content for all of the sewage is considerably below the normal for even a domestic sewage. This is quite in contrast with a single analysis made on sewage from the Broadway outlet at 9:15 a. m. on September 25, 1913, at a time when it contained no corn products wastes, and is significant as indicating that the large quantity of volatile solids in the Broadway sewer are due to carbonaceous organic matter, rather than nitrogenous organic matter. There is a marked rise in the nitrogen content with the rise in



of Decatur Sewage.

residue, but the rise is only a small fraction of that which takes place in the residue.

The albuminoid ammonia corresponds very closely with the organic nitrogen. The nitrogen as free ammonia, nitrites and nitrates seems to be of little significance other than as a rough measure of the strength and as indicating a degree of freshness in all sewer outlets.

Oxygen Consumed: The oxygen consumed figures confirm in a general way the conclusions as to relative organic content that may be drawn from the figures for residue on evaporation and the oxygen consumed figures also show the larger amount of carbonaceous matter in sewage containing corn products wastes. The, determinations

TABLE XIV.

ANALYSES OF DECATUR SEWAGE.

Lab. No.	Source	Turbidity	Color	Residue on Evaporation				Chlorine in Chlorides	Oxygen Consumed		Nitrogen as						Alkalinity	Ph. Alk.	Total Organic Nitrogen	
				Total		Dissolved					Free Amm.		Alb. Amm.		Nitrites	Nitrates				
				Tot.	Fix.	Tot.	Fix.		Tot.	Dis.	Tot.	Div.	Tot.	Dis					Tot.	Dis.
24521	Sangamon R. above sewer outlets	10	10	339	215	314	190	4	12.7	3.2	.112	.120	.112	.08	.005	.76	264	....	.176	.144
24520	Sangamon R. below sewer outlets	25	15	384	248	272	243	10	17.4	11.6	1.600	1.520	.960	.88	.030	.76	270	....	2.800	1.280
24525	Broadway or Main sewer 5 A.M., 10 P.M., weighted sample	250	45	1182	659	848	573	58	119.0	87.0	9.600	9.20	8.000	7.60	.300	1.52	304	2	13.920	12.800
24534	Broadway or Main sewer 5 A. M....................	150	25	1148	562	1065	547	12	216.0	124.0	16.00	16.00	24.000	20.00	.000	.68	270	....	34.400	33.60
24533	Broadway or Main sewer 9:10 A. M	500	45	3047	538	976	502	15	242.0	117.0	18.00	17.20	34.400	28.00	.480	1.40	314	....	52.000	40.00
24537	Broadway or Main Sewer 10 P. M.................	150	35	714	463	699	461	65	75.0	64.0	12.00	10.00	3.360	2.80	.290	1.12	316	....	5.600	4.400
24524	Union St. Sewer weighted sample, 5 A. M., 10 P. M.	130	60	852	420	683	428	65	131.0	67.0	24.00	16.80	4.480	2.40	.250	1.60	330	6	6.400	4.800
24528	Union St. sewer, 5 A. M. . .	260	40	781	425	550	388	45	45.0	36.0	9.20	7.60	2.400	1.32	1.350	1.80	282	....	10.000	4.400
24529	Union St. sewer, 11 A.M. . .	200	80	825	496	697	505	103	75.0	58.0	17.20	16.80	4.600	1.80	.380	1.12	358	....	7.200	4.800
24536	Union St. sewer, 10 P. M. . .	170	50	629	365	608	352	60	70.0	43.0	19.20	17.20	3.680	1.80	.700	1.20	336	....	4.800	4.240
24523	Oakland Ave. sewer. 5 A. M. 10 P.M., weighted sample	475	90	1004	509	705	494	40	142.0	54.0	24.00	14.40	8.800	3.36	.215	.80	410		13.760	5.600
24532	Oakland Ave. sewer, 5 A.M.	20	30	494	295	484	300	29	16.8	13.6	12.80	12.80	1.320	1.20	.018	.48	354	....	2.400	1.600
24526	Oakland Avenue Sewer, 11 A. M	350	55	755	351	532	337	40	111.00	41.0	26.00	25.00	4.600	2.00	.000	.60	386	....	7.200	3.040
24530	Oakland Avenue sewer. 10 P. M........................	210	50	610	335	542	320	35	64.0	42.0	20.00	20.00	2.800	1.72	.015	.72	362	....	6.880	4.800
24522	7th Ward Sewer weighted sample, 5 A.M., 10 P. M.	60	40	697	408	612	393	40	45.0	39.0	14.80	14.00	1.680	1.20	.012	.36	410	....	2.400	1.720
24531	7th Ward sewer, 5 A. M. . .	20	35	615	404	607	408	45	13.8	11.4	12.00	10.00	.848	.760	.000	.16	398	....	.800	.800
24527	7th Ward sewer, 11 A. M..	30	30	637	400	603	396	40	14.0	10.4	13.20	14.00	.880	.800	.000	.44	398	....	2.000	2.000
24535	7th Ward sewer, 10 P. M...	35	30	572	378	540	353	28	24.8	22.0	8.80	8.80	1.800	.920	.003	.36	344	....	2.000	1.760
24525 24524 24523 24522	Weighted average	217	48	1079	588	796	529	59	139.0	79.0	13.40	11.26	6.886	6.000	.272	1.46	318	....	11.620	10.250

of oxygen consumed for all except the Seventh Ward sewer are considerably higher than would be expected in a normal domestic sewage, whereas the determinations for the Seventh Ward sewer are again typical of a weak domestic sewage.

Influence of Corn Products Wastes: A strong characteristic of the sewage is the presence of industrial wastes, particularly those from the Corn Products Works which find their way to the Broadway sewer outlet. During certain hours of the day the wastes from the Corn Products Works preponderate to such an extent both in quantity and strength as to entirely modify the character of the sewage flow. Any purification works that may be built to take the entire sewage flow from the city must be designed with special reference to these wastes. The added burden to purification works that would be caused by these wastes cannot be reliably estimated on the basis of the limited data available, but considering their relative resistance to decomposition by ordinary sewage treatment processes, it would seem. that the cost of treatment works may be doubled.

Influence of Gas Wastes: There is another characteristic of the sewage from the Broadway outlet which is not revealed in the analyses, namely, oily films and odors that are principally due to gas house wastes. Such wastes, while small in quantity, constitute a serious nuisance in the stream by covering the surface with an unsightly oily film which is not only inimical to fish life, but also prevents in large measure the self-purification of the underlying sewage polluted water. Also the oily wastes adhere to the banks of the stream, resulting in unsightly and malodorous accumulations. When sewage is to be treated, gas house wastes constitute a serious disturbing factor, owing to tarry matters, which tend to clog sewage treatment devices and interfere with their proper bacterial action. The only practicable solution of the gas house wastes problem is treatment of these wastes at the gas plant, so that no tarry liquids or oily matters. even in very small quantities, may enter the sewers. Fortunately this can be accomplished by sedimentation, sometimes assisted by treatment with lime and followed. by filtration through coke or cinders. If coke is used, it may be periodically removed and utilized for fuel.

GENERAL DISCUSSION OF PROBLEM AT DECATUR

Available Stream Flow for Dilution: The low water flow in the Sangamon at Decatur every year is likely to be less. than 50 cubic feet per second, and during dry years, such as 1908 and 1913, the flow may be less than 25 cubic feet for months at a time. The Sangamon at Decatur is not quickly responsive to summer storms, and the increased flow, due to an extensive storm, does not develop until the day following the storm. Local storms may have a negligible effect on the stream flow. Time did not permit of making as thorough study of rainfall and runoff data, such as might throw light on the behavior of the stream following storms of varying magnitude and extent. Tentatively it may be stated that 30 cubic feet per second is the maximum quantity that may be relied upon following a characteristic local shower in the summer time. It will thus be seen that in dry weather the dilution available for the dry weather flow of sewage may be very slight (sometimes it is less than is taken out for water supply) and that there is also but slight dilution available for the first foul flow of storm water.

General Requirements Imposed by Stream Flow and Existing Sewer System: As the sewerage system of Decatur is on the combined plan, and as its conversion into a separate system is out of the question, it becomes necessary to consider the treatment of both the dry weather sewage and a portion at least of the storm flow. This leads to the very important questions of how much of the storm flow must be intercepted for treatment and how the treatment may best be carried out.

Assumptions Made as a Basis of Further Discussion: To throw some 'light on these questions, it will be first necessary to make some assumptions in the light of the best available data. These assumptions should be carefully checked and modified, if in error, by further observations that should be made by the city and which will be outlined later. In general, however, it is believed they represent fairly closely the actual conditions to be anticipated.

First. It is assumed that corn products wastes and gas house wastes will be separately cared for.

Second. Any works now constructed should meet the needs of a population tributary to the sewers of 40,000, a figure assumed to be reached in 1923. This is a local estimate and is tentatively accepted, but census returns would indicate 45,000 to be a more correct figure.

Third. It is assumed on the basis of sewage measurements made on December 21, 1912, that the dry weather sewage flow for a population of 40,000 will average 4,000,000 gallons per 24 hours.

Fourth. The storm water runoff from the city streets of Decatur is assumed to have about the same value for dilution purposes as the water that flows in the Sangamon above Decatur and the dilution of the dry weather flow necessary to produce inoffensive conditions is taken at 5 cubic feet per second per 1,000 persons tributary to the sewers or a volume dilution in the ratio of 1 to 32.2. Of course, this last assumption is incorrect because the first storm runoff is apt to be very foul, due to the flushing out of accumulations of solid matters from the sewers, and all of the storm runoff will be more or less contaminated by dirt washed from the streets. On the other hand, the dilution figure chosen is rather liberal, and before the entire volume of storm water required for dilution purposes runs off it will have cleared up materially. The volume of storm runoff required over and above that afforded by the river for complete dilution is 170 cubic feet per second, a quantity that will be produced in Decatur by a rainfall over the area tributary to the sewers at the rate of about 0.2 inch per hour.

Treatment for Dry Weather Flow: In view of the long periods of dry weather, when the flow in the river may not be above 25 cubic feet per second, or about .6 cubic foot per 1,000 persons tributary, and in view of the further consideration that the dilution available is during exceptionally dry seasons even less than this, it would seem that for the dry weather flow nothing short of purification to the nonputrescible state and reasonably free from suspended matter and color will prove adequate. This can probably be most economically accomplished by a plant comprising the following parts:

1. Grit chambers.
2. Screen chambers.
3. Primary sedimentation tanks with separate sludge digestion chambers.
4. Sludge drying beds for primary tanks.
5. Sprinkling filters.
6. Final sedimentation tanks with separate sludge digestion chambers.
7. Sludge drying beds for secondary sedimentation tanks.

It is not intended to recommend the above as the only acceptable method of sewage treatment, and it is entirely possible that local considerations may warrant the use of other devices, but they represent an arrangement that will produce acceptable results.

Treatment of Storm Flow: To obtain an indication of the best treatment for storm flow, Figure 24 has been prepared. This diagram assumes that the dry weather flow is entirely taken care of and considers only the excess storm flow, more or less mixed with sewage. The abscissa in the diagram represent added volumes of storm flow, each volume being equal to the assumed volume of dry weather flow. The ordinates represent the diluting water necessary to take care of successive volumes of storm flow. As the flow increases, the first four or five volumes of storm flow require an increasing quantity of diluting water because the dry weather sewage still remains the predominating factor. Succeeding volumes of storm flow, however, decrease the quantity of diluting water necessary until 32.2 volumes have been added, when no diluting water is necessary to prevent nuisance. These features are shown graphically by curve A. Since there has been assumed but 30.0 cubic feet per second available for diluting purposes in the river, it appears that there will be about 27 times the dry weather flow that is not adequately diluted and still requiring an average dilution by 67 cubic feet per second. Moreover the first few volumes are very highly polluted. The treatment of

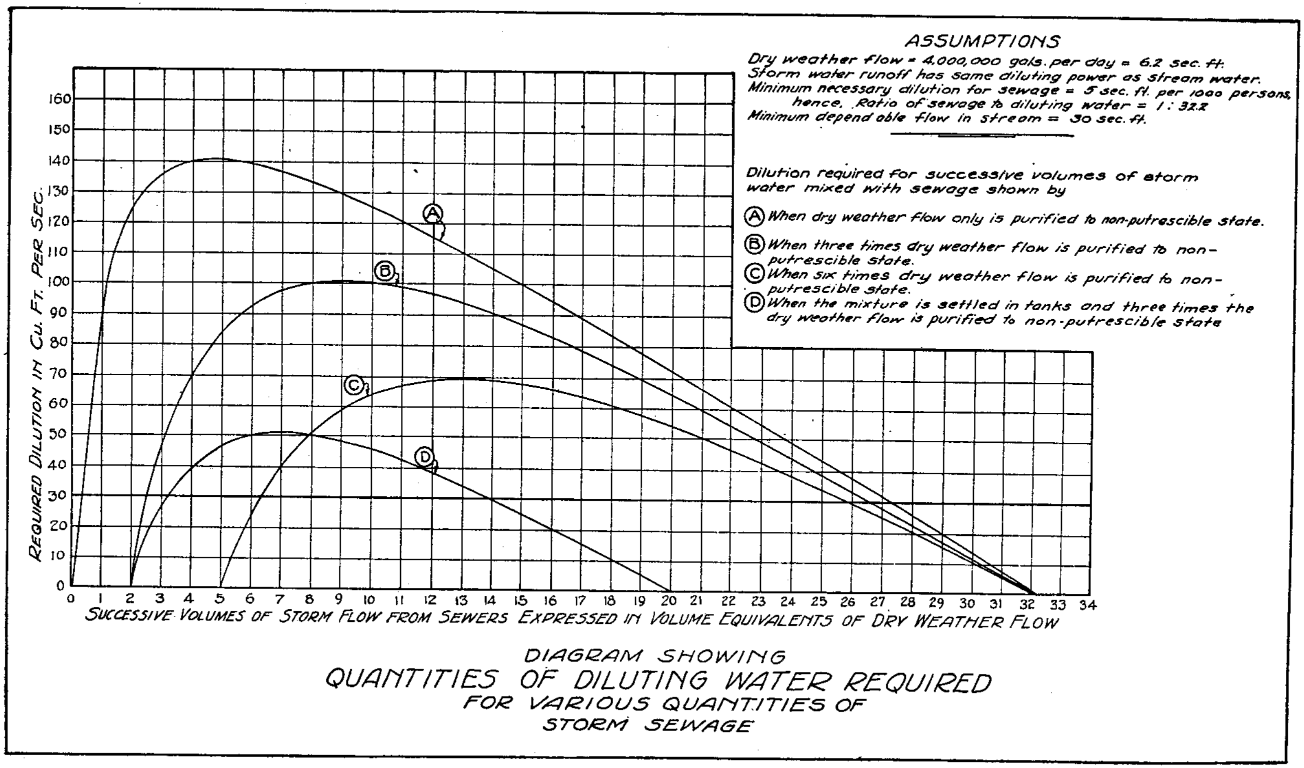


Fig. 24.—Quantities of Diluting Water Required for Various Quantities of Storm Sewage.

this enormous quantity, as described above, is out of the question for economic reasons.

Curve B shows what the conditions would be if three times the dry weather flow is treated as outlined. Here about 24 volumes require further dilution, for which an average quantity of diluting water of 44 cubic feet per second is required.

Curve C shows that with 6 times the dry weather flow purified, about 19½ times the dry weather flow is still inadequately diluted, and that the average additional dilution required is about 25 cubic feet per second.

Curve D shows what would result if the storm flow represented by Curve B were submitted to a tank treatment which would reduce the volume of diluting water necessary for its inoffensive disposal by one-third, or, say, to 20 volumes instead of 32.2 volumes. We then find that there are only about 9½ volumes that are inadequately diluted and that the average additional dilution required would be 12½ cubic feet per second. This scheme would produce some visible pollution of the river, but it would be of but short duration.

For purposes of comparison, the cost of works for treating three times the dry weather flow to a non-putrescible state may be taken as $240,000 and the cost for similarly treating six times the dry weather flow will be double this or $480,000. If instead of treating the additional three times the dry weather flow, as above, an additional 24 times the dry weather flow be treated merely by sedimentation in tanks having a retention period of one-half hour, the cost would be about $30,000. To this must be added the increase in cost of an enlarged intercepting sewer to carry four to five times the capacity of an interceptor for a plant giving a more complete treatment to six times the dry weather flow. This increase would probably not exceed $75,000 The total cost, therefore, of treating three times the dry weather flow completely and 24 times the dry weather flow in tanks would be about $345,000 as against $480,000 for giving a complete treatment to six times the dry weather flow. Moreover, the effectiveness of the former would be much greater than the latter. There can be no question as to the correct choice on the basis of the data assumed.

There are other combinations that might be made to advantage. For example, the extensive treatment of but twice the dry weather flow and tank treatment of a greater quantity of storm flow. The indeterminate factors are so numerous, however, that these further inquiries will not be pursued.

Indeterminate Factors Requiring Further Investigation: Among the more important indeterminate factors are the following:

(a) Stream gagings and river gage heights at Decatur;
(b) Hourly rainfall records;
(c) Storm runoff from sewers;

(d) Character of mixed sanitary and storm sewage;

(e) Behavior of Sangamon following storms of varying magnitude and extent, with reference to pollution.

All of these should be determined more accurately during the coming season of low water.

Stream Gagings and River Gage Heights: The principal stream flow data which serve in this report as a basis for deductions relative to the Decatur sewage disposal problem were not made at Decatur at all, but at Riverton and Monticello by the United States Geological Survey. Moreover they are based on a single daily gage reading,

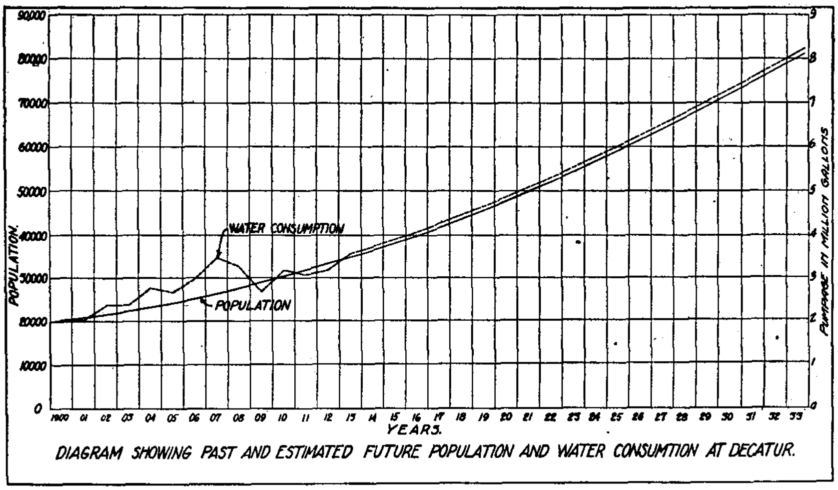


Fig. 25.—Diagram Showing Past and Estimated Future Population and Water Consumption at Decatur.

whereas a continuous record of gage heights is necessary to a full consideration of the treatment necessary for storm sewage. The few measurements made by the State Water Survey were helpful in interpreting analyses and obtaining a knowledge of minimum flows, but gave no continuous record. To meet requirements, the city should establish an automatic gage that will give continuous records. In connection therewith the State Water Survey may be called upon to make a sufficient number of stream gagings to give a reliable rating curve, from which to determine rates of discharges at various gage heights.

Provision should be made by the city for installing weirs at each of the sewer outfalls and automatic water level gages in connection therewith, so that a continuous record of the sewage flow may be had. Comparisons of sewage flows with coincident flows in the river, hour by hour, or even minute by minute, would then be possible.

Rainfall Records: Coincident with the study of stream flow, continuous rainfall records should be kept at Decatur and preferably at other points on the watershed also. The Decatur records at least should be kept by a recording gage which will give the minute-to-minute variations. The other gages may be of the type that are read one or more times per day.

Analyses of Sewage and Sewage Polluted Water: To reach sound conclusions as to the proper treatment of successive volumes of storm runoff, the city should equip its laboratory at the water purification works for analyzing storm sewage. Samples of normal dry weather flow should also be analyzed at frequent intervals. The storm water discharges should be analyzed with reference to securing a knowledge of the composition and minute-to-minute changes during storms of varying magnitude.

The laboratory should also be used for making frequent analyses of the Sangamon river at numerous points in a downstream direction in a manner similar to the work carried out by the State Water Survey. Inasmuch as dry weather conditions are rather fully presented in this report, the further analyses should be directed toward a study of the influence of summer storms.

Industrial Wastes: The greatest complication to the Decatur sewage disposal problem is the necessity for caring for the wastes from the corn products plant of the Staley Manufacturing Company. These are, roughly, from 6 to 8 times as strong as normal domestic sewage. The volume of the wastes is about 1,000,000 gallons per day and the probable future growth of the plant will double the volume. Further, the wastes are particularly refractory to biological decomposition, such as is commonly used in sewage treatment.

Unfortunately little along the line of treating corn products wastes has been worked out, though such wastes have been greatly reduced in volume and strength by economies introduced into the manufacture of starch and other corn products.

It would seem highly desirable to equip a testing station where various biological and other methods may be tried out on the corn products wastes alone and on these wastes mixed with city sewage in proportions likely to occur in actual practice. Such experiments cannot be planned, carried out and results made available in less than one year.

The elimination of gas house wastes is a comparatively simple problem. Treatment of these wastes for the removal of oily and tarry substances so that they may be discharged into a stream without causing nuisance or be conveyed to sewage treatment works without interfering with the processes of purification has been extensively studied by the Massachusetts State Board of Health and others. The results of such studies show that sedimentation of the wastes, assisted by treatment with lime and followed by rapid filtration through coal or coke, furnish an effective and economical method of handling them. Since the volume and character of gas house wastes vary somewhat at different plants, it is desirable, before constructing any permanent works, to conduct a few simple experiments on a small scale to permit of better determining the size of tanks and area of filters required.

REPORT ON SEWAGE DISPOSAL ALONG THE NORTH BRANCH OF THE CHICAGO RIVER AND ITS TRIBUTARIES*

At the request of Mr. P. R. Barnes, attorney for the Northwest Sanitary Drainage Association, the State Water Survey has made inquiry into the condition of the North Branch of the Chicago river and its tributaries and the present status of sewage disposal methods in various communities located along these streams. The Northwest Sanitary Drainage Association is an organization formed for the purpose of securing adequate sanitary drainage for that portion of the Sanitary District lying in the drainage area of the North Branch of the Chicago river.

The activities undertaken by the State Water Survey comprise the following:

1. Various conferences in the office of Mr. Barnes.

2. An inspection on July 26, 1912, of the Skokie, or east branch of the North branch of the Chicago river, below Winnetka. This inspection was made by the director and engineer of the Survey in company with Messrs. P. R. Barnes and W G. Hibbard, the latter being a member of the Northwestern Sanitary Drainage Association and a resident of Winnetka.

3. An inspection on September 28, 1912, of the North branch between its confluence with the North Shore Drainage channel and Morton Grove. This inspection was made by the director and engineer of the Survey in company with Messrs. Barnes and Robert Dick. The latter is secretary of the Northwest Sanitary Drainage Association.

4. A consultation with Mr. Wisner, chief engineer and Mr. Langdon Pearse, division engineer for the Sanitary District of Chicago,. on October 11, 1912.

5. A detailed inspection of the watershed of the North branch and its tributaries by Mr. Ralph Hilscher, assistant engineer of the State Water Survey. Copy of Mr. Hilscher's report in detail is herewith attached. (See appendix.)

6. An examination of preliminary report and plans prepared by the engineers of the Sanitary District relating to the solution of the sewage disposal problems within the district and north of the Chicago city limits.

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*Report by Paul Hansen, Engineer State Water Survey.

The inquiries and studies that the State Water Survey has made do not permit of submitting in detail recommendations for the proper treatment of the North branch of the Chicago river and its tributaries for the purpose of eliminating pollution and otherwise promoting their usefulness. This would involve far more thorough surveys and engineering studies than the present means of the State Water Survey will allow, but it is possible to set forth the broad principles that apply and to present certain conclusions on the basis of the data contained in the preliminary report of the engineers of the Sanitary District.

For the purpose of making clear the attitude of the State Water Survey, the broad facts and general considerations that should govern in approaching a solution of the North branch problems will first be stated. Next there will be taken up a discussion of the preliminary report of the engineers of the Sanitary District, and in conclusion a statement will be made with reference to the proper order of procedure in meeting present and future requirements of the North branch drainage area.

GENERAL CONSIDERATIONS THAT SHOULD GOVERN IN CONNECTION WITH THE REGULATION OF THE NORTH BRANCH OF THE CHICAGO RIVER AND ITS TRIBUTARIES.

1. The North branch of the Chicago river and its tributaries are subject to marked irregularity in the volume of flow, varying from practically nothing in dry seasons to out of banks in wet seasons, a condition which results in objectionable pollution in the former instance, even though the streams receive comparatively small quantities of sewage and other putrescible wastes, and which results in flooding of cellars and other flood damage in the latter instance.

2. The value of the land lying along the North branch and its tributaries is sufficiently great for residential and recreative purposes to warrant the exclusion of any sewage or other wastes which may render the waters of these streams unsightly or malodorous at any point. A more stringent requirement than this is not demanded, inasmuch as the streams will never be used as sources of public water supply.

3. The North branch and its tributaries are now polluted in dry seasons to an objectionable degree in various localities. The quantity of wastes entering, however, is not sufficient to cause the streams to be objectionable throughout their entire course. The principal points of objectionable pollution, as indicated upon the accompanying map, are at Niles, where the main stream receives the sewage from Norwood Park and Edison Park, at Morton Grove, at Winnetka and Glencoe. The last mentioned two communities are on the Skokie. In addition, there enters the North branch and its tributaries more or less sewage from institutions, clubs and private residences which,

unless properly cared for, will add in an unwarranted degree to the pollution of the stream. Practically all of the contamination now entering is due to domestic sewage, though at Morton Grove the conditions are aggravated by wastes from a pickle factory.

DISCUSSION OF REPORT ON SEWAGE DISPOSAL ALONG THE NORTH BRANCH OF THE CHICAGO RIVER, PREPARED BY THE ENGINEERS OF THE SANITARY DISTRICT.

This report divides the problem into four elements, as follows:

1. The North branch of the Chicago river (main stream) outside of Chicago;
2. The West branch, upon which are located Shermerville and Glenview;
3. The Skokie or East branch, into which drain portions of Glencoe and Winnetka;
4. North Shore of Lake Michigan north of Evanston and south of the Lake county line.

The last element does not strictly belong to a consideration of the North branch of the Chicago river and its tributaries. Nevertheless a relation between the two exists with reference to Glencoe and Winnetka. To the above four elments may be added for purposes of present discussion another, namely, that portion of the North branch (main stream) lying within the city limits of Chicago. The middle branch is not included as an element for the reason that at the present time it receives no objectionable drainage and demands no special treatment.

North Branch Within Chicago City Limits: In discussing the various elements above enumerated, the last may be considered first, inasmuch as it can easily be eliminated from the remainder of the discussion.

The city of Chicago has already adopted the policy of permitting no additional sewage to enter directly into the North Branch, and as soon as practicable, interecepting sewers will be built which will convey all of the sewage normally drained toward the North Branch into the main North Shore Drainage Channel of the Sanitary District. Before the sewage is discharged, however, into the Channel, it will be passed through sedimentation tanks of the Emscher type.

The above intercepting sewers will care for the sewage from Norwood Park, Forest Glenn, Edgebrook, Edison Park and Niles Center. The last mentioned has not yet installed a sewerage system, though one is contemplated.

This policy of the city of Chicago effectively and satisfactorily solves the problem with the city limits, though it may take two to three years before the necessary construction can be completed.

It may be added that the Sanitary District has recently provided temporary relief by clearing the channel of the North Branch of obstructions in order to prevent, as far as possible, the formation of stagnant pools in the summer time. This work involved the expenditure of $7,500.

North Branch (Main Stream) North of Chicago City Limits: Referring to that portion of the North Branch, lying north of the city limits, the principal pollution here enters from Niles and Morton Grove. Neither of these cities have systems of sanitary sewers, though more or less sanitary waste finds its way into storm sewers and private drains. As already noted, the situation is further complicated at Morton Grove by pickle factory wastes.

The studies made by the engineers of the Sanitary District, indicate clearly that the most economical method for caring for the sew-

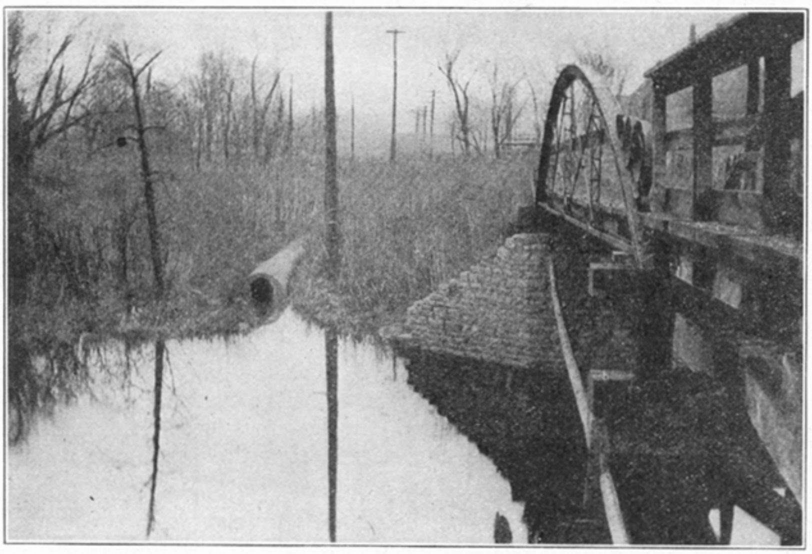

Fig. 1.—Outlet to New Sewer System, Morton Grove.

age from these two communities is by installing small independent sewage treatment plants. The process recommended is sedimentation, filtration by means of sprinkling filters and final sedimentation of the effluent before discharging it into the stream. Pumping will be necessary on account of flat topography.

Some question may be raised as to the suitability of the design and the size of the installation, but manifestly treatment involving final filtration of some sort will prove much cheaper than an intercepting sewer, and it will prove both cheaper and more effective than partial treatment supplemented by extensive improvements in the channel of the stream.

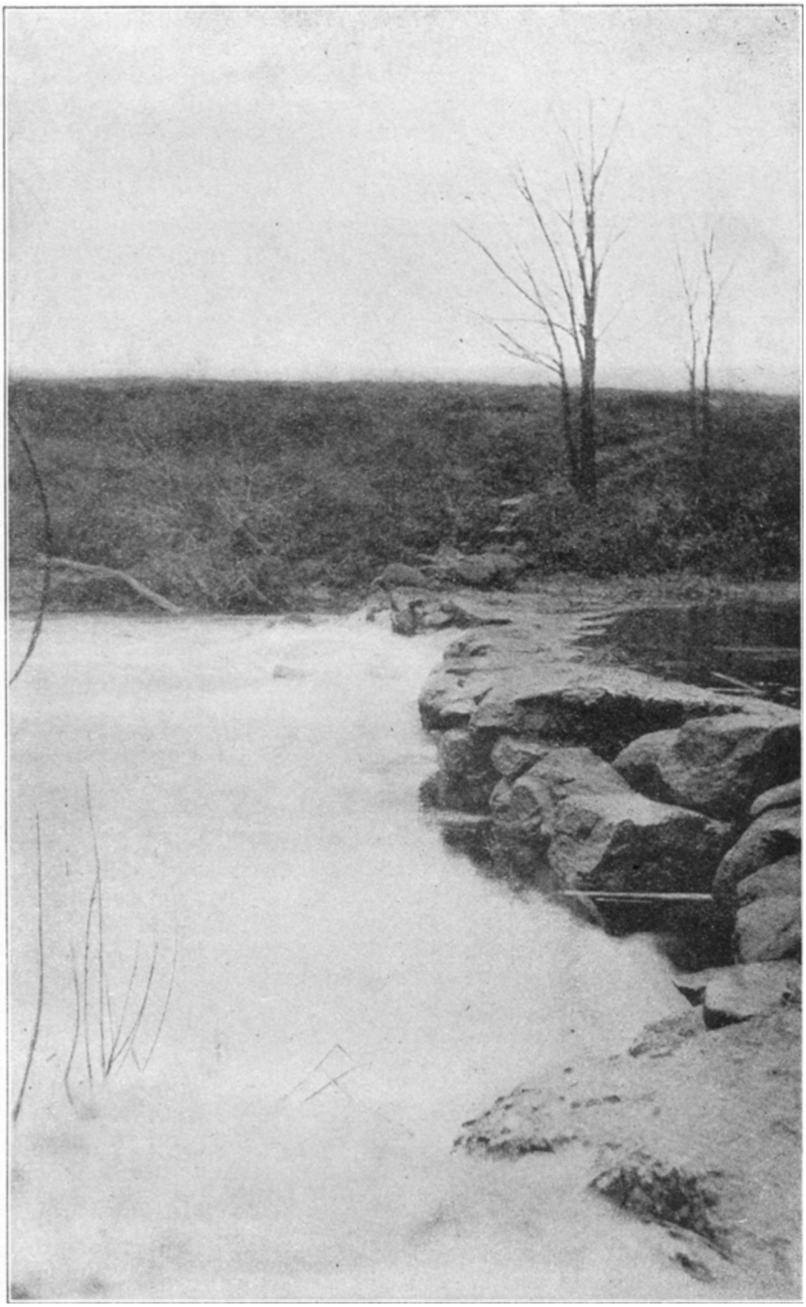

Fig. 2.—Dam One-half Mile Below Morton Grove.

The West Branch of the North Branch: The West Branch at the present time, receives but little sewage contamination, and such as it does receive, comes from St. Joseph's Home, near Shermerville, Golf Clubs and private residences. Some of this is partially purified; the rest flows directly into the stream and, in the case of St. Joseph's

Fig. 3.—Ditch Carrying Effluent from Winnetka Septic Tank Along Roadside.

Home, may at times cause a local nuisance. The treatment recommended for such sewage is by means of small installations for the individual institutions, clubs and houses.

The main problem of sewage disposal on the west branch lies in the future when Shermerville and Glenview, now small but growing residence communities, shall have installed sanitary sewerage systems. The studies of the engineers of the Sanitary District, go to show that at such time the most economical solution of the problem will be, as in the case of Morton Grove, the installation of separate sewage treatment plants. Because of the flatness of the topography, pumping of the sewage will be necessary.

The Skokie or East Branch of the North Branch: The most acute nuisance conditions now existing in the drainage area, are along the Skokie opposite Glencoe and Winnetka. This stream receives partially treated effluents from septic tanks and because of the absence of stream flow in the summer time, and the ill-defined character of the stream channel, foul odors arise and very unsightly conditions prevail.

The solution of this problem recommended by the Sanitary District is the construction of an intercepting sewer beginning at the north end of the North Shore Channel, in Wilmette, extending thence along the lake shore northward to the southern boundary line of Winnetka, thence westward to the Skokie valley, and thence in a generally northwesterly direction to Adams street, Glencoe. This interceptor will intercept the effluent from one existing septic tank in Glencoe and two existing secptic tanks in Winnetka. Remodelling of these tanks is recommended to enable them to produce a more satisfactory effluent. This interceptor will entirely eliminate all sewage contamination in the Skokie valley within the Sanitary District. It will not, however, eliminate the contamination that reaches the Skokie from Highland Park, Highwood, Fort Sheridan and Lake Forest.

The ultimate solution of the Skokie problem must involve cooperation on the part of those communities that lie north of the Sanitary District. What form this cooperation will take cannot, at present, be outlined. It may be pointed out, however, that Lake Forest in studying its own sewage disposal problem, has found this problem so interwoven with the problems presented by the other North Shore communities, that it proposes to call for a cooperative study by all of the communities along the North Shore of the sewage disposal problems of the North Shore as a whole.

Construction of the interceptor above described, has already been authorized by the trustees of the Sanitary District, so that this improvement is assured within the course of a few years.

Lake Shore Towns Draining Toward the Lake: The problem of disposing of the sewage which now drains toward the lake in the communities of Winnetka and Glencoe, has only an indirect relation to the disposal problem within the drainage area of the North Branch of the Chicago river and its tributaries, in that a diversion of this sewage from Lake Michigan may involve pumping it back into the Skokie valley.

The engineers of the Sanitary District propose several practicable solutions for this problem, and the State Water Survey has not yet been informed as to the one finally decided upon.

The first proposition involves extending a branch of the proposed intercepting sewer along the Lake Shore to Hazel street, Glencoe, which will intercept the tank, effluents from an existing tank now located at Hazel street, and a proposed tank to be built at Elder street in Winnetka.

The alternative plan is to extend the branch of the interceptor only to Elder street, Winnetka, or a distance of approximately one-half mile, and to construct in tunnel a rising main from Hazel street to Adams street, in Winnetka, which will permit of pumping the effluent from the tank at Hazel street into the intercepting sewer in the Skokie valley at Adams street.

The latter plan seems to be somewhat cheaper, though there may be other considerations which may affect a choice.

ORDER OF PROCEDURE IN MEETING PRESENT AND FUTURE REQUIREMENTS.

From the foregoing discussion, it will be seen that the only corrective measures of a public character that have not been authorized, relate to the disposal of sewage from Morton Grove,* Glenview and Shermerville. Morton Grove is the only one of these three communities now producing an objectionable quantity of sewage, and it is highly desirable to have the proper disposal of this sewage authorized at an early date. Nothing can be done at Shermerville and Glenview until sewerage systems are installed, but coincident with the installation of the sewerage systems, there should also be installed sewage treatment works.

With all municipal sewage properly cared for, the authorities of the Sanitary District should demand a proper disposal of all sewage from institutions, clubs, private residences and industrial plants.

For the highest development of the Northwest Branch and its tributaries, assuming that these streams and their valleys are to form an ornamental feature of a desirable residential district and possibly public parks, it will be necessary to do more than merely dispose of the sewage. At the present time, the streams are subject to excessive floods which may do considerable damage to residential property and destroy the channels of the streams, and at other times they are subject to very small flows or no flow at all, which results in the formation of stagnant pools and unsightly conditions regardless of how completely the sewage and other wastes are purified. To overcome such objectionable conditions, it is highly advisable to improve the channels and to provide for the storage of flood waters.

Work of this character is very costly, and is quite aside from the problem of securing a sanitary disposal of sewage and other wastes,

*Since this report was written Morton Grove, Glenview and Shermerville have been taken into the Sanitary District and designs are now under way for partial treatment of the sewage from Morton Grove in an Emscher tank.

though it must be recognized that the improvement of the channel and the equalization of the flow of a stream minimizes the difficulty and also the cost of properly disposing of sewage.

River control, however, does not fall within the province of the Sanitary District, except incidentally, and when it results in a net economy. The Northwestern Sanitary Association should bend its efforts toward obtaining these improvements by other means.

APPENDIX.

A SANITARY SURVEY OF THE NORTH BRANCH OF THE CHICAGO RIVER.*

As a part of a study of the pollution of the North Branch of the Chicago river, the undersigned was detailed to inspect the territory in question during the first week of December, 1912, and to submit a descriptive report thereon. The following contains the data collected.

There are several points at which sewage is discharged into the North Branch of the Chicago river and its tributaries by villages and private institutions, and for various reasons, it is held by the Northwest Sanitary Drainage Association that this constitutes a state of affairs that should not exist. Taxes have been collected for uses of the Chicago Sanitary District for a number of years, but the majority of residents of this territory are unable to believe that they have derived just benefit in return. It is held by them that the Sanitary District ought to provide a more satisfactory outlet for the sewage of their district, not that the North Branch of the Chicago river is now overburdened by sewage, but because (so they claim) the future growth and development of the district, and consequent increased volume of sewage *will* result in a series of nuisances, *will* produce a menace to public health, and *will* cause real estate values to fall short of what they would normally be. There is some question as to the authority of the Sanitary District to provide means for improving drainage facilities of inland communities, and the trustees hold that the main purpose for which the district was constituted is fulfilled when sewage is kept out of the lake.

In order now to test the situation, a bill of complaint has been brought in the name of George Weldon, et al. vs. The Village of Morton Grove, and prosecuted by Attorney P. R. Barnes, who represents the Northwest Sanitary Drainage Association. A new sewerage system was recently completed by Morton Grove which discharges into the stream in question, but which collects practically only storm water at present. An endeavor will be made in this suit to restrain the village from discharging more sewage into the stream without treatment. George Weldon and R. J. Bickerdike, two land owners on the stream below, are the complainants.

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*A report by Ralph Hilscher, Assistant Engineer State Water Survey.

A map accompanying this report, shows the location of the territory under consideration, and on it are shown the locations of the various sources of pollution.

DESCRIPTION OF RIVER AND WATERSHED.

The North Branch of the Chicago river has a watershed area above the northern corporation limits of Chicago of about 90 square miles. About 50 square miles. of this lying within Cook county, is included in the Chicago Sanitary District. The greater part of this land is very flat. Elevations range over the entire watershed from about 30 to about 150 feet above lake level. Along the eastern border the land rises rather rapidly to a bluff along the lake shore, but, in the main, the Chicago river valley is flat country and, in places, low and swampy. The Skokie marsh is swamp land lying just to the west of Winnetka, Glencoe and Highland Park, and through it drains the most easterly of the three branches which unites to form this North Branch of the Chicago river.

The flow in this river fluctuates between wide limits. As the land is flat and the soil quite porous the runoff would normally be Comparatively slow, but this territory is unusually well drained with tile and ditches, and this has the effect of removing storm water rapidly, causing very large flows in the river during short periods, followed by comparatively long periods of low water. At minimum stage there is no flow at all, which results in the stream bed being occupied by a series of stagnant ponds. In the territory under consideration, the banks are riot very high, but the fall in the stream bed is fairly rapid and the water, as a rule, is held within the banks at flood periods. A profile along the county line on the north is shown on the map. From this it is seen that the elevation of the Skokie branch at that point is 50 feet, and those of the other two branches are both 65 feet above lake level. At the point where the river crosses the northern corporation line of Chicago, the elevation of the stream bed is 9. Just above Morton Grove near where the three branches unite, the bed is at about elevation 30. These elevations indicate falls in the various portions of the stream about as follows:

	Distance, miles	Total fall	Fall, feet per mile
Skokie branch	9	20	2.2
Middle branch	9	35	3.9
West branch	9	35	3.9
North branch (below Morton Grove)	6	26	4.3

Along the branches, north of Morton Grove, the banks of the stream are quite low, rising, as a rule, not more than three or four feet above the stream bed. Below, where the branches join, the fall in the river is more rapid and the immediate banks are generally six feet or more high. Also along this lower portion of the river bluffs, rising to a height of fifteen to twenty feet, are frequently seen at a distance of a hundred feet, more or less, from the stream. These banks and bluffs are, as a rule, wooded and in many places quite picturesque.

The land in this locality is used almost exclusively for farming purposes. Truck gardening to supply the produce market of Chicago is extensively carried on. The most desirable land for this purpose in the vicinity of Chicago, in fact, probably lies along the north branch.

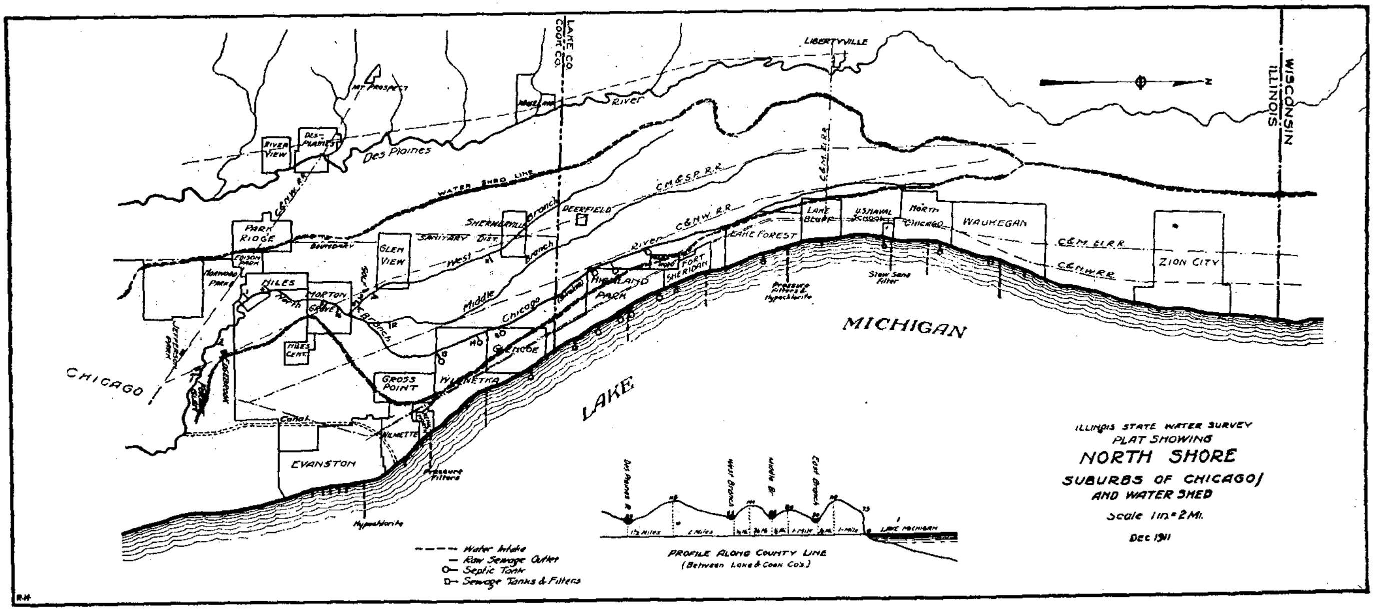
In earlier days, when what is now Cook county and vicinity, was inhabited almost entirely by Indians, the federal government, in making a treaty with these people to acquire possession of this land, adopted the method of making grants to certain influential whites who were living among the Indians, for services rendered by these whites in inducing the Indians to give up their lands. These few persons were privileged to select their grants wherever they chose from all that large territory acquired, and they selected about 3,000 acres lying on both sides of the Chciago river just below what is now the village of Morton Grove. These men were probably interested primarily in the fertility of the soil, and chose as they did because of this land's productiveness, but probably also because of its altitude, good drainage facilities and general attractiveness.

The watershed of the Chicago river, north of the city limits, is one of the most sparsely populated portions of the area included within the Sanitary District. Following is a table giving the populations in this territory of about forty square miles' area.

Years:	1910	1900	1890
Rural	2,842	3,773	3,415
Incorporated villages	5,580	3,217	330
Total	8,422	6,990	3,745
Percent increase	20.5	86.7	....

There is at present an average of about one person for every three acres of this territory which includes six entire villages, and parts of two others. The average density of population in these villages alone, is about one person for each 1.6 acres. It is seen, therefore, that these incorporated portions of the territory are also thinly populated. Glencoe and Winnetka have between one and two persons per acre, and are very well improved villages, typical of the north shore. Edison Park is small, but seems to have developed into a village of suburban residences. The other villages on the watershed are primarily farming centers. They are fairly large in area, but these areas mainly are divided up into truck gardens.

Pollution of the River: On the accompanying map are indicated the locations of the various sewer outlets, public and private, which discharge into the Chicago river above Forest Glen station. These sources of pollution are numbered on the map and will be referred to accordingly. At the time of the inspection a large quantity of water



North Shore Suburbs of Chicago and Watershed.

was flowing in the river and the current was swift in places, so that conditions were by no means offensive at any point in the main stream. The character of the stream under more favorable conditions cannot be definitely described on the basis of observations thus far made.

One of the complainants in the suit against Morton Grove owns land about ¼ mile below sewer outlet No. 1. This is the outlet to sewers serving that small community known as Forest Glen within Chicago city limits. Not more than five or six hundred people are living here. This sewer discharges from the side of the bluff, just below a public street, and from there the sewage flows beneath a public sidewalk, thence through a ditch, a few hundred feet long to the river. There are several houses quite near this sewer outlet, and at least a local nuisance is produced. The odor is quite noticeable to one in the vicinity and the outlet is conspicuous and unsightly. A rather large quantity of storm water was carried by the ditch at the time observed, so this nuisance is undoubtedly much worse in dry times.

Outlet No. 2 serves that subdivision of Chicago known as Edgebrook. This is about a 30-inch outlet and discharges from the abutment of a highway bridge. It is a combined sewer and carries practically only storm water at the present time. This is a new subdivision and houses are very few and very scattered. The land here, however, is high and wooded and attractive, and it seems likely that it will develop further in the near future.

Sewage from the Norwood Park system is discharged into a ditch near the Chicago & Northwestern tracks, about half a mile southeast of the station, and then it flows in an open ditch across country to the river at outlet numbered "3." Here also a very serious local nuisance is produced. Sewage from probably 1,500 people is carried by this ditch which has a very slight grade. The ditch is extremely foul and unsightly and, of course, gives off characteristic odors. In reaching the river the ditch crosses several public highways. It was excavated primarily to remove this sewage and but very little dilution is afforded until the river is reached.

Edison Park, now a part of Chicago, has a population of about 600, and is served throughout with combined sewers which have an outlet in the center of the village of Niles to a very small creek which is tributary to Chicago river at point No. 4. A Catholic Polish home in Niles, recently completed, will also be served by this sewer. A very serious nuisance is said to result in Niles from this method of disposal and it is easy to believe such a statement, although no very objectionable condition prevailed at the time of the visit. The sewer discharges into the creek not farther than 100 feet from one house. Other houses are nearby. The sewage flows past this nearest house within only a few feet and then beneath the main street of the village, along which are various business establishments and dwellings.

The village of Morton Grove has for some years had a single drain along the main street which discharges through a 16-inch outlet into a small arm or bayou at point No. 5. This sewer was built primarily for removal of surface water, but there are also connected about seven houses, and Poehlmann Brothers' green houses, where twenty-five or more men are employed. There is also discharged through an iron pipe at point No. 5 the waste from the William Henning pickle factory. In this factory cucumbers are soaked in brine in large vats for several weeks and then are placed with the same brine in barrels and shipped to Chicago, where the process is finished. A comparatively small amount of brine remains in the bottom of each vat and this is washed to the river. The bayou into which this sewage and brine are discharged is said to be more or less of a nuisance at certain times when long dry periods have prevailed. This point of discharge is decidedly unsuited to receiving putrescible organic matter, owing to the fact that very slight dilution is provided. There is little or no current in this bayou to carry the sewage away from the outlet.

Outlet No. 6, shown on the map, is supposed to discharge only storm water at present from the west part of the built-up portion of Morton Grove. As a matter of fact, more or less putrescible waste enters, as evidenced by the appearance of the effluent. This system was but recently completed, and it is said there are known to be but two persons now contemplating connections with it. However, a public water supply is soon to be put into service and this will very likely result in rather numerous sewer connections within a few years. The village now has a population of nearly 1,000 and it has shown a substantial growth of about 45 per cent during the past ten years.

Outlets Number 7, 8, 9 and 10 are from buildings on the links of the Glenview Golf Club. There is one large clubhouse here and about half a dozen private homes occupied only in summer time. Probably sewage from an average of about one hundred people enters the stream at these points.

Outlet No. 11 is from St. Joseph's Home, a Catholic institution, having a population of about 800 people, built southeast of Shermerville. The village itself is very small and discharges only surface drainage into the river.

Outlet No. 12 is from a single farmhouse built on the river bank.

The village of Winnetka has two septic tanks and Glencoe has one, discharging to the Skokie branch at points 13, 14 and 15, respectively. A combined population of probably about 1,500 drains its sewage to these three tanks.

Beyond the boundary of Cook county there is also sewage discharged through septic tanks into this stream at Highland Park and at Highwood. In addition to these there are a few private outlets from estates near Lake Forest.

These septic tanks from the North Shore towns are all on very low ground and their effluents travel considerable distances in open ditches before reaching the Skokie, which in that locality is very sluggish. These ditches are in low, swampy land which is subject to overflow at certain times of year and are notoriously foul. To relieve the situation there the Sanitary District is preparing to construct an intercepting sewer which will follow southward from the Glencoe tank to the south boundary of Winnetka, thence eastward to the lake and south along the lake shore to the Wilmette canal.

EFFECT OF POLLUTION.

As already stated, no obnoxious effects upon the river itself by sewage could be observed at the time of investigation owing to there being a large runoff at that time. When the flow in the river becomes practically zero it is easy to believe the contention that objectionable conditions prevail just below some of the sewer outlets. The few local nuisances noted during the investigation, such as at Niles, Norwood Park and Forest Glen, would undoubtedly be much intensified in dryer and warmer weather.

When the stage of the stream is at its lowest, there are places where the river bed is exposed across its whole width, thus dividing the water off into a series of stagnant pools. It is common testimony among residents along the stream that some of these pools become foul smelling and unsightly. In a few instances pools have been artificially formed by constructing low dams two or three feet high, across the stream at places where the river bed would normally be exposed. At some places, such as at bridges where brush wood accumulates or where a tree falls across the stream, it is said dams become accidentally formed. The effect of these dams theoretically tends to be beneficial, no doubt, in that they increase to some extent the quantity of water in the stream at lowest stages above what it would normally be and thereby increase the amount of available dilution for sewage. The benefit thus derived would, however, be very small and would be practically nil in case any large amount of sewage were to be handled.

The property of George C. Klehm, a complainant, in a former bill of complaint, comprises some 90 acres within Morton Grove along the river immediately below sewer outlet No. 5. George Weldon and R. J. Bickerdike, the two complainants in the present bill, occupy farms on the river just south of the Morton Grove village limits. Part of Klehm's property is used as a park and near the lower end of it is built a low stone dam. About ¾ mile farther downstream is another dam. These dams maintain some depth of water at all times in the river adjacent to these claimants' property. They contend that the river becomes foul smelling at times. At one time the water was allowed to drain out of the upper pool with the hope of relieving the situation, but, instead, conditions were made worse by exposing an unsightly stream bed and by decomposition of organic matter which had accumulated on the bottom.

As to the effect of present or future stream pollution upon neighboring property values, little can be definitely said. For farming purposes only, the land in this vicinity is said to yield a fair return on an investment of from $200 to $300 per acre. Anything above these figures paid for land outside the villages is, in a large measure, speculative and these speculative values have reached as high as $1,500 per acre. Any effort to show by figures that objectionable conditions along the Chicago river have deleteriously affected the property values would be quite futile, owing to this speculative trend which fixes values quite independently, as a rule, of present shortcomings, banking upon future developments. In fact, all figures show that there has been a sharp advance in selling prices during the past few years. However, it is obvious that any condition which causes inconvenience or discomfort will cause the particular community to be less desirable as a place to live in. This must necessarily affect the salability of neighboring property in the end.

SUMMARY.

The territory in the vicinity of the North branch of the Chicago river above the Chicago city limits is primarily a farming community at the present time, and is one of the most sparsely populated portions of the Chicago Sanitary District.

Sewage is discharged into this stream, generally in small quantities, at numerous points shown on the accompanying map. Outlets 1, 2, 3, 4, 5, 13, 14, and 15 are known to produce serious local nuisances. Numbers 1, 2, 3 and 4 discharge sewage from within Chicago. Numbers 13, 14 and 15 will probably be diverted in the near future through an intercepting sewer to the Wilmette canal. The stream forms itself into a series of pools in summer time, some of which are said to be offensive.

This stream has natural beauty and attractiveness, but is not now extensively used for recreative purposes. Although neighboring land is not now extensively sought for residential purposes, it seems very probable that developments will render it very desirable in a short time. If this stream be kept in a more or less pure state it can be made attractive for recreation purposes. The river is not large enough to handle satisfactorily any large amount of raw sewage. If it is allowed to become overburdened with pollution an undesirable class will be attracted and real estate values will suffer.

INVESTIGATIONS ON THE DISPOSAL OF CANNING FACTORY WASTES AT WASHINGTON, ILLINOIS*

With the growth of the canning industry and with more stringent legislation regarding stream pollution, the problem of disposal of cannery waste has become serious and demands study. Most of the wastes of the canning process are liquid, containing a large quantity of organic matter in solution or in very fine suspension. The simplest method of disposal would be by dilution in a large volume of water. However, since the factory must be located in the region where the product is grown, it is usually at some distance from any large stream and satisfactory disposal by this method is often impossible. It has been customary at most canning factories to turn the waste into the nearest stream, be it large or small. In the majority of cases, the stream being small, dilution to furnish sufficient dissolved oxygen for oxidation of the organic matter is not available. As a result decomposition of the waste takes place for miles along the course of the stream, polluting the water and creating disagreeable odors. The complaints against the nuisance which naturally arise from the landowners and residents in the vicinity of the water course demand consideration.

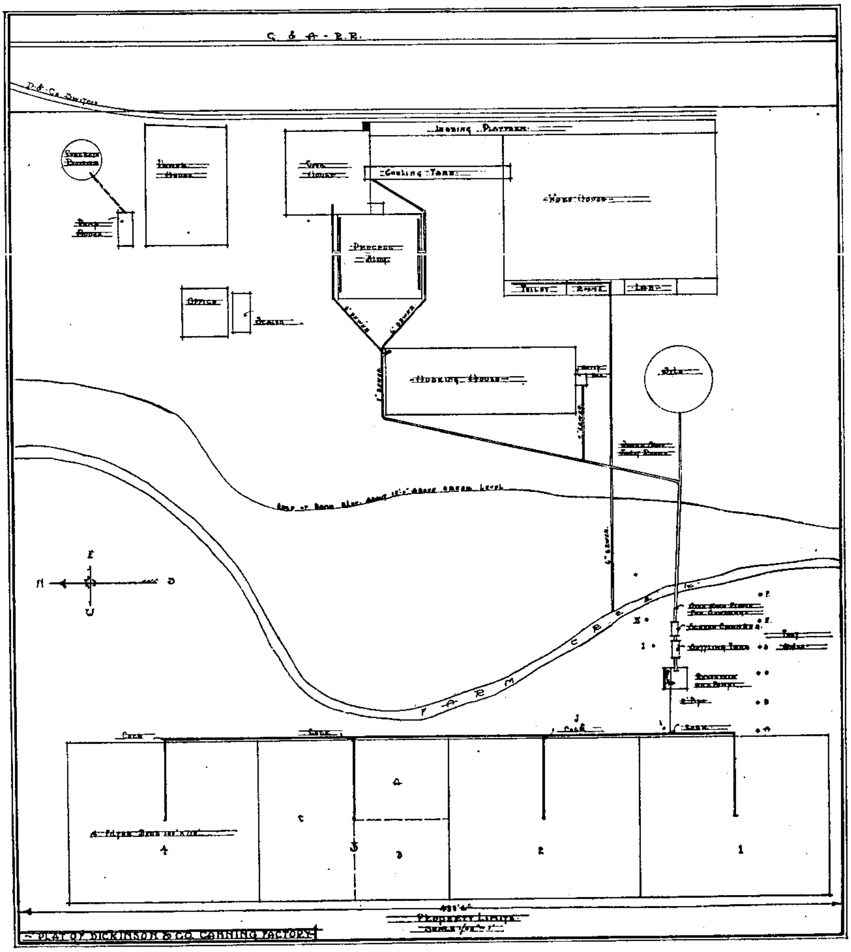
At Eureka, Illinois, much dissatisfaction had been occasioned because of the discharge of the waste from the Dickinson & Company canning plant at that place into a small creek nearby. A conscientious effort was made by the company to find a satisfactory, practical method of disposal. Coagulation experiments with varying amounts of lime and alum were made and certain settling and filtering methods tried. No data regarding the treatment was recorded, but their efforts along this line were apparently unsuccessful. Finally Professor Bartow, Director of the Illinois State Water Survey, was requested to assist with the problem. He paid a visit to the factory, made observations and collected samples of the waste which were analyzed. Following his visit, a tile was laid, through which the waste from the factory could be discharged into a larger creek, about a mile distant. After it was put in use the complaints concerning the waste became less serious, so the problem did not need further attention.

*Abstract of thesis prepared by Duane Englis under the direction of Prof. Edward Bartow and Paul Hansen, in partial fulfillment of the requirements for the degree of Master of Science in Chemistry.

The dissatisfaction at Eureka was, nevertheless, a forerunner of trouble elsewhere. Towards the close of the first operating season of another factory operated by Dickinson & Company and located at Washington, Illinois, the same problem assumed a difficult aspect. Immediate injunction suits were threatened by irate riparian owners, whose property was adjacent to the polluted creek.

STREAM POLLUTION BY WASTES FROM CANNERY AT WASHINGTON.

The accompanying plat (see Diagram I) of the Dickinson & Company plant at Washington shows the location of the various

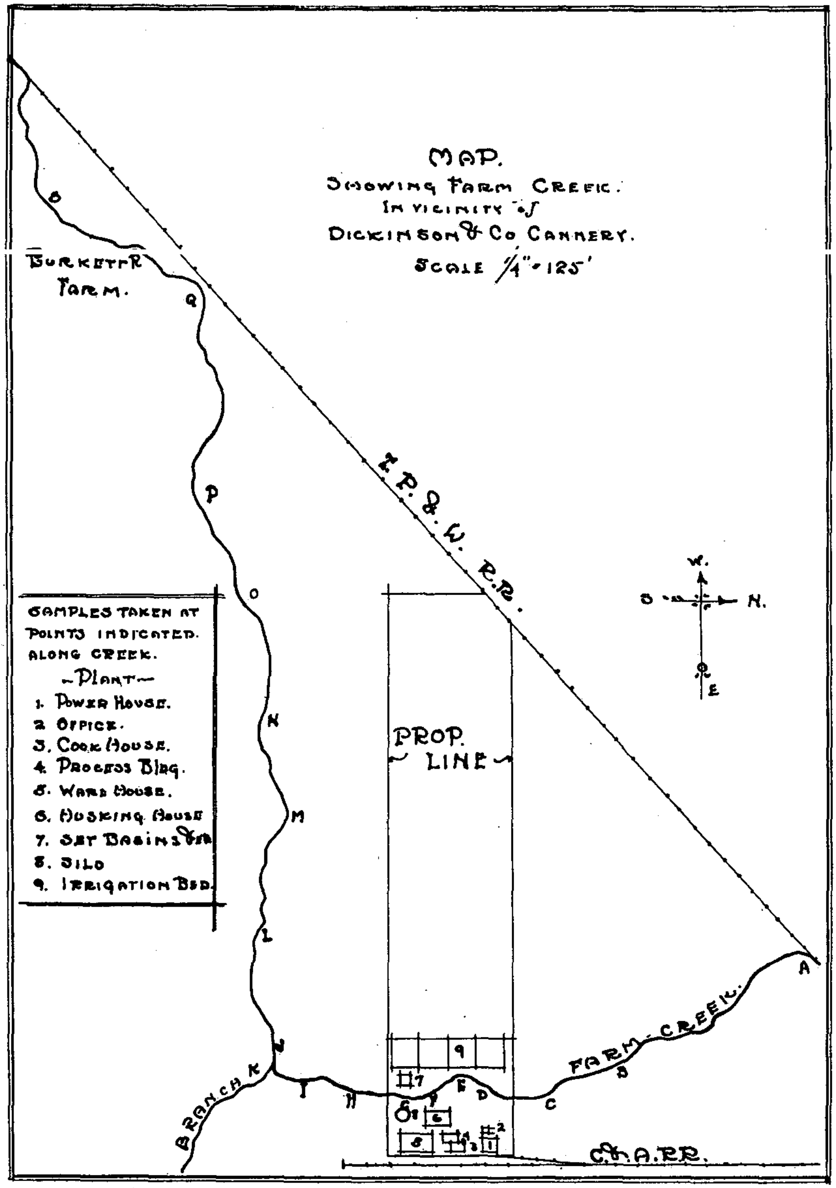


Diag. I.—Plat of Dickinson & Company Canning Factory.

factory buildings with reference to the creek into which the wastes were discharged. Just above the factory (see Diagram II) a large city sewer empties into the stream and, in the mingling of this sewage with the canning waste, offensive putrefaction is rapidly promoted. The creek itself is very small, and were it not fed by the city sewer and canning waste, would undoubtedly go dry during the summer. For some distance below the plant the creek pursues a winding course through a somewhat wooded territory. This land is given over to pasturage. The owner, who conducts a stock farm, had been accustomed previous to the erection of the factory to use the creek for stock watering purposes. The pollution by the waste prevented this, whereupon the owner of this farm became one of the chief complainants. Just below the stock farm, as one proceeds down the stream, is the Burkett dairy farm. The barns and outbuildings are very near the creek and add somewhat to the pollution. About a quarter of a mile further downstream the T. P. & W. R. R. pumping station is located. A dam is here built in order that the water may be held back and used for locomotive boiler purposes. Some complaint also came form the railroad company, because the excessive foaming which the polluted water caused in a boiler made it necessary for the company to abandon this source of supply during the canning season. Beyond the dam the course of the stream again lies through pasture land for some distance. At times offensive conditions persisted for a few miles beyond the dam and gave rise to more or less complaint from land owners along this portion of the stream also.

WASTES PRODUCED DURING PEA PACK.

The wastes from the factory during the pea pack originate from several sources. Near the husking shed (see Diagram I) machines known as viners are erected. The peas are cut in the field with a mower, loaded on racks like hay and hauled to these viners, which shell out the peas by a sort of threshing process. During this threshing the vines are considerably bruised and beaten. They are conveyed from the viners to a large conveyor, which runs through the center of the shed for its entire length and carries the vines up into a large silo. In the so-called husking shed the shelled peas are first panned, then washed in a horizontal, rotary wire cylinder under a constant spray of water. The wash water from the peas is permitted to flow over the vines in the conveyor so as to give them a rough rinsing before their passage to the silo. As the vines have been macerated and bruised, a large quantity of organic matter is extracted from them. Most of the water escapes through an outlet at the end of the conveyor, but quite a large quantity is held by the vines and carried on the silo. In the silo it percolates slowly through the mat of vines and thus acquires a still higher organic content before emerging from the silo drain. In the process build-



Diag. II.—Map Showing Farm Creek in Vicinity of Dickinson & Company Cannery.

ing (see Diagram I) where the product is canned, a further quantity of waste is produced by the washing of the floors and machinery. After canning and cooking, the cans are cooled by being conveyed through a long tank of water. Fresh cold water is continuously introduced at the bottom of the tank and the hot water is allowed to escape at the top. However, this overflow can scarcely be considered a waste of objectionable nature.

WASTES PRODUCED DURING CORN PACK.

The origin of the waste from the canning of corn is quite analogous to that from the canning of peas. The corn is snapped in the field and hauled to the husking shed, where it is machine husked. One of the essential parts of a husking machine is a series of rubber rolls which tear the shucks from the ear of the corn. In order to keep these rolls cool it is necessary to maintain a constant spray of water upon them during operation. Most of this water is entrained by the husks, or drains, from the floor into a conveyer for removing the husks. Since there are a number of husking machines in operation, the quantity of water used in connection with the shucking of the corn is quite large. In the process building the corn is cut from the cob. The cobs are conveyed over to the husking shed and discharged into the same conveyor used to carry the shucks, and the conveyor in turn discharges into the silo. As was the case in the maceration of the pea vines, the water extracts a high organic content from contact with the cobs and shucks. Additional wastes from the silo, process building and cooling tank are similar in origin to those produced during the pea pack.

RESUME OF PEA AND CORN PACK.

There is then produced in the canning of both corn and peas a large quantity of liquid waste of high organic content. Of the approximately 60,000 gallons of water which is consumed daily by the factory during operating seasons, by far the greater portion finds its way into the general waste of the plant. The conditions brought about by the discharge of this waste into the creek gave origin to the complaints which occasioned a study of the problem.

INVESTIGATIONS BY THE STATE WATER SURVEY PRIOR TO SEASON OF 1913.

The Dickinson Canning Company realized the seriousness of the situation and desired to better the existing conditions. They again entered into correspondence with the State Water Survey and asked their immediate assistance. As a result, in May, 1912, Mr. Ralph Hilscher, assistant engineer of the Survey, visited the canning factory and made a preliminary report which included a description of the plant, the canning process and nature and approximate quantity of the waste to be treated.* Following this report, Mr. Paul Hansen, engineer for the Survey, drew up plans and made recommendations for the construction of an experimental plant to treat a portion of the waste by various methods, such as settling, sand filtration, contact beds, percolating filters and broad irrigation.** The object in view was to determine the most economical method of treating the entire quantity of waste produced at the factory in a manner to avoid future complaint. Acting on his advice, the canning company installed the experimental plant. Visits were made by Mr. Hilscher and by Mr. Hansen, during which certain lines of experimental procedure were carried on or outlined.† Because of other duties in the factory, those in charge rather neglected the experimental plant. It became necessary, therefore, to have a trained man on the ground to superintend the operations at all times and Mr. A. C. Lucas was placed in charge. Only a few days of the canning season were then remaining and hence the time was too short for obtaining conclusive data.‡ However, such data as were obtained during the season furnished the basis for the following recommendation of Mr. Paul Hansen.¶

"The results obtained at the experimental plant for treating the wastes from the Dickinson & Company's plant at Washington, Illinois, during the last operating season were not conclusive. This was due to several factors.

First: The experimental equipment was scarcely completed and in operating order before the operating season at the cannery, which lasts a matter of only six weeks, was more than one-half over.

Second: The work of experimentation suffered from lack of having some technically trained person on the ground at all times.

Third: The operating season was cut unexpectedly short, due to an excessively hot spell which caused a premature ripening of the corn.

"Notwithstanding the above, some information was obtained which in all probability will permit of taking care of the wastes from the cannery during the coming operating season with little if any offense. It is not known if the method about to be suggested is the most economical or the most suitable for permanent installation, but at any rate its cost will not be excessive and in all probability the

*Illinois State Water Survey. Preliminary Report on Canning Factory of Dickinson & Co., Washington, Ill., by Ralph Hilscher.

**Illinois State Water Survey. First Progress Report on Operation of Experimental plant at Washington, Ill., by Paul Hansen.

†Second and Third Progress Reports on Operation of Experimental Plant at Washington, Ill., by Ralph Hilscher and Paul Hansen.

‡State Water Survey, Fourth Progress Report on Operation of Experimental Plant at Washington, Ill., by A. C. Lucas.

¶State Water Survey, Fifth Progress Report on Operation of Experimental Plant at Washington, Ill., by Paul Hansen.

expenditure necessary may be in part utilized in connection with a more permanent installation.

"One striking feature of the experiments as conducted, was the very large quantity of liquid wastes that were absorbed by the fine black soil, common in the neighborhood, when in a dry condition. Fortunately, the corn pack occurs at a season of the year when the soil is usually very dry. It is true that there may be a few thunder showers, but, as a rule, these supply only a small proportion of the water that the soil is capable of absorbing. It would seem, therefore, that this quality of the soil might be utilized for taking care of the liquid wastes during the coming season. There is danger, of course, that unusual rains may prevent the proper working out of the scheme, but, on the other hand, unusual rains will sufficiently swell the volume of the stream which now receives the wastes to prevent any serious nuisance if all of the wastes are discharged into it.

"Accordingly, it is recommended that the Cannery Company construct four broad irrigation beds of one-fourth acre each, by grading and embankments in some such manner as shown on the accompanying drawing. The beds on the drawing are shown as being square in plan. This shape, however, is not essential and in all probabilitiy it will be found advantageous to conform to the natural topography in laying out the beds. This may result in the use of oblong beds or beds of irregular shape.

"For the present it is not believed advisable to underdrain the beds for the reason that the experiments, as far as conducted, indicated that practically all of the water absorbed is held by capillary attraction. It was found that very little of the liquid applied to the beds appeared in the underdrains, and such as did appear gave evidence of having passed rapidly through contraction cracks in the soil. If, at a later date, underdrains are found advantageous, they can be put in at any time.

"With the present arrangement of sewers at the canning factory it will be necessary to pump the wastes through a low lift in order to reach a suitable site for placing the irrigation beds. The plans, therefore, show a wrought iron force main laid from the pumps to a distributing chamber of very simple design, whereby the wastes may be diverted onto any of the beds. It is anticipated that under ordinary conditions of operation the wastes for an entire day will be discharged upon the surface of one bed, and that each bed will be used once every four days. Rainfall conditions may, however, necessitate occasional deviations from this schedule.

"In order to keep the surface of the irrigation beds as clean as possible, thereby facilitating their operation, some preliminary treatment of the wastes is necessary. The experiments indicated that preliminary screening is advantageous for removing large quantities of corn cobs, husks and corn silks, and, therefore, a screening chamber has been incorporated on the drawing consisting of a series of graded screens which seems to be the most effective arrangement under the particular conditions in hand.

"As a further preliminary treatment, a so-called sedimentation tank is included, and this has a retention period of approximately one-half hour, based on the daily flow of the wastes. As a matter of fact, it does not appear that many solids will settle, but a very large quantity of the solids will float to the surface, and it is important that these be removed before reaching the irrigation beds. To this end there are placed within the tank a series of hanging baffles arranged to facilitate the removal of the floating matter at frequent intervals during the day's run. The tank is also provided with a hopper bottom which will facilitate removing such sludge as does accumulate at frequent intervals without stopping the flow of wastes through the tank.

"Some provision must be made for the disposition of the solid matter that is removed from the screen chamber and sedimentation tank, and this can best be taken care of by simply burying in trenches. A convenient arrangement of these trenches is as follows: Excavate one large trench perhaps 3 feet wide, 1 foot deep, and 50 feet long. Parallel with this and at a distance of not more than 18 inches start a second trench, and as the first trench is filled with the wastes throw earth obtained from excavating the second trench over them. This process can be contined indefinitely by merely adding new trenches. Considerable labor, of course, is involved, but at the present time this is the only practicable method of getting rid of these solids that suggests itself.

"Following the sedimentation tank there must be a pump well or reservoir. For permanent construction and considering the rather stable character of the wastes, this pump well should be capable of holding a one-half day's or, better, a whole day's supply, so that all of the wastes may be pumped by a centrifugal pump on to the irrigation beds at once. Inasmuch as the present installation may not be permanent, it is believed advisable to keep the initial cost down as much as possible by making the pump well small—that is to say, of a capacity somewhat larger than that of the sedimentation basin. If experience should indicate the necessity of having a larger basin, it is believed that this can be provided in an acceptable manner by an excavation in the natural earth.

"All tank construction is of wood for the purpose of reducing the cost, but if desired concrete or steel may be used.

"In order to learn more concerning the inoffensive disposal of wastes from canneries, it is recommended that the experiments be continued during the coming operating season and such experiments should include, of course, observation of the broad irrigation beds."

In addition to the above recommendations of Mr. Hansen, Dr.

Bartow made the further suggestion that chemical studies on the ground be included. This study called for frequent analyses of the various wastes, waste effluents and waters of the stream receiving the wastes.

On the recommendation of the Survey, Mr. Duane Englis was placed in charge of the investigation and, acting under the supervision of Dr. Bartow and Mr. Hansen, carried on the experimental work during the season of 1913. The object of the investigation herein described is to throw further light on the undetermined factors of previous work.

INVESTIGATIONS DURING THE PEA CANNING SEASON OF 1913.

The normal duration of the pea pack for the Washington factory is usually about three weeks, starting some time in the early

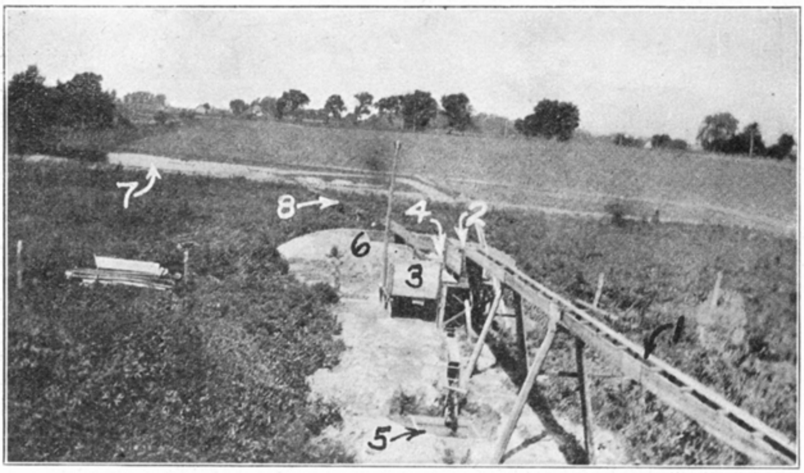


Fig. I. A General View of Plant During Pea Pack, Showing Position of the Several Devices.

part of the month of June. The pack of 1913 began Saturday, June 14th. The factory work of this day was of a nature to try out the machinery and to note the condition of the crop regarding maturity. On the following Monday the real pack may be said to have started and future references will be made to this date. A prolonged period of hot weather caused a very rapid maturing of the peas, which occasioned more than a usual number of hours of operation per day and brought the pack to a close on June 30th, after but two weeks of operation. As regards number of cans per acre, the pack was quite up to normal.

Description of Experimental Devices: The plant for the disposal of the waste was constructed with but few deviations from the plans submitted by Mr. Hansen in the Fifth Progress Report.

The main sewer of the factory was joined to a trough which carried the waste over the creek and discharged same into the screen chamber. Immediately beyond the screen chamber and receiving the waste from it was the settling basin. Both were of wood construction and the dimensions were as designated in the plans. The material used in their manufacture was somewhat heavier than specified, being 2½ instead of 2 inches in thickness, and the workmanship of the construction was substantial. No baffles had been placed in

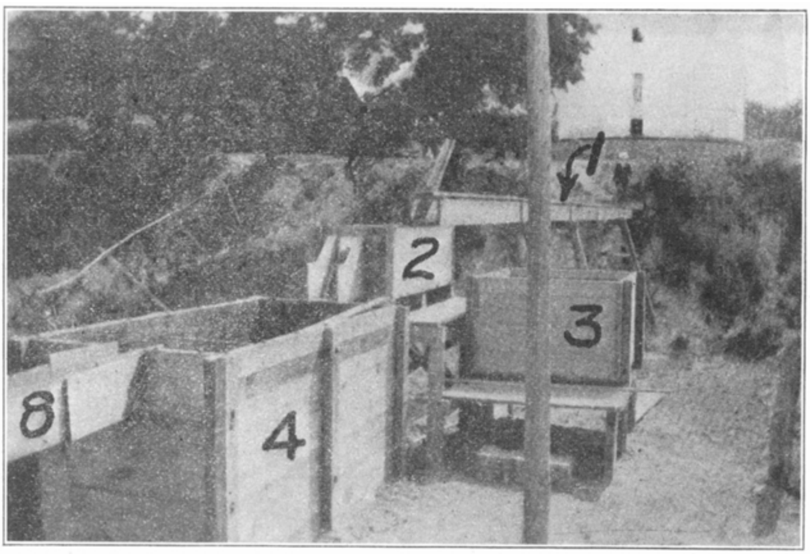


Fig. II. Near View of the Screen Chamber and Sedimentation Tank.

the settling basin, nor screens in the screening chamber, as they were not deemed necessary during the pea pack. Just south of the screening chamber and in a position convenient to receive the solids screened from it was a box about five feet square and three feet deep. Some twenty-five feet to the east was another box of dimensions about four feet square and two and one-half feet deep. This was set in the ground so as to be low enough to admit sludge from the settling basin and was connected to the sludge outlet by a wooden trough. Both of these boxes were of wood and of fairly good construction.

At a short distance beyond the settling basin was the storage reservoir built about half in excavation and half in fill with a total depth of about seven feet. The top three feet were lined with timber

13 feet by 13½ feet in plan. Below the timbers the earth excavation sloped in to an area of about three feet square at the bottom.

A removable trough led from the settling basin over the reservoir to the southern and lowest irrigation bed and discharged near its center. There was sufficient fall to allow a gravity feed to this bed. The other irrigation beds were laid out in a line directly north, as can be noted in the plat. (See Diagram I.) Each bed was approximately square in shape and of area ¼ acre. Though the general level of all had been established, they were only roughly leveled. The embankments were placed as indicated and the ground given a thorough cultivation.

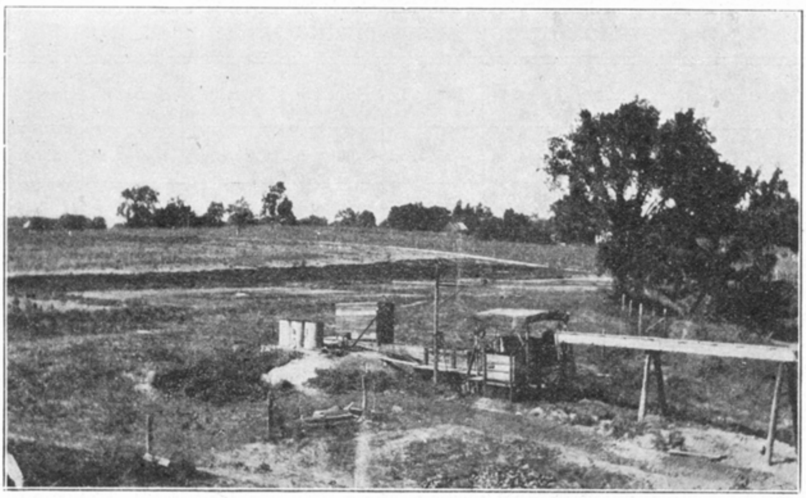


Fig. III. General View of Experimental Plant During Corn Pack.

The centrifugal pump, which was to have been set up for pumping from the reservoir to the irrigation beds, arrived but a few days before the season closed and was not installed for use during the pea pack.

The accompanying pictures will perhaps convey an idea of the appearance of the experimental devices. Fig. I gives a general view of the whole plant. The several devices are indicated by the numbers: (1) Trough from main sewer, (2) Screening chamber, (3) Box for screenings, (4) Settling basin, (5) Box for sludge for settling basin, (6) Reservoir, (7) Irrigation bed, (8) Temporary trough to irrigation bed. In Fig. II the numbers correspond to numbers in Fig. I. Fig. III is a general view of the experimental plant during corn pack.

In order to carry out the suggested chemical work, considerable apparatus was necessary. This was furnished by the State Water Survey and was quite ample for the determinations to be made.

Almost the entire first week of the pack was spent in preparing the laboratory. The coal room and boiler room of the warehouse (see Diagram I), which were given over for this purpose, were first cleaned and made ready for use.

Nature and Quantity of Wastes: The composition of the waste as shown in Table 1 indicates its character. All samples collected from the settling basin were fairly representative. Very little of the solids were separable by filtration, but appeared to be in very fine suspension. The color of the waste was a dark brownish green.

TABLE I.

COMPOSITION OF THE WASTE DURING PEA PACK OF 1913.

Date of Collection	June 24	June 25	June 26	June 27	June 28	June 30
Hour of Collection	9:00 a. m.	9:00 a. m.	9:00 a. m.	10.00 a. m.	11:30 a. m.	2:00 p. m.
Solids at 100° (Raw)	9970	18200	27790	21400	10425	9915
Loss on Ignition (Raw)	7685	15200	23185	17500	8465	8235
Ash (Raw)	2285	3000	4605	3900	1960	1680
Total Organic Nitrogen (Raw)	269	450	586	665	205	246
Solids at 100° (Filt.)	9680	15255	27010	20594	......	......
Loss on Ignition (Filt.)	7570	12755	22085	17570	......	.....
Ash (Filt.)	2110	2500	4925	3024	......	......
Total Organic Nitrogen (Filt.)	....	384	....	....	198	......
Oxygen Consumed	1000 +	2880	2960	3072	1336	1260
Chlorine	170	152	261	365	300	235
Alkalinity	Acid	Acid	Acid	–2304	–1740	–1300
Turbidity	Very decided	Decided	Decided	Decided	Decided	Decided
Color	Brownish green	Brownish green	Brownish green	Brownish green	Brownish green	Brownish green
Odor	Fermented peas	Fermented peas	Fermented peas	Fermented peas	Fermented peas	Fermented peas

Note—Determinations in parts per million.

As the effluent from the silo increased in quantity and became a more important constituent of the total waste, the dark color, as well as an odor of souring peas, was much more pronounced. Contrary to the corn waste of the previous season, the pea waste putresced very readily, the decolorization with methylene blue being almost instantaneous.

At the beginning of the pack it was planned that the data regarding the quantity of waste should be obtained by estimating the capacity of the pump and timing it as it pumped from the reservoir. Since the pump was not installed, it was necessary to resort to some other method of estimation.

On June 28th the settling basin was drained and used as a measuring box. As a result of several fillings a flow of about 2,635 gallons per hour was obtained. Table II gives the number of capper hours (hours during which caps are placed on cans) the factory was in operation each day during the pack, with the respective quantity of waste which would be produced at the above rate during this time.

At best, the approximation of the quantity of waste is very rough, but is approximately checked by the records of water supply pumped.

The storage reservoir gave some trouble, due to leakage from its earth bottom, and introduced some complications in examining water from test holes to secure effluents from the broad irrigation beds, as will be noted later.

TABLE II.

QUANTITY OF WASTE DISCHARGED ON SOUTH IRRIGATION BED DURING PEA PACK OF 1913.

Date—June	14	16	17	18	19	20	21
Capper hours	5	8	9	9	11	14	14¾
*Addition	1	2	2	2	3	3	3
Total hours	6	10	11	11	14	17	17¾
Gallons waste	15,810	26,350	28,985	28,985	36,890	44,795	46,770

Date—June	23	24	25	26	27	28	30
Capper hours	15½	12¼	14½	15	15	10¾	10
*Addition	3	3	3	3	3	2	2
Total hours	18½	15¼	17½	18	18	12¾	12
Subtraction for waste to reservoir	......	......	......	......	14½	7	......
Hours to bed	18½	15¼	17½	18	3½	5¾	12
Gallons waste	48,747	40,187	46,112	47,430	9,222	15,149	31,620

* Extra hours and allowances made for washing factory floors and machinery.

Screening Chamber: A few vines and peas constituted the floating solids. The vines collected at the outlet of the screening chamber, which, it will be remembered, contained no screens, and formed a very effective screen to other floating particles. At the close of the pack the surface of the waste, which was maintained at the level of the top of the weir, was covered with a two-inch layer of vines. The screening box itself was found to be almost full of peas.

Settling Basin: From the settling basin some 40 cubic feet of sludge, consisting for the most part of hard peas embedded in a thick green slime, were drained to the sludge box. Probably many of the peas found here would have settled out in the screening chamber, had it been capable of holding more. It is estimated that the complete screenings and settlings for the two weeks would approximate about 65 cubic feet of solids, a comparatively small amount.

Irrigation Beds: Only the southern irrigation bed was used during the pea pack, for the reason that it alone allowed the gravity feed, which was necessary in the absence of the pump. The bed was somewhat low at the southern end and was not crowned to any extent. An attempt had been made to level it, but the surface proved too soft for horses. Therefore the ground was left in a poor condition in this respect. It had been well plowed and harrowed, however, and appeared capable of absorbing water rapidly.

For the first few days the waste did not remain on the surface of the ground to any extent. About the fourth day there was a slight ponding in the lower portion, over approximately one-fifth the total area of the bed. The ponding increased from day to day. Until the afternoon of the sixth day no rain had fallen, so the weather conditions were most favorable to the success of irrigation. At this time a moderate precipitation occurred and cloudiness, with frequent heavy rains, continued through the four days following. The resulting additional quantity of water on the bed appreciably lessened its capacity for the waste. On the ninth day about three-fourths of the area was covered. The amount increased until the twelfth day, at which time the waste stood 8 or 10 inches deep on the southern half and only a few high places in the northern portion were not submerged. Although this was the greatest quantity of the waste which was present on the bed at any time, the rate of absorption by the bed was such that after a day and a half of disuse only a small puddle at the southern end remained. After the fourteenth day following the beginning of the pea pack, the effluent from the silo constituted the entire waste. On the seventeenth day the silo wastes were diverted from the irrigation beds. By the nineteenth day, or two days after the discharge onto the beds ceased, the ground used for irrigation had become quite dry. At the point of discharge there was a slight crust of vines and leaves. The soil did not appear to have become sticky, but still seemed to retain its natural character. Furthermore, no disagreeable odor was perceptible from the bed at this time.

While the waste was standing on the bed a rapid evolution of gas bubbles indicated that a decomposition was taking place. Until the eighth day the odors arising had not been very objectionable, and even at this time were not serious. After the ninth day the weather became very warm and the temperature of the waste on the bed was 39° on the eleventh day at 12 m. At 2 p. m. it was 40°, and at 5 p. m. 39°. On the morning of the twelfth day at 5 a. m. it had dropped to 26°, but the progress of decomposition shown by the gas bubbles was as rapid as ever.

In order to determine the efficiency of the irrigation project, a number of test holes were dug with a post auger to a depth of about 4 feet at various distances from the bed. In digging, about 2 feet of top soil was first penetrated. Immediately below was a thin layer of yellow clay, followed by a stratum of coarse sand and gravel. A formation of sticky blue clay which was almost impervious to moisture underlaid the gravel. Hence any drainge from the beds was forced to appear above this formation. The plat (see Diagram I) of the factory shows the approximate positions of the holes. The two nearest the bed are about four feet distant and each succeeding hole is 25 feet further outward. All penetrated into the gravel and the water rose from 6 to 12 inches in most of them.

Samples of the water were collected from each hole and their analysis is shown in Table III. Even in those holes nearest the bed there was no odor, taste, color or turbidity. A sample from hole marked "H" did not decolorize methylene blue on standing over twenty-four hours. Some time during the thirteenth day the trough carrying the waste to the bed started leaking a short distance beyond the reservoir. The waste flowed into one of the test holes, B, but did not affect the others. However, in the determinations made on the fourteenth day D and E show an abnormal rise in oxygen con-

TABLE III.
CHARACTER OF WATER IN TEST HOLES.

Date	June 27, 1913, 4:00 p. m.					June 30, 1913, 2:00 p. m.				
Place of Coll.*	Oxy. Cons.	Cl.	Odor	Color	Turb.	Oxy. Cons.	Cl.	Odor	Color	Turb.
A	4.7	67.0	0	0	0	8.2	6.2	0	0	0
B	1.8	40.0	0	0	0		(Filled	from	top)	
C	1.6	40.0	0	0	0	18.8	28.8	0	0	0
D	2.7	41.0	0	0	0	80.0	255.0	Str. sour peas	Gr.	Sl.
E		(No	water	appear	ed)	130.0	230.0		Gr.	Sl.
F	10.0	142.0	F.	Sl	0	7.8	127.0	F.	Sl.	0
G		(Not	yet	dug)		11.4	72.0	0	0	0
H		(Not	yet	dug)		0.7	15.0	0	0	0

Note :—Str.=strong; F.=faint; Gr.=greenish; Sl.=slight
*Letters refer to Diagram I.

sumed and even the green color and odor of the waste. One may account for this from the fact that during part of the eleventh and twelfth days the waste was turned into the reservoir which, as noted, had a leaky bottom.

The character of the water in the test holes gives in general evidence of a high degree of purification affected by the broad irrigation beds.

Creek Inspection: When the pea pack started considerable water was flowing in the creek. The rains of the sixth to the tenth days increased the flow to such an extent that during this time the waste could probably have been turned directly into it without occasioning any objection. As a matter of fact, a relatively small quantity of the waste did enter the stream all during the pea pack. Samples of the water collected at the points C and G indicated on the map were analyzed and found to be of the composition as shown in Table III. While the creek was still high the turbidity was great.

Oxygen consumed and chlorine were determined each day from samples collected at various points along the course of the creek. The points are shown on Diagram II and the results of the determination recorded in Table IV. At point C the city sewer empties into the creek, and at E the waste from the process building is discharged. On the eleventh day the creek was high enough to afford sufficient dilution and the contamination from these sources was not serious. It will be noted that just at the point E, marking the entrance of untreated wastes above referred to, the oxygen consumed rises rapidly, while the city sewer does not seem to affect the creek very much. As the creek lowers after the rainy weather, the relative proportion of the waste increases and is shown by the corresponding rise in chlorine and oxygen consumed. In the passage of the

TABLE IV.

CREEK INSPECTION DURING PEA PACK OF 1913.

Date	June 26		June 27		June 28		June 30	
Hr. of Coll.	2:00 p.m.		2:00 p.m.		3:00 p.m.		4:00 p.m.	
Place of Coll.*	Oxy. Cons.	Cl.	Oxy. Cons.	Cl	Oxy. Cons.	Cl.	Oxy. Cons.	Cl
A	1.0	5.5	1.2	5.0	....	....	....	....
B	1.2	5.5	1.1	5.0	....	....	....	....
C	1.1	8.5	1.1	6.0	....	....	....	....
D	1.2	8.0	1.6	7.0	3.0	10.0	2.3	24.0
E	5.2	21.0	13.0	80.0	39.6	98.0	....	....
F	9.4	35.0	10.2	68.0	48.8	170.0	....	....
G	10.9	35.0	16.6	86.5	34.4	154.0	31.0	142.0
H	10.6	38.5	13.2	86.0	30.2	135.0	26.0	140.0
I	9.5	44.0	13.3	86.5	28.2	132.0	....	....
J	5.4	45.0	8.0	57.5	10.1	82.0	24.4	140.0
K	....	....	1.2	5.0	1.2	5.5	....	....
L	....	....	4.4	42.0	7.7	63.0	24.0	150.0
M	....	....	....	....	3.4	45.0	8.0	70.0
N	....	....	....	....	....	....	6.4	63.0
O	....	....	....	....	....	....	6.8	65.0

*Letters refer to Diagrams I and II.

waste down the creek a marked decrease in the oxygen consumed takes place below J. This is due to the dilution with the branch from the southeast, whose nature, as indicated from samples collected at the point K, is about the same as that of the larger stream above C. Below the junction of the two streams a steady decrease in the oxygen consumed occurs, as a longer time is afforded for the oxidation of the waste by the air.

During the collection of samples several places were noticed where peas had lodged along the bank. These, however, were very few in number and did not give rise to any odor or appear to be decomposing.

A few days after the season closed an inspection trip was made for a greater distance down the creek. The weather at this time was intensely hot and dry. Below the plant the water appeared darker in color than above and at one place, where a log lay across the stream, a considerable quantity of green scum had collected. Quite an odor was perceptible in the immediate neighborhood, but was not perceptible at any distance. At another place, where the course of the stream lay through the barnyard of the Burkett farm, a number of hogs were seen wallowing in the creek, which caused a marked turbidity in the creek below.

On a whole, the contamination of the creek by the water was not great, and such as did occur did not give rise to complaint. Emptying the contents of the settling basin into the creek at the termination of the pack did, however, cause foaming in the boilers

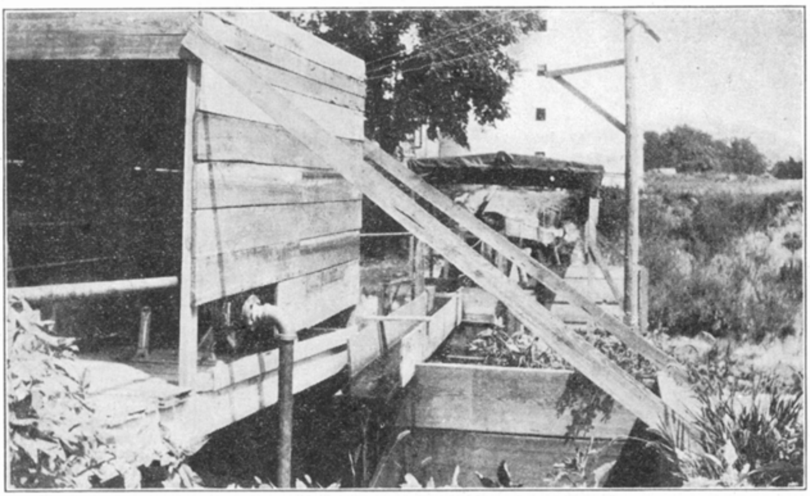


Fig. IV. Pump and Motor Shed Over Reservoir Used During Corn Pack.

of the T. P. & W. R. R. pumping station. Emptying the sedimentation basin during low water need not occur in practice, however.

Summary of Investigation During Pea Pack: The results of the operation of the experimental plant at Washington during the pea canning season of 1913 indicated that modified broad irrigation, as described in the foregoing, could be counted upon to economically give satisfactory results. Although the pea pack was of short duration and the experimental plant in a somewhat incompleted state of construction, the operation gave an opportunity for a preliminary study and pointed out conditions which were to be remedied before the commencement of the corn pack.

INVESTIGATIONS DURING THE CORN CANNING SEASON OF 1913.

The corn packing season started August 18th and continued through September 6th. The pack was of very short duration, both in hours per day and the number of days in operation. This was due to the fact that the unusually dry period had cut the yield per acre about half.

Additions and Modifications to the Experimental Plant: The principal change in the experimental plant after the pea pack was in the method of discharging the waste upon the irrigation beds. The old gravity feed used during the pea pack, which led from the settling basin to the southern and lower irrigation bed, was removed. The waste from the settling basin was then turned directly into the reservoir. On a platform above the center of the reservoir an American centrifugal pump was installed. This pump was one of the low-pressure, single-stage, horizontal belt-driven type, with a 3-inch suction and 2½-inch discharge. The power was furnished by a 5 H. P. Fort Wayne motor. A shed was built over the pump and motor, a view of which is shown in Figure IV. A 2½-inch pipe line was laid from the pump to the irrigation beds with branches leading to the center of each bed in the manner indicated in the plat. Outside of the irrigation beds, the pipe was laid on top of the ground, but inside the beds it was placed about a foot and a half below the surface so that soil could be cultivated without interference. A layer of brick was placed at the surface around the discharge pipe at the center of each bed to prevent erosion. Figure V shows the discharge pipe of the lower irrigation bed. Application of wastes onto the

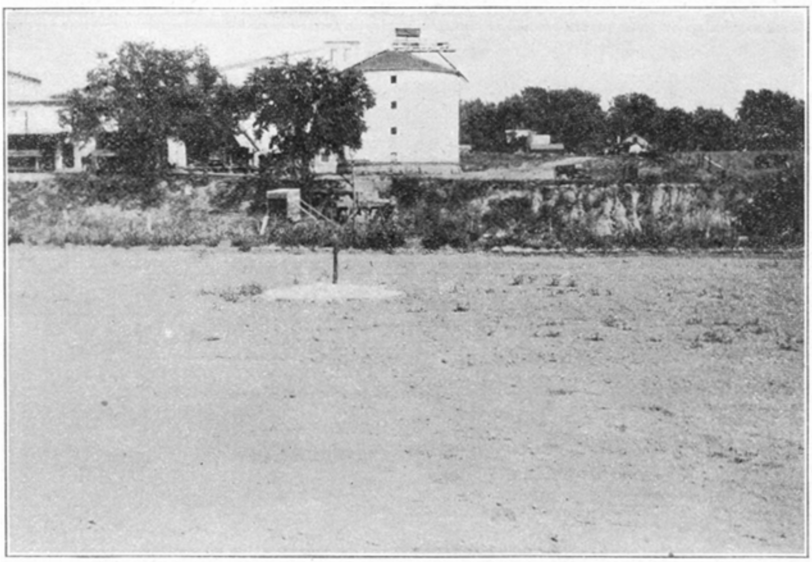


Fig. V. Discharge Pipe of Southernmost Irrigation Bed.

several beds was controlled by suitably placed valves, shown on plat.

The screens for the screen chamber and the baffles for settling basin were built and put in place as specified. The bottom of the reservoir was covered with brick and the brick were given a coating of cement in an effort to prevent leakage such as had occurred during the pea pack.

Nature and Quantity of Waste: Ordinarily the combined liquid wastes from the corn pack have a milky appearance with occasional floating corn grains, corn silk, husks and cobs. They have a characteristic corn odor, not disagreeable, but objected to by some. The liquid became putrescible, but slowly, compared with domestic sewage and many industrial wastes.

TABLE V.
COMPOSITION OF WASTE DURING CORN PACK OF 1913.

Date 1913	Hour	Nature	Solids	Loss on Ig.	Ash	Total Nitrogen	Oxy. Cons.	Cl.	Alkalinity
August 18	5:00 p.m.	screened	7346	6330	1016	140.0	1340	. . . . . .	—972
August 18	5:00 p.m.	settled	5260	4485	775	59.0	1080	250	. . . . . .
August 18	5:00 p.m.	filtered	5060	4287	773	. . . .	980	. . . . . .	. . . . . .
August 19	4:00 p.m.	raw	12539	11555	984	172.5	1410	. . . . . .	—395
August 19	4:00 p.m.	screened	14225	13467	758	248.2	1630	. . . . . .	. . . . . .
August 19	4:00 p.m.	settled	10127	. . . .	. . . .	165.6	1240	360	. . . . . .
August 20	5:00 p.m.	raw	2873	2447	426	. . . .	98	. . . . . .	. . . . . .
August 20	5:00 p.m.	screened	1624	1210	414	. . . .	90	. . . . . .	. . . . . .
August 20	5:00 p.m.	settled	1934	1525	409	. . . .	164	. . . . . .	—486
August 21	10:00 a.m.	raw	11480	10174	1306	307.8	1600	. . . . . .	—374
August 21	10:00 a.m.	screened	9680	8385	1595	180.8	1400	. . . . . .	—332
August 21	10:00 a.m.	settled	5928	4848	1080	159.9	1000	330	—241
August 23	2:45 p.m.	raw	8755	7495	1260	. . . .	1400	. . . . . .	. . . . . .
August 23	2:45 p.m.	screened	7868	6715	1153	81.2	1320	. . . . . .	—572
August 23	2:45 p.m.	settled	8167	6945	1222	130.5	1340	355	—413
August 26	5:00 p.m.	settled	8613	6977	1636	91.2	1130	562	—1040
August 28	1:30 p.m.	settled	8880	7280	1600	152.2	1700	485	—1062
August 30	1:15 p.m.	settled	7750	6440	1310	123.2	1460	435	—590
September 1 . . .	5:30 p.m.	settled	10660	8820	1840	152.0	1720	675	—756
September 3 . . .	2:30 p.m.	settled	5810	4910	900	65.8	1170	210	—448
September 5 . . .	11:00 a.m.	settled	8270	6650	1620	143.7	720	500	—696

NOTE—In all cases the color was greenish white, the turbidity very decided and there was an odor of fermented corn.

In 1913 the wastes differed somewhat in color from the wastes of the previous year, because of the presence of pea vines in the bottom of the silo which gave a very decided greenish brown color to the silo drainage and thus was of sufficient volume to tinge the waste from the husking shed and packing house.

A number of analyses of the waste were made and the results of these are embodied in Table V. These samples are designated as settled and were collected from the reservoir. These analyses indicate that the waste as applied on the irrigation beds contained an average of about 8,000 parts per million of dissolved and suspended solids.

At the beginning of the "scrub" (periods at noon and night when the floors and machinery are washed) there would be a great quantity of cut corn and large waste particles in the effluent, thus making the solids run abnormally high for a few minutes. This is due to the fact that the bulk of solid matter is quickly washed from the machinery at the first application of water. Toward the close of the "scrub" the water is practically clear. The decreasing solid content may be noted in the sample of the third day, which was collected after the "scrub" had been in progress about twenty minutes.

Sometimes the settled sample ran a litle higher in solids than the screened, due to rather wide and rapid variations in the crude waste.

As the following tables for quantity of solids removed from settling basin and screening box will show, by far the larger portion are removed by the former. After a few days, sampling of crude wastes was stopped and only samples of the settled effluent collected from the reservoir.

The quantity of waste as applied upon the irrigation beds was determined by the time the centrifugal pump was in operation. The capacity of the pump was different for each bed, due to varying lengths of piping. The several rates were obtained approximately from the time required for the pump to lower the water in the reservoir a definite distance.

Screening Chamber: The bulk of the rough solids of the raw waste were removed in the screening box. They consisted for the most part of cut corn, some shucks, silks and cob ends. The greater part of such solids came down during "scrub time" and kept one employe busy removing them during the early part of the scrubbing.

The screening seemed to be fairly efficient, but the fact that the screens were so close together made the removal of solids between them very difficult. The first and third screens were dispensed with after a few days' operation and this permitted cleaning with much greater ease.

Another difficulty met with in this connection was that the screens would clog up rapidly during "scrub time" and the mat of silks and shucks would not allow the water to pass through fast enough to keep the screen chamber from overflowing.

The difficulty was overcome by removing the weir at the outlet of the screen chamber, thus reducing the depth of liquid to merely that required to remove the flow. This in turn caused solids to pack firmly against the screens, due to the pressure of the water upon them, and the level of this somewhat impervious mat would not raise fast enough but that it was possible to keep the chamber from running over. When the level of the water would rise near the top, a sort of scraper of width equal to that of the screen box was placed against the screen and the clogging solids were pushed down, thus lowering the level of the water and prohibiting the threatened overflow.

The change was also of advantage in the removal of the solids from the box. A scoop shovel with numerous ½-inch perforations was used for this purpose. Since most of the solids, though settling to the bottom, were still of but little greater density than water a large portion would escape from the shovel before they could be brought above the surface of the water with the chamber as originally built. When the weir was out the level of the water was usually not very much above that of the solids and their removal was effected with comparative ease.

No decrease in the removal efficiency of the screen chamber was apparent after the change above mentioned.

Table VI gives the amount of solids removed per day. Since

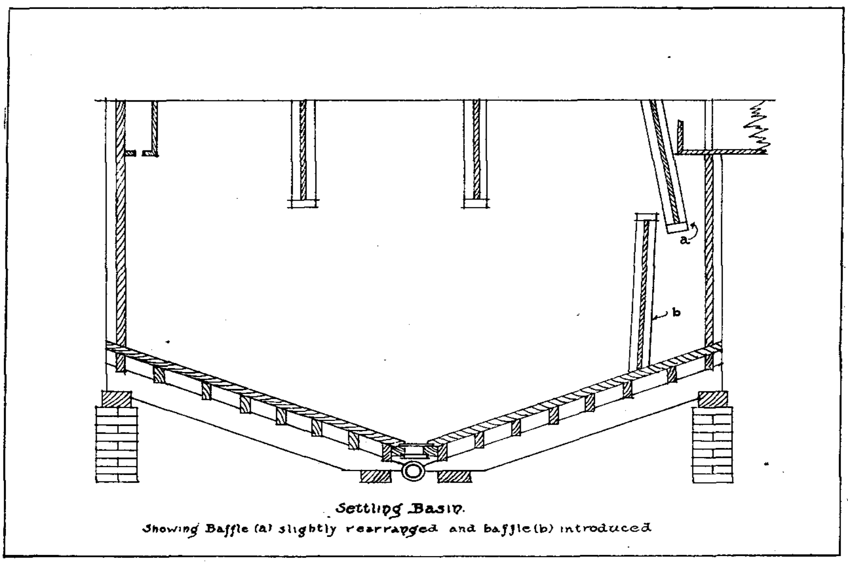
TABLE VI.
SOLIDS REMOVED DURING CORN PACK, 1913.

		Skimmings			Screenings		
Date 1913	Gallons Waste	Cu. Ft.	Lbs.	P. p.m.	Cu. Ft.	Lbs.	P. p.m.
August 19	6,440	0.6	36	670	15.75	1310	24,400
August 20	16,820	1.2	72	515	21.00	1745	12,100
August 21	11,120	3.8	216	2,330	19.25	1600	17,250
August 22	19,865	8.7	504	3,050	31.50	2620	16,000
August 23	26,160	7.5	432	1,986	42.00	3490	13,300
August 25	35,700	13.7	792	2,660	21.00	1745	5,850
August 26	25,860	12.0	720	3,340	24.50	2040	9,450
August 27	34,105	8.7	504	1,780	17.50	1455	5,130
August 28	25,225	10.0	576	2,730	21.00	1745	8,280
August 29	32,860	7.5	432	1,580	17.50	1455	5,320
August 30	31,000	5.0	288	1,120	21.00	1745	6,750
August 31	43,170	3.8	216	600	14.00	1165	3,230
September 2	29,895	7.5	432	1,730	19.25	1600	6,430
September 3	10,604	5.0	288	3,260	15.75	1310	14,800
September 4	32,465	8.7	504	1,860	17.50	1455	5,380
September 5	32,608	10.0	576	2,120	17.50	1455	5,350
September 6	29,358	7.5	432	1,760	19.25	1600	6,520

these were measured at about 8:00 a. m., the quantity recorded is really that for the solids of the previous operating day.

The solids were of such stock feeding value that the proprietor of the Burkett dairy farm was glad to arrange to haul them away each day. Thus the problem of their disposal was quite easily solved.

Settling Basin: The baffles were placed in the settling basin as specified and gave good results. The effluent from the basin was quite free from any coarse solids. Scarcely any floating particles collected for some days and the quantity which settled was very slight. These were not drawn off at once and after a time decomposition set in and gas bubbles could be seen rising to the top. Frequently a veritable boiling effect would be noticed and some of the solids, having become lighter through the decomposing action, would be freed from the mass below by the evolution of gas and came to the top, where they were readily skimmed off. In case this "boiling" would take place near the outlet end, some of the solids would be carried over into the reservoir. To prevent this, another baffle was put in place, so that it reached to the bottom of the tank and attained a height just above that of the level of the bottom of the last baffle. The arrangement after the change is indicated in Diagram III. By this means all solids were directed upward inside of



Diag. III.—Settling Basin Showing Baffle (a) Slightly Rearranged and Baffle (b) Introduced.

the last baffle and thus no appreciable quantity was carried over into the reservoir.

The settlings from the sedimentation basin and reservoir were drained occasionally into the sludge box, from which they were dipped out and hauled away and applied to land. The use of trenches as recommended was not found convenient during the test run.

The quantity of skimmed solids removed is also recorded in Table VI. A leak in the reservoir allowed a great deal of water to run down the trough into the sludge box and so diluting the settled solids drawn off there that it was impossible to get any accurate estimate of their quantity. The quantity was, however, comparatively small.

In connection with the solids removed at the screen chamber and settling basin, it may be well to make the following note: At the end of the husking shed is a concrete sump box about 4 feet square and 2½ feet deep. Into this the drains from the husking house and process building empty, and a single tile leads from it to the main sewer, as may be noted in the plat. A screen was fixed in this sump box to hold back some of the solids and about a barrel or so was removed each day by one of the teamsters and used for stock feeding purposes. This quantity is not included in the tables.

Reservoir: In spite of the improvements on the reservoir since the pea pack, it still seemed to be far from water-tight. During the first few days of use the waste leaked out quite rapidly. When the reservoir was pumped almost dry, some of the water would seep back, in small streams, through cracks in the bottom. A sack of bran was emptied into the reservoir full of waste and allowed to stand over night and this reduecd the outward leakage to a negligible quantity, so far as computation of results was concerned. Nevertheless there was introduced the difficulty already alluded to, of not being able to ascertain the volume of sludge deposited, and the water in the test holes near by, as well as the appearance of the gravel stratum in the creek bank, indicated that small quantities of waste were also entering the soil.

The principal cause of difficulty experienced with the use of the storage reservoir, however, was its limited capacity. If it were not nearly empty at the beginning of "scrub time" the abnormally large quantity of waste coming from the factory during this period was sufficient to gain very rapidly on the pump and threaten to overflow the reservoir. A larger pump would, of course, have avoided this particular difficulty, but a larger reservoir is also needed for securing a larger dose on the irrigation beds.

Irrigation Beds: No improvement had been made in the irrigation beds since the pea pack except to drag down some of the high places in the southernmost unit. The other three had grown up in weeds and it was necessary to plow and harrow them again. The surfaces of all the beds were very uneven, so at the beginning of the corn pack a gang of men was put to work to get them leveled down in proper shape. It had already been found almost impossible to flood a whole bed with the pump and reservoir in use, so in establishing the level of the third bed it was decided to divide it in halves and then subdivide one of these halves into quarters. The labor of removing quite a large quantity of dirt was thus saved, for the dirt was used in the construction of the cross embankments. An elbow and a short length of pipe was attached to the discharge pipe in this bed, so that the discharge could be directed to any di-

TABLE VII.

IRRIGATION BED TIME SHEET DURING CORN PACK OF 1913.

Date	No. of Bed Receiving Waste	Capper Hours	Interval of Pumping	No. of Minutes	Rate Gallons per Minute	Gallons During Interval	Total Gallons Pumped		Rate of Application Gallons per Acre
							To Bed	During Day	
August 18, 1913...	4	4	5:06— 6:50 p.m.	104	62	6,440	6,440	6,440	25,760
August 19, 1913...	1		9:02— 9:38 a.m.	36	87.5	3,150			
August 19, 1913...	1	10	4:00— 4:42 p.m.	42	87.5	3,680	13,830	13,830	55,400
August 19, 1913...	1		5:30— 6:50 p.m.	80	87.5	7,000			
August 20, 1913...	1		7:07— 7:40 a.m.	33	87.5	2,890	2,890		
August 20, 1913...	2	7.5	4:15— 6:40 p.m.	145	76.7	11,120	11,120	14,010	11,460
August 21, 1913...	3		7:12— 7:45 a.m.	33	64.75	2,250			
August 21, 1913...	3	9	1:50— 4:00 p.m.	130	64.75	8,420	19,740	19,740	78,960
August 21, 1913...	3		4:30— 6:50 p.m.	140	64.75	9,070			
August 22, 1913...	4		7:10— 8:20 a.m.	70	62	4,340			
August 22, 1913...	4	9.75	1:28— 3:30 p.m.	122	62	7,560	26,160	26,160	104,640
August 22, 1913...	4		4:30— 7:50 p.m.	200	62	12,400			
August 22, 1913...	4		9:45— 10:15 p.m.	30	62	1,860			
August 23, 1913...	1		1:30— 2:38 p.m.	68	87.5	5,950			
August 23, 1913...	1	12.75	4:30— 5:40 p.m.	70	87.5	6,125	35,700	35,700	
August 23, 1913...	1		7:00— 7:50 p.m.	50	87.5	4,375			142,800
August 23, 1913...	1		8:50— 12:30 p.m.	220	87.5	19,250			
August 24, 1913...	1	0	7:00— 7:45 a.m.	45	87.5	3,940	9,940	3,940	13,760
August 25, 1913...	2		6:50— 7:40 a.m.	50	76.7	3,835			
August 25, 1913...	2		11:05— 12:05 p.m.	60	76.7	4,600			
August 25, 1913...	2	9	2:20— 3:36 p.m.	76	76.7	5,840	25,806	25,806	
August 25, 1913...	2		4:28— 5:22 p.m.	54	76.7	4,241			103,440
August 25, 1913...	2		5:45— 6:00 p.m.	15	76.7	1,150			
August 25, 1913...	2		6:40— 8:00 p.m.	80	76.7	6,140			
August 26, 1913...	2		6:50— 8:00 a.m.	70	76.7	5,365			
August 26, 1913...	2		11:40— 12:45 a.m.	65	76.7	4,985			
August 26, 1913...	2	10.5	3:00— 4:00 p.m.	60	76.7	4,600	29,500	29,500	
August 26, 1913...	2		4:50— 5:20 p.m.	30	76.7	2,300			118,000
August 26, 1913...	2		5:30— 6:00 p.m.	30	76.7	2,300			
August 26, 1913...	3a		6:20— 8:30 p.m.	130	76.7	9,950			
August 27, 1913...	3a	10	10:50— 11:53 a.m.	63	64.75	4,075	11,325		
August 27, 1913...	3b		2:30— 4:30 p.m.	120	64.75	7,250			181,100
August 27, 1913...	3c		4:45— 8:35 p.m.	230	64.75	1,490	1,490	26,225	238,200
August 28, 1913...	3c	11	6:58— 8:20 a.m.	82	64.75	5,310			
August 28, 1913...	3c		12:51— 3:10 a.m.	139	64.75	9,000	22,760		
August 28, 1913...	4		4:40— 9:25 p.m.	285	64.75	18,450		22,760	
August 29, 1913...	4	11	7:00— 8:30 a.m.	90	62	5,580			
August 29, 1913...	4		9:00— 10:00 a.m.	60	62	3,720	31,000		124,000
August 29, 1913...	1		3:40— 9:30 p.m.	350	62	21,700		31,000	
August 30, 1913...	1		9:26— 10:38 a.m.	72	87.5	6,300			
August 30, 1913...	1	12.5	1:15— 2:42 p.m.	87	87.5	7,115			
August 30, 1913...	1		4:00— 4:45 p.m.	45	87.5	3,940	43,170		172,680
August 30, 1913...	1		5:10— 5:45 p.m.	35	87.5	3,065		43,170	
August 30, 1913...	1	0	6:30— 10:50 p.m.	260	87.5	22,750			
August 31, 1913...	2		7:00— 8:00 a.m.	60	87.5	5,250	5,250	5,250	21,000
September 1, 1913.	3a	6	11:45— 1:10	84	76.7	6,445	6,445		25,770
September 1, 1913.	3a		3:38— 4:35 p.m.	57		3,690			
September 1, 1913.	3a		5:35— 7:30 p.m.	115	64.75	7,450	2,345	29,895	355,200
September 1, 1913.	3b		6:50— 10:00 p.m.	190		12,310			
September 2, 1913.	3b		10:05— 10:25 a.m.	20	64.75	1,295	2,137		34,200
September 2, 1913.	2		11:17— 11:30 a.m.	13		842			
September 2, 1913.	4		11:30— 11:49 a.m.	19	76.7	1,457			
September 2, 1913.	1		11:55— 12:05 a.m.	10	62	620	620		2,480
September 2, 1913.	1		4:22— 4:46 p.m.	24	87.5	2,100		10,989	
September 2, 1913.	2		7:00— 7:14 p.m.	14	87.5	1,225	3,325		13,300
September 2, 1913.			7:15— 8:00 p.m.	45	76.7	3,450	4,907		18,088
September 3, 1913.	4		10:17— 10:29 a.m.	12	62	744	744		2,976
September 3, 1913.	3b		10:29— 12:37 p.m.	128	64.75	8,385	11,750		188,000
September 3, 1913.	3b		1:50— 2:42 p.m.	52	64.75	3,365			
September 3, 1913.	3	10.75	2:42— 3:00 p.m.	18	64.75	1,164		32,555	
September 3, 1913.	3c		4:20— 5:50 p.m.	90	64.75	5,840	20,061		160,488
September 3, 1913.	3c		6:05— 6:55 p.m.	50	64.75	3,237			
September 3, 1913.	3c		7:00— 9:30 p.m.	150	64.75	9,820			

TABLE VII—CONTINUED

IRRIGATION BED TIME SHEET DURING CORN PACK OF 1913.

Date	No. of Bed Receiving Waste	Capper Hours	Interval of Pumping	No. of Minutes	Rate Gallons per Minute	Gallons During Interval	Total Gallons Pumped		Rate of Application Gallons per Acre
							To Bed	During Day	
September 4, 1913.	3c	......	6:58– 7:25 a.m.	27	64.75	1,747.	....	....	....
September 4, 1913.	3c	......	9:07– 9:19 a.m.	12	64.75	777.	2,525.	....	4,050
September 4, 1913.	4	......	9:29– 9:39 a.m.	10	87.5	870.	870	....	3,482
September 4, 1913.	2	9.25	9:46–10:03 a.m.	17	76.7	1,305.	....	....	....
September 4, 1913.	1	......	10:17–10.24 a.m.	7	87.5	612.	612.	32,608	2,450
September 4, 1913.	4	......	11:55–2:45 p.m.	170	62	10,540	....	....	....
September 4, 1913.	4	......	3:30– 4:10 p.m.	40	62	2,480	15,400	....	61,600
September 4, 1913.	4	......	4:35– 5:15 p.m.	40	62	2,480	....	....	....
September 4, 1913.	2	......	5:15– 7:50 p.m.	155	76.7	11,895	13,200	....	52,800
September 5, 1913.	2	......	6:42– 9:20 a.m.	148	....	11,340	....	....	....
September 5, 1913.	2	5	11:30– 2:45 p.m.	195	76.7	14,950	29,358	29,358	117,433
September 5, 1913.	2	......	4:30– 5:10 p.m:	40	....	3,068	....	....	....
September 6, 1913.	1	6	12:15– 5:15 p.m.	300		26,250	26,250	26,250	105,000
September 7, 1913.	1	0	7:00– 8:45 a.m.	105	87.5	9,185	9,185	9,185	36,740
September 8, 1913.	2	......	8:00– 8:12 a.m.	12	76.7	921	921	....	....
September 8, 1913.	3c	......	8:23– 8:41 a.m.	18	64.75	1,165	2,360	....	....
September 4, 1913.	3c	0	8:59– 9:19 a.m.	20	64.75	1,295	....	13,739	....
September 8, 1913.	4	......	10:20–10:33 a.m.	13	62.	806	806	....	....
September 8, 1913.	1	......	10:33–11:39 a.m.	66	87.5	5,775	9,742	....	....
September 8, 1913.	1	......	4:02– 4:45 p.m.	43	87.5	3,937	....	....	....

vision of the bed by simply turning this pipe around. With this arrangement a better idea was gained as to how much the beds could absorb. Figure VI shows the southern bed before it was well leveled. Figure VII shows the subdivided bed.

Table VII gives the quantity of waste discharged during the season and shows a higher average in gallons per day during the previous year, showing that fewer hours of work per day had little influence on the quantity of water used. The wastes included the clean water from the cooling tank.

A few experiments were made to determine the quantity of waste the beds would absorb. Bed 3a with an area of $\frac{1}{16}$ of an acre was first placed in operation on the tenth day (August 27) at 10:50 a. m. and the amount of liquid applied is recorded in Table VII. The water had disappeared from the surface of the bed by 1 p. m. after the first application. It was almost gone by 7:00 p. m. after the second application made between 2:30 and 4:30 p. m. This dose approximated 181,000 gallons per acre per day, but was applied at two intervals. The waste was then turned on 3b and a continuous dose of a slightly greater quantity per acre applied. Before morning it had disappeared.

On the eleventh day (August 28) the entire waste of the day was pumped on to bed 3c ($\frac{1}{8}$ acre in area) with much the same result. The ground at this time was in the best of condition, for it had just been cultivated and carefully leveled. Though the dose applied would approximate a rate of 131,000 gallons per acre per day, the bed was not entirely covered until the last application. The waste had disappeared below the surface at 5 a. m. on the 29th.

Since the above dose did not appear to tax the capacity of the soil, an attempt was made to find a maximuum quantity that could be applied. With this idea the entire waste of the fifteenth day (September 1) was turned on bed 3a. At the close of the day the water stood over the bed to a depth of some three or four inches. About twenty-four hours elapsed before this heavy dose of 355,000 gallons per acre was taken up by the ground.

Proper dosing was impossible because the capacity of the pump was such that a rapid application could not be made. It was also almost impossible to flood the large beds, even by two consecutive

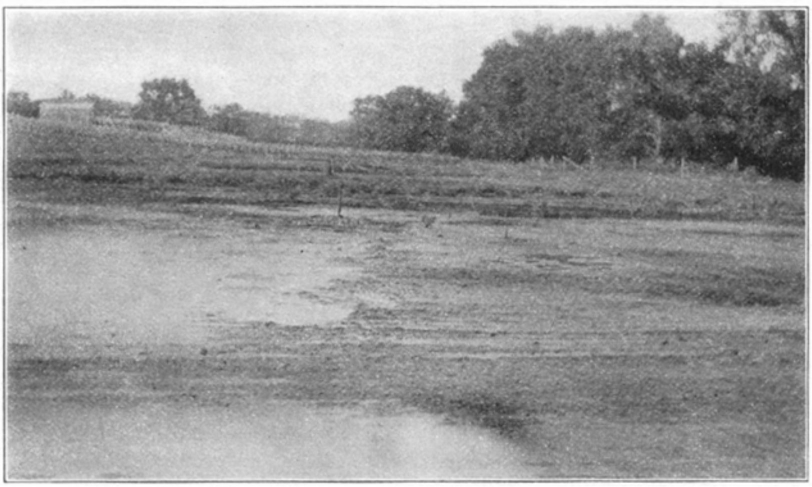


Fig. VI. View Showing Unlevel Condition of Southernmost Bed and Consequent Ponding of Wastes During Corn Pack.

days' pumping. Although as high as 350,000 gallons per acre, or perhaps even more, were applied, yet 100,000 gallons per acre seems to be a conservative amount that will bring the best results. If a greater quantity than this is applied too much time is required before the bed dries sufficiently for proper cultivation and preparation for the next application.

In cultivating the bed an ordinary garden rake was first used, but this proved rather impractical, for the surface was packed too firmly. Light harrowing was next tried and with good success. The small $\frac{1}{16}$-acre plats were of course rather difficult to harrow, but still no great inconvenience was experienced in this respect. By keeping a few inches of the top soil well stirred and aerated, the absorbent power did not diminish during the period of operation, nor was the surface of the bed worked much out of level. The advantage of keeping the bed level may not at first be apparent. In fact, it would appear that perhaps a slight crowning would be conducive to a more even distribution. Such, however, is not the case. In the dosing experiments in which the beds were thus crowned, the loose condition of the earth permitted channels to quickly form so that the waste flowed directly from the point of discharge to the outer and lower portions of the bed. Consequently the center was left as an island. The actual working experience during the experiments indicated quite conclusively the advantage of maintaining the beds level rather than crowned.

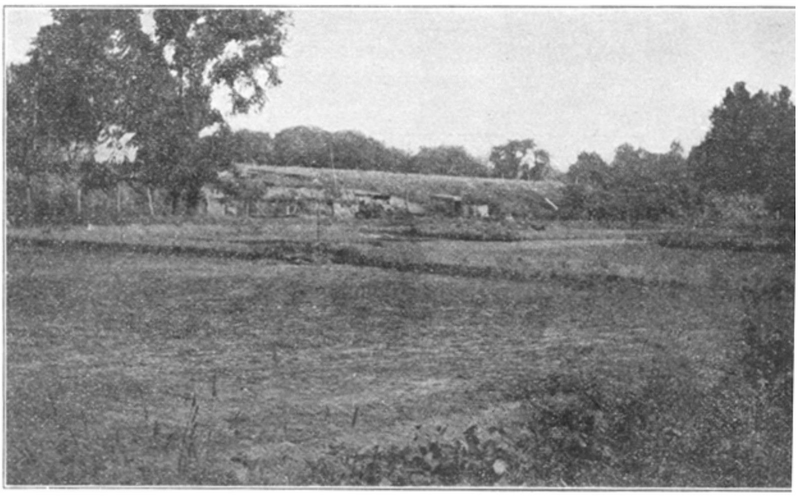


Fig. VII. Bed Subdivided for Securing Dosing Effect During Corn Pack.

The weather conditions during the pack were very favorable to the success of the irrigation method. Considerable rain fell during the night of August 17 (just prior to the first day of actual operations), but with the exception of a few light showers no further precipitation occurred during the rest of the season.

Samples were collected from the test holes (see Diagram I) which had been dug during the pea pack and from a few more which had been dug later. Determinations for oxygen consumed and chlorine were made on the samples and the results obtained are recorded in Table VIII. Those from holes near the reservoir show a rather high oxygen consumption and gave a sour odor. There was doubtless some seepage through the cracks in the bottom of the reservoir. This seepage reached the gravel strata into which the holes had been sunk, hence the contamination. Very little of this seepage, however, seems to have reached the creek.

Creek Inspection: The regular creek inspection trips were begun at the start of the pack. A very great rise in oxygen consumed opposite the factory resulted from the discharge of a portion of the wastes into the stream untreated. These wastes included water from the cooling tank and the so-called process building. A few tests showed that the water from the cooling tank was of such a character that it could be turned directly into the creek, but to avoid laying a special sewer for this tank, the whole waste was turned into the general sewer and discharged through the experimental plant. The decrease in oxygen consumed between the 23d to the

TABLE VIII.

CHARACTER OF WATER IN TEST HOLES DURING CORN PACK OF 1913.

Date	Place of Collection / Determination	A	B	C	D	E	F	I	J	I.	II.
Aug. 20 1913	Oxygen Consumed	4.4	20.8	20.6	13.4	appeared	10	....	....	63.0	15.4
	Chlorine	140.0	88.	150.0	98.0		119	....	....	61.0	90.0
	Color	0	0.	0.	0.		0	....	....	0	0
	Odor	0	sour	sour	earthy		0	....	....	sour	....
	Turbidity	0	slight	sour	earthy		0	....	....	decided	slight
Aug. 25 1913	Oxygen Consumed	9.2	14.8	58.0	None appeared	None	12.6	....	....	87.0	21.0
	Chlorine	135.0	9.5	58.0			116.	....	....	69.0	103.0
	Color	slight	slight	slight			....	....	....	....	....
	Odor	sour	sour	sour			....	....	....	sour	sour
	Turbidity	slight	decided	decided			decided	....	....	decided	decided
Aug. 30 1913	Oxygen Consumed	....	....	....	....	....	....	35.4	48.0	....	....
	Chlorine	....	....	....	....	....	....	150.0	118.0	....	....
	Color	....	....	....	....	....	....	slight	slight	....	....
	Odor............	....	....	....	....	....	....	earthy	earthy	....	....
	Turbidity	....	....	....	....	....	....	slight	slight	....	....

25th at points below D readily shows the improvement in conditions due to this alteration in the sewerage system.

Table IX records the result of the determinations in connection with the creek inspection. The points at which samples of the creek water were taken are located on Diagram II and are the same as those from which the samples were taken during the pea pack. Above the point C (see Diagram II) scarcely any water was flowing after the pack had been in progress a few days, and had it not been for the city sewer and a spring a short distance above, the creek would probably have gone dry. Near the sewer and for about a quarter of a mile downstream the water was quite dark, but gave no objectionable odor. After the rearrangement of the factory sewerage system, the creek conditions seemed to gradually improve. A slight rise in oxygen consumed at G even after the change is due to a

TABLE IX.

CREEK INSPECTION DURING CORN PACK OF 1913.

Date 1913	Aug. 18		Aug. 19		Aug. 20		Aug. 21		Aug. 23		Aug. 25		Aug. 27		Aug. 30		Sept. 8	
Place of Coll.	Oxy. Cons.	Cl.	O. Con.	Cl.	O. Con.	Cl.	O. Con.	Cl.	O. Con.	Cl.	O. Con.	Cl.	O. Con.	Cl.	C. Con.	Cl.	O. Con.	Cl.
A	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
B	6.6	30.0	6.4	32.0	7.0	33.0	....	....	3.8	44.0	7.2	41.0	6.0	45.0	64.0	51.0	27.2	122.0
C	11.8	90.0	9.8	123.	9.2	95.0	....	....	4.4	87.0	12.0	117.0	13.2	113.0	11.4	101.0	32.4	133.0
D	9.4	44.0	7.2	80.0	9.1	74.0	9.5	150.0	4.2	154.0	5.5	135.0	7.2	85.0	6.2	111.0	23.8	98.0
E	....	....	....	....	....	....	6.4	113.0	165.0	255.0	10.5	136.0	5.0	67.0	56.0	86.0	27.4	54.0
F	....	....	....	....	205.0	172.0	128.0	188.0	59.5	152.0	8.0	145.0	4.2	66.0	6.2	87.0	24.4	53.0
G	11.3	56.0	490.0	210.0	160.0	145.0	82.0	155.0	64.0	158.0	14.5	133.0	18.8	75.0	17.8	80.0	25.0	49.0
H	....	....	50.5	125.0	52.0	112.0	58.5	144.0	68.0	220.0	18.5	120.0	7.9	60.6	9.2	70.0	27.4	49.0
I	7.8	62.0	15.2	86.5	....	....	50.0	86.5	54.0	142.0	11.0	196.0	5.0	54.0	4.9	7.4	28.6	48.0
L	....	....	9.8	90.0	....	....	21.4	120.0	40.0	210.0	10.0	122.0	6.0	74.0	58.0	80.0	29.2	56.0
M	....	....	5.5	61.8	....	....	10.6	105.0	29.6	210.0	11.9	175.0	....	....	4.7	72.0	27.0	77.0
N	....	....	5.0	60.0	....	....	11.8	115.0	12.8	142.0	10.7	204.0	8.0	135.0	4.4	78.0	18.2	97.0
O	....	....	....	....	....	....	8.4	90.0	....	....	10.9	150.0	9.8	174.0	4.8	135.0	10.6	16.0
P	....	....	....	....	....	....	....	....	....	....	....	....	10.4	155.0	7.6	170.0	7.8	108.0
Q	....	....	....	....	....	....	....	....	....	....	....	....	....	....	5.3	65.0	5.8	99.0
R	....	....	....	....	....	....	....	....	....	....	....	....	....	....	10.8	55.0	7.0	91.0
S	....	....	....	....	....	....	....	....	....	....	....	....	....	....	5.8	45.0	16.6	42.0

little seepage from the reservoir and to the sewer from the canning factory toilet rooms, which has its outlet at this point.

On August 29th quite an extended trip was made down the stream. Figure VIII, taken near point P, shows some of the Burkett farm buildings and feed yards close to the creek bank. A spring is said to feed the stream at this point. Figure IX was taken a few hundred yards further downstream. In the foreground is the railroad dam and in the background the T. P. & W. R. R. pump station. What little water that was flowing in the creek was almost entirely held back by the dam and pumped out for boiler purposes. About fifty yards beyond the dam the creek was quite dry except for an occasional puddle. In these, as at the Burkett farm, hogs

Fig. VIII. View Showing Proximity of Burkett Farm Buildings to the Creek.

were wallowing. Some distance further on, at S, there was found quite a body of clear water and a few yards further down the creek was dry again.

On the whole, one may safely conclude that the method of disposal of the canning waste did not affect the creek at all after the change of tile causing the pollution indicated by the first series of stream analyses. Not only the general inspection, but the chemical examination proves it. No sludge and slime formed in the stream bed and the water was only of the usual turbidity and color of any similar small stream at that season of the year. The single complaint heard was that the mosquitoes were worse that year than ever before and for lack of other cause this was laid at the door of the canning factory. It is highly improbable that the water which stood for a very short time on the irrigation beds would be as liable to offer a place of breeding for the insects as the puddles and still water in the creek. That the mosquitoes were numerous, however, cannot be denied.

Other Treatment Experiments: Although the treatment experiments with contact beds and sand filters during the previous year had been rather unsuccessful, it was deemed advisable to make further investigation along this line. The tanks which had been used for this purpose were rather badly rusted. However, the holes were soldered and each given a couple of coats of engine paint on the inside. Having thus been put in fairly good shape, they were set upon

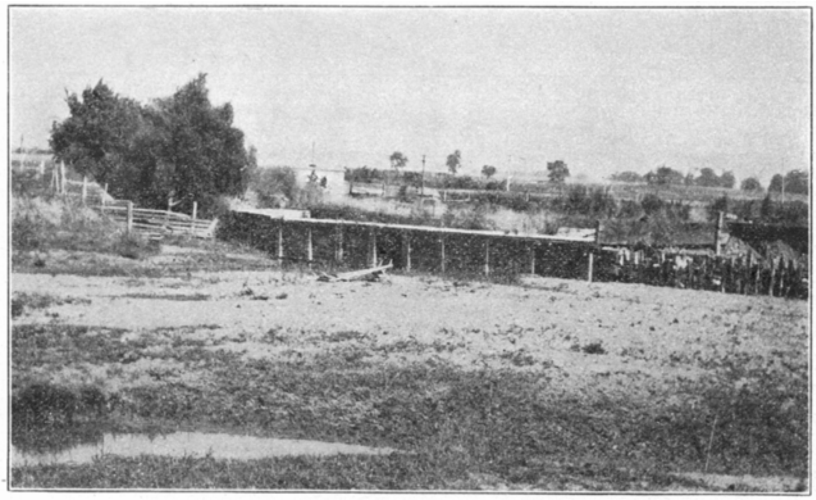


Fig. IX. Railroad Dam and Pumping Station.

the south side of the reservoir in order that they would be convenient for dosing.

In tank No. 1 crushed rock of greatest dimensions from 1 to 1½ inches was placed until a depth of about 2½ feet was obtained. This was seeded with a bucket of sludge from the toilet room sewer and then dosed with the waste. No appreciable improvement or modification could be noted, though a contact of one, two and three hours, was tried.

For a sand filter, tank No. 2 was filled to a depth of about ½ foot with coarse gravel, then covered with a 3-foot layer of fairly coarse sand.

In order to duplicate to a certain extent the conditions represented by the irrigation beds, an earth filter was constructed in tank No. 3. About six inches of gravel was placed in the bottom, then dirt was added. This was rather firmly packed until a depth of 2½ feet above the gravel was attained, then an additional half foot was placed in the loose state.

The two filters were dosed as stated in Table X. The effluent in both cases had very slight color and turbidity and possessed a somewhat earthy odor. The sand filtration was more rapid than the dirt, and, apparently, a little more efficient though the experiments were not continued long enough to obtain a good measurement of the efficiency of either. Table XI gives the results of a few determinations on the filtered effluent in comparison with that of the untreated waste. It will be noted that both filters showed a tendency to improve with age. Unfortunately they were not started soon enough to give any conclusive evidence as to how long they could work without clogging, but there was no apparent decrease in the rate at which they could absorb the waste during the time they were in operation.

TABLE X.
SMALL FILTER EXPERIMENTS DURING CORN PACK OF 1913.

Date 1913	Bed	Dose gallons	Rate per acre	Time req. waste to disappear from surface	Time req. eff. to appear
Aug. 29, 1:30 p.m.	Sand	8.25	100,000	Less than 5 min.	None appeared
Aug. 29, 1:15 p.m.	Earth	16.5	200,000	One hour	None appeared
Aug. 30, 1:15 p.m.	Sand	8.25	100,000	Less than 5 min.	Slight drip after 5 min.
Aug. 30, 1:15 p.m.	Earth	16.5	200,000	One hour	Two hours
Aug. 31.	Sand	8.25	100,000	One hour	To hours
Aug. 31.	Earth	16.5	200,000	. . . .	. . . .
Sept. 3.	Sand	8.25	100,000	8 min.	2 or 3 min.
Sept. 3.	Earth	16.5	200,000	54 min.	20 min.

TABLE XI.

Date 1913	Method treatment	Oxy. Cons.	Chlorine	Acidity	Solids
Aug. 30.	Settled	1460	485	—1062	7750
Aug. 30.	Earth	550	545	— 272	6900
Sept. 3.	Settled	1170	210	— 448	5810
Sept. 3.	Earth	107	570	?	. . . .
Sept. 3.	Sand	169	405	— 404	5707

In addition to the filtration experiments, some effort was made to determine by small laboratory experiments the effect of a different period of settling upon the effluent. Nothing satisfactory being obtained from these, varying amounts of alumina cream were added and samples agitated for some time. The results of the investigation are given in Table XII and indicate that precipitation and settling are of little practical application.

TABLE XII.

PLAIN SEDIMENTATION AND CHEMICAL PRECIPITATION EXPERIMENTS DURING CORN PACK OF 1913

Date 1913	Treatment	Solids	Decrease in pts. per mil.	Decrease in percentage
August 18	Screened	7346	....	.....
August 18	Settled over night	5260	2086	27.3
August 18	Filtered	5060	2286	31.0
August 26	Settled	8613	....	.....
August 26	Stood 14 hours	7625	988	11.45
August 26	Stood 14 hours with 25 cc. $Al(OH)_3$	7565	1048	12.15
August 28	Settled	8880	....	.....
August 28	Settled 4 hours+1 cc. Al $(OH)_3$	8380	500	5.64
August 28	Settled 4 hours+10 cc. Al $(OH)_3$	8312	578	6.52
August 28	Agitated 30 minutes, settled 3½ hours + 10 cc. Al $(OH)_3$	8285	605	6.81
August 28	Agitated 30 minutes, settled 3½ hours + 10 cc. $Al(OH)_3$	8192	688	6.97
August 28	Settled 4 hours	8560	320	3.60
August 30	Settled	7750	....	.....
August 30	Contact bed	7455	295	3.81
August 30	Earth filter	6900	850	10.95
September 1	Settled	10660	....	.....
September 1	Earth filter	7112	3548	21.40
September 3	Settled	5810	....	.....
September 3	Sand filter	3707	2103	34.50

COST OF CONSTRUCTION.

Below is given an itemized list of the expenditures for the construction of the experimental plant. Beside the articles which were purchased especially for the plant, probably some material at the factory was used and not considered. The use of the 1½ acres of ground, given over to the experimental plant, would be worth about $15 a year and the current for the motor cost about $1 per day of its operation.

Lumber and tile	$ 34.35
Building paper and tile	2.00
Sand, cement and lumber	4.13
Two tanks	65.00
Pipe and fittings	97.40
Steel stock	6.18
Electrical equipment	6.40
Leveling beds	32.00
Centrifugal pump	25.00
One 5 H. P. motor	50.00
Labor	27.38
Total	$349.94

It is estimated that a permanent plant might readily be built for $1,000,00 not including land.

CONCLUSIONS.

Crude liquid wastes from the process of canning corn and peas on a large scale are high in color, carry more or less suspended matter, when fresh, have an odor characteristic of the vegetable being canned, and when in a putrescible condition, have a very foul, and to some, a nauseating odor. The corn wastes putresce less rapidly than do the wastes from pea canning and the odor of the putrefying wastes is on the whole somewhat less disagreeable in the former than in the latter. This is probably explainable on the basis of the higher nitrogen content of peas. The total residue on evaporation of both wastes is in the neighborhood of 1,600 parts per million of which about 10% remains as ash after ignition.

The bulk of the coarser solids in both wastes may be removed by a suitably designed screen chamber. Such a chamber should have two or more screens placed in a flume at intervals of not less than 3 feet apart. The screens should be made up of bars with openings of about ½-inch, and the bars should have an inclination to the horizontal of about 30° with the toe of the screen pointing upstream. There should be a free outlet from the flume so that the depth of water beyond the screens will be only such as will be necessary to carry off the waste. The screenings can be best handled by from time to time pushing them downward on the screen and when there is a large accumulation, they may be removed with a perforated shovel. The width of flume should not be less than 18 inches, and the depth should be at least 1 foot. Such a chamber will suffice to treat about 75,000 gallons per day. The screenings from the corn wastes averaged about 91.5 cu. ft. per 100,000 gallons.

Plain settling basins remove a comparatively small quantity of solid matter by sedimentation, because so large a proportion of the solids will float, and because the settleable solids are soon raised by gases of decomposition. Unfortunately, defects in the experimental plant did not permit of securing an accurate measurement. A considerably larger portion of solids that escape the screens may be removed by skimming from between baffles placed in the sedimentation chamber. The quantity of solids thus removed during the corn pack was approximately 28 cu. ft. per 100,000 gallons of waste. Generally speaking it would be better to make no effort to settle the solids after they have passed the screens, but rather pass them through a skimming chamber or through fine screens before the liquid enters the dosing chamber or reservoir.

The entire contents of the dosing chamber or reservoir, including such sludge as may settle, can best be disposed of on filters or broad irrigation beds. Experience during the experiments would indicate that the storage reservoir or dosing chamber should be of sufficient capacity to cover a single filter unit to a depth of about 3 inches, and this quantity should be applied within an hour.

The soil available for irrigation at the Washington cannery is capable of absorbing, without the use of underdrainage, the wastes from the factory at a very high rate during the three to six weeks of the canning season. By dosing one of a group of four beds every fourth day, a quantity of approximately 80,000 gallons per acre per day, based on the entire area, may be applied under most favorable conditions. For actual working conditions, however, it is believed inadvisable to figure on a rate of application of more than half this amount, or 40,000 gallons per acre per day. The wastes applied in this manner will be absorbed in a period of about 12 hours and during this period no objectionable putrefactive action on the surface of the beds is likely to occur. The beds will dry out with sufficient rapidity, so that they may be cultivated upon the second or third day, thus placing them in readiness for the application of another dosing on the fourth day. The cultivation of the beds is an important feature in securing success, and this cultivation can best be carried out by harrowing with the addition of such hand labor as is necessary to keep the beds level.

The experiments on the treatment of wastes on contact beds and on intermittent sand filters was of too short duration to give reliable results. In a general way, however, the use of contact beds does not appear promising, whereas sand beds may be used to great advantage where sand is available in sufficient quantity and at sufficiently low cost.

The problem of the disposal of the waste at the cannery at Washington has been adequately solved by the use of broad irrigation beds, as described, and it is quite probable that favorable conditions can be found at other canneries in the state of Illinois. On the other hand such methods must be regarded as of special applicability dependent upon the availablity of suitable soil, and it must be emphasized that no specific problem of cannery waste can be properly solved without taking due cognizance of local conditions.

PRELIMINARY REPORT ON PROPOSED IMPROVED SEWAGE DISPOSAL FOR GENESEO*

Geneseo was visited October 31, 1912, with reference to inadequate final disposal of sewage. As the experience of Geneseo is more or less typical of many of the smaller communities of the state, the report based on the above visit is given in full as follows:

PRESENT SEWERAGE CONDITIONS IN GENESEO.

The existing sewers in Geneseo have been installed from time to time as needed, and some of the sewers at present in use are over 20 years old. The construction has been more or less haphazard, and not in line with any well conceived general plan. In 1896, however, Mr. W. F. Ewing of Chicago was engaged to plan a system of sewers to cover the entire town and replace the inadequate sewers then in existence. Mr. Ewing recommended the combined system, that is to say, a system in which storm water and house sewage is carried in the same conduits. He proposed to intercept the dry weather flow and convey it to a suitable point where it could be purified or disposed of inoffensively by dilution. The storm water flow, however, was to be permitted to discharge directly into Geneseo creek. The quantity of sewage which he proposed to intercept was not specifically mentioned, but judging from the design of the intercepting chambers, the intercepted sewage would probably represent 5 or 6 times the domestic sewage flow.

The plans of Mr. Ewing were carried out only in part. Some of the sewers shown on these plans were constructed and others were not. A number were constructed in accordance with specifications and some were not. At any rate, it appears that the present sewers are somewhat in disrepair and are not capable of satisfactorily meeting the needs of the town. The intercepting sewer proposed has been only partially built and carries the sewage to a point just above the Rock Island railroad bridge, whereas the original plans contemplated carrying the outfall to a point well below the built up portion of the city. In addition to the outfall of the intercepting sewer which constitutes the main outlet of the city, there are 4 or 5 minor outfalls in the southern part of the city discharging into Geneseo creek. Owing to the fact that Geneseo creek has at times practically no flow, it becomes highly polluted and a decided nuisance to all persons residing

*Report by Paul Hansen, Engineer.

within a distance of 1,000 feet or so of the stream's course. In addition to the nuisance caused by odors, the stream is rendered unfit for cattle watering, a use to which it would normally be placed throughout the three miles of its course from Geneseo to its confluence with Green river.

The sewage disposal problem at Geneseo is complicated by the fact that in addition to ordinary domestic sewage, the creek receives the wastes from a corn and pea canning factory, a creamery and a gas works. The domestic sewage flow would probably not exceed at the present time 100,000 gallons per day, and in all probability not more than one-third of the population, that is to say about 1,000, contribute to the city's sewage. The cannery wastes on the other hand are large in quantity, contain very much more putrescible matter than does the sewage and moreover the bulk of this waste is produced at a time of the year when the stream contains the least natural flow. Basing an opinion upon conditions existing elsewhere, it is estimated that the flow of wastes from the cannery amount to about 50,000 gallons per 24 hours, and are at least five times as strong in organic matter as the city's sewage. Putrefactive decomposition of cannery wastes is to most persons even more disagreeable than that of sewage. The same remarks will apply to the creamery wastes, though these wastes will probably not exceed 500 gallons per day. The creamery wastes alone would not be a serious factor in connection with the handling of the sewage, for when creamery wastes are mixed with sewage, they are readily amenable to methods of sewage treatment. The gas house wastes are primarily objectionable, because of the unsightly oily film which they form upon the surface of the water in the stream. The most objectionable gas house wastes can be readily kept out of the sewers without undue expense to the gas works and this should be done, for gas wastes interfere with any form of final disposal of the sewage that may be adopted.

From time to time, especially during the past few years, vigorous complaints have been made relative to the condition of the stream, and damage and injunction suits have been threatened. The city authorities now recognize the necessity of remedying conditions and propose to attack the problem actively until it is solved.

DETRIMENTAL EFFECTS OF STREAM POLLUTION.

Before taking up a discussion of the various methods for preventing stream pollution, it will be advisable to define some of the effects resulting from excessive stream pollution in order that the objects to be attained by various methods of sewage disposal may be more clearly understood. It is now generally accepted that natural streams should be maintained in clean condition. The term "clean stream" means that the water flowing in the stream must be inoffensive to sight and smell and must, moreover, contain no suspended matters, which will tend to clog the channel or cause foul sludge deposits. A higher degree of purity than this is impracticable for the reason that as the land is more and more completely utilized for the benefits of mankind a certain degree of pollution is inevitable. The soil requires fertilizing, domestic animals must be pastured, from the built up communities there is more or less unpreventable surface drainage of an objectionable character and intermittent pollution caused by malicious or careless persons cannot be entirely prevented. It will, therefore, be seen that a surface stream cannot be maintained in its original and pristine purity, but must receive some contamination, which while not rendering the stream offensive, will still render its waters unfit for human consumption. Surface streams are, of course, often used as sources of public water supply, but in such cases the water must first be purified by methods now well understood. In some rare instances, where purification is not used, the entire watershed is owned, patroled and kept free from inhabitants in order to maintain the water in a pure condition.

Much is said about the danger to public health of a polluted stream and while these dangers exist, their exact character is not generally understood. A polluted stream is of danger to the public health primarily in connection with its possible use as a source of water supply, but as already pointed out, no water supply should be taken from a surface stream unless the water is purified by well established methods. It may happen, however, that a stream is too grossly contaminated to permit of adequate purification for water supply purposes. Just what this maximum degree of contamination is, is a matter which depends largely upon local conditions and must be decided in each case in the light of these local conditions.

Stream pollution may affect public health in certain other ways, more particularly in connection with those streams that are used for recreation purposes. Summer campers along streams are apt to bathe in the stream and use the water for various culinary operations, and in such cases pollution of the water may result in some water borne disease. It is beginning to be recognized at the present time that streams devoted largely to recreation purposes deserve special protection as regards their purity, but even in such cases, absolute sanitary purity of the water cannot possibly be obtained.

In the popular mind, bad odors are most generally associated with injury to health, but this is quite an erroneous notion. It is true that constant subjection to foul odors may cause symptoms of nausea and possibly by a general lowering of the vital resistance may render the body more susceptible to the onset of some specific disease, but odors have no direct effect in causing specific disease any more than do disgusting sights or even sea sickness which also produce nausea. It is not intended to minimize the detrimental effects of bad odors, for these in themselves constitute a sufficiently great evil to warrant the expenditure of large sums for a more satisfactory disposal of sewage or other foul smelling wastes. The statements above made are simply for the purpose of avoiding any unnecessary alarm.

Many complaints of stream pollution are based upon alleged infection of cattle by drinking water. Undoubtedly a highly polluted liquid, more particularly sewage, may contain certain poisons or disease germs that will cause cattle to sicken and even die, but fortunately cattle are not subject to the diseases which are so commonly carried to human beings by sewage infected water. There are a few well authenticated instances of cattle being poisoned by drinking from grossly polluted streams, but after all there is very little evidence to show that there is any wide-spread detrimental effect to cattle from this cause. Many inquiries regarding the effect of polluted streams upon cattle have been made, but few instances have been found where this influence is deemed to be serious. At any rate it must be recognized that a visibly contaminated stream is not a satisfactory source of drinking water for cattle, and cattle owners have a reasonable right in demanding a clean stream. Some would maintain that cattle should be supplied with water that is equal to that which is ordinarily demanded for human beings. If such is the case, it would mean that all cattle owners must prevent their cattle drinking in surface streams for the reason, as already outlined, that some pollution of surface streams is inevitable.

POSSIBLE METHODS OF REMEDYING EXISTING CONDITIONS.

Having reviewed the present conditions with respect to sewage disposal in Geneseo, and having outlined what may reasonably be demanded in maintaining streams in a clean condition, it will now be possible to take up the methods whereby local conditions may be remedied. Sewage disposal may be accomplished satisfactorily in two ways broadly speaking, namely, by dilution and by means of sewage treatment.

Disposal by Dilution: Disposal by dilution may be accomplished when there is present in the diluting water a sufficient quantity of oxygen to permit of the decomposition of sewage under aerobic conditions. This simply means that there must always be an excess of oxygen, for as soon as the oxygen in a liquid containing decomposable matter is completely exhausted, the decomposition becomes anaerobic and productive of foul odors. With surface streams in a normal degree of purity the dilution required is about 4 cu. ft. per second per 1,000 persons tributary to the sewers, provided the character of the sewage is not modified by the presence of other than domestic wastes. In Geneseo, sewage is decidedly modified by the presence of industrial wastes, and this is a factor that must be carefully considered in connection with possible disposal by dilution. Reliable data as to the quantity of diluting water required by cannery wastes and creamery wastes are not now available, and before the problem at Geneseo can be intelligently solved, this data must be obtained.

In Geneseo disposal by dilution, of course, has reference to the disposal of the sewage from the city into Green river. This would involve the construction of a long outfall sewer sufficiently large to take the domestic wastes only. It will be perfectly permissible to discharge into Geneseo creek all storm water. In addition to the construction of the outfall sewer, it may be necessary to construct sedimentation tanks for the purpose of removing the coarser solid matters from the sewage and thus prevent the deposition of sludge which may obstruct the channel of the stream and develop a nuisance through its decomposition. The cost of such a project as this cannot be estimated until there are available complete surveys, but it probably will not exceed $20,000. In any event, it will prove much cheaper than sewage treatment.

Disposal by Treatment: There are various methods of sewage treatment, and the selection of the method to be used must depend very largely upon local conditions and local requirements. To give some understanding as to the character of these methods, it may be well to outline briefly certain methods of sewage treatment now in use. In order that these may be more clearly described, they will be taken up in the order in which they were developed.

Sewage Farming: The first method of sewage treatment to be used upon a large scale was application of sewage to farm land. This is commonly known as sewage farming or broad irrigation. Sewage farming would at first seem to be the ideal method since it suggests the complete utilization of human wastes, and it was undoubtedly this idea that popularized this method of sewage disposal in European practice. The cities of Paris, France, Berlin, Germany, and others of lesser importance developed great sewage farms upon which all of the sewage from these cities was conveyed and disposed of. The objections to this method may be realized when it is known that the sewage from only about 100 persons can be disposed of on an acre of land without water-logging the land, and that for Paris the area of the sewage farms is somewhat over twice the area of the city. Again, to deliver the sewage at the required points, demands long and expensive conduits and large and powerful pumping stations. Furthermore, sewage farming cannot be successfully carried out, unless it is conducted along the most scientific lines and by a carefully trained corps of men. In Europe the rainfall is much more evenly distributed through the year and amounts to only about one-half of the precipitation in our eastern states, which conditions have made it possible to conduct sewage farming with some degree of success, but it is interesting to note that in the more recent reports of the sewerage engineers of the city of Berlin, sewage farming has been pronounced uneconomical and they have recommended in favor of the more modern methods of sewage treatment which do not aim at sewage utilization. Perhaps the uneconomical side of sewage farming may be better appreciated when it is indicated that only one part per 1,000 by weight of sewage is organic matter and the constitutents in a ton of sewage that have manurial value are worth about 2 cents.

Intermittent Sand Filters: In the latter 80's the objectionable contamination of streams in Massachusetts became so great that the Massachusetts State Board of Health turned its attention to developing methods of sewage purification, and to this end there was established an experiment station at Lawrence. As a result of the experiments conducted at Lawrence, the successful operation of so-called intermittent sand filters was worked out and this type of sewage purification proved to be a very successful one under conditions obtaining in Massachusetts. An intermittent sand filter consists merely of a level bed of sand with a minimum thickness of about 3 feet, suitably underdrained and provided with means for discharging the sewage upon its surface. The mode of operation is to apply a dose of sewage having a maximum depth of about 3 inches once or twice per day. The effective agents in purifying the sewage are microscopic organisms, principally bacteria, which take up residence in the interstices of the sand grains mainly within the upper few inches. These organisms which feed upon the complex organic compounds contained in the sewage reduce these compounds in their life processes to a simpler and simpler character until finally they are completely mineralized and appear in the effluent in the form of nitrates. If the bed is in successful operation, the effluent produced is clear, odorless and colorless and gives a good analysis upon both chemical and bacterial examination. In some cases the degree of purity is so great that the effluent may be drunk with impunity. Whereas the sewage of a population of only 100 can be treated upon an acre of sewage farm land the sewage from a population of 1,000 to 1,500 may be treated upon an acre of intermittent sand filters.

Intermittent sand filters are especially economical to build when there is found suitable material such as sandy or gravelly deposits, and in Massachusetts and New England generally these deposits are very often available. In the middle west, however, sandy and gravelly deposits suitable for intermittent filtration are very rare, and hence, the cost of this form of treatment is very great, and in many instances, prohibitive. Intermittent sand filtration has still another disadvantage, especially for large communities, namely, that the area required is often so great as to render the process impracticable.

Contact Beds: In an effort to secure more concentrated methods of sewage treatment, there was developed in England what is known as the contact bed. A contact bed is a shallow, water-tight basin, filled with a coarse material such as broken stone, broken brick, cinders, etc. This device is provided with inlet and outlet arrangements whereby the sewage may be admitted into the basin until the interstices of the contact material are completely filled. The sewage is then permitted to stand in contact (hence the name), for a period of time and is finally drawn off. The action which takes place in a contact bed is precisely similar to that which takes place in an intermittent sand filter, that is to say, it is biological in character.

The contact bed has the advantage over the intermittent sand filter bed in that the bacterial activity takes place throughout the material composing the bed, whereas in intermittent sand filters it takes place mostly at the surface. For this reason it is possible with a contact bed 5 feet in thickness to apply a population load of about 5,000 to 7,000 persons per acre, as against 1,000 to 1,500 persons per acre possible with intermittent sand filtration. Though contact beds are more costly to construct per unit of area, yet under ordinary circumstances, especially where all materials must be transported, the cost of contact beds is materially cheaper than intermittent sand filters for treating the same quantity of sewage.

Contact beds have another advantage in that they can be so operated as to prevent the appearance of sewage above the surface of the contact material and hence they are especially applicable where it is desirable to minimize odors in the immediate vicinity of the plant. From this it should not be understood that sewage purification plants are necessarily a nuisance in their neighborhood, though it must be admitted that intermittent sand filters, even when well designed and operated, may produce objectionable odors within a distance of 200 to 500 feet of the filter beds.

The effluent from contact beds is not of as high a grade as that produced by intermittent sand filters. It is likely to be dark colored and somewhat turbid, but if the beds are properly designed and properly operated, it should be stable, that is to say, it will not undergo any further offensive putrefaction.

Sprinkling Filters: Even contact beds proved to be quite expensive as to space and material required, and renewed effort was made to secure more intensive treatment. As a result of these efforts there was developed the so-called sprinkling filter. This device consists of a bed of coarse material very similar to that used in contact beds, but with a minimum thickness of 5 ft. Preferably they should have a minimum thickness of 6 feet. These beds are thoroughly underdrained and provided at the surface with nozzles or other sprinkling devices. The sprinkling system must be carefully designed, so that the same quantity of sewage will be applied to every square foot of area. This device, unlike the intermittent sand filters and the contact beds, can be operated continuously for the reason that the slow percolation of the sewage through the mass of material permits of aeration and contact at the same time. With sprinkling filters, the sewage from a population of anywhere from 10,000 to 20,000 persons can be treated upon an acre of area, as against 5,000 to 7,000 per acre with contact beds. These filters produce an effluent that is very much like that produced by contact beds, though it is apt to contain somewhat more suspended matter, to remove which the sprinkling filter process is generally followed by sedimentation of the effluent for a period of about two hours.

The cost of sprinkling filters, for a given quantity of sewage, is undoubtedly less than the cost of any other sewage treatment device, provided it is desired merely to obtain a non-putrescible effluent, but it has certain disadvantages, particularly in small communities. The first disadvantage is that the application of the sewage on to the surface of the beds causes considerable odor to be produced in the neighborhood of the plant and under certain conditions this odor may be carried for distances of a quarter of a mile or more. The odor nuisance can be overcome by covering the beds with a superstructure, but this adds materially to the expense, and is otherwise somewhat of a disadvantage. Furthermore the sprinkling filters are rather complex in their design and operation, and for best success should be under the supervision of a technically trained man. For the small community this is, of course, out of the question, but perfectly feasible in cities of considerable size.

Preparatory Treatment: Sedimentation: Along with the development of the treatment devices above outlined, there has been a material development in the so-called preparatory processes. These comprise the removal of grit in grit chambers, the removal of floating materials by screening and the removal of suspended matter in sedimentation tanks. As sedimentation is the most important of these, it alone will be dealt with. It was soon found that sedimentation of sewage, even for a short period, rendered it materially more amenable to treatment by filtration beds or contact beds. On the other hand, it introduced a serious sludge problem. The difficulty of adequately disposing of sludge has been regarded as a paramount problem in connection with sewage disposal for the last fifteen years.

About 1898, there was developed in England a so-called septic tank which was hailed in Europe as the solution of the so-called sludge problem. This tank was diffierent in no essential from an ordinary tank, except that it was provided with a much longer period of retention than had been customary in plain sedimentation tanks. The period of retention varied in the early septic tanks, anywhere from 12 to 48 hours. It was found that the sludge in the bottom of these tanks was materially reduced in volume, often amounting to only one-third of the original volume. Investigation indicated that this reduction in volume was due to a disintegration and liquification of a large amount of the solids by bacterial activity. Somehow or other the name "septic tank" secured a tremendous hold upon the popular imagination, and by many laymen treatment in septic tanks has been regarded as a complete method of purification. As a matter of fact it never has been a complete method of purification, and was never so regarded by its originators.

As experience with septic tanks became more and more extended, it was recognized that these tanks had certain serious defects. In the first place, it was found that with many sewages the effluent was extremely odoriferous and was so depleted in its oxygen content that it could not be properly treated upon filtration devices or in contact beds. Again, complications arose due to the violent fermentation which takes place in septic tanks, especially during hot summer weather. When this fermentation occurs, the sludge deposited upon the bottom is thrown up by gas bubbles and passes out with the effluent so that in many instances it has been found that the effluent contained materially more suspended matter than the influent.

Material improvement upon the septic tank has been effected within the last few years by the development in the Emscher drainage district in Germany of what is known as the Emscher tank. This is a two-story tank, having a sedimentation chamber in the upper story and a digestion chamber in the lower story. The period of sedimentation is short and the sewage is kept separate from the digesting sludge, so that as it emerges from the tank it is in a fresh condition (that is, contains dissolved oxygen) and is thus much more readily amenable to treatment on filter beds, and is also more suitable for direct discharge into a water course in case disposal by dilution is made use of. The sludge digestion chamber retains all the advantages of the septic tank and seems to eliminate all of the disadvantages. It is probable, if in Geneseo disposal by dilution is decided upon, that this form of tank will be most suitable for a preliminary treatment to prevent the accumulation of the sludge deposits in the bed of the stream.

SEWAGE TREATMENT AS APPLIED TO GENESEO.

If a sewage treatment plant is to be built at Geneseo in an economical manner, it will be necessary to secure a fairly complete separation of domestic sewage and industrial wastes on the one hand from storm water and surface drainage on the other. To do this would mean a rather thorough remodeling of the existing sewerage system. How much of a burden this would place upon the community cannot be stated definitely at the present time. To determine this factor, careful estimates of cost should be made on the basis of a thorough examination of the existing sewerage system, coupled with studies for its conversion into a system on the separate plan.

A suitable site for purification works can undoubtedly be found at a point not very far distant from the city, perhaps one-half mile, in a downstream direction from the built-up portion of the community. While no surveys are available upon which to base a definite statement, yet it is believed that the natural fall is sufficient to make it possible to reach sewage treatment works by gravity. The type of treatment works to be adopted can only be determined after complete estimates of cost have been made, but other things permitting, decided preference should be given to intermittent sand filters. It would be futile to hazard an estimate of cost with the data at hand, but there can be no doubt but that sewage treatment will prove very much more costly than disposal by dilution.

Method of Procedure for Securing the Desired Improvements: The foregoing rather lengthy recital should demonstrate first of all that the sewage disposal problem now before the city of Geneseo is a very complex one and will involve the expenditure of large sums of money. In the light of these facts it is essential that the situation be exhaustively studied and that while improvements should be installed with all reasonable dispatch, yet there must be allowed a considerable time for the obtaining of the necessary data.

The most important data to be obtained relate to the dry-weather flow of the Green river, and this unfortunately will not be obtainable until the next dry period, which is not apt to occur until the latter part of the coming summer. However, it is proposed to watch the river closely and should an unusually low flow occur during the coming winter, stream gagings will be made by the State Water Survey.

It Will also be necessary to obtain further data regarding the character and amenability to treatment of the wastes from the cannery, and this is another point that cannot be ascertained until the next operating season, which will not occur until September of next year.

About the only thing that can be done in the meantime is to have studies made of the existing sewerage system with a view to obtaining reliable estimates of cost for their conversion into a system on the separate plan. No matter what form of final disposal of the sewage is adopted, it would be decidedly advantageous to have the putrescible wastes and storm water carried in separate conduits. If disposal must be effected by treating the sewage, then this conversion must be largely accomplished at once. If the final disposal be by dilution, the conversion may take place gradually.

To make the above outlined studies relative to the sewerage system, there should be employed a competent consulting engineer, well versed in sewerage and sewage disposal matters. This engineer should also be retained to prepare plans for sewage treatment works should such be decided upon, or plans for an outfall sewer into Green river, together with such settling tanks as are necessary for partial treatment, should disposal by dilution prove the more satisfactory.

The State Water Survey will be prepared (1) to make stream measurements as already indicated, (2) to make further studies on the treatment of the wastes from the cannery, the creamery and the gas factory, (3) to co-operate with the engineer locally employed, so far as this may be accomplished by conferences, and (4) to review and report upon the final plans.

A STUDY OF TYPHOID FEVER IN ROCKFORD, ILLINOIS, IN THE LATE SUMMER AND FALL OF 1913*

ORGANIZATION OF WORK AND ACKNOWLEDGMENTS.

During the months of July, August, September and October, 1913, an unusually large number of cases of typhoid fever developed in Rockford, Illinois. With the memory of a serious water-borne epidemic that occurred in the early part of 1912 freshly in mind, the local authorities were alarmed and called upon the State Board of Health to make an investigation. Dr. C. E. Crawford, chief inspector of the State Board of Health, was directed by his board to make full inquiry into the matter, and to call on such other state bureaus as might be of assistance. To this end the State Water Survey was invited to assist in the investigation and was represented by Mr. Paul Hansen, engineer. At a later date Mr. H. N. Parker of the Department of Dairy Bacteriology of the University of Illinois was called in to give special assistance. Dr. W. E. Park, health commissioner of Rockford, because of his intimate knowledge of local conditions and his previous valuable inquiries relative to the prevalence of typhoid fever, was also invited to participate in this investigation and become one of the signatories to this report. H. F. Ferguson, assistant engineer of the State Water Survey, was on the ground most of the time and rendered important assistance in the investigation of cases and the preparation of diagrams.

Special work of an analytical character was performed by the State Food Inspection Bureau, this department being represented by Dr. C. E. Gable and J. F. Johnston.

Most valuable assistance was rendered by the city through various officials. Special recognition and thanks are due Mr. G. G. Crane, superintendent of water works. The investigators are also greatly indebted to Miss Violet Jensen and Miss Peterson of the Visiting Nurses' Association for the collection of detailed information concerning a number of cases.

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*Joint report by C. E. Crawford, M. D., Chief Inspector Illinois State Board of Health; Paul Hansen, Engineer Illinois State Water Survey; H. N. Parker, Dairy Bacteriologist, University of Illinois; and W. E. Park, M. D., Health Commissioner of Rockford.

RESULTS OF INVESTIGATION IN BRIEF.

For convenience, the results of the investigations, divided into conclusions and recommendations, are first stated briefly. A more extended treatment, embodying all the important facts and a full discussion of the methods used in conducting the investigation, is contained in the main report which follows.

1. No single source of infection was responsible for the outbreak; there were found various sources active separately and in conjunction; some were responsible for but few cases, while others gave rise to groups of large size.

2. The most formidable group, comprising some 95 cases, probably resulted from a single case, namely, an employe at the Briggs bakery. Through him a number of persons were infected by contaminated bread or pastry or both, and from one or more of these persons the Smith, Darrow and Union dairy routes were infected. The principal medium for conveying the infection was contaminated milk bottles, though other causes of a more or less obscure character were operative. The studies made of this group contribute very interesting and instructive data to the epidemiology of typhoid fever, which should be of much assistance to the health department, and these data have been made a basis for a number of the recommendations which follow.

It is but justice to state that the above mentioned dealers maintain in their establishments what is generally regarded as good, and in the case of the Union dairy even excellent, sanitary conditions, but the results demonstrate that personal error or individual carelessness must always be guarded against. It may safely be stated that at the present time the danger of infection at the bakery and the Union dairy is passed.

3. The public water supply has not been responsible for the recent outbreak of typhoid. In fact, the public water supply as now furnished to the consumers is of exceptionally good quality from a sanitary standpoint. Certain defects do exist in the water works system, however, which should be remedied at the earliest practicable date along the lines itemized under "recommendations."

4. One outbreak of typhoid of a minor character resulted from a social gathering at which food was infected under conditions that suggest a typhoid carrier.

5. As many of the cases were infected in the summer season, it is not surprising that the investigation showed a marked number of cases among vacationists and persons who bathed, fished and went boating in neighboring polluted streams.

6. There were a number of cases of obscure origin, characteristic of summer and autumnal typhoid which in the future may be largely avoided if fly infection, privies, shallow wells and various unsanitary conditions are remedied.

7. But few contact cases were discovered, a very favorable commentary on current practice among local physicians in securing the disinfection of typhoid discharges.

RECOMMENDATIONS.

In view of the various findings described in detail in the succeeding report and outlined in brief in the preceding conclusions, the following recommendations are made:

1. The appropriations of the health department should be increased to permit the employment of trained technical men to serve as inspectors of dairies, bakeries, restaurants, markets, soda fountains, etc.

2. An ordinance should be passed and enforced prohibiting the collection and use of milk bottles belonging to one dairy by another dairy, and all dairies selling milk in Rockford should be required to have their bottles marked in a distinctive manner.

3. All dairies should be required to have effective means for regularly sterilizing milk bottles and other milk containers.

4. The health department should report promptly to dairymen the existence of all cases of communicable disease.

5. All connections between the public water supply mains and factory fire protection systems should be abandoned at the earliest date consistent with securing an adequate substitute independent of the public supply mains.

6. The Peach street wells, constituting a portion of the public supply, should be permanently abandoned or adequately protected against contamination by specially constructed casings. It is questionable, however, if the expenditures necessary to protect the wells are warranted because of the limited yield of these wells. The use of Peach street well No. 3 may be continued for the present, provided it is kept, as now, under close analytical observation.

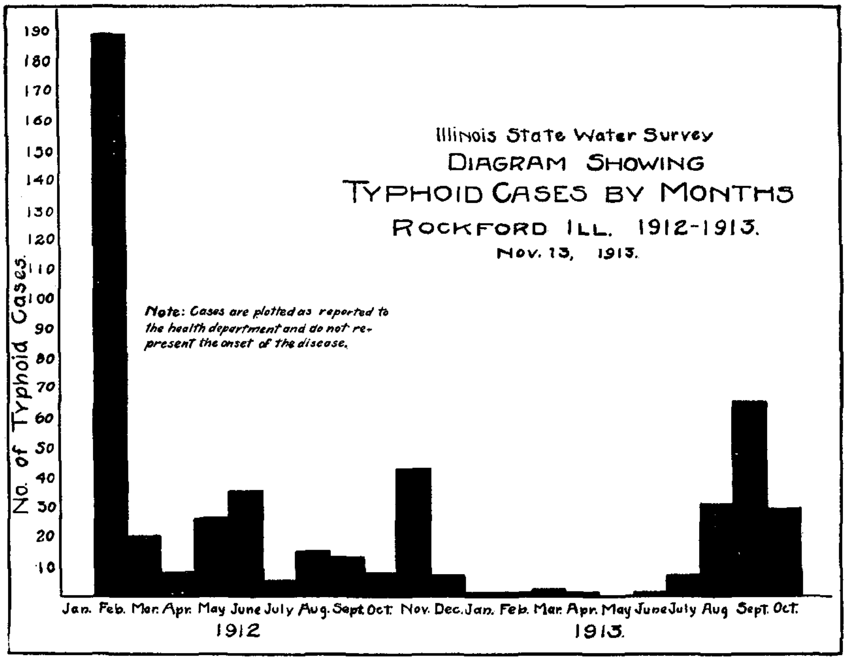
7. The sewer from closets on property adjacent to the old reservoir, while of very remote danger to the water supply, should be removed and replaced by a new connection discharging into the Park avenue sewer.

8. The installation and continued use of yard hydrants should be discouraged because the drain opening provided on these hydrants for frost protection permits polluted water from near the ground surface to be siphoned into the delivery pipe.

9. A comprehensive engineering study should be made of the Rockford sewers, with a view to a rapid extension of the system to all parts of the city in conformity with a consistent plan which takes cognizance of future needs and which will permit the early and economical conveyance of all putrescible liquid wastes to a suitable point or points where they may be adequately purified so that

Rock river and neighboring streams may be preserved in a reasonably clean condition.

10. For the study of future typhoid fever occurring in Rockford, the attached information blanks should be used by the health department. The short blank, to be printed on postcards, is for physicians to fill out and the long blank, which may be printed on 5x8-inch index cards, is to be filled out by a trained representative of the health department. By obtaining promptly the detailed information



Diag. I.—Typhoid Cases by Months, Rockford.

called for, it is believed that outbreaks can be prevented or checked in their incipiency. A similar method of inquiry may be used profitably in connection with other transmissible diseases.

REPORT IN DETAIL.

MONTHLY DISTRIBUTION.

From the beginning of 1913 up to the time of the investigation herein described, there occurred 165 cases, all but 9 of which occurred after July 1. The occurrence of these cases by months is shown graphically on Diagram I. There is also shown on this diagram the occurrence of cases during the year 1912, a glance at which shows the enormous preponderance of cases during the epidemic of February, which was unmistakably traceable to the contamination of the public water supply. The persistence of typhoid following the February epidemic suggests the seeding of the community with typhoid infection, resulting in various contact infections and numerous local outbreaks. With the exception of a marked rise in November, 1912 (to be referred to later), the decline in typhoid fever continues more or less steadily until May, 1913, the first month following the great epidemic when no cases were reported. In July, 1913, the occurrence of 11 cases caused some uneasiness, and when this was followed by 51 cases in August and 59 cases in September, there developed a feeling of general alarm.

MAGNITUDE OF OUTBREAK.

During the first ten months of 1913 there were 165 cases, but judging from present tendencies, there will be a total of about 175 by the end of the present year. Of the cases that occurred up to date 11 have died and there is a probability that there will be a few additional deaths. The case rate for the year may be estimated at about 350 per 100,000 population and the death rate will be possibly 26 to 30 per 100,000 population. But a few years ago these rates would not have been considered excessive, and many cities with polluted water supplies were carrying a death rate from typhoid of 50 and over per 100,000 population per annum with entire complacency.

Thanks to popular interest in public sanitation, greater activity on the part of public health officials and the installation of improved water supplies and other sanitary engineering works, the death rate from typhoid has been greatly reduced in our cities and at the present time a death rate of 20 per 100,000 population is regarded as unnecessarily high. The more progressive cities now aspire to keep, and actually do keep, the rate below 10. In this respect the cities have surpassed the country, for the rural death rate for the country at large is still in the neighborhood of 20 per 100,000.

From the foregoing remarks it will be understood that Rockford is not a typhoid-ridden town, yet there has been during the past three months far more typhoid than present standards warrant, and this is all the more inexcusable for a city having a public water supply of absolute sanitary purity at it source.

It is interesting to note at this point that Dr. E. O. Jordan* referred during his investigation of February, 1912, to the probability of a general increase in the typhoid of the city and predicted outbreaks such as that which has just occurred.

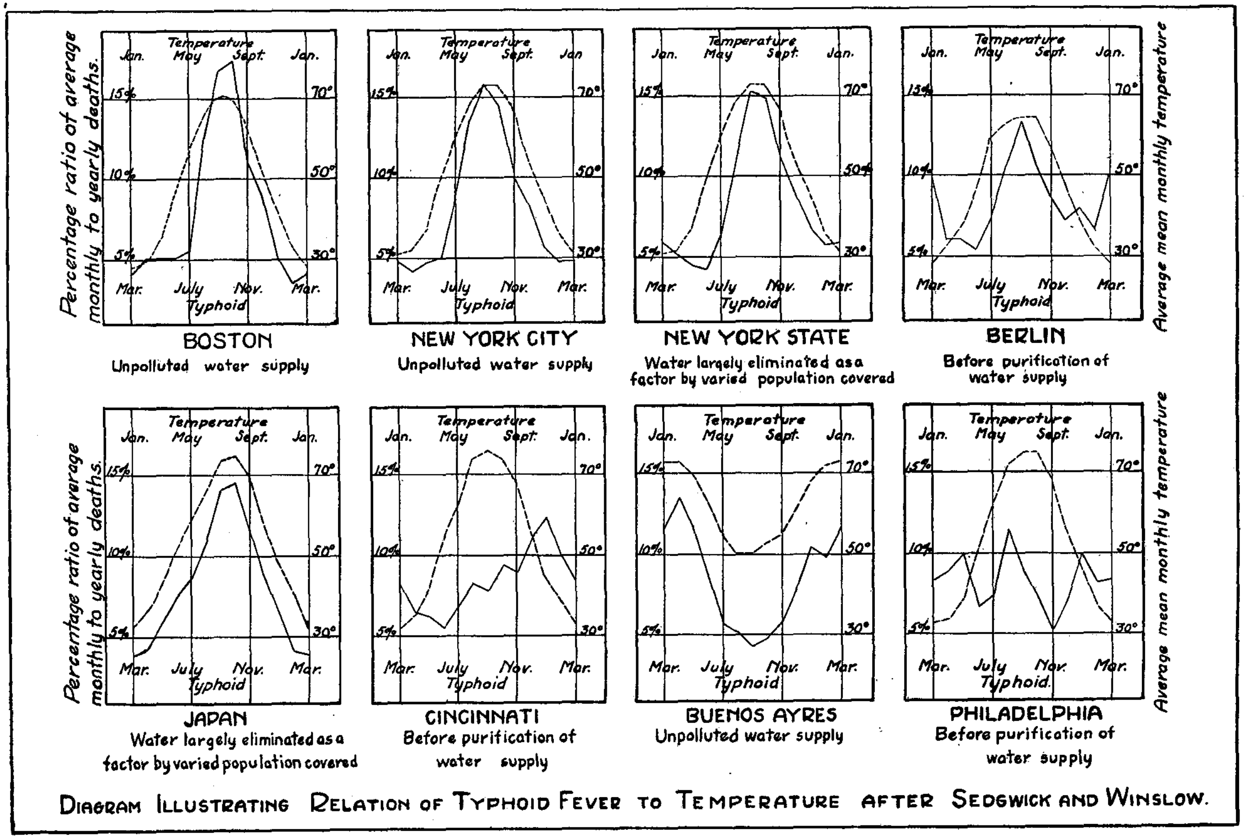
*J. Infectious Diseases, 11, 21-43.

RELATION OF TYPHOID TO TEMPERATURE.

Before proceeding to a detailed consideration of the incidence of the disease, certain broad observations may be made upon the distribution of the disease with reference to temperature conditions. As a result of the study of a large amount of statistical data, Sedgwick and Winslow have shown that so-called endemic, or, as they prefer to call it, prosodemic, typhoid follows closely the rise and fall of mean monthly temperatures. This may be considered the normal distribution of the disease and may be explained in part at least by the prolonged life and virulence of the typhoid organisms outside the human system under high temperature conditions, by the increased activity of flies and possibly other insect carriers of the disease and by the greater exposure of individuals to the disease during the summer vacation and outing season. Sedgwick and Winslow made numerous diagrams of typhoid deaths for various cities and countries where normal typhoid conditions prevail. These diagrams exhibit a striking coincidence of mean monthly temperature and the monthly typhoid death rates. In order to secure this coincidence, however, it was necessary to plot the typhoid deaths about two months before they occurred, thus allowing for the average periods of incubation and sickness before death.

In those places where normal typhoid did not prevail, in other words, where there occurred *epidemics* due to any cause, more particularly to polluted water supplies, the typhoid curves departed in a most marked manner from the temperature curve. This departure was very characteristic for those cities in the temperate zone having polluted water supplies drawn from surface streams. These diagrams show spring and autumn peaks in the typhoid curve corresponding to the spring and autumn floods in the streams. A few examples are shown on Diagram II.

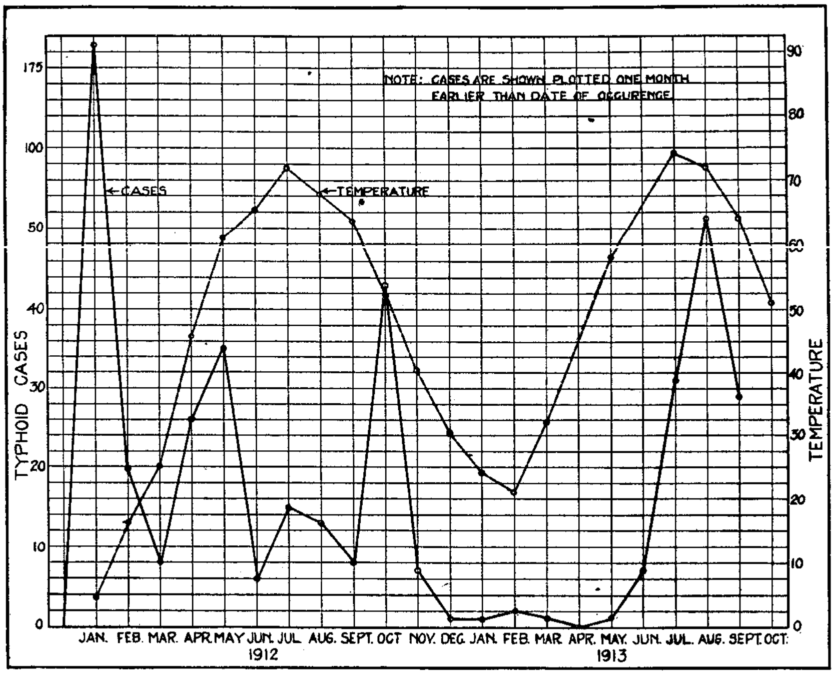
For the purpose of analyzing the occurrence of typhoid fever in Rockford in the light of the above deductions, Diagram III has been prepared, showing the monthly variations in temperature and the cases of disease that developed during each month. From this diagram it will appear that the distribution of the disease during 1912 was very far from the normal, while in 1913 it roughly approximates the normal. On the other hand, there is nothing to prevent an epidemic of typhoid occurring at a time when the prosodemic typhoid is at a maximum, and to determine this it will be necessary to make a more detailed study of the disease, case by case. A point to be emphasized, however, is that the occurrence of the disease during 1913 would at any rate lead one to expect a number of cases of miscellaneous and obscure origin that cannot be definitely explained. As a matter of fact, this is precisely the condition encountered; some marked epidemics have been discovered, but there remains a large number of cases of such miscellaneous and obscure origin as to make



Diag. II.—Relation of Typhoid Fever to Temperature After Sedgwick and Winslow.

it virtually impossible to obtain the data that will definitely fix the cause and mode of infection in each case.

Because of the obscurities and complexities indicated, the prevalence of typhoid during the late summer and fall of 1913 is very much more difficult to study than was the epidemic of February, 1912. That lamentable outbreak was due to a single cause, namely, the public water supply, acting over a period of but a few days, while

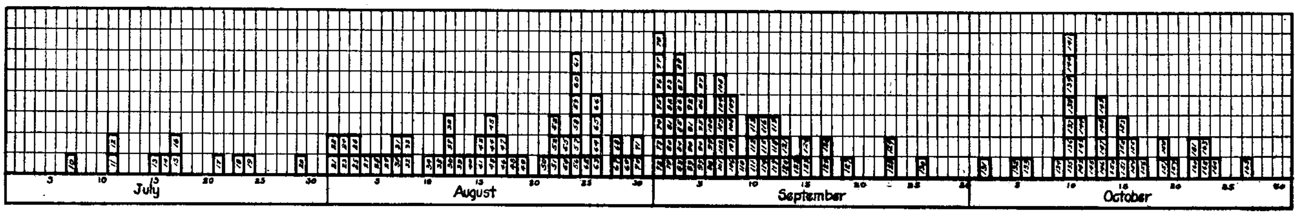


Diag. III.—Relation Between Temperature and Seasonal Distribution of Typhoid Fever at Rockford.

the more recent rise in typhoid was, as will be shown, due to many causes, only a few of which were sufficiently general in their influence to create an epidemic.

DAILY DISTRIRUTION OF TYPHOID.

Diagram IV shows the occurrence of typhoid cases day by day during the months of July, August, September and October, 1913. On the diagram each case is represented by a small rectangle placed according to the date on which the patient went to bed, as closely as it was practicable to ascertain this date. The figures placed within



Diag. IV.—Chronological Distribution of Typhoid Cases at Rockford.

the rectangles are the numbers of the cases used for convenience in the studies that were made.

One hundred and sixty-five cases occurred from January 1 to November 1, 1913, with a great preponderance during August and the first two and a half weeks in September. There is also a marked rise during the middle part of October. The configuration of the diagram suggests the activity of some cause or causes beginning early in July and continuing with increased effect until the beginning of the last week in August and then subsiding rather rapidly during the two weeks following. The cases, of course, do not appear coincident with the time of infection, for the disease does not manifest itself until eight days to about three weeks have elapsed. A new period of infection Starts apparently during the last week in September and remains active for a very few days. But little more than the above can be deduced from Diagram IV as it stands, but by splitting it up into groups it will be possible to secure some more illuminating evidence as to the cause or causes of the disease. Before undertaking this, however, it will be advisable to take up certain other general considerations.

GEOGRAPHICAL DISTRIBUTION OF TYPHOID.

Diagram VI is a map of the city, showing by means of dots the residence of each of the cases of typhoid. The small number accompanying each dot is the case number and corresponds to the numbers found in the small rectangles on Diagram IV. Other features are also shown on the map, including dairies, water mains, and connections between mains and factory fire-fighting systems.

An examination of the map shows that the cases have a tendency to concentrate in the northwestern part of the city, which includes a medium to high-class residential district, located for the most part on high ground. Throughout the remainder of the built-up portion of the city there is a scattering of cases without any well-defined tendency toward concentration, though a slight increase in the density of spots is observable in the east and southeast sections of the city.

The deduction that may be made from the above is, first, that there has been some source, or sources, of infection generally active throughout the city, and, secondly, that there has been some other source, or sources, active throughout limited areas. As the cases that are distributed throughout the city are scattered and comparatively few in number, one may assume that the sources of infection were but mildly active, but in the northwest part of the city there is evidence of very marked activity.

With reference to those cases that seem to be scattered over the entire city with a fair degree of uniformity, two explanations are ordinarily sought, namely, infection by the public water supply or infection by those miscellaneous sources which are active during the summer months. These latter include among others, visits to typhoid infested cities or country districts, bathing, fishing and boating in polluted bodies of water, infection by flies and personal contact with persons having the disease or who are typhoid carriers. Should cases be spread throughout the city when prosodemic typhoid is not active, then it is most likely to be attributable to the public water supply. When, however, the prevalence occurs in late summer or the fall, then much circumspection must be exercised before condemning the public water supply.

These cases which are concentrated in parts of the city may be regarded as of local origin, and in seeking an explanation inquiry should be made into the source of milk supply, polluted wells, social gatherings, food supplies, especially bakers' goods and foods eaten raw. There are also many other possibilities which may suggest themselves in the course of a thorough investigation. Among such in the city of Rockford are connections between the public water supply mains and factory fire-fighting systems, which are also fed by polluted water from Rock river and from cisterns. From the general map or Diagram IV, but little evidence is obtained upon these points and a closer analysis of the data becomes necessary.

DISTRIBUTION OF TYPHOID ACCORDING TO AGE AND SEX.

Sometimes a consideration of the distribution of typhoid cases according to age and sex is suggestive of lines of inquiry, and such a distribution is presented in Table I.

TABLE I.

Sex	Age								Totals	
	0-9	10-19	20-29	30-39	40-49	50-59	60 and above	Not Noted		
Male..........	6	28	31	17	7	8	3	4	104	64%
Female........	5	11	19	11	5	5	1	4	61	36%
Total....	11	39	50	28	12	13	4	8	165	100%

As is frequently the case, the number of males exceeds the females, and the greatest number of cases occurs among those between the ages of ten and forty years. The excess of males is ascribed to their greater activity and hence their greater exposure to infection. The preponderance of cases between the ages of ten and forty is due in part to the large number of persons between those ages, greater mobility during this period of life and a degree of immunity to typhoid on the part of very young children and old people.

On examining the figures for Rockford, however, we find that only 36 per cent of the cases occurred among females and that as much as 64 per cent occurred among males. This is an unusual disproportion. By way of contrast, it may be pointed out that in the water-borne epidemic of 1912, which reached all alike, the sex distribution was about evenly divided, there being 99 males and 94 females. The unusual prevalence of typhoid fever among males in the present typhoid outbreak must be accounted for by travel and by outings, which are more extensively indulged in by the male population than by the female population.

TABLE II. PER CENT OF TOTAL CASES BETWEEN THE AGES INDICATED IN EPIDEMICS OF 1912 AND 1913.

Age	0-5	6-15	16-30	31-45	46 +	Not Noted
1912	6.9%	23.3%	46.0%	14.8%	9.0%	....
1913	3.0%	17.6%	44.3%	18.2%	12.1%	4.8%

Table II gives the age distribution arranged differently from the preceding table for the purpose of making a comparison with the age distribution in 1912. The differences here shown are not great. It may be said that the age distribution is approximately normal, though showing a rather high percentage of cases among older persons. This normal age distribution may be more apparent than real and this can only be ascertained by examining the age distribution in various groupings of the cases. This phase of the matter will be discussed under suitable headings.

GROUPING ACCORDING TO PLACE OF EMPLOYMENT.

Having reviewed certain general characteristics pertaining to the cases under consideration, an attempt will be made to develop certain groupings to throw more light on the origin of the disease. Table No. III gives a grouping according to place of employment or occupation, from which it will be observed that the cases are distributed through a wide range of employment, and that there are no large groups that would attract attention to any one place as harboring any general source of infection. The largest number of cases among workmen at any one place are the eight cases at the Union Furniture Company's factory in the southeastern part of the city. These cases are somewhat scattered in point of time and constitute a small percentage of the total number of employes, namely, 150 to 200. If the source of infection was the company's well, then a much larger number would have been simultaneously infected instead of being infected during a period of seven weeks. It would not be proper, however, to leave the impression that the sanitary conditions at the Union Furniture Company's factory are all that they should be, for quite the contrary is the case. In this section of the city there is no system of sewers and the company provided toilet facilities for its employes by constructing a huge vault about 25 feet square, over which is placed a very rudely constructed privy, which by no possibility can be maintained in a properly clean condition. The vault, which may be more adequately described as a hole in the ground loosely lined with boards, is about 150 feet from a well perhaps 50 feet in total depth, which until October 8 was used as a source of drinking water supply. On the date mentioned the well was closed by the health authorities. The well is still further subject to the possibility of contamination by a smaller cesspool about 200 feet distant, which receives the discharges from the office plumbing.

While the relative locations of the well, vault and cesspool are to be condemned, yet the well has to the present time been prevented

TABLE III. GROUPING ACCORDING TO PLACE OF EMPLOYMENT.

Name of Concern	Address	Drinking Water	Number of cases	Number of employees
Barber-Coleman	Loomis and River Sts	Well	1	400
Barnes Drill Co.	814-830 Chestnut	City	1	50
Bell Telephone Co.	214 North Main	City	1	98
Briggs Bakery	825 Mulberry Street	City	2	12
Burr's Bakery	200-206 S. Main Street	City	1	46
Burson's Knitting Co.	506 South Main Street	Well	4	650
Eastwood-Stockburger	124 South Main Street	City	1	2
Eclipse Gas Stove Works	707-709 S. Main St.	City	1	175
Emerson-Bratingham Co.	Independence Avenue	Wells	5	1000
Empire Manufacturing Co.	11th Street	Well	1	200
Forbes Foundry	....	....	1	....
Forrest City Knitting Co.	Catherine and Magnolia	City	1	100
Free Sewing Machine Co.	18th Ave. cor. 13th Street	Well	1	300
Greenlee Brothers	12th and Columbia Ave.	Well	1	370
Hess-Hopkins Tannery	Acorn and Tanner St.	Well	2	250
Kurtz Action Factory	Eighteenth Avenue	Well	2	300
McGlashan Harness Co.	515-517 W. State Street	City	1	6
National Lock Company	1930 Seventh Street	City	3	250
Northwestern Railroad	....	....	1	....
Postal Service	222 South Main Street	City	2	5
Register-Gazette	101 W. State Street	City	1	45
Rockford Cabinet Co.	19th Avenue and 12th St	Well	1	230
Rockford Chair & Furniture Company	920 Ninth Street.	City	5	175
Rockford Iron Works	642 Race Street	City	1	20 to 100
Superior Furniture Co.	7th and 23rd Avenue	Well	1	75
Trahern Pump Company	707–709 S. Main Street	City	1	75
Union Furniture Co.	18th Avenue, cor. 8th	Well	8	150

from being the source of infection because of the fine, sandy character of the local formation. Such material causes a certain degree of purification to take place in the foul liquids as they pass from vault or cesspool to the well. The accompanying analyses (Table IV) give evidence of this purifying action, yet show remaining traces of contamination.

The most probable source of infection, if persons were actually infected at this factory, is the privy, which because of its inconvenient arrangement might readily cause an employe to soil himself with fresh fecal matter. This would also explain the intermittency of the cases. While it will never be possible to state definitely that employes became infected with typhoid in the manner above described, yet it is significant that in nearly all the cases no other explanation of their occurrence has been discovered.

While discussing the Union furniture factory, it may be well to emphasize the fact that sanitary conditions at and near this factory, as well as other factories in the same section of the city, are very bad, owing to the absence of sewerage. The land in the vicinity is flat and is frequently flooded with water often saturated with sewage and other filth. The soil becomes grossly contaminated and great numbers of mosquitoes breed during the summer time.

TABLE IV. ANALYSES UNION FURNITURE COMPANY'S WELL.

No. 26156 Collected September 23, 1913; No. 26255 Collected October 6, 1913, from Sixty-Foot Drilled Well.

Laboratory Number	Appearance			Residue on Evaporation	Chlorine in Chlorides	Oxygen Consumed	Nitrogen as				Alkalinity	Bacteria per cc.		Colon Bacillus			Indol
							Ammonia										
	Turbidity	Color	Odor				Free	Albuminoid	Nitrites	Nitrates		Gelatine	Agar	10 cc.	1. cc.	0.1 cc.	
26156	0	0	1d	414	15	.7	.000	.040	.000	16.00	206	164	66	1+	2—	2—	—
26255	0	0	0	384	16	.6	.000	.034	.000	12.40	206	20	18	1+	2—	2—	+

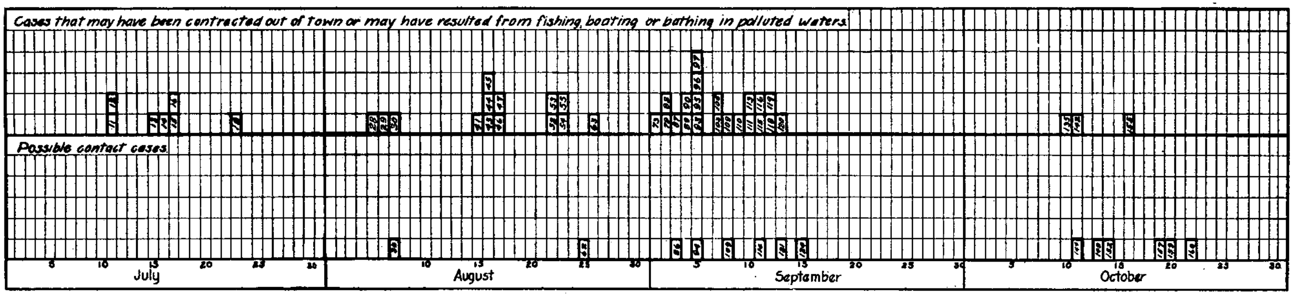
At the Emerson-Bratingham works there were five employes who contracted typhoid and three of these cases began so close together as to suggest possible infection at the plant. An examination of the data, however, shows that there were only five cases in a total number of about 1,000 employes, and moreover all these cases can be more satisfactorily accounted for under heads which will appear later.

In all the other factories having more than one case among its employes, the cases occurred at such wide intervals as to render out of the question a common source of infection or even infection by contact.

In short, the evidence at hand does not indicate that any of the industrial plants in Rockford had anything to do with the marked increase in typhoid during the past few months. In a number of the factories the sanitary arrangements are poor and such as to promote the spread of typhoid. Systematic inspections should be made and the objectionable conditions corrected.

CASES IMPORTED AND AMONG PLEASURE SEEKERS.

Forty-five out of the 165 cases may have been infected outside of Rockford or may have resulted from bathing, fishing in or boating on waters known to be polluted. (See Table V and Diagram V.) No cases were included who were out of town at a time when they were probably not infected. The marked preponderance of males (see Table V and Va) adds force to the theory that these 45 cases



Diag. V.—Chronological Distribution of Typhoid Case Groups as Indicated. Rockford Typhoid Investigation.

were infected from outside sources. This does not mean that all of these cases were necessarily infected in the manner described, and as a matter of fact a number of cases can be accounted for in other ways. The figures are significant, however, and indicate the importance of travel, vacations and outings in the causation of so-called autumnal typhoid.

TABLE V. AGE AND SEX OF IMPORTED CASES.

Sex	Ages							Total
	0-9	10-19	20-29	30-39	40-49	50-59	60+	
Male..........	2	19	10	2	3	0	1	37
Female	1	1	3	2	1	0	0	8
Total	3	20	13	4	4	0	1	45

So many cases occurring among those who wish to avail themselves of the pleasures afforded by neighboring streams, more particularly Rock river, directs attention to the necessity of maintaining these streams in a reasonably clean condition. Rockford is growing to be a great offender in this connection, for many of its sewers discharge above the dam, where the stream is best adapted to recreation purposes and where pollution is most offensive because of the nearness of good residence and shopping districts and two much-traveled highway bridges.

TABLE Va. DISTRIBUTION OF CASES REPRESENTED IN TABLE V.

Sex	Cases that had been out of town	Bathing	Fishing	Boating	Total cases represented	Per cent of total
Male..........	22	25	5	3	37	82
Female	5	2	0	5	8	18
Total	27	27	5	8	45	....

Before making any more important expenditures for the sewerage system, a careful study under expert direction should be made of future needs, so that all future sewerage installations can be carried out in conformity with a consistent plan whereby the sewage may now and in the future be adequately and economically disposed of. A far-sighted policy with reference to sewerage improvements will in the long run save the city much money. When Rockford has cleared its own skirts, it should keep close watch on other communities and industrial concerns to prevent them from unduly polluting Rock river and neighboring streams, so that these great assets for beauty and recreation may be held unimpaired for the use of all the people.

CONTACT INFECTION.

In every outbreak or prevalence of typhoid fever there are found a number of cases in houses which have harbored previous cases, and the time interval between cases, namely, a week to a month, strongly suggests contact infection. These instances are distinct from those in which two or more cases in the same house occur simultaneously. Again, there are instances of longer time intervals which are ordinarily accompanied by improper final disposal of earlier patients' discharges and by generally unsanitary conditions. As an illustration of the foregoing may be mentioned conditions in Winnipeg, Manitoba,* during the years 1900 to 1903, when an excessive amount of typhoid prevailed. A house-to-house canvass of one district, by no means the worst from a general sanitary point of view, showed that in 56 per cent of the houses in which typhoid occurred there were secondary cases.

In contrast with this, in Rockford there were only 11 apparent contact cases occurring in houses in which there had been previous cases during the present year, representing about 7.1 per cent of all the houses studied. There were other houses in which two or more cases occurred, but the short time interval (one to four days) between cases suggests simultaneous infection from a common source, rather than contact infection. In addition to apparent contact cases in the same house with other cases, there were three cases that were evidently the result of contact with previous cases not in the same house.

Contact infection played a comparatively unimportant part, as illustrated by Diagram V. A partial explanation of the favorable showing may be found in the rather large number of cases that were treated at the two hospitals, and in addition to this, much commendation is due the local physicians for systematic disinfection of discharges and the instruction of individuals in personal prophylactic measures to prevent the spread of the disease by fingers and food.

The health department must also share the credit for the small number of contact cases because of its systematic disinfection of privy vaults following the epidemic of 1912.

PARKS.

Much has been heard by the investigators about well water drunk from wells at various public and pleasure parks in and near the city, but there is no epidemiological evidence to convict these resorts as contributors to the recent excess of typhoid fever. Exceptions to the rule may be persons who bathed in the river near Love's, and particularly Black Hawk Park, the latter being below all city sewers,

*Report on Typhoid Fever by E. O. Jordan, Winnipeg, 1905.

but these cases have already been included under the head of camping, fishing, swimming and boating.

As a well on the golf grounds at Sinissippi park has been accredited with great positiveness by some as having been the cause of infection, the locality was visited and carefully inspected. Not more than one or two of the eight cases that gave a history of having been to the park could have possibly drunk from the well, for it is in a remote part of the golf links and accessible only to golfers. Only one of the cases played golf and drank the water. Further, the construction of the well and its distance from a privy in that portion of the park are such as to render the possibility of contamination of the water exceedingly remote.

While discussing parks, it may be said that it is not impossible that carelessness or filthy practices in the use of some of the park toilets may have caused infection to pass from one person to one or more others and produced the disease by a sort of indirect contact. No evidenct of this form of infection was obtained, and in the very nature of the case it will be appreciated that the requisite information is difficult to secure.

SOCIAL GATHERINGS.

The first group of cases that presented the characteristics of an epidemic resulting from a social gathering occurred in early August. In investigating these cases the health department observed that they had attended the same church gathering.

The story of the affair runs as follows: On Friday evening, August, 25, one of the ladies of a church on the east side had the ladies' club of that church at her home. During the evening a light luncheon was served, including on the menu Allen's ice cream and sandwiches made of McPherson's bread and some home-made pressed meat. In all there were about 15 persons present, including members of the family. Nine days after the gathering one of the ladies present came down with typhoid. During the next eleven days four more persons who attended the gathering came down. One of the ladies present who did not herself fall ill took home to her husband and sister some of the sandwiches and ice cream and this food was eaten by them the same night. Both these last mentioned persons were seized with the disease within the two weeks following and one died. There was still another case that may be attributed to the occasion, namely, the son of the family at whose house the gathering was held. This young man spent most of his time away from home selling tea from a wagon which he drove about the country. It was his usual custom to return home on Friday and remain until the following Monday. He was apparently not present at the gathering (his mother's memory seems uncertain on this point), but it is practically certain that he partook of the food. For a week previous to the gathering the son had been feeling rather poorly, but was able to attend to his business. This fact suggests the possibility of his having been the source of infection of the food that was eaten, but it is rigidly maintained by his mother that he had nothing to do with either the preparation or the serving of the food. Severe illness overtook the young man eleven days after the gathering or two days following the severe onset of the first case in the group.

The circumstances seemed insufficient to account for the infection of the food by the son, nor could a case be made out against the ice cream or bread, for there was no evidence of any other cases resulting among the customers of the dealers in these items of food. Inquiry into the past history of the family, however, revealed another possible source of infection. The mother had typhoid about ten years ago, the father had the disease in a mild form during 1905 and the daughter (away from home during the recent epidemic) had typhoid in 1907 or 1908. This series of cases, culminating in the infection of a number of persons at one time, suggests the probability of the mother being a typhoid carrier since her attack of ten years ago. Inasmuch as she regularly prepares the food eaten by the family, it is quite possible for even a person of cleanly habits, but without exerting unusual antiseptic precautions, to infect the food she may be handling. In the case under consideration the moist pressed meat was a specially favorable vehicle for holding and keeping alive the typhoid organisms.

MILK AND BREAD INFECTION.

The several groups of cases hitherto described are of relatively minor importance in the present outbreak, compared to four large and apparently inter-connected groups involving three milk supplies and one bakery.

For the purpose of presenting graphically the facts connected with these groups, a few tables and diagrams have been prepared. Table VI gives a list of dairies among whose customers cases of typhoid occurred. In this table is shown also the number of cases on each dairy route, the total number of customers supplied by each dairy and the approximate number of quarts of milk sold. One is at once struck with the very large number of cases among the customers of the Smith and Darrow dairies, though they are comparatively small dealers. The Smith cases represent 10.8 per cent and the Darrow cases 7.3 per cent of their respective customers. The Union dairy also has a number of cases among its customers, but since this is a very large concern, this number represents but 0.5 per cent of all its customers. All others have but few cases among their customers, which do not warrant suspecting these supplies as sources of infection. But one exception to this last statement remains, namely, the E. Erickson dairy, which has 8 cases among its consumers. This dairy, because of its apparent non-relation to the three other dairies above mentioned, will be discussed separately farther on.

Another tabulation (Table VII) is given, showing the bakers who supplied bread to persons overtaken by typhoid, the number of cases among the customers of each and the approximate daily output in loaves of bread. This table is not so striking as the preceding, owing to the practice of individuals of purchasing bread from various stores, yet there are a strikingly large number among the users of the Briggs bakery products, namely, 29 in all.

The bare figures presented in the two preceding tables serve merely to attract attention to certain dairies and a certain bakery as

TABLE VI. DISTRIBUTION OF CASES AMONG DAIRIES.

Name	Address	Number of Cases	Number of Customers	Quarts
Aspgren	129 Fairfield Ave	2	200	250
Branthaver	1028 Kilburn St	2	225	300
Carlson, A	722 South Fifth St	5	150	300
Carlson, J. E	1119 Tenth St	1	170	210
Darrow	519 Furman St	33	450	500
Erickson, A.	704 Eighth St	2	200	300
Erickson, E	1223 Charles St	8	175	400
Ekstron, G. J.	......	2	......	......
Ferguson	1436 Camp Ave	3	160	180
Forest City	2015 S. Main St	3	340	400
Gradin	308 Buckbee	3	95	160
Giffin	306 N. Central Ave	1	160	250
Jones	North of town.	2	200	250
Johnson, Victor	R. F. D. No. 10.	2	......	......
Kenny	School St.	1	......	......
Larson, Herbert	2305 E. State St.	5	250	650
Lungren, G.	......	1	......	......
Murkfelt	120 Shaw St	3	*	......
Nelson, Herman	1815 Charles St	1	150	175
Nelson, Axel R.	830 Rockton Ave	2	200	325
Nelson, Amel	1329 Second Ave	2	225	270
Nelson, E. A	119 Tenth St	1	......	......
Nelson, E. W.	Harlem Road	1	......	......
Rundquist, A	Baker Place	2	150	180
Sanitary Dairy	R. F. D. No. 9	1	......	200
Skinner	R. F. D. No. 7	2	150	260
Smith, J. T	Avon St	38	350	380
Standard	1536 Second Ave.	8	1100	1300
Thomas, H. D	R. F. D. No. 1	2	......	200
Union Dairy	216-218 S. Church St	31	5600	5300
Wallin	......	1	......	200
Stores	R. F. D. No. 7	1	......	3 cows

*Only a few quarts to neighbors.

possible sources of infection for a large number of the cases studied. For the purpose of developing relationships more clearly, a map (Diagram VI) of the city has been prepared, showing by different conventional signs the cases among the customers of the Smith, Darrow and Union dairies and the Briggs bakery. Those cases shown by two or more conventional signs indicate that the patient has used the products of the several dealers corresponding to the several signs. In addition to the map, and to be used in conjunction with it, is Diagram VII, showing the daily incidence of the cases among the customers of the four dealers under consideration. The date of incidence for each case is taken as the date upon which the patient went to bed, as nearly as this date was obtainable. The numbers in each diagram are for cross reference and correspond to those on the map.

Referring first to Diagram VII, it will be observed that there is a scattering of cases among the Briggs bakery customers in the latter part of July, which increase in frequency of occurrence during the early part of August. The occurrence of almost daily cases continues throughout August and falls off abruptly with a few cases during the first days of September.

After the first week in August cases of fever began to appear on the Smith route and rose rapidly in member to epidemic proportions by the end of the second week in August. This condition continued with more or less fluctuation through the first third of September, followed by a scattering in the middle third of that month.

TABLE VII. BAKERIES.

Name of Bakery	Address	Number of Cases	Approximate daily output in loaves
Appelholm & Nystedt	1319 14th Ave	2	650
Asprooth Company	118 Kishwaukee Ave	7	600
Beans	431 W. State St	18	2500
Briggs	825 Mulbury St	29	350
Bun Brothers	110 W.State	3	1500
Carlson	....	6	....
Clark, W. A	419 E. State	7	1000
Keig & Stevens	614 Cedar	9	8000
Landwehr	1532 W. State	5	800
McPhearson	510 W. State	14	2500
Nygren & Peterson	103 Seventh St.	1	....
Tureson, James	1407 Seventh St.	4	600
Lovelace & Terry	1110 Kilburn	20	3000

The termination was brought about by the shutting down of the dairy on the fourth of September by the health authorities. This stands out very clearly in the diagram.

Beginning with the middle third of July cases began to appear on the Darrow route, but the number did not rise to alarming proportions. Through August there was a mere sprinkling of cases, while during early September the frequency of occurrence was sufficient to attract critical attention. A temporary cessation of cases occurred about coincidently with the dropping off in Smith cases. This is all the more apparent when it is explained that case 128 occurred in the same house with 126 and was either a contact case or had a long prodromal period. During the latter part of September something seemed to have happened in the Darrow dairy, for beginning with October 10 there was a sharp outbreak which subsided by the beginning of the last week in October.

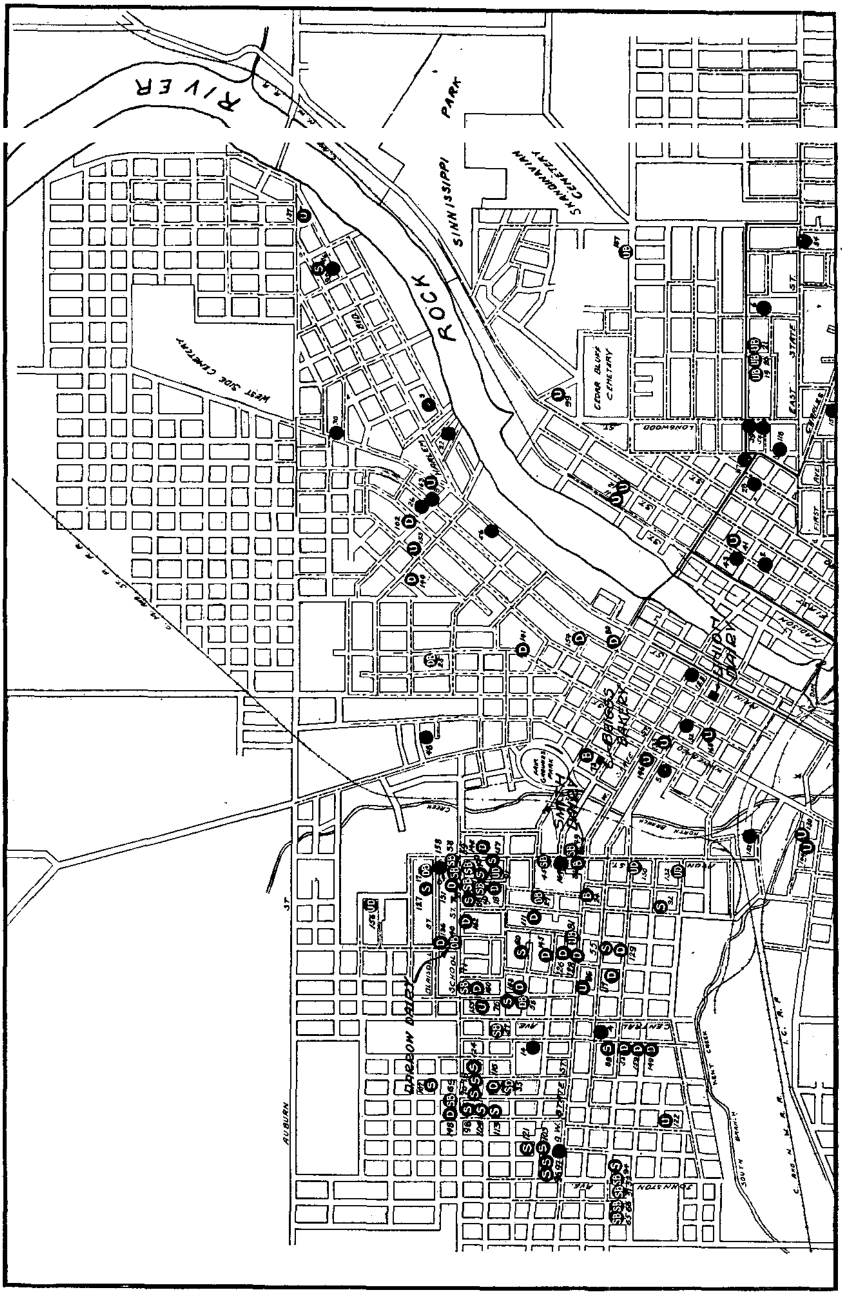
Similar in characteristics to the incidence of typhoid among the customers of the Darrow dairy, though beginning about a month later, is the incidence of cases on the Union dairy route. The three cases in August and the sprinkling of cases in September is possibly not significant, since practically all these cases may be explained on a basis other than milk infection, but most of the cases occurring during the sharp outbreak in October cannot be readily explained as being other than milk infections.

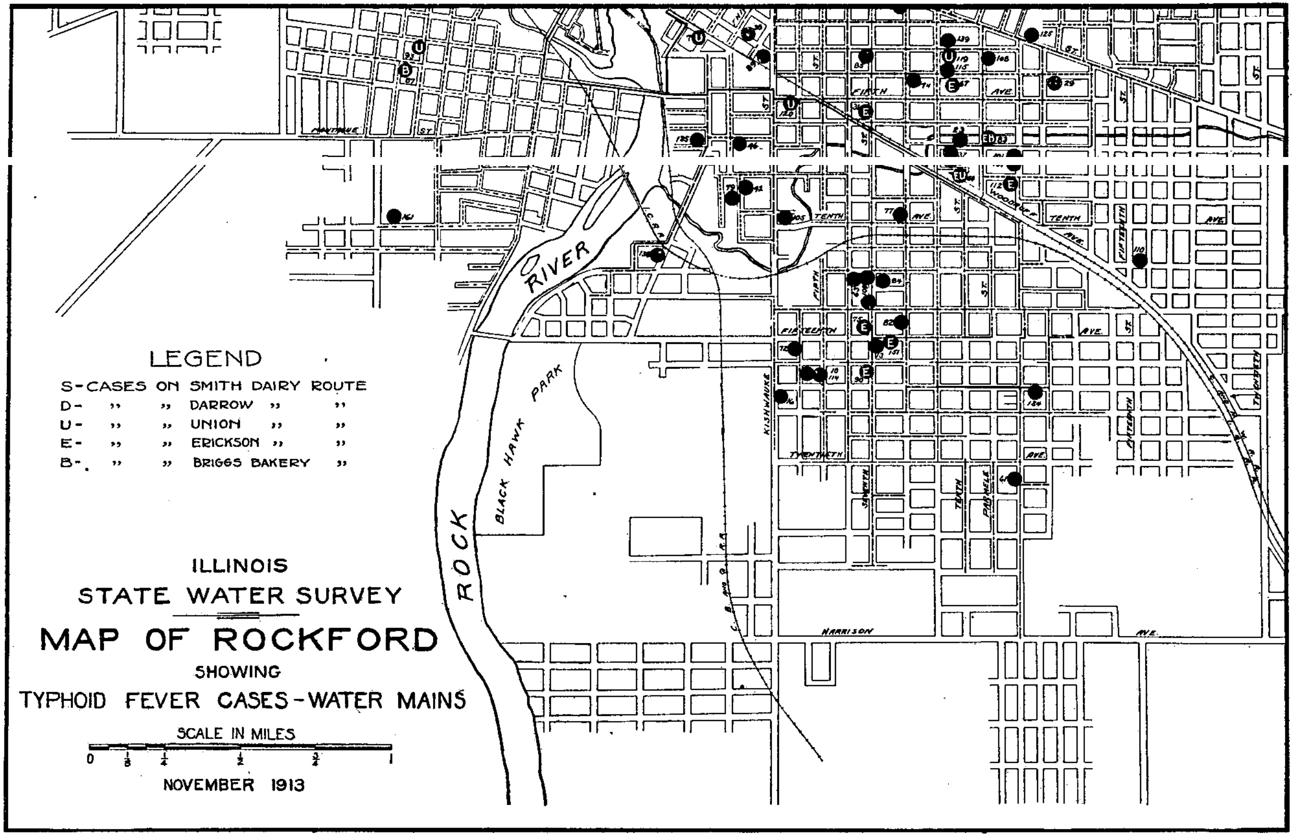
Another feature about the diagram to be noted is that some of the cases plotted appear in two or more of the groups, and it is particularly observable that there are a number of coincidences between the early dairy cases and the cases that used Briggs bread.

Reference to the map shows that the various cases plotted on the diagram are thickest in the northwestern section of the city, lying between the two forks of Kent creek. There are, in fact, in this district but four cases which did not obtain milk or bread from the dealers under consideration, and all but one of these cases occurred before the middle of July. The Smith cases are confined to this district because Smith delivered in this district only. A sprinkling of Darrow cases occurs between the North branch of Kent creek and the river marking the more extended route of the Darrow dairy, and cases using Union dairy milk and Briggs' bread appear sparsely scattered over the greater part of the city, since these concerns deliver throughout a wide area. The principal significance of the map lies in the fact that it shows the close inter-relation between the Smith and Darrow routes and the inter-connection of the customers on these two routes with the Union dairy and the Briggs bakery route and with each other.

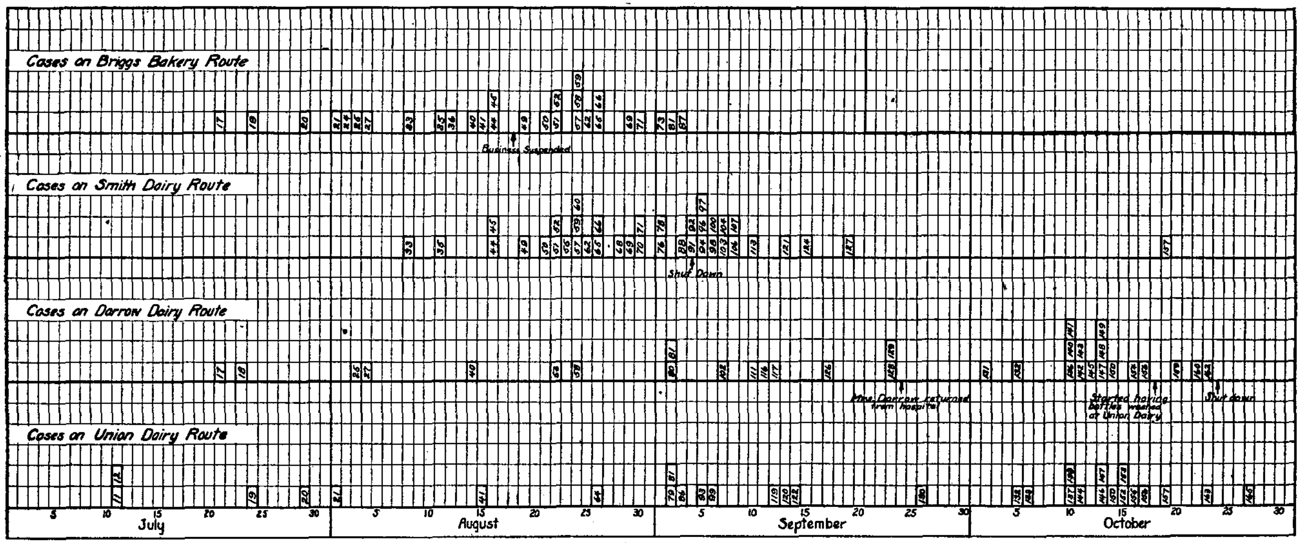
A broad consideration of the diagram and map suggests a possible relation between the cases among the customers of the three dairies and the Briggs bakery, and if one may venture to make further deductions without a closer examination into details, the diagram suggests that infection started in the Briggs bakery, was transferred to either or both the Smith and Darrow milk routes and from there was perhaps in turn transferred to the Union dairy route. To test this and a variety of other theories that were developed in the course of the investigation, many cases were repeatedly visited and inspections were made which resulted in the accumulation of a large amount of detailed data. Nevertheless, these data were not as complete as desirable, owing to the manifest difficulty of obtaining various facts which at the time of occurrence seemed trivial and insignificant. But a consideration of such information as is available is most suggestive and does much to throw light upon the sources and modes of infection.

It has been suggested that the large number of cases may have been caused by polluted water from the public supply mains, which in turn may have become infected through connections with factory fire protection systems. This theory cannot well be maintained, at least for a large proportion of the cases, for the reason that among the Smith cases 14 out of 35 used exclusively well water for drinking,


ROCK
RIVER
SINNISSIPPI
PARK
SCANDINAVIAN CEMETERY
WEST SIDE CEMETERY
CEDAR BLUFF CEMETERY
AUBURN
ST
SCHOOL
CENTRAL
AVE
DARROW DAIRY
JOHNSTON
NORTH BRANCH
KENT CREEK
SOUTH BRANCH
STATE
ST
EAST



Diag. VI.—Map of Rockford, Showing Typhoid Fever Cases—Water Mains.



Diag. VII.—Chronological Distribution of Typhoid Case Group as Indicated.

and the same holds true for 5 out of 33 among the Darrow cases and 2 out of 31 among the Union dairy cases. That a water epidemic may have been coincident with the milk epidemic cannot be denied on the basis of data thus far presented, but the probabilities of water infection will be taken up under a discussion of the water works farther on.

An examination of the available histories of the several cases shows the following: On the Smith route 25 out of a total of 38 could not be readily explained on any other basis than milk infection. On the Darrow route 18 out of a total of 33, and on the Union dairy route 15 out of 31 could be explained only on the basis of milk infection. That is to say, other explanations did not fit in with the facts in the history of these cases. The remaining cases may or may not have been milk infected cases, since some of them give histories of being in contact with previous cases, of having been out of town or having bathed in polluted streams.

There are additional items of information that support the milk theory of infection. For example, case 106 is that of a little girl 10 years old, who lived in the northern part of the city, remote from the infected district, but drank Smith's milk on the occasion of a brief visit to her cousin's on Avon street and subsequently came down with typhoid. Nothing about this case gave a clue to any other source of infection. Another case in point is case No. 107, a two-year-old child that drank Smith's milk and well water, the latter being in no way suspected of pollution. This child had not been away from home at any time within the incubation period of the disease.

The weight of evidence, therefore, indicates that a great majority of the cases shown on the diagram were due to infected milk or bread, or both, according to the distribution shown on the map and diagram.

A most interesting question that arises in connection with any epidemic is what started the infection. The mere fact that conditions are unsanitary or that milk or water is polluted does not answer the question, because the specific germs of typhoid fever must be present to cause the disease. Polluted water and dirty milk are consumed every day by thousands of people, yet, providentially, disease results in but comparatively few instances.

The detailed facts relating to the cases are generally difficult and often impossible to ascertain, yet in the epidemic under discussion some facts have been unearthed which are very convincing as to how infection of the several milk supplies and the bread supply took place. All theories will be presented so that an estimate of their relative merit may be reached.

Case No. 25 (see map and diagram) was a man of 39 years of age who was employed in the Briggs bakery as a driver of a delivery wagon, and upon occasions when baking was not completed until late at night, assisted in wrapping the loaves of bread and in loading bread, pastries and cakes into the delivery wagons. This work was generally performed from three until five in the morning. This man became sufficiently ill with typhoid fever to force him to bed on August 6 (the date upon which his case is plotted in the diagram), but for over a month previous to this time he had been feeling badly and suffered more or less with diarrhea, and in point of fact his case had been diagnosed as typhoid a week or ten days before he was confined in bed.

Cases Nos. 33, 35 and 44, among the first on Smith's route, are known to have eaten bread and pastry from the Briggs bakery. For case No. 35 the evidence of eating bread is not very positive. Case 45, which is also one of the early cases, may have contracted the disease while camping, and there is much evidence to support this view. Cases 33, 35 and 44 may have become infected by bread from Briggs' and while in the prodromal stages of the disease may have infected the milk bottles, which in turn may have infected a considerable part of the milk supply, or, more probably, the increasing number of infected bottles constituted the vehicles of the disease. This theory is fortified by the fact that the bottles at the Smith dairy were not sterilized.

While the above is a plausible explanation, there is another explanation which is better bolstered by the facts available. Case No. 49, a little girl 7½ years old, has already been mentioned as a user of Briggs' bread, and to this may be added cakes, as might be expected in the case of a small child of that age. This little girl lived in a house on Smith's property and adjacent to the dairy. She also had an elder brother who worked for Mr. Smith in the capacity of wagon driver and collector of milk from farmers on Wolf Grove and State roads.

It is especially to be noted (and this is not unusual in small children) that the little girl was at no time severely ill with the disease and was able to be up and about most of the time, a most dangerous situation from the viewpoint of spreading infection. In cases where the attack of the germs meets with such great resistance, it is reasonable to assume that the period of onset, that is the period from the time of infection to the time of the appearance of acute symptoms, is a long one and it is probable that case 49 was infected and became an active distributor of bacteria before cases 33, 35 and 44.

Now the little girl may have infected the milk in one of two ways, namely, directly through her presence in the dairy building or indirectly through her brother. As for direct infection, it was reluctantly admitted by Mr. Smith that the little girl entered the dairy building and filled milk bottles, which caused her to handle the bottles and the bottle caps with fingers that may have been soiled by a recent defication. This possibility is readily believable when one considers the youth of the child and the unlikelihood that she washed her hands after each use of the toilet. The above are the virtually admitted possibilities, but there are likewise other possibilities by which the milk may have been contaminated by the child, for a child of seven and a half is not endowed with great discretion, nor can she be watched at every move. Furthermore, this child may not have infected the milk only once, but may have done so several times. The first time may have affected only a few bottles, while subsequent times may have affected a whole can or more.

As for indirect infection, it is stoutly maintained by those concerned that the brother never went near the young sister during her illness and, therefore, could not have carried the disease. On the other hand, during the prodromal stage, when no one could have been aware that she had typhoid fever, he came into direct or indirect contact with his sister, possibly through the use of the same water closet. Transmission of the girl's infectious discharges to the milk by flies is only remotely possible, since no privies are in use on the premises.

After the Board of Health compelled the brother to stop working for Mr. Smith, he was succeeded by a youth in whose family typhoid fever existed (see case No. 52) and who may have been a source of indirect infection of the route. The likelihood that both employes contributed to the infection seems probable, for patrons have reported that milk bottles were picked up from doorsteps on the trip to the farms for milk and filled on the way back by dipping the bottles into the milk cans. Of course, this practice was disgustingly unsanitary and dangerous.

While the facts set forth in the previous paragraph represent a possibility for original infection, they are probably more pertinent in explaining how the infection of the milk may have been prolonged by infecting fresh cans of milk with dirty, infected bottles in which the typhoid bacilli had had ample time to multiply to great numbers.

Also of significance in the above connection is the possibility of infecting the milk of the Darrow dairy, for it is recorded that Smith frequently collected and used Darrow's bottles, thus causing them to become infected, and as will be seen later, Darrow had no effective means for disinfecting bottles.

A word or two should be said relative to the general character of Smith's dairy. The milk is obtained from a number of farms near the city on which there are no present cases of typhoid, nor have there been any recent cases. The farms are clean and in all essential respects meet with the municipal requirements. On the other hand, the bottling house maintained by Smith in the city is not up to standard. Ordinary cleanliness that should surround the preparation of any food was lacking, and until the city health authorities demanded proper screening, the place was infested with flies. The greatest criticism may be based on the absence of suitable means for sterilizing bottles, cans and utensils and the failure to use present apparatus to the best advantage. Provision should be made for boiling or steaming the bottles for a period of at least twenty minutes as the only practicable and reliable method, according to the opinion of dairy experts. Hypochlorite of calcium used properly and with caution might be successfully adopted as a sterilizing agent, but cannot be definitely recommended.

The milk from the Darrow dairy may have been infected in one or more of four ways, as follows:

1. Case No. 25, already referred to as the typhoid-infected employe of Briggs' bakery, while working in the bakery was in the habit of dipping milk out of a can. Can and milk were furnished by Darrow. The can was returned to Darrow and re-used, perhaps without thorough sterilization.

2. Mrs. Darrow (case No. 40) may have been infected by Briggs' bakery products, which she regularly used, and may in some unknown way have contaminated the milk supply.

3. There may have been an indirect infection from case No. 17, a man 61 years old, who was the first among the users of milk on the Darrow route to contract the disease. He also was a regular user of Briggs' bread and his illness can possibly be explained on the basis of infection from this source. He was an employe in the works of Emerson-Brattingham Mfg. Company and the history of his case gave no clue to any other source of infection. A son of this man was employed by Mr. Darrow as a wagon driver previous to July 1, and it is said that his sole function was to deliver milk. He did not work in the bottling house, nor did he have occasion to handle the milk to any extent. Further, it is not probable that the son was infected from the father, inasmuch as a trained nurse had been employed and the father was never, so far as is known, in intimate contact with the son. Moreover, the patient's discharges were all disinfected and disposed of by the nurse. Another possibility suggests itself, namely, the direct contamination of milk bottles by the patient, but this possibility is remote, as according to the information obtained, a bottle was never brought into the sick room. Therefore, infection of the Darrow route from case No. 17 by contamination of bottles or indirectly through the son is improbable.

4. The fourth possibility has already been suggested, namely, the infection of Darrow's bottles by milk and customers of the Smith dairy.

As to the relative merits of these several possibilities, little can be said with assurance, but certain further observations are illuminating. The first seven or eight cases to appear on the Darrow route (including No. 25, the Briggs' bakery employe, who must also be regarded as a consumer of Darrows' milk) were all users of Briggs' bread. It, therefore, appears that these early scattered cases may have been due to Briggs' bread, rather than Darrow's milk. Though the informal manner used by case No. 25 in drinking from the milk can at the bakery may, as already noted, have been responsible for these cases, there is a strong argument against this theory, in that many more cases would normally have resulted from an infection of this character. With bread on the other hand, one would not expect many cases, because the germs must rapidly die on a loaf of bread and can only endure sufficiently long to carry infection when the bread is fresh and moist.

That intestinal bacteria may be carried on bread is borne out by the bacterial studies of Miss Katherine Howell on one hundred loaves of bread purchased in Chicago, and bread as a medium for transmitting typhoid is demonstrated by Miss Howell's citation of a bread-borne epidemic at the government hospital for insane at Washington, D. C.

There is much argument in favor of the theory that the Darrow milk as a supply did not become infected at all until the latter part of September, since the cases on this route until that time were sporadic and in many instances give histories that point to other sources of infection; but the fact that they ran along at the time with and in the same manner as the Smith cases lends much color to the belief that these infections were caused by occasional Darrow bottle returned from the Smith route.

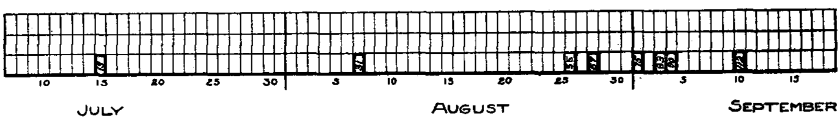
That the cases of typhoid fever on the Darrow and Union dairy routes were occasioned by infected bottles from the Smith dairy seems further evident from the fact that within ten days after September 4th, when the Board of Health closed down the Smith dairy, but few new cases on the two other routes appeared. During the 18 days from September 20 to October 8 only 6 new cases appeared in Rockford. Of these cases case No. 128 may be readily explained as a contact case or one having a long prodromal period. Case No. 130 also presents strong evidence of being due to causes other than infected milk. The other cases within this period of low morbidity present obscure histories and cannot be readily placed.

On October 10th there was a recrudescence of the epidemic on both the Darrow and Union dairy routes, which at first was very puzzling, but which in the end was satisfactorily explained by the discovery that the new outbreak began just fifteen days after Mrs. Darrow returned from the hospital.

The chain of evidence could not be definitely followed to the point marking the infection of the Darrow milk by Mrs. Darrow, but Mrs. Darrow's return and the recrudescence stand out in such a striking relation that a connection between the two seems evident.

The infection on the Union dairy route is readily explainable by its use of Darrow's bottles. The short duration of the outbreak on both routes is a favorable commentary on the general care and cleanliness of the two establishments. Had they been dirty dairies, the outbreak would have been more prolonged and very likely of greater intensity.

Justice requires that credit be given Mr. Darrow for a reasonably clean dairy, and special commendation is due him for his practice of using no bottles belonging to other dairies. Had this practice been rigidly pursued by the Smith dairy, the other milk outbreaks might have been avoided. The Darrow dairy practice is defective because of inadequate cleaning and sterilizing of bottles and cans. The various washing powders and soaps that have been relied upon to effect



Diag. VIII.—Chronological Distribution of Typhoid Cases on Erickson's Dairy Route.

sterilization are not sufficiently germicidal, and more thorough methods, as steaming or boiling for 20 minutes, should be adopted. Rigid care should be used in handling the milk and none but thoroughly reliable help should be employed.

The line of reasoning that attributes the cross infection from the Smith to the Darrow dairy through the use by Smith of Darrow's bottles applies in a measure to the Union dairy. The small number of cases among the customers of the Union dairy, compared with the total number of customers, makes a bottle infection a reasonable explanation. Probably most, if not all, of the August and September cases on the Union dairy route are attributable to the Smith dairy.

The outbreak on the Union dairy route during October has already been accounted for as being involved with the similar outbreaks on the Darrow route through an interchange of bottles. These last cases can be accounted for in no other way and emphasis is added to this theory by the detailed histories of the cases, which show that they in no way came in contact with each other and some of them occurred in remote parts of the city corresponding to the large area covered by the Union dairy delivery. The fact that the Union dairy washed the bottles of the Darrow dairy has, contrary to general supposition, no significance, since this took place from October 19 to 25, after the height of the outbreak had passed and since that time there have been no new cases on the Union dairy route.

Surprise may be felt that the Union dairy should be involved, since it is thoroughly modern and equipped with the most approved and modern apparatus for pasteurizing, bottling and otherwise handling milk. The results of epidemiological study and inspection of some of the bottles show that the bottle washing process is not carried out in a way to positively assure either freedom from dirt, or sterilization. This experience should serve to emphasize the fact that no matter how perfect the machinery and other equipment, human care and cleanliness cannot be discarded in conducting a dairy business.

On the E. Erickson milk route (see Diagram VIII) one of the eight cases occurred on July 15, another on August 7, and the remining 6 cases were grouped between August 26 and September 10, a period of 16 days. The cases on this route are believed to be entirely independent of the Smith and Darrow routes, as they are in a part of the city remote from these two routes. The Erickson route does more or less overlap the Union dairy route. The latter in fact extends over the entire city, but all the evidence obtainable is aganist the theory of a relation between the two.

The distribution of the cases, combined with the fact that they constitute but a small proportion of Erickson's customers, suggests the possibility of bottle infection, perhaps originating with case 31, which occurred on August 7th. Cases Nos. 13 and 31, because of their isolated position, cannot be attributed to infection from Erickson's milk.

The detailed evidence is not conclusive in favor of milk infection, though it is significant that only one of this group of cases, namely, No. 64, can be readily attributed to sources other than milk. This case had been out of town until two weeks before taking sick and while in town had bathed in Rock river, near the dam. Five of the other cases give no evidence that would incline one's opinion one way or the other, but the remaining case, namely, No. 75, is somewhat illuminating. This was a young mother who just one month before being fatally attacked by typhoid gave birth to a child. The general cleanliness of the premises, the good nursing the woman received and other factors render it highly improbable that she acquired typhoid from any other source than the food and drink she took, and further inquiry does not reveal that the bread and foods other than milk are open to suspicion.

The weight of evidence thus leans to the conclusion that the infection of a number of bottles on the E. Erickson route was responsible for some or possibly all of the cases occurring on this route between August 26 and September 10, but the facts obtainable were so incomplete that, as above stated, a positive conclusion cannot be reached.

CORRECTIVE MEASURES.

The extensive infection of milk supplies that has taken place calls for remedial measures to prevent a recurrence and the most essential of these may be enumerated as follows:

First. The employment of a technically trained man to devote his entire time to inspecting periodically all dairies and to give instructions in how to produce clean milk.

Second. The continuance of periodic bacterial analyses of all milk supplies in the city, to be followed by prompt notification of the dairymen if the supplies do not come up to standard.

Third. The passage and enforcement of an ordinance forbidding collection and use of bottles belonging to other milk dealers. Each dairy should be required to have its bottles marked in a distinctive manner.

Fourth. The requirement on the part of every dairy that there be means for effectively sterilizing bottles, other milk containers and utensils, and that these means be regularly and systematically employed.

Fifth. Prompt reporting by the health department to the dairymen all cases of communicable disease.

Sixth. Thorough sterilization at the Smith and Darrow dairies of all bottles, cans, apparatus and utensils under the direct instruction and supervision of a health officer before these dairies are permitted to resume business.

WATER SUPPLY AS POSSIBLE SOURCE OF INFECTION.

The next possible source of infection to consider is the source of the drinking water supply. Of the 165 cases studied in the investigation, 106 or 64 per cent used city water only, 30 or 18 per cent used well water only, and 19 or 12 per cent used both city and well water. The remaining small percentage of the total is represented by one person who used only bottled water, one person who used only boiled city water and eight cases concerning which no information could be obtained.

So large a proportion who did not use city water at all would cast much doubt upon the city water as a source of infection, and at any rate it would eliminate it as the only source of infection. Here, as with sex distribution, the present epidemic is quite in contrast with the epidemic of 1912, for in the latter every case gave a history of having regularly used city water. The case against the city water supply is rendered still weaker when it is considered that 28 of the cases using city water exclusively, as recorded on the regular city report cards, gave histories of having been out of town and camping, and swimming or fishing in polluted waters.

Notwithstanding the above, there remain 70 to 80 cases scattered throughout the city that may or may not have been due to water. As shown in the preceding discussion, a great number of these can almost certainly be explained as due to milk and bread infection. After these are deducted there is a small residuum, perhaps 20 cases or so, mostly scattered throughout the east side, which cannot be definitely explained primarily because of lack of data. Various possibilities exist to account for these cases, such as lack of sewerage and consequent use of privies, causing exposure of fecal matter in such a way that it may be transported by flies and other insects; defective plumbing that may permit a similar or more direct infection; public bath houses in which strict sanitary cleanliness is not maintained; dirty soda fountains and a variety of other factors.

It cannot be maintained that many of the cases already attributed to other causes are in reality due to the infection of the public water supply, for they do not have any of the characteristics of a water outbreak. The cases are too much localized, show a too intimate relation to dairy routes, bread routes and other causes, and do not present a sufficiently characteristic rise and decline for a typical water-borne epidemic.

Perhaps the best evidence of the impossibility of a water epidemic can be obtained by a consideration of certain features of the water works. At the water works pumping station there is now practically speaking no possibility whereby the supply may become infected. Old Peach street well No. 2, which figured so prominently in the epidemic of 1912, has been abandoned and its connection with the collecting main plugged. The old reservoir has been carefully repaired and made thoroughly waterproof for both inside and outside pressure. Nearby privies have been removed and water closets with sewer connections substituted. These sewer connections are carefully laid and are near only such piping as is practically always under more or less pressure. While the sewer passes rather near the old reservoir and at a few feet elevation above its bottom, the present condition of the reservoir assures the practical absence of danger.

To make doubly sure and to provide against any future conditions likely to develop, it is recommended that this sewer be removed and replaced by a new sewer making connection with the sewer in Oak Park avenue.

The gravity line which formerly conveyed water from the three Peach street wells was dug up and thoroughly repaired to Peach street well No. 3. At this point the work of uncovering the pipe became so difficult and expensive because of its great depth that further repairs were not believed to be profitable. Therefore, a gate valve was inserted just beyond well No. 3, thus cutting off Peach street well No. 5. The present water works authorities have abandoned well No. 5 partly because of the difficulty of gaining access thereto with a sound pipe line and partly because of an apparently leaky condition of the well casing. Well No. 5 may, however, be brought into service at any time by merely opening the gate valve above referred to and starting the deep well pump. The sanitary safety of having a public supply well in a public street within a few feet of a sewer is very questionable, due to the possibility of a defective casing. This well should be dismantled at the earliest practicable date and permanently abandoned or the casing should be adequately reinforced and protected, for a future water works administration may overlook the dangers involved and use the well in time of emergency, as No. 2 well was used in January, 1912.

Well No. 3 is now in good condition and the water therefrom flows in a thoroughly tight and tested pipe line to the reservoirs and the pumping station. Frequent analyses are made of water from the well, so that any tendency to contamination may be at once detected. Well No. 3, like well No. 5, is, however, subject to the dangers of a defective casing, and the well should either be abandoned or a casing of special construction should be used to make absolutely sure of protection against the entrance of contaminated water.

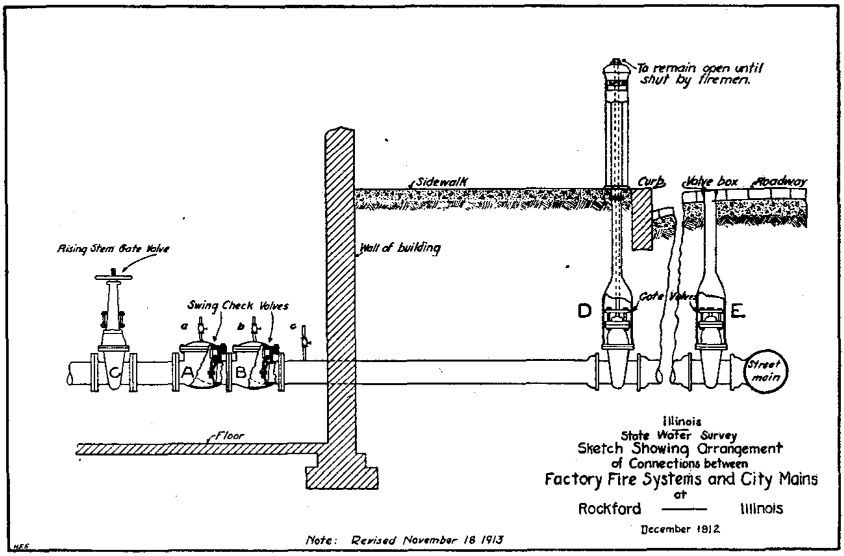
The superintendent of water works states that because of the comparatively small yield of these wells, about 1,000,000 gallons per day, and the great depth of the water level, the special construction necessary to fully protect the casings against leakage would be greater than is warranted.

Another but rather remote danger that threatens the public water supply is the entrance through defective casings of more or less polluted ground water from near the surface into the group of wells constituting the so-called shaft and tunnel system. No such defective casings now exist and a periodic inspection of the casings would be ample protection against this form of contamination. Still more positive protection would be afforded by plugging the wells tightly at depths just above the tunnel levels, but this would permanently prevent access to the interior of the wells for cleaning, blasting or other operations that may from time to time be necessary to prolong the usefulness of the wells.

The pump pits which during February, 1912, were found subject to grave pollution, have been cut out altogether. This not only brings about greater sanitary safety to the water supply, but also brings about greater economy in the operation of the pumping machinery.

The only points at which the water works are still vulnerable is at the various connections with factory fire protection systems, but here the danger is reduced to a minimum by the introduction of double check valves, together with means for readily testing their condition. Still further safety is accomplished by making systematic monthly inspections of all these connections. It is conceivable, however, and this represents the element of danger, that with a long-neglected connection of this character both check valves might happen to be stuck in an open position at the same time.

Further evidence of a possible connection between factory fire fighting systems and typhoid fever was sought in the reports of Mr. A. C. Lyons, who regularly inspects these connections, the records of the fire department and the records of flushing operations. These will be taken up in the order mentioned, but before doing so it is advisable to give a general description of the connections. Diagram IX shows the general arrangement of these valves. A and B are the



Diag. IX.—Arrangement of Connections Between Factory Fire Systems and City Mains, Rockford.

double check valves, C and D are two gate valves which are always left open, except when shut down for repairs. Valve D is also used for shutting off the city supply during or after a fire. Valve E is the city cutoff valve manipulated by city officials only. To make sure that fire protection from the city mains is always instantly available, the valves C and D are connected by wire with the Western Union Telegraph Service in such a way that instant notification is given to the fire insurance companies should the valves be closed. The insurance requirements also stipulate that a certain pressure must constantly be maintained in the factory, which in Rockford is in excess of ordinary domestic pressure, the former being about 85 or 90 pounds and the latter about 50 pounds per square inch. The water pressure, therefore, tends to maintain the check valves tightly seated and danger results only when the city pressure for some reason or other becomes greater than that in the factory system. At such times the check valves may open and become stuck in an open position. The foregoing statement assumes the check valves to be free from defects in the seat, a condition which does not always obtain, especially in old valves. Defective seating permits a small continuous leakage. With but a single check valve, the danger of the valve remaining open is a very real one, for corrosion of joints, solid obstructions adhering to the valve seats, and tuberculation of the valve chamber that prevents a free swing of the valve disk may readily cause water from a factory system to flow into the city mains when the pressure is reversed. With two valves the danger is very much reduced for it is only remotely possible that both valves will fail to operate, especially when they are examined once each month.

In examining a pair of check valves, a pressure gage is first placed upon a small pipe connection *a* which gives the pressure in the factory sprinkler system. The gage is next placed upon *c* which gives the city pressure at that point. The pressure in the sprinkler system should always be greater than that in the adjacent city mains. Next the cutoff valve E is closed, and the pressure in the pipe between the cutoff valve and the check valves is relieved by opening the valve on *c*. The pressure gage is then placed on b, and if this pressure is above city pressure, it indicates that valve A is in a leaky condition. If the pressure is below city pressure it indicates that A is tight, but that B is in a leaky condition. If A is leaking, the extent of leakage can be roughly determined by opening the valve on *b* while keeping valves on *a* and *c* closed. If B is leaking, the extent of leakage can be roughly measured by opening the valve on *c*, while keeping valves on *a* and *b* closed. To learn if both valves are leaking, the gage when placed on *c* must show a pressure with a tendency to rise ultimately reaching that in the sprinkler system. The amount of the leakage past the two valves is roughly measured by opening *c* with *a* and *b* closed. Samples are collected from *c* for bacterial analysis in order to determine if the water in the city mains is subject to pollution.

The substance of Mr. Lyons' report is embodied in Table VIII. At the time of last inspection (October 14, 1913) all valves were in good condition and have been in good condition with one exception during all of 1913. The one exception was found at the Rockford Book Case Company on February 8, 1913. The leaky valve proved to be old and defective, and was promptly replaced with a new and perfect one.

The most significant part of Mr. Lyons' report is that both check valves on a double check connection may simultaneously be out of order as exemplified by the north fire connection at the Rockford Desk Company's factory on inspection November 20 and 21, and

TABLE VIII. SUMMARY OF REPORT OF INSPECTIONS OF FACTORY FIRE CONNECTIONS BY W. C. LYONS, CHIEF INSPECTOR OF WATER WORKS.

Name of Factory	Status of Fire Connection	Date when Established	Dates of subsequent imperfections	Condition of check valves	Results of analyses	Remarks
Skandia Furniture Company	Fire Connection shut off	June 21, '12 (Approx.)				Connected with city mains thru Rockford Desk Co.
Union Furniture Company	Fire Connection shut off	Sept. 13, '12				
Rockford Cabinet Company	Fire Connection shut off	May 24, '12				
Rockford Bookcase Company	Double check valves	Nov. 21, '12	Dec. 19, '12....	Tight.........		
			Jan. 15, '13....	"		
			Feb. 8, '13.....	One leaking....		
			Mar. 28, '13....	Tight.........		
			Apr. 13, '13....	"		Defective valve replaced by new one.
			May 13, '13....	"		
			June 21, '13....	"		
			July 26, '13....	"		
			Aug. 15, '13....	"		
			Sept. 8, '13....	"	Good	
			Oct. 14, '13....	"	"	
Free Sewing Machine Co.	Three check valves, firepump shut down and sprinkler system filled with citywater. Fire pumps in operation.	May 29, '12	May 29, '12....	Tight.........		
		Aug. 26, '12	Aug. 19, '12....	"	Fair	
			Aug. 16, '12....	"	Bad	Sample above first check.
					Fair	Sample above 2nd check.
			Sept. 9, '12....	"		
			Oct. 15, '12....	"	Suspicious.....	Sample below 2nd check
			Nov. 8, '12....	"		
			Dec. 31, '12....	"	Suspicious.....	
			Jan. 15, '13....	"		
			Feb. 8, '13....	"		
			Mar. 28, '13....	"		
			Apr. 19, '13....	"		
			May 13, '13....	"		
			June 21, '13....	"		
			July 26, '13....	"		
			Aug. 15, '13....	"		
			Sept. 8, '13....	"	Good	
			Oct. 14, '13....	"	Good	
Rockford Desk Company	Two 6-inch connections both provided with double check valves. Also connected with fire pumps of Skandia Furniture Co.	Oct. 8, '13	Nov. 20, '12....	Valves on north connection leaking.......	Bad	On Jan. 15 old imperfect check valve replaced with new one
			Nov. 21, '12....	Still leaking ...		
			Dec. 10, '12....	Still leaking ...		
			Jan. 15, '13....	Tight.........		
			Feb. 21, '13....	"		
			Mar. 6, '13....	"		
			Apr. 26, '13....	"		
			May. 21, '13....	"		
			June 21, '13....	"		
			July 26, '13....	"		
			Aug. 15, '13....	"		
			Sept. 5, '13....	"		
			Sept. 10, '13....	"	North service "bad"	
			Sept. 17, '13....	"	North " "good" South " "bad"	
			Sept. 24, '13....	"	North " "good" South " "	
			Oct. 14, '13....	"	North " " South " "	

TABLE VIII. SUMMARY OF REPORT OF INSPECTIONS OF FACTORY FIRE CONNECTIONS, BY W. C. LYON, CHIEF INSPECTOR OF WATER WORKS.–Cont.

Name of Factory	Status of Fire Connection	Date when established	Dates of subsequent imperfections	Condition of check valves	Results of analyses	Remarks
Rockford Mitten & Hosiery Co. and Burson Knitting Company	Fire pump shut off and system filled with city water. On June 3 fire pump operating with city water shut off. System refilled with city water after test.	May 24, '12	July 16, '12....	Fire pump idle		
			Aug. 17, '12...	" " "		
			Sept. 24, '12...	" " "		
			Oct. 21, '12....	" " "		
			Nov. 22, '12...	" " "		
			Dec. 4, '12....	" " "		
			Jan. 15, '13....	" " "		Double check valve system now ready for service.
			Feb. 21, '13....	" " "		
			Mar. 6, '13....	" " "		
			Mar. 27, '13....	" " "		
			Apr. 26, '13...	" " "		
			May 13, '13....	" " "		
			June 21, '13....	" " "		
			July 29, '13....	" " "		
			Aug. 19, '13....	" " "		
			Sept. 17, '13...	" " "		
			Oct. 14, '13....	" " "		

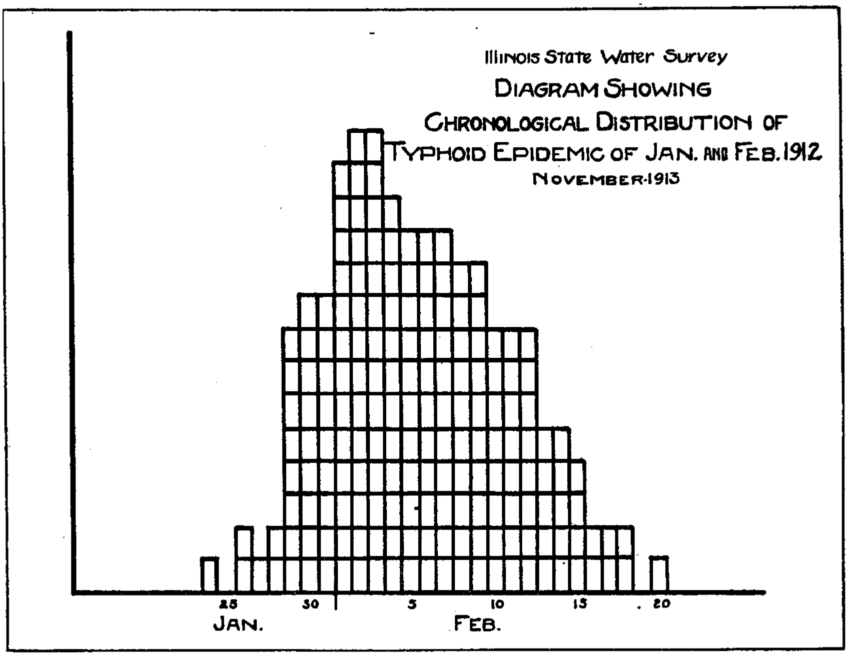
December 10, 1912. Water from the factory service was apparently passing both these valves, but the report does not state in what quantity. Replacement of one of the valves, which was old and imperfect, relieved the difficulty.

On September 10, 1913, a bacterial anaylsis of the water on the city side of the north fire connection of the Rockford Desk Company was reported "bad," but a check analysis on the 17th of the month was reported "good." On the latter date a sample from the south service was reported "bad," but check anaylsis on the 24th was reported "good." On all of these dates the physical inspection showed the valves to be tight.

The fire connection at the Rockford Mitten and Hosiery Company is the only one that could by any possibility have been a factor in the recent epidemic if the geographic distribution of the cases (see map) may be used as an index. It would naturally be expected that the greatest number of cases would occur in the district which receives the bulk of the polluted water. The only district that has a marked preponderance of cases is that which lies within the fork of the two branches of Kent creek, and in the northwestern part of the city. This group of cases has been shown with virtual certainty to be due principally to milk and bread infection. But for the sake of argument this theory may be assumed to be in error.

It is conceivable then that a very severe fire in the northwestern part of the city may have so taxed the water supply that water from the fire connection of the Rockford Mitten and Hosiery Company might have flowed in great quantity to the northwestern part of the city, though, as an inspection of the system of water mains (see map) will show, the flow of water in the main to which this factory is connected must normally be in the opposite direction, toward the southward.

Considering the incidence of the cases it is impossible to place a probable time at which the water could have become infected. The epidemic is wholly unlike a water born epidemic, as will be seen by comparing diagram No. IV with Diagram X. The former shows the daily incidence of typhoid during the present epidemic and the latter gives the incidence for the typically water-borne epidemic of February, 1912. In the 1912 epidemic the time when the infection took place



Diag. X.—Chronological Distribution of Typhoid Epidemic of January and February, 1912.

can be determined almost to a day, but in the recent epidemic the rise is gradual and one can only assume with a stretch of the imagination first, that a mild water infection occurred about the middle of July to account for the marked increase in cases during early August; second, that infection occurred during the middle of August to account for the rise during the latter part of August and the first part of September, or third, that infection occurred during the latter part of September to account for the renewed outbreak in the first half of October. There is also the possibility that infection of the water took place at all three times. One must, therefore, look for an extraordinary demand on the water supply in the northwestern part of the city during the middle of July, the middle of August and the latter part of September.

When the records are examined, however, one finds that during the above mentioned three periods there was no great fire in the northwest during the middle of August. A single hose was, however, used for the period of about one day to extinguish a fire on a refuse dump. During the entire period of the outbreak there was certainly no fire in the northwest, or in the entire city, that produced a marked increase in the daily consumption of water or a marked reduction in the city pressure, both of which conditions would have been essential to effect a diversion of polluted water from the Rockford Mitten and Hosiery Company's plant.

An examination of flushing operations shows that only on the eleventh of August was there an unusual amount of hydrant flushing, on which day 17 hydrants were flushed. The quantity of water so used probably did not exceed 70,000 gallons distributed through the day. This would certainly not reverse the flow in the large main passing the Rockford Mitten and Hosiery Company's factory which carries in an opposite direction at least half a million gallons per day.

The flushing of hydrants no doubt had an effect in stirring up deposits in the pipes due to rusting of the mains, and possibly due to accumulated growths of harmless organisms. Conditions were probably aggravated by the fact that new pipes had been laid in the northwestern part of the city during the summer and new pipe is very apt to impart a tarry taste to the water for a considerable period of time. None, however, of these objectionable manifestations with reference to the water supply has any significance in relation to disease.

Returning again to Mr. Lyons' report, additional confirmation is had that the fire connection at the Rockford Mitten and Hosiery Company had nothing to do with the typhoid outbreak inasmuch as this connection while having but a single check valve until October, 1913, was never during 1913 under pressure from the fire pumps and moreover the entire sprinkler system was filled with city water.

While connections with factory fire protection systems probably had nothing to do with the recent epidemic, yet the recorded failure of even double check valves to completely prevent the entrance of polluted water into the distribution system, demonstrates the wisdom of doing away with such connections altogether. It would be unwise to do this immediately owing to the risk of destruction of life and property by fire, but the abandonment of the connections should be effected just as soon as an adequate substitute for the protection afforded by the public supply can be installed.

A large number of water analyses have been made in the city laboratory and as many of these have been interpreted as showing the public water supply to be of unsatisfactory quality they deserve some comment. A remarkably large proportion of samples gave excellent analyses and the few poor results may be counted within the limits of ordinary analytical error. The analyst, Dr. J. E. Porter, in fact indicates by notes that occasional unsatisfactory results are due possibly to unsterile containers. There are other analyses which in all probability are not in error and yet not entirely favorable. A lack of knowledge concerning the precise conditions under which the samples were collected prevents specific comment being made, but it is significant that some of the samples have been collected from yard

TABLE IX. REPORT OF ANALYSES MADE BY DR. C. E. GABLE IN THE CITY LABORATORIES OF ROCKFORD.

Collected Friday, October 24, 1913.

No.	Source	Name	No. Colonies on Agar After 48 Hours at 37.5° C.	10 cc. in Lactos Oxbile Produced % Gas	Colonies on Endo Media	Remarks
62	Well	Charles Dow	23	0	No typhoid	Good
63	Cistern	Charles Dow	1000	0	No typhoid	Suspicious
64	Well	J. A. Stiles	3	0	No typhoid	Good
65	Well	A. D. Stiles	118	66% after 90 hours	No typhoid	Suspicious
66	Well	C. R. Hall	220	52% after 90 hours	No typhoid	Suspicious
		C. R. Hall	220	16% after 18 hours	No typhoid	
67	Well	H. Crandall	94	0	No typhoid	Good
68	Well	S. Pierpont	6	20% after 90 hours	No typhoid	Good
69	City	T. J. Abbott	207	78% after 90 hours	No typhoid	Suspicious
70	City	W. F. Murphy	6	0	No typhoid	Good
71	City	J. E. Edwards	26	0	No typhoid	Good
72	City	D. Alexander.	421	0	No typhoid	Suspicious
73	City	S. Central Ave and W. State Street	8	0	No typhoid	Good
		Collected Wednesday, October 29, 1913				
74	Well	2116 School St	44	0	....	.....Incubated 38 hrs.
75	Well	2111 School St	10	0		“
76	City	424 Albert Ave	9	0	....	.... “
77	City	618 Oakley Ave.	7	0	....	.... “
78	City	1437 School St			....	....
		D. Alexander	9	0		“
79	City	D. Alexander			....	....
		519 Furman St.	480	0		Suspicious “
80	City	T. J. Abbott			....	
		438 N. Avon	200	0	....	Suspicious “
81	City	119 N. Avon	20	0	....	.... “

NOTE—A milk bottle was used in collection of one of the following samples: 73, 72, 71, 70 or 69.

hydrants which are very apt to yield a polluted water, due to the siphoning in of water from about the base of the hydrant through a small drainage opening inserted for frost protection. Other samples have been obtained from or near new mains which are apt to have a high bacterial content; still others are obtained from mildly heated pipes within houses in which a marked multiplication of bacteria may take place.

On October 24 and 29, a number of samples of the public water supply were examined bacterially by Dr. C. E. Gable of the State Food Inspection Bureau, and are presented in Table 9. One of these, regarded as suspicious on the first date, gave a good analysis on the second date. On the other hand, one suspicious sample obtained on the first date was confirmed in the bacterial count, but not by the gas formation on the second date. The count in the second instance was made after but 38 hours incubation, and the colonies could only be observed after close scrutiny with a magnifying glass. A second suspicious sample on the second day gave 480 bacteria to the cubic centimeter, but no gas formers. The appearance of the plate indicates all of the bacteria to be of the same species, and it was subsequently learned that the water was obtained from a faucet which has a patent so-called filter attached to remove occasional iron rust; besides the pipe leading to the faucet paralleled for a considerable distance a hot water pipe. These considerations are ample to explain the unfavorable showing.

All analyses made in the laboratory of the State Water Survey indicate the Rockford public water supply to be of excellent quality from a sanitary point of view. A tabulation of these analyses is included as Table X. Suitable allowance must be made for occasional rather high bacterial counts for the reason that at least a day was required for shipment.

While analyses have been discussed at considerable length, in deference to the weight that has been given them in a popular discussion at Rockford, it should be borne in mind that analyses of the public water supply, unless made on or about the date when infection may have been active, will shed but little light on the possibility of the water supply being a factor in the recent epidemic. This is due to the fact that the water is normally unpolluted, and that there is no way at present whereby pollution can continuously get into the mains without early detection. If the water had been a factor—which it has not been—the period or periods of contamination must have been very brief and no analyses now will detect whether such a period did or did not exist.

In concluding this discussion on water supply, it seems but just to pay high tribute to the present water works management, which has been most vigilant in all matters threatening the quality of the water. The criticisms of the water works relate, not to administration, but to mechanical defects which in the hands of some future and possibly less well informed and less cautious management may result in contamination of the supply, unless the mechanical defects are corrected along the lines recommended.

GENERAL CONSIDERATIONS.

The great headway gained by the recent outbreak of typhoid before it was firmly under control suggests the desirability of establishing an organization and methods for studying possible future outbreaks by the local health department. Of first importance is the employment

TABLE X. ROCKFORD ANALYSES—CITY SUPPLY.

Date	Lab. No.	Turb.	Color	Odor	Res.	Cl.	O. Cons.	Nitrogen				Alk.	Bacteria		Gas			Indol	Source
								Free Am.	Alb. Am.	NO_2	NO_3		Gel.	Agar	10.	1.0	0.1		
Sept. 16, 01 . . .	9388	clear	0	none	2989	3	1.1	.020	.018	none	.2	......	......	......	......	......	......	......	Tap—City Water
Nov. 24, '03. . .	11633	slight	0	none	2912	3.2	1.5	.016	.012	.001	.2	......	......	......	......	......	......	......	Pump Station
Dec. 8, '04.	12745	......	......	......	353	7.5	7.8	.032	.192	000	.08	......	......	......	......	......	......	......	City Water
Nov. 13, '05 . . .	13748	clear	0	none	267	4.0	1.1	.012	.022	000	.2	282.2	......	......	......	......	......	......	" "
Apr. 2, '06.	14176	clear	.1	none	311	4.0	.9	.036	.066	000	.2	281.2	2350	......	1—	2—	2—	......	" "
May 31, '07 . . .	16080	5	0	0	295	9.0	1.55	.024	.048	000	.04	280.9	35	......	1—	2—	2—	......	Tap city water
Sept. 23, '07. . .	16533	0	0	0	280	6.0	1.8	000	.032	000	.16	293.1	20	......	1 +	2—	2—	......	" " "
Oct. 14, '07. . . .	16600	0	0	0	295	6.0	1.2	.004	.020	.002	.16	288.9	0	......	1—	2—	2—	......	" " "
Oct. 14, '07. . . .	16601	0	0	0	325	6.0	1.3	.004	.040	.004	.24	297.4	0	......	1—	2—	2—	......	" " "
Oct. 14, '07. . . .	16602	0	.8	tar	307	6.0	1.6	.012	.028	000	0	299.6	0	......	1—	2—	2—	......	" " "
Oct. 14, '07. . . .	16604	0	0	0	319	6.0	1.5	.020	.048	.004	.16	297.4	0	......	1?	2—	2—	......	" " "
Apr. 11, '10. . . .	20859	5	0	0	316	7.0	1.1	.024	.040	000	.52	308	6	......	1—	2—	2—	—	House fountain
Apr. 11, '10. . . .	20860	0	0	sweet	325	7.0	1.1	.032	.032	000	.28	308	16	......	1—	2—	2—	—	Hydrant in garret
Apr. 12, '10. . . .	20861	0	0	slight	315	6.0	1.0	.024	.064	000	.16	306	14	......	1—	2—	2—	—	Tap in house
Apr. 12, '10. . . .	20862	0	0	0	311	6.0	1.1	.016	.032	000	.24	.306	13	......	1—	2—	2—	—	Tap Nelson schoo
June 12, '11. . . .	22073	0	0	0	303	8.0	.5	000	.008	000	.28	302	10	......	1—	2—	2—	—	City tap
June 12, '11	22074	30	35	0	314	10.0	.5	.008	.016	000	.04	306	63	......	1—	2—	2—	—	Tap at dead end
Nov. 27, '11. . .	22720	0	0	0	302	5.0	.5	000	.008	.016	.28	280	60	......	1—	2—	2—	—	Reservoir
Nov. 27, '11. . .	22721	0	0	0	300	6.0	.3	000	.008	.003	.28	280	9	......	1—	2—	2—	—	Water works
Jan. 29, '12. . . .	22936	0	5	2d	308	7.0	.5	000	.080	000	.16	226	6	......	1—	2—	2—	+	Tap City Hall
Mar. 11, '12. . .	23084	3	3	0	319	5.0	.4	000	.000	.006	.28	290	120	......	1—	2—	2—	—	Reservoir
Mar. 11, '12. . . .	23085	2	2	1	315	5.0	.1	.024	.056	000	.6	290	4	......	1—	2—	2—	—	Pumping pit
Mar. 11, '12. . . .	23087	2	5	1	300	3.0	.1	000	.024	000	.56	288	1	......	1—	2—	2—	—	City tap
Mar. 21, '12. . .	23123	2	5	1e	397	5.0	.2	.040	.040	000	.16	284	59	......	1—	2—	2—	—	Tap City Hall
Mar. 21, '12. . .	23126	2	3	0	302	7.0	.0	000	.040	000	.44	286	15	......	1—	2—	2—	—	Reservoir
Apr. 3, '12.	23192	0	0	0	300	5.0	.1	000	000	000	.36	.284	38	......	1—	2—	2—	—	Tap City Hall
Apr. 3, '12.	23193	0	0	0	300	5.0	.1	000	.000	000	.28	284	19	......	1—	2—	2—	—	Reservoir
Apr. 15, '12. . . .	23229	0	0	0	310	7.0	.3	000	.000	000	.36	290	5	......	1—	2—	2—	—	"
Apr. 15, '12.	23230	0	0	0	308	7.0	.2	000	.000	000	.36	292	62	......	1—	2—	2—	—	City Tap
Apr. 15, 12.	23231	0	0	1e	325	7.0	.3	000	.000	000	.2	290	220	......	1—	2—	2—	—	" "
Apr. 29, '12. . . .	23294	0	0	0	318	5.0	.3	000	.056	000	.44	294	17	......	1—	2—	2—	—	" " City Hall
June 27, '12. . . .	23554	0	0	0	308	7.0	.0	000	.064	000	.28	292	105	......	1—	2—	2—	—	" "
June 27, '12. . . .	23555	0	0	0	311	5.0	.3	000	.084	000	.32	294	780	......	1—	2—	2—	—	" " Ashland Ave
July 23, '12	23693	0	3	0	305	4.0	.2	.062	.042	000	.36	294	40000	......	1 +	1+1—	2—	—	" " W. State
July 23, '12	23692	0	4	0	307	7.0	.1	.064	.016	.001	.36	294	178	15	1—	1+1—	2—	—	" " E. State
July 23, '12	23691	0	3	1e	299	8.0	.1	.032	.024	000	.36	294	1	3	1—	1+1—	2—	—	" " Main st.
July 23, '12. . . .	23690	0	3	0	293	7.0	.1	.048	.016	000	.36	296	2	3	1—	2—	2—	—	Reservoir

TABLE X. ROCKFORD ANALYSES—CITY SUPPLY—CONTINUED.

Date	Lab. No.	Turb.	Color	Odor	Res.	Cl.	O. Cons.	Nitrogen				Alk.	Bacteria		Gas			Indol.	Source
								Free Am.	Alb. Am.	NO_2	NO_3		Gel.	Agar	10.	1.0	0.1		
Sep. 3, '12....	23916	2	5	0	406	11	1.6	000	000	000	.44	286	12	10	1—	2—	2—	—	Tap So. Third St.
Sep. 3, '12....	23917	1	5	0	410	10	1.7	000	000	000	.16	286	2	1	1—	2—	2—	—	" No. " "
Sep. 3, '12....	23918	3	5	0	337	11	1.8	000	000	000	.20	286	10	0	1—	2—	2—	—	1225 N. Church St.
Sep. 3, '12....	23919	2	5	0	352	11	1.5	000	000	000	.16	286	42	31	1+	1—1+	1+1—	—	New Reservoir
Sep. 16, '12....	23978	0	5	2a	327	8	1.9	000	000	000	.52	288	60	......	1—	2—	2—	—	Rockford College
Sep. 16, '12....	23979	0	5	0	373	8	1.5	000	.040	000	.44	286	50	1	1—	2—	2—	—	1250 E. State St.
Sep. 16, '12....	23980	2	5	0	351	8	1.7	.040	.040	000	.68	288	4	2	1—	2—	2—	—	City Hall
Sep. 16, '12....	23981	0	5	0	443	8	1.6	.040	.032	.002	.36	284	24	9	1+	2—	2—	—	1005 S. Main St.
Oct. 21, '12....	24173	0	0	0	305	9	.8	.008	000	.003	00	288	2	1	1—	2—	2—	—	2426 W. State "
Oct. 21, '12....	24174	0	0	0	304	9	1.0	000	000	.002	.24	278	4	3	1—	1—1+	1+1—	—	Kishwaukee & 3rd St.
Oct. 21, '12....	24175	0	0	0	305	10	1.1	.016	.003	000	.32	284	1	0	1—	2—	2—	—	Reservoir
Nov. 18, '12...	24324	0	0	2e	301	6	1.2	.096	.056	000	.36	280	19	4	1—	2—	2—	+	" — Old
Nov. 18, '12...	74325	0	0	0	309	6	1.0	.032	.056	000	.36	280	10	1	1—	2—	2—	—	" — New
Nov. 18, '12...	24326	20	0	1a	293	1	1.5	.024	000	.002	.12	252	8	1	1—	2—	2—	—	No. 5 Well
Nov. 18, '12...	24327	0	0	0	327	6	.8	.040	.024	000	.40	280	25	0	1—	2—	2—	—	N. Second and Rural
Nov. 18, '12...	24328	0	0	0	311	5	1.1	.024	000	000	.40	280	128	0	1—	2—	2—	—	427 S. Second
Dec. 2, '12....	24437	0	0	0	317	4	1.2	000	.040	000	.32	296	20	2	1—	2—	2—	—	City Hall
Dec. 2, '12....	24438	0	0	0	292	5	1.2	000	.043	000	.28	288	20	4	1+	2—	2—	—	" Tap
Jan. 18, '13....	24610	0	0	0	300	7	1.0	000	.014	000	.64	284	100	4	1—	1—1+	2—	—	Walker School
Jan. 18, '13....	24611	0	0	0	296	6	1.1	000	.014	000	.48	282	80	3	1—	2—	2—	—	City Hall
Jan. 18, '13....	24612	0	0	0	297	6	1.1	.018	.010	000	.44	284	100	4	1—	2—	2—	—	Reservoir
Mar. 31, '13...	25000	0	0	0	330	6	.5	.064	.016	000	.44	284	31	6	1—	2—	2—	—	City Hall
Mar. 31, '13...	25001	0	0	0	319	6	.4	.040	.160	000	.24	280	58	10	1—	2—	2—	—	507 E. State St.
Mar. 31, '13...	25002	5	0	0	327	5	.5	.016	.024	000	.40	280	20	6	1+	2—	2—	—	1005 So. Main "
Apr. 29, '13....	25189	10	0	0	275	3	.8	.046	.024	000	.24	290	350	50	1—	2—	2—	+	18th Ave. & 11th St.
Aug. 25, '13....	25977	0	5	0	312	9	.8	.004	.044	000	.16	284	40	370	1—	2—	2—	—	1005 S. Main "
Aug. 25, '13....	25978	0	0	0	304	7	1.4	000	.060	000	.16	284	50	30	1+	2—	2—	—	1420 Blaisdell "
Aug. 25, '13....	25979	0	0	0	304	8	.7	000	.004	000	.16	288	60	43	1+	2—	2—	—	1340 Woodruff Ave.
Aug. 25, '13....	25980	0	0	0	303	8	.8	.054	.400	000	.16	286	920	140	1+	2—	2—	—	1340 Home Place
Sep. 2, '13....	26035	30	25	0	309	8	2.0	.040	.024	000	.24	282	280	410	1—	2—	2—	+	1201 Clover Ave.
Sep. 2, '13....	26036	5	0	0	287	2	1.0	.048	.072	000	.32	274	367	157	1—	2—	2—	+	18th Ave. & 11th St.
Sep. 2, '13....	26037	0	0	0	312	6	1.6	.016	.032	000	.32	280	40	370	1—	2—	2—	—	1075 N. 2nd St.
Sep. 2, '13....	26038	1	0	0	302	8	1.5	.032	.064	000	.52	280	85	40	1—	2—	2—	—	Pumping Station
Sep. 23, '13....	26155	0	0	0	312	5	1.0	000	.072	000	.44	288	37	21	1—	2—	2—	—	325 E. State St.

of one or more assistants to the health commissioner with special training in public health work. Such training is now being given by a number of the leading universities and colleges throughout the country.

The blanks at present in use for recording information regarding typhoid fever cases are not in sufficient detail to enable one to study all forms of outbreak. On the other hand, it is not probable that more complete information than that called for on the blank now in use can be obtained from the physicians. It is not the function of practicing physicians to perform epidemiological work, but rather to look after matters of individual cure and personal hygiene.

To meet the situation, it is recommended that two blanks be used, one to be printed on addressed mailing cards and filled out by the physicians, the other to be printed on 5x8 filing cards calling for full detailed information and to be filled out as a result of further investigation on the part of the health authorities promptly on receipt of the physicians report. Suggested form for the larger cards is given below.

The information obtained by means of the cards should be carefully studied by the assistance of spot maps, by diagrams and other methods of which this report may be more or less suggestive.

SUGGESTED FORM FOR SECURING INFORMATION RELATIVE TO TYPHOID FEVER CASES BY THE LOCAL HEALTH AUTHORITIES.

Record No.................

TYPHOID FEVER RECORD.

1. Name of Patient ....
2. Residence, street and number ....
3. Age ....
4. Sex ....
5. Occupation and place of business....................................
6. Name of Physician ....
7. Date when patient took to bed ....
8. Date of first symptoms ....
9. Date of physician's first visit ....
10. Date of leaving bed on recovery ....
11. Date of relapse ....
12. Date of death ....
13. Was Widal test made?...... Date .... Positive or negative ....
....
14. Was spleen enlarged and were rose spots present?..............
15. Was patient absent from city during the two months previous to illness? .... If so, state where he visited and between what dates ....

16. If patient changed residence during two months previous to illness, give former address and date of change. . . . .
. . . .

17. Character of residence (private house, boarding house, apartment, hotel, etc.)
. . . .

18. State source of drinking water . . . . At home . . . . At place of business. . . . . . . .Elsewhere . . . .

19. State source of milk supply and name of dealer . . . . Was milk habitually drunk?. . . . . Was it occasionally used, as in tea or coffee, or in ice cream?. . . . .
. . . .

20. Were oysters, lettuce or celery eaten raw within three weeks before illness?
. . . .

21. From whom was bread obtained?. . . . .

22. Did patient fish or bathe in neighboring streams?. . . . .
If so, state at what point or points . . . .

23. Did patient use any public baths or swimming pools?. . . . .
If so, give dates. . . . .

24. Give number of persons living in same house or apartment. . . . .
Also give number in whole building in case of hotel, apartment house, etc.
. . . .

25. Give names of other cases in same building and dates when they went to bed
. . . .

26. Give names and approximate dates for cases among business associates . . . .
. . . .

27. Give names and approximate dates for cases among friends (include school mates) . . . .
. . . .
. . . .

28. Did patient attend any social gatherings where food was served within two months before illness?. . . . . If so, give dates . . . .
. . . .

29. Describe sanitary condition of premises. Note especially outdoor privies, cesspools, wells and refuse piles. . . . .
. . . .

30. Is house well screened? . . . .

31. Had patient a separate room?. . . . .

32. Had patient a trained nurse or was nursing done by member of the family or household . . . .

33. Were stools and urine disinfected? If so, describe how this was carried out and note length of time continued. . . . .
. . . .
. . . .

Remarks: To include any facts, statements, or comments not included in the foregoing that may throw light on the source and mode of infection
. . . .
. . . .
. . . .

Information given by . . . .

Information obtained by . . . .

Date of obtaining information . . . .

REPORT ON THE WORK OF THE STATE WATER SURVEY IN THE FLOODED DISTRICTS OF ILLINOIS DURING APRIL, 1913*

From April 8 to April 24, 1913, a corps of representatives of the State Water Survey were engaged in the flooded districts of Illinois in protecting water supplies and in supervising sanitation and the process of cleaning up. The following report describes in a general way the extent and character of the work done. There will first be taken up a description of the methods used and results accomplished, and then will follow an itinerary covering the places visited and the work done by each individual of the party.

CHARACTER OF SANITARY WORK DURING AND AFTER THE FLOOD.

For the purpose of description, the work done by the State Water Survey may be divided into four parts, as follows:

(1) Treatment of public water supplies believed to be contaminated.

(2) Treatment of wells and cisterns believed to be contaminated.

(3) Supervision over the protection and handling of water supplies in refugee and military camps.

(4) Supervision over cleaning up process.

Adjutant General Dickson, who was in general charge of the flood relief work, has pointed out four stages in connection with the handling of a great flood, namely:

First: "Protection," or the efforts on the part of threatened communities and individuals to keep out the flood waters, and to remove and protect their goods and other belongings where the water has entered.

Second: "Rescue," or the work of saving lives in those districts where protection has been unsuccessful.

Third: "Relief," or the process of furnishing food and clothing to those who have been rendered destitute.

Fourth: "Rehabilitation," or the cleaning up and restoration of homes and the resumption of regular business activities.

This classification of the various flood stages is a very apt one and serves to make clear the opportunities afforded for effective work by the State Water Survey. There is little that can be done by the Survey during the first two stages. During the period of relief,

*By Paul Hansen, Engineer State Water Survey.

however, most effective work can be accomplished, as this is the time of greatest demoralization with respect to sanitary conditions, the time moreover when the people, owing to exposure and lack of food have a lowered vital resistance, and are therefore readily subject to infection, and also the time when danger of infection is greatly increased through personal contact as a result of concentration in limited spaces, whether these be refugee camps or the houses of neighbors. These various factors combined with flood polluted wells and cisterns, render imminent the ravages of pestilence. Typhoid fever especially is apt to develop inasmuch as it may gain a foothold through contact, and then be spread rapidly through the medium of inadequately protected water supplies that may be in use.

The work which the State Water Survey was able to perform during rehabilitation is scarcely less important than that performed during the relief period, inasmuch as at this time public water supplies may be again placed in operation, private wells and cisterns which were submerged by the flood waters require careful cleaning and treatment to render the water safe, and there is a very large amount of work to be performed in connection with general sanitation.

The work of the State Water Survey, as well as the entire flood relief work in Illinois, was very much facilitated by the availability of the steamer "Illinois," which plied up and down the Ohio and Wabash rivers, carrying supplies and serving as a moving headquarters for those in charge of the various branches of the work. At each place visited a conference was hastily and informally called and participated in by the village or city authorities and General Dickson, together with his various temporary assistants. Among the latter were included: Dr. C. E. Crawford, of the State Board of Health; Major Jacob Frank, Military Surgeon on the Governor's Staff; Mr. Henry Stewart, Representative of the American Red Cross, the Chicago Chamber of Commerce, and the engineer of the State Water Survey. From time to time others joined these conferences, and there were also sub-conferences split off from the main conferences for the purpose of discussing various details of the relief work necessary.

METHODS USED IN CONDUCTING WORK.

At strategical points, representatives of the State Water Survey were landed and placed in immediate charge of the Survey's activities. This feature of the Survey's work is of greatest importance and significance for the reason that it is impossible to rely merely upon instructions given to local authorities, no matter how simple these instructions may be, or how clearly stated. With a man actually on the ground for the purpose of engaging in the work himself and of organizing local committees for his assistance, there may be reasonable assurance that reliable work is being done.

Upon arriving in a community the first thing done was to make a thorough inspection of conditions with special reference to water supply. Following this, those wells and cisterns that had been completely submerged by the flood waters were emptied, thoroughly cleaned and washed on the inside with a strong sterilizing agent, usually hypochlorite of calcium, though in some instances permanganate of potash was used. Those wells and cisterns which had not been submerged by the flood, but which were believed to be contaminated were merely treated with solutions of hypochlorite, applied in sufficient quantity to insure sterilization. Additional wells and cisterns were treated as rapidly as the recession of the flood waters would permit.

After the flooded areas became uncovered, the work of cleaning and restoration was begun, and in this connection full instructions were given relative to the manner of conducting this work. In some of the communities visited, labor gangs were organized among those who were receiving rations from the state, for the purpose of cleaning streets and alley ways.

In illustration of the necessity of having competent directors of sanitation on the ground at all times, it may be noted that when left to their own devices, the people in the flooded districts used the large quantities of lime that had been shipped to them in a most ineffective manner. The general practice was to strew it about on lawns and wet areas in comparatively large lumps. The only possible advantage that this practice could have would be in its application to cellars for the purpose of assisting the drying out of the floors, but as a deodorant or sterilizing agent its effect was practically nil.

The Survey men first of all insisted that the use of lime should not be substituted for removing dirt and filth. Lime when used was applied in the form of a milk instead of in lumps in almost all instances. When applied to cellar walls as a deodorant and a sterilizing agent, it was used in the form of whitewash. When used for the purpose of disinfecting fecal deposits, such deposits were heavily covered with a thick emulsion. When used for deodorizing slime deposits (and it may here be mentioned that all flood deposits whether such are polluted or not have a peculiarly disagreeable odor), the milk of lime was used in the form of a spray from a sprinkling can. These methods secured a much more thorough application of the lime than is usual, and prevented its being used wastefully.

At Shawneetown, the conditions were very much different from most other places visited, owing to the concentration of the population in refugee camps. Here it is believed that the Survey accomplished a great deal of good in connection with protecting the camp water supplies, and in providing the camps with proper sanitary conveniences.

The camp water supplies were drawn from farm wells or springs. These supplies normally are of good sanitary quality, but due to the advent of the refugees, there was much danger of them becoming contaminated by not being adequately protected. For example, one spring directly alongside of a much travelled road was being utilized. Another spring was endangered by locating directly above it an improvised pig-pen and stable yard. All persons were allowed free access to these sources of supply, and the handling of the water in distributing it to the camps was conducted in a manner that would readily admit of contamination. All of these sources of supply were thoroughly protected by suitable structures placed about them, and the distribution of the water to the camps was placed under careful supervision. At the time of arrival a great lack of sanitary conveniences existed among the camps at Shawneetown, and this condition was soon remedied by the construction of sinks covered with tents. These were maintained in a cleanly condition and the contents were periodically sterilized.

The very valuable and cordial assistance that was given the work of the State Water Survey at Shawneetown by the militia officers deserves special mention.

PUBLIC WATER SUPPLIES.

Fortunately, few of the public water supplies were sufficiently affected by the flood to render them a serious menace to public health. At Cairo owing to the exceedingly large amount of turbidity carried by the flood waters, it was not possible with the purification works at hand to secure a clear and colorless water. The water was rendered safe, however, by the installation of a hypochlorite treatment plant, whereby hypochlorite was applied to the supply in quantities that would assure sterilization. Some improvement was also affected in the physical appearance of the water by modifying the methods of applying the chemical coagulants used in connection with the process of filtration.

At Metropolis the public water supply, derived from a deep well which yields a water of excellent quality from a sanitary point of view, was contaminated by the necessity of admitting polluted flood waters to a collecting reservoir in order to prevent the reservoir from collapsing. The water was soon rendered safe, as in the case of Cairo, by the application of hypochlorite of lime as a sterilizing agent. Shortly after the flood began to recede it was possible to resume the use of the well water alone.

At Mt. Carmel the water works was put out of commission for a few days, and for an additional few days it was necessary to pump unpurified water into the distribution system. Prompt warnings, however, were given the people of the city to boil the water, and by the time the representative of the State Water Survey arrived on the ground, the supply drawn from the Wabash river was again being filtered and delivered to the consumers in a wholesome condition.

At Grayville, Carmi, and Harrisburg, the water supplies are at all times drawn directly from the stream, and it is not probable that the condition of these supplies was materially worse from a sanitary point of view during the flood than they are at other times. The State Water Survey stands ready to cooperate with the local officials or water companies in all of these communities with a view to securing a more satisfactory source of supply or improving the existing supply by means of filtration. At Harrisburg, the installation of a filtration plant is now definitely assured.

Mounds, Mounds City and Brookport, all have public water supplies derived from tubular wells, and so protected against surface contamination that the flood water had no effect upon the quality of the water as delivered to the consumers.

While the various activities of the State Water Survey could not be fully completed until the waters had entirely receded, yet each representative stayed upon the ground long enough to be fully assured that the instructions left and the example set by his own work would be fully carried out.

ITINERARY.

In order to present somewhat circumstantially the amount of work done and the places visited by the representatives of the State Water Survey, the following itinerary is set forth.

On the evening of Monday, April 7th, a telegram was received from Governor Dunne requesting the services of the State Water Survey in connection with flood relief work in the southern part of the state, and instructing the parties sent out to report to Adjutant General Frank Dickson at Mounds or Cairo. A meeting of the staff of the State Water Survey was held that night for the purpose of discussing methods of attacking the work, and of preparing necessary chemicals and other equipment for the trip.

On the morning of April 8th, Mr. Paul Hansen, engineer, and Mr. W. G. Stromquist, one of the assistant engineers, proceeded to Mounds, which place was reached about noon. It was learned that General Dickson was then at Cairo, but owing to defective telephone connections it was impossible to get in touch with him. However, Cairo was reached about 6:30 in the evening, through the courtesy of the naval reserves, who placed one of their launches at our disposal. That evening a conference with General Dickson was had during which he described the flood situation and the General in turn was advised as to what services the staff of the State Water Survey was in position to render. He then instructed the engineers to join a party on the steamer "Illinois" which left Cairo on noon of the following day.

The rest of the Survey party was communicated with and instructed to meet the steamer at Mound City. During the morning of April 9 it was possible to inspect the water works at Cairo, and to make preliminary arrangements for sterilizing the water and increasing the efficacy of the filter operation. Otherwise there was practically nothing to be done at Cairo, inasmuch as that city had been quite successful in protecting itself against the flood situation. Mr. Stromquist remained at Cairo for the purpose of assisting the Cairo Water

Company to install a hypochlorite treatment plant, and was instructed to look after the water supply and sanitary conditions at Mounds and Mound City with the assistance of Mr. W. F. Langelier, inspector who arrived in Cairo on Thursday, the 10th, from Mt. Vernon.

The "Illinois" reached Mound City about three o'clock in the afternoon of April 9, where it was joined by Messrs. H. P. Corson, chemist; Ralph Hilscher, assistant engineer; Harry F. Ferguson, engineering assistant; and F. W. Tanner, bacteriologist.

Metropolis was reached on the evening of the 9th, and at this point, Mr. Tanner was taken ashore with instructions to look after the conditions in both Metropolis and Brookport. Brookport is but a few miles from Metropolis, and was accessible either by rail or boat.

On the night of the 9th and 10th the boat lay over at Paducah, but got under way early on the morning of the 10th and steamed up the river to Golconda, where it made its first stop. At that point Mr. Ferguson was taken ashore and placed in immediate charge of the work at that village and also at Roseclare and Elizabethtown, nearby communities in an upstream direction which were accessible by boat.

On the evening of the 10th, the Illinois reached Shawneetown where she remained until noon of the following day, thus affording considerable time for inspecting flood conditions and refugee camps. Mr. Corson was left in charge at Shawneetown.

Upon leaving Shawneetown, the Illinois steamed directly to Mt. Vernon, Indiana, where it arrived on the afternoon of the 11th. After taking on a few supplies, it was again under way for a trip up the Wabash river. No landings, however, were made that evening. On the night of the 11th and 12th, the boat lay moored to some trees until early morning.

On the 12th, landings were made at Little Chain Hill, Dog Town and Maunie on the Wabash and Equality on the Little Wabash. These places were primarily refugee points, for people whose farms and farm houses had been flooded. They were completely surrounded by water and the people were in a destitute condition. The sanitary conditions were, however, no worse than usual, and the water supply was in fairly safe condition. Accordingly no one was left at any of these places, though Equality and Maunie were subsequently visited by Mr. Hilscher.

On the evening of April 12, the Illinois returned to Mt. Vernon, Indiana, where it lay over night and took on large quantities of supplies, principally clothing for the destitute. On Sunday, the 13th, the Illinois made a rapid trip to Cairo, stopping only at Shawneetown for the purpose of leaving off supplies, and Paducah for the purpose of taking on coal. Avoidance of stops was necessary on account of the shortage of coal.

Mr. Hilscher was left at Mt. Vernon with instructions to visit all flooded towns in the valleys of the Wabash and Saline rivers, and to provide such relief from impure drinking water and unsanitary conditions as was possible. The towns visited by Mr. Hilscher were Harrisburg, Equality, Carmi, Maunie, Mt. Carmel and Grayville. Serious conditions were found only at Harrisburg, where a large portion of the town had been inundated and many wells and cisterns were contaminated. At Mt. Carmel, the water works had been flooded and the water supply was cut off for several days, but the enterprise of the water company officials resulted in getting the water works in operation again in a minimum of time and the supply suffered but little contamination.

Covering the period of April 15 to 17, the Illinois made a second trip up the river for the purpose of distributing food and clothing. This trip gave an opportunity for conferring with the various representatives of the Survey, and reviewing the work which they had done. On this trip it was found expedient to permit Mr. Tanner to leave Metropolis and Brookport in order to assist Mr. Ferguson at Golconda. It proved that transportation facilities between the three towns of Golconda, Roseclare and Elizabethtown were not very good, and that it had been impracticable to give adequate attention to conditions at Golconda. This was especially unfortunate in view of the fact that the support of the work by the village officials at Golconda was not very cordial. The work remaining to be done in Golconda, however, required but a single day, after which, namely on the 18th of April, Mr. Tanner returned to Urbana. At the end of the trip upstream, which terminated at Mt. Vernon on the evening of the 18th, Mr. Hansen left for Urbana, but remained in touch with the representatives in the field. Only one additional change, however, proved advisable, namely, the transference on April 20 of Mr. Ferguson to Shawneetown to assist Mr. Corson. Mr. Corson, Mr. Hilscher and Mr. Tanner returned to Urbana on the 23rd.

SUMMARY.

The real value of the work of the State Water Survey in the flooded district of Illinois cannot be very well estimated, but it is believed to have been very effective, primarily due to having men on the ground to make sure that all instructions were fully carried out and to actually take part in the work. It is significant that as yet no epidemics of typhoid fever or other intestinal disorders have developed, and it is these diseases that are most to be feared under conditions that existed, owing to the extensive pollution of wells, cisterns and in some instances public water supplies. The results which the Survey has to show are characteristic of public health work in general. If the work is well carried out and successful, there is no tangible way of measuring the extent of the success, but if the work is neglected, the damage may become all too distressingly measurable through the development of a disastrous epidemic.

SANITARY ENGINEERING AND AGRICULTURAL ENGINEERING*

Sanitary Engineering is a somewhat restricted specialty, while Agricultural Engineering is, perhaps, broader in its scope than any other branch of the engineering profession. This statement is certainly true if we accept as a definition of engineering, the use and control of the material and forces of nature for the benefit of mankind, because more of the materials and forces of nature are used on the farm than in any other line of business. The work of the sanitary engineer is ordinarily confined to projects of considerable magnitude relating to the water supplies, the sewerage systems and the refuse disposal systems of cities. It also has to deal with plumbing and plumbing fixtures in buildings and houses, but this is a branch nowadays commonly left to the architect. It includes heating and ventilating, but this likewise has become so specialized that it is handled by a class of engineers known as heating and ventilating engineers. The work of the agricultural engineer, though relating to problems of comparatively small magnitude and rarely very costly, yet covers practically the entire engineering field.

It is not probable that many of the specific engineering problems of the ordinary farm will be solved by the sanitary engineering specialists, though such specialists will from time to time be called upon in connection with the design and installation of water supplies and sewerage systems for institutions and large country estates. The great mass of sanitary engineering work on farms will, however, be relegated to the agricultural engineer, to the architect, to the contractor, and in most cases to the farmer himself. There is, however, much within the experience of the sanitary engineer which renders him in a favorable position to offer much suggestive advice to agricultural engineers, architects, contractors, and farmers, and it will be the object of this paper to discuss in a general way some of this experience.

The field is so very broad that an adequate discussion of all phases of engineering work on the farm which have a sanitary relation cannot be presented within the limits of a paper. Therefore, those subjects such as heating and ventilating, plumbing and plumbing fixtures, sanitary construction of houses and drainage for the prevention of mosquito breeding and other sanitary purposes which do not in practice fall within the field of the sanitary engineering specialists, will be

*A paper by Paul Hansen, Engineer, State Water Survey, read before the American Society of Agricultural Engineers, December 30, 1913.

disposed of with a few brief paragraphs, whereas, the bulk of the discussion will be devoted to the public water supply and to the sewerage system.

SANITARY CONSTRUCTION OF HOUSES.

The key to the sanitary construction of houses is the avoidance of floors and surfaces that cannot be readily cleaned and the avoidance of dark and damp spaces. To accomplish this, an elevated location should be selected, but should this prove impracticable, great care should be exercised to make the cellar or basement thoroughly watertight and to intercept all ground water before it reaches the cellar by means of a drain tile placed completely around the house at a level with the base of the foundation. An outlet for the drain must be provided at some convenient point. Preferably the excavation necessary to accommodate this drain tile should be back filled with broken stone or gravel to within a foot of the surface; the top foot may be of ordinary loamy earth. The floor of the cellar should be constructed of concrete made waterpoof, and with a smooth surface. All portions should be sloped to one or more points at which should be placed outlet drains having a trapped connection to the house sewerage system.

When possible, polished hardwood floors should be used throughout the house and removable rugs should be used instead of carpets which latter cannot be regarded as other than dirty and unsanitary notwithstanding the advent of the vacuum cleaner.

Closets, if possible, should be given an outside window, dark, corners should be avoided and in every room there should be an abundance of sunlight, even if it does fade the carpets and the wall paper. Sunlight is a great purifying medium and should be present in every house in abundance. To this end dark curtains and closed blinds should be done away with.

Opportunities should always be provided for securing a frequent change of atmosphere in the rooms. Where because of the coldness of the climate, and the use of storm sash, this cannot be satisfactorily accomplished by means of open windows, small ventilating openings in or under the windows should be provided, and there should be placed in the house a number of open fireplaces, which though inefficient heaters are very efficient ventilators. Aside from the usefulness of fireplaces as ventilators, they add great cheer on cold winter evenings. Whether fireplaces are used or not, there should be provided a reliable furnace or hot water heating plant.

PLUMBING AND PLUMBING FIXTURES.

There are but few principles to be laid down in connection with the selection and installation of plumbing and plumbing fixtures. First of all is, that if possible all plumbing fixtures in the house should be grouped around a single vertical soil pipe extending from the basement through the roof. This soil pipe should be of cast iron of substantial thickness and put together with bell and socket leaded joints with all bell ends looking upward. The top should be left open and should extend at least two feet above the roof of the house. It may, if desirable, be concealed within a false chimney or placed in, a chimney with several flues. The soil pipe at the base of the house makes a turn and discharges into the house sewer, which is made of vitrified sewer pipe carefully laid with cemented joints and never less than 6 inches in diameter. The turn at the bottom of the soil pipe should be made with a tee or Y special, placed with the through leg in line with the sewer for rodding out obstructions. Contrary to general opinion, it is not necessary to place a trap on this sewer, and it is quite permissible to provide, for the ventilation of the sewer by means of the upcurrent through the soil pipe.

The usual plumbing fixtures comprise laundry tubs in the basement, kitchen sink, possibly a lavatory with closet on the first floor, and bathroom fixtures, including bathtub, washbasin and closet on the second floor. These, of course, may he elaborated according to the size of the house or to suit the owner's fancy. Sometimes it is desirable to have two bathrooms and additional fixtures, such as a shower bath and a slop sink.

In the selection of fixtures the widest range of choice is available and the prospective buyer is limited only by his taste, and by his pocketbook. Most modern plumbing fixtures are designed to promote cleanliness and sanitation, but there is nevertheless some latitude in the selection of plumbing fixtures to secure those that may be readily kept clean and which will have no inaccessible corners and cause wet walls. While there is a great range in point of price from which to select consistent with good plumbing installation, yet it is false economy to buy unsubstantial and cheap fixtures, since they are constantly getting out of order and causing no end of annoyance and expense.

There are a few items of design that require attention. The bathtub should have an outlet flush with the bottom, and not flush with the side, and at right angles with the bottom, as with this arrangement it is almost impossible to completely drain the tub. Nor should there be used an inlet to the tub which is placed below the water level when full, for it is quite possible that a lowering of the water pressure (such as may readily occur with a small farm water works) may cause the inlet to become the outlet and persons in the laundry or kitchen below may be somewhat surprised at seeing a soapy water issue out of the faucet. For the wash basin, the best arrangement is the flush metal stopper actuated from below by means of a suitable handle placed at the back of the basin. Such stoppers are in common use on Pullman sleeping cars. The device, however, is rather costly and complex, and, therefore, not always desirable. The best substitute is the old-fashioned rubber stopper, though this is somewhat objectionable owing to the attached chain which readily accumulates dirt.

All plumbing fixtures must be securely trapped and there are many highly satisfactory traps now on the market for all manner of fixtures. City plumbing ordinances ordinarily and quite properly require that in addition to the trap there shall be a vent connected to a vertical vent pipe running through the house parallel with the soil pipe. These vents are intended to prevent syphoning of the traps, but in the ordinary farm dwelling the venting of plumbing fixtures may for economy's sake be omitted.

A word may be said with reference to the construction of the interior of the bathroom. Most to be desired, of course, is the tile floor and high marble or tile wainscoting, but this elaboration can rarely be enjoyed on the farm. The next best is a well laid oil-cloth floor covering of best quality with a wainscoting of oilcloth, either plain or stamped to imitate tiling. The waiscoting in any event should be carried well up above the height to which splash may reach. The remainder of the wall and ceiling should be papered with glazed waterproof paper of a light color and simple design.

An approximate estimate of cost of plumbing a house is given in the following tabulation, and the figures relate to a two-story house with basement:

Soil pipe with necessary Y and T connections	$15.00	to	$ 30.00
Two set tubs for laundry	20.00	to	60.00
Kitchen sink with drain board	7.50	to	30.00
Bath tub	20.00	to	200.00
Wash basin for bath room	7.50	to	40.00
Closet	17.50	to	75.00
Necessary piping and faucets for hot and cold water, including hot water boiler	20.00	to	40.00

Looking at the matter in another way: Complete house plumbing, including wood–zinc tub, sink and laundry tubs, iron enameled wash basin and porcelain water closet may be installed for $200.00. Complete house plumbing, including porcelain closet, wash basin and sink and iron enameled bathtub and laundry tub, may be installed for $300. The first represents cheap and flimsy construction; the latter represents substantial though not fancy construction; and is well worth the additional hundred dollars.

DRAINAGE FOR THE PREVENTION OF MOSQUITO BREEDING AND OTHER SANITARY PURPOSES.

The advantages of land draining for agricultural purposes are well known by all up-to-date farmers. But land drainage has also an additional and very important value, namely, for the purpose of draining swampy areas and thereby preventing the breeding of mosquitoes. The writer has in mind certain districts in Ohio which were drained primarily with this object in view, though, of course, the same operation opened up large additional areas for agricultural purposes.

In certain flat or low-lying territory, deep drainage may be utilized for lowering the ground water level, which facilitates the maintenance of dry cellars and makes possible the installation of sanitary sewerage systems. One such case existed in a rural community near the city of Louisville, Kentucky, where the topography was such that large areas used for residential purposes were more or less flooded during certain seasons of the year, with here and there small pools which lasted throughout a large portion of the year. There was no possibility of draining cellars, because there was no drainage course. Sanitary sewers could not be installed because there was no available point of discharge, and if there had been, the entrance of ground water into the sewer conduits would have prevented the economical final disposal of the sewage. The installation of a drainage system lowered the ground water level to an extent that made it easily possible to maintain dry cellars. Mosquitoes and malaria disappeared, and there is now under way the installation of sanitary sewerage which will afford houses in this locality all of the sanitary advantages and conveniences of the most favored localities.

WATER SUPPLY.

Sources of Water Supply: The principal sources of water supply on farms are wells and cisterns. Occasionally under favorable conditions, the supply may be obtained from a spring, and in certain instances where the ground water supply is limited, surface streams are utilized. The conditions under which it is permissible to use a water supply from a stream for domestic purposes are so few as to be practically negligible. It must be recognized, however, that streams, even though moderately polluted, may constitute satisfactory water supplies about the barns and for stock watering. In occasional instances a small waterfall on a stream may be utilized for pumping. For all practical purposes, however, it is not necessary to consider streams. Somewhat detailed attention will, however, be devoted to wells, cisterns and springs in the order mentioned, which is also the order of their relative importance.

Wells: There are various kinds of wells available for farm uses and as they differ greatly in their relation to sanitation, it is necessary to obtain clearly -in mind, how they differ. Wells may be broadly divided into dug wells and tubular wells.

Dug wells are of comparatively large diameter, rarely less than 3 feet, and are lined with brick or stone. The lining in a substantially constructed well is made with cemented joints, and the water is permitted to enter from the water-bearing strata through the bottom only. More crudely constructed wells have linings without cemented joints. Dug wells range in depth from 5 or 6 feet to about 100 feet, but the great majority have depths ranging between 10 and 40 feet.

When a greater depth than 50 feet must be penetrated to reach the water-bearing strata it is found more convenient to do so by sinking a tubular well. Tubular wells are generally of small bore, seldom exceeding 12 inches in diameter. When passing through loose material, they must be cased with steel or wrought iron pipe, but in solid rock no casing is ordinarily required. Where the water-bearing stratum is in loose material, it is necessary to use some form of strainer which will admit the water freely, but will exclude sand. There is practically no limit to the depth of tubular wells, except present limitations imposed by the art of drilling. It is unusual, however, for water wells to exceed a depth of 2,500 feet, and the great majority of tubular wells on farms are less than 150 feet in depth.

There is another type of tubular well which is shallow, namely, the drive well. This is nothing more than a pipe shod with an iron driving point and provided at its lower end with a strainer or screen. Drive wells are driven into the ground as one would drive a pile. It is only applicable, however, where an abundant supply of water can be secured at depths of less than 30 feet in comparatively loose material.

There is one form of well which is on the dividing line between the tubular and the dug well. This is the tile-lined well. The diameter of the tile-lined wells generally varies from 8 inches to about 18 inches, and the method of drilling is that ordinarily used for tubular wells in loose material. The lining, however, instead of being of steel pipe, provided at its base with a strainer, consists of vitrified sewer pipe let down into the well with open joints. These wells have all the characteristics of dug wells so far as pollution is concerned, but resemble tubular wells in the methods used in sinking them.

Another grouping of wells relates to the material in which water is found, and under this grouping we have drift wells or wells in loose material above bed rock and rock wells. Drift wells may be subdivided into so-called surface wells obtaining their water from water-bearing strata fed from the surface in the immediate neighborhood, and deep drift wells which receive water from a considerable distance. The dividing line between these two classes is a rather indefinite one, but the extremes represent widely divergent conditions. There may also be another sub-division relating to the character of the water-bearing material such as clay, sand, sand and gravel, and gravel. Rock wells may be sub-divided into groups, according to the character of the rock, and the depth at which it is found. For example, there are wells in sandstone, wells in limestone, surface rock wells, and deep rock wells.

Finally, and of much importance from a sanitary point of view, all wells may be grouped into two classes according to the pressure under which the water is found. When the water is under no pressure, we may for want of a better name, term it a common well. Where the water is found under pressure due to the presence of overlying impervious strata, the well may be described as under artesian pressure. This pressure may be so great as to cause the water to rise above the surface of the ground, in which case, the well becomes a true artesian well.

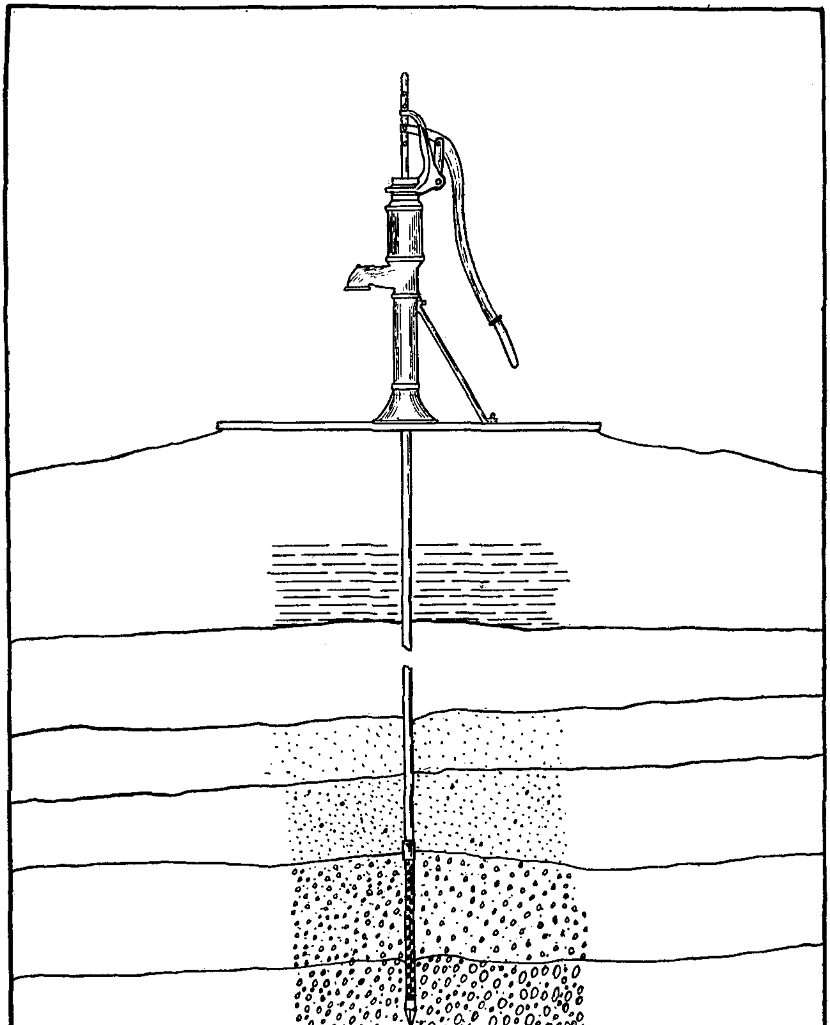


Fig. I.—Drive Well Adequately Protected Against Surface Contamination.

Having reviewed the various types of wells, it will be possible to consider the relative purity of water derived from them.

Pollution of Wells: Broadly speaking, there are but two types of wells which are subject to serious contamination, namely, the dug well and the well of whatever construction which derives its supply from limestone rock.

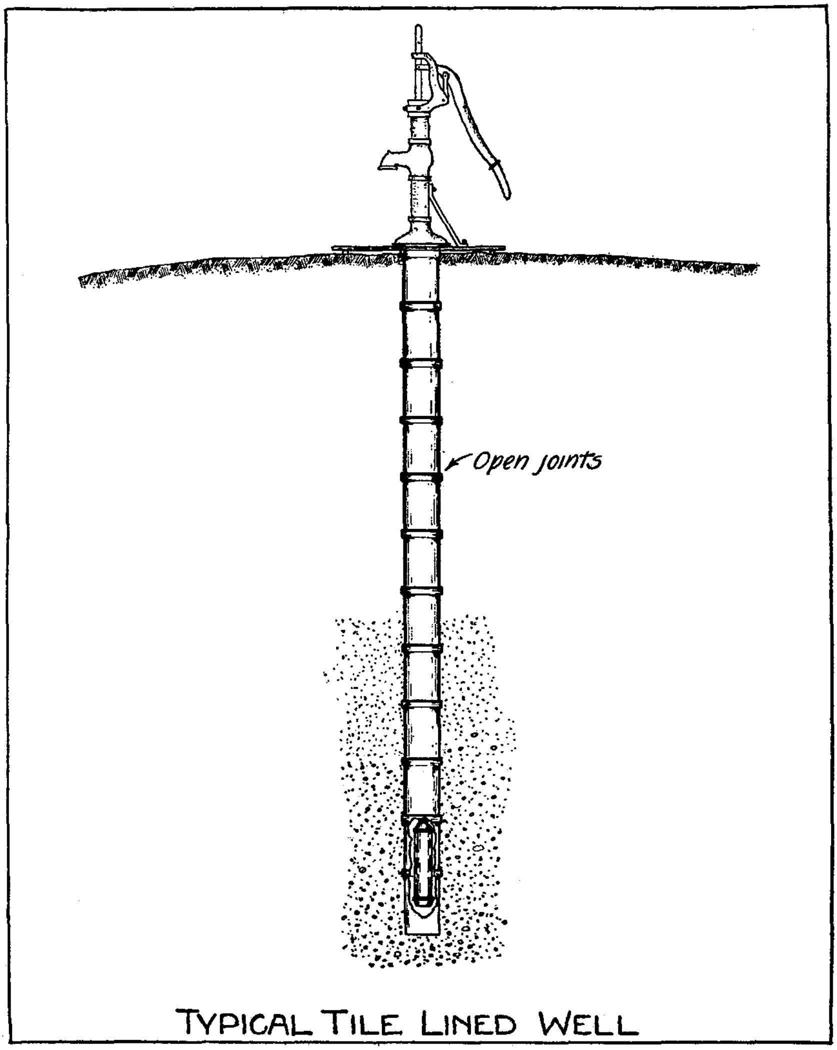


Fig. II.—Typical Tile Lined Well.

The dug well (and this includes tile-lined wells) may receive pollution through penetration of polluting material downward through the soil into the water-bearing stratum and thence into the well. This occurs when privies or cesspools are placed within close proximity to shallow dug wells. Sometimes leaching cesspools with open bottoms are placed near dug wells and are sufficiently deep to enter the same stratum from which the well derives its water. The porosity of a water-bearing stratum serves to carry off the liquids which are received in the cesspool, and from the point of view of sewage disposal is a very satisfactory arrangement, but from the point of view of water supply it is quite unsatisfactory.

Pollution through the soil, however, in the case of dug wells is far less common than is popularly supposed, but pollution by direct entrance of filthy and infectious matter from the surface at or near the top of the lining of the well is far more common than is popularly realized. Where privies or other accumulations of filth are near such wells the surface wash during heavy storms may carry pollution into the well. Furthermore much filth is tracked about on the feet of persons, domestic animals and poultry, some of which from time to time is scraped off on the covering of the well and thus finds its way readily into the water supply. A very common source of pollution of shallow wells results from the entrance of small animals, such as rats, mice, frogs and an occasional cat or rabbit. These may not cause specific diseases, but when in a decaying condition may render the water unpalatable, and in any event such pollution is not pleasing to the esthetic sense.

The accompaniyng cut, Figure 3, shows clearly how readily dug wells may receive direct contamination from the surface of the ground. Figure 4 shows how a dug well may be adequately protected against surface contamination. It will be observed that no opportunity is given for the entrance of pollution into the well through or underneath the covering, which is made of concrete. Even the manhole is placed at a slight elevation above the general level of the concrete surface, so that no drainage may enter. An ordinary well-fitting manhole cover will serve the purpose, but if extra precautions are desired, the manhole should be of the gasketed type and bolted down. To further protect the well, surface drainage which percolates into the ground in the immediate vicinity of the well is forced to travel at least 6 feet in a downward direction by plastering the outside of the well with Portland cement mortar so as to render it impervious.

It is still possible for a well constructed as above described to receive sub-surface pollution, but slow percolation or filtration of polluting material through the soil results in a very high degree of purification, and if surface privies, manure piles and pig pens are maintained at a distance of 50 feet or more, there is no likelihood of serious contamination of the well water in ordinary soils. In the case of cesspools, however, the distance should be made at least 500 feet, and preferably some other means of sewage disposal should be sought.

Wells in limestone rock are the most treacherous of all wells because of the action of water on limestone which creates large underground channels by a process of solution and erosion. It thus becomes possible for water to travel great distances under the ground

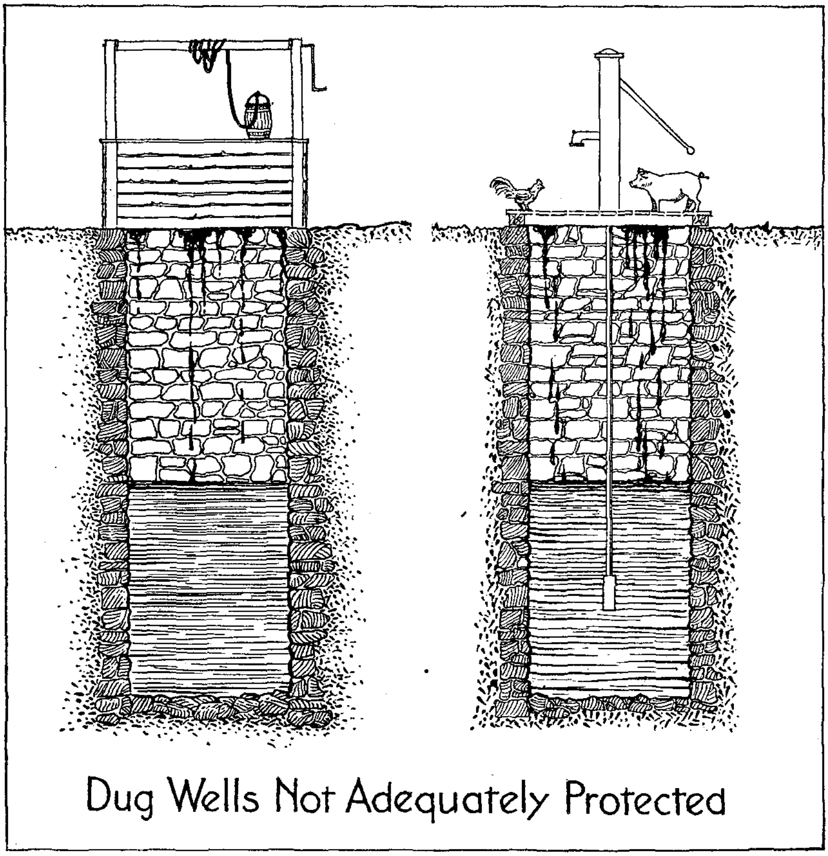


Fig. III.—Dug Wells Not Adequately Protected.

without undergoing any greater degree of purification than would obtain in surface streams. Even a sanitary analysis of the water in limestone regions is unreliable unless it happens to show pollution, for the entrance of contamination is often intermittent. In typical limestone regions in Kentucky whole communities get rid of their sewage by discharging it into so-called sinks or openings in the ground which lead to subterranean water-worn channels in the limestone bedrock. Often wells penetrating the same channels are used for domestic purposes and it usually takes an epidemic to convince the public of the danger.

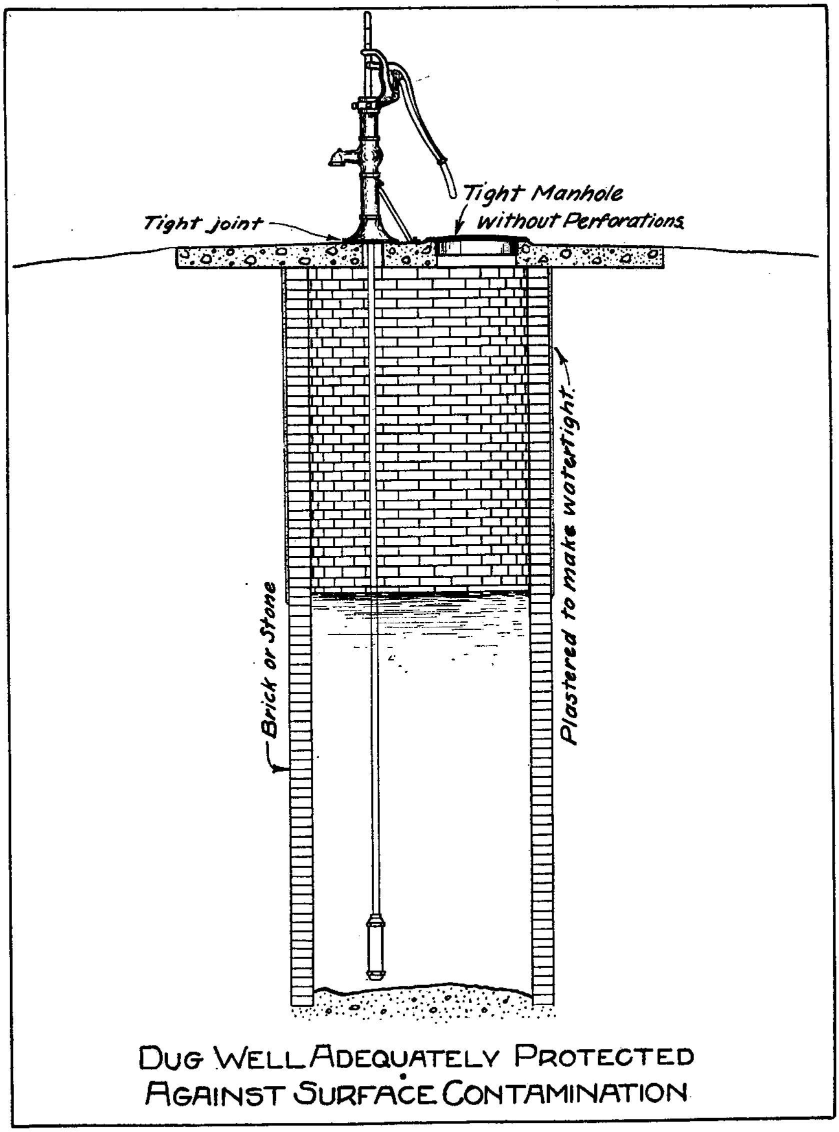


Fig. IV.—Dug Wells Adequately Protected.

All other types of wells are comparatively free from the danger of contamination, yet it must be recognized that even tubular wells when poorly arranged are subject to contamination from the surface. Moreover the steel casings used in connection with tubular wells are sometimes corroded to an extent that causes them to leak badly and admit polluted water from the surface or near the surface. Artesian wells always yield water of good sanitary quality, for the very fact that they are under pressure necessitates the existence of impervious strata lying above the water-bearing stratum, and further the water almost certainly will have had a sufficiently long passage through the earth to insure complete self-purification. It is only in the flowing wells, however, that danger from contamination is completely removed, for even in artesian wells, if the pressure does not force the water above the surface there is a danger from defective casings, as above outlined. In concluding the discussion of the ways in which well waters may become contaminated, emphasis should be given to the fact that many perfectly good ground waters are contaminated after they are brought to the surface by unsanitary handling.

Cisterns: The rain water cistern in regions where only hard or otherwise objectionable water may be obtained from wells has not been developed to the best advantage. If properly collected and stored, rain water constitutes a most desirable water supply for all domestic purposes, and its availability in adequate quantity will be greatly appreciated by the women on the farm. The dimensions of cisterns as ordinarily constructed are determined by rule of thumb, which gives sizes approximately correct for the storage of water in the eastern states, where the rainfall is far more evenly distibuted than through the central west. In Illinois, for example, the average annual rainfall is 30 inches or more, and most of this is precipitated during the winter and spring months. At comparatively frequent intervals, such as in 1895, 1908, 1911 and 1913, there are periods of as much as six months in duration and extending over large areas when the rainfall is almost negligible. It becomes, therefore, desirable to provide cisterns of greater storage capacity than is now customary. A storage equivalent to half of the minimum annual precipitation is believed to be advisable. This will permit the conservation in dry years of nearly the entire rainfall and in wet years will render possible the utilization of far greater quantities of rain water.

It has always been customary to divert the first flow of roof water, so that the roof may be properly washed and only clear water enter the cistern. This is one way of securing a reasonably clear water, but it results in large waste which can be readily prevented by equipping a large cistern with a suitable form of filter. Figure 5 represents a cistern of 15,000 gallons capacity and suitable for a house having a roof area of about 1,600 square feet. It is provided with a filter wall, which consists of two thin walls of brick separated

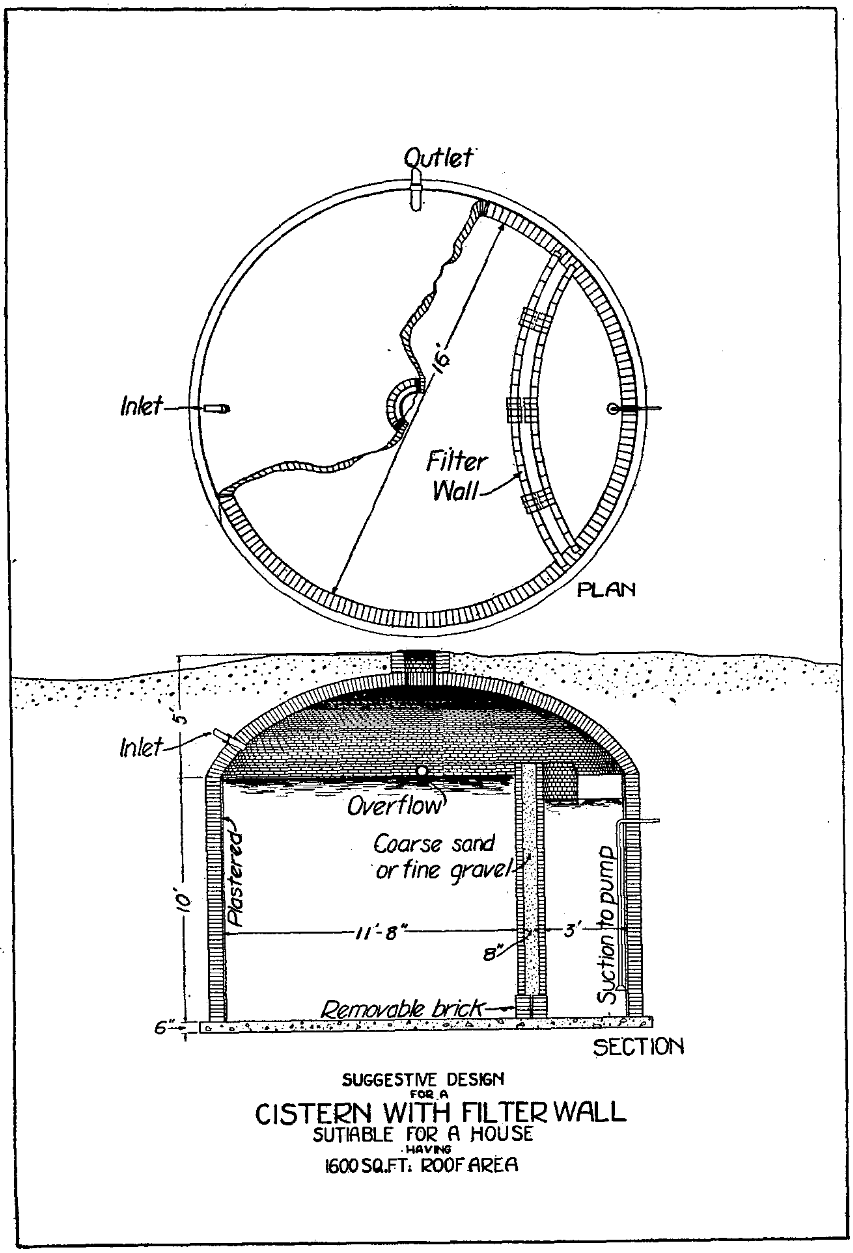


Fig. V.—Suggestive Design for a Cistern with Filter Wall.

by an 8-inch space filled with a coarse sand or fine gravel. The vertical joints in the brick work are made with cement mortar, while the horizontal joints are laid dry. At the base are placed a number of loose brick at several points, so that the sand or gravel may be removed when it becomes unduly clogged. The filter wall is built in an arch shape so as to give it strength against the pressure of water on the upstream side, and the raw water compartment is made much larger than the filtered water compartment so as to obtain the full benefit of sedimentation before filtration. Sedimentation may be much assisted by the occasional use of about two pounds of dissolved crystal alum and about one pound of freshly slaked lime, the latter in the form of a dilute mixture with water. This application of chemicals need be made only two or three times a year. It results in making the water slightly hard, but this increase in hardness will be scarcely perceptible. The alum will prove unobjectionable because none of it will pass into the filtered water basin. It assists sedimentation by creating a floculent precipitate which entrains the finely divided solid particles washed from the roof and causes them to settle more rapidly. The use of alum also will remove in large measure the color from water that is derived from shingled roofs.

Figure 6 illustrates another form of filtering device which may be used in connection with a cistern. This filter is built according to principles for many years successfully used in the purification of public water supplies by what is known as the slow sand filtration process. It is more costly than the method previously described, but is more certain in its action and has a higher bacterial efficiency. Also it is more readily accessible for cleaning and repairs. The maintenance of a filter of this type involves the removal of about a half inch of sand once in a year or perhaps once in two years, which can best be done when the cistern is drawn low at the end of the summer season. A small quantity of alum, not over half pound, in solution, together with about a quarter of a pound of freshly slaked lime, introduced into the filter compartment during the first rainfall after cleaning, will materially increase its efficiency during the early part of the filter run.

The foregoing discussion has been based upon the current practice of utilizing the rain water from the house roof only, and the question may be raised as to whether it would not be highly desirable to carefully conserve the water from the barn roof and from the roofs of any other buildings that may exist upon the farm. Where sufficient roof area is not available it may be desirable to prepare catchment areas on the surface of the ground. This may be accomplished by paving limited areas or by keeping them in sod. In the latter instance the area must be roughly about five times as large as the paved or impervious area. It is essential, however, that such areas be protected against undue contamination and to this end they should

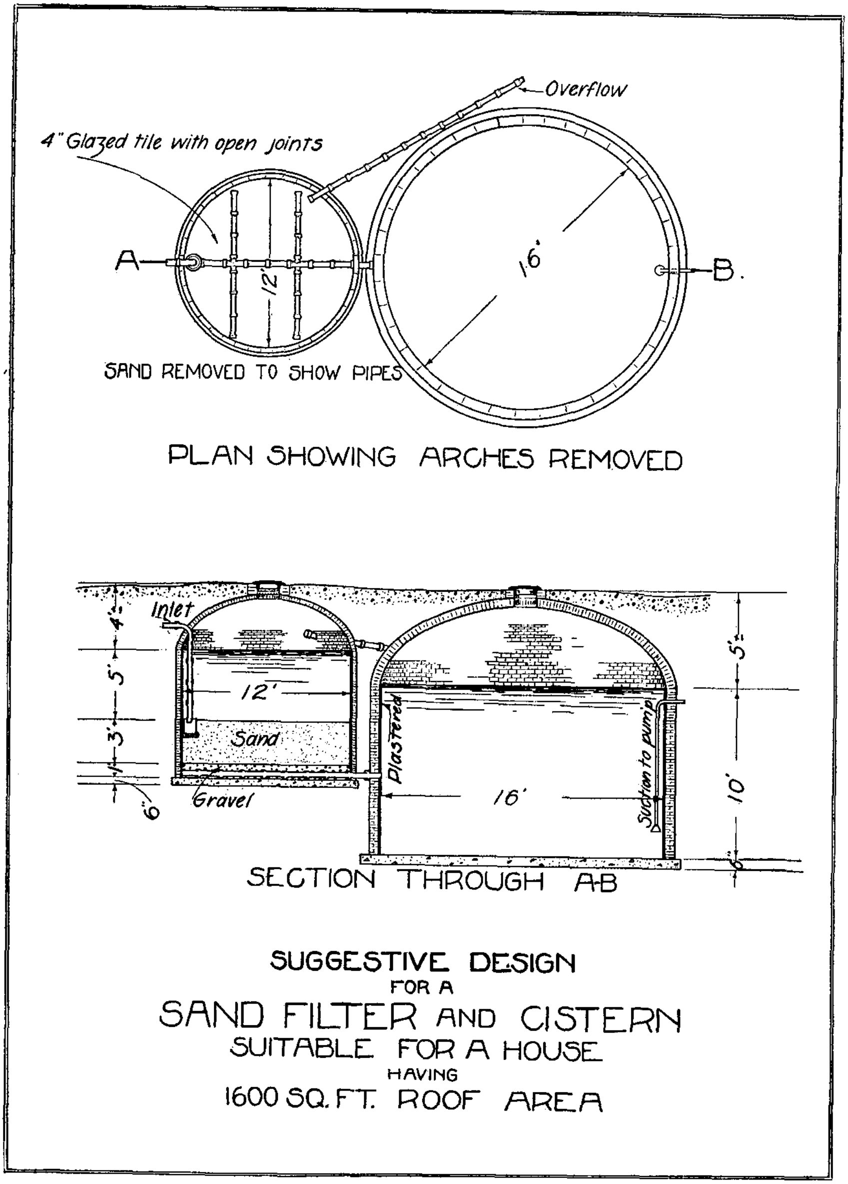


Fig. VI.—Suggestive Design for a Sand Filter and Cistern.

be fenced in and the drainage from nearby areas subject to pollution must be diverted. If an enclosed lawn is utilized it may be so arranged as to be an object of beauty as well as a source of water supply. By these various means it is quite practicable to obtain an abundant supply of very soft water for all domestic purposes which will prove far superior to the supplies that are ordinarily derived from wells. Moreover, in houses which have plumbing and pumps for distributing the water it will be feasible to do away with the double system of piping and pumping arrangements made necessary by the combined use of hard and soft water.

The illustrations shown depict rather substantial construction made necessary by the large size of the structures, but suitable for use in almost any kind of soil. In actual practice it is customary to use a much cheaper form of construction, as for example, thin walls of cement plaster applied directly to the sides of the excavation or a mere 4-inch wall of brick plastered on the inside. While this sort of construction seems very flimsy, its frequently demonstrated stability under favorable conditions may be accounted for by the fact that the water pressure within the cistern is always greater than the pressure of the ground water outside of the cistern, thus the lining is pressed outward against the excavation, thereby preventing collapse. The essential point in any case, however, is that the cistern be made absolutely water tight, otherwise much of the stored water may be lost by seepage into the ground.

A cistern with a filter wall as depicted in Figure 4 can be built for about $300. The cistern and filter shown in Figure 5 will cost about $400. If a cheaper form of construction is desired, such, for example, as the cement plastered walls, it will be necessary to use a smaller diameter, and, therefore, two cisterns will have to be built to afford the same capacity as the one illustrated. Two small cisterns with cement plastered walls and filter partitions, as shown in Figure 4, and having combined the same capacity as the single cistern shown will cost approximately $200.

Springs: In more or less rolling or hilly country springs may often be used to great advantage on the farm. Sometimes they are found at a sufficient elevation to permit of supplying the house by gravity. In other cases not at such an elevation the water may be present in sufficient quantity to permit the installation of a water ram, a machine which utilizes the principle of impact to pump a portion of the water flowing through it to any elevation desired. The machine is easily installed, can be purchased at a comparatively small price and does its work with practically no attention and without operating cost. Sometimes it becomes desirable to utilize a spring both for a domestic water supply and for cooling milk and butter. In such a case a structure shown in Figure 7 may be utilitzed to advantage. It will be observed that the water which is pumped to the house is maintained at a higher level than that which is used for cooling purposes in order to prevent its contamination. Furthermore, it is tightly covered by an impervious concrete floor. It is assumed in this case that the volume of water is not sufficient for the utiliza-

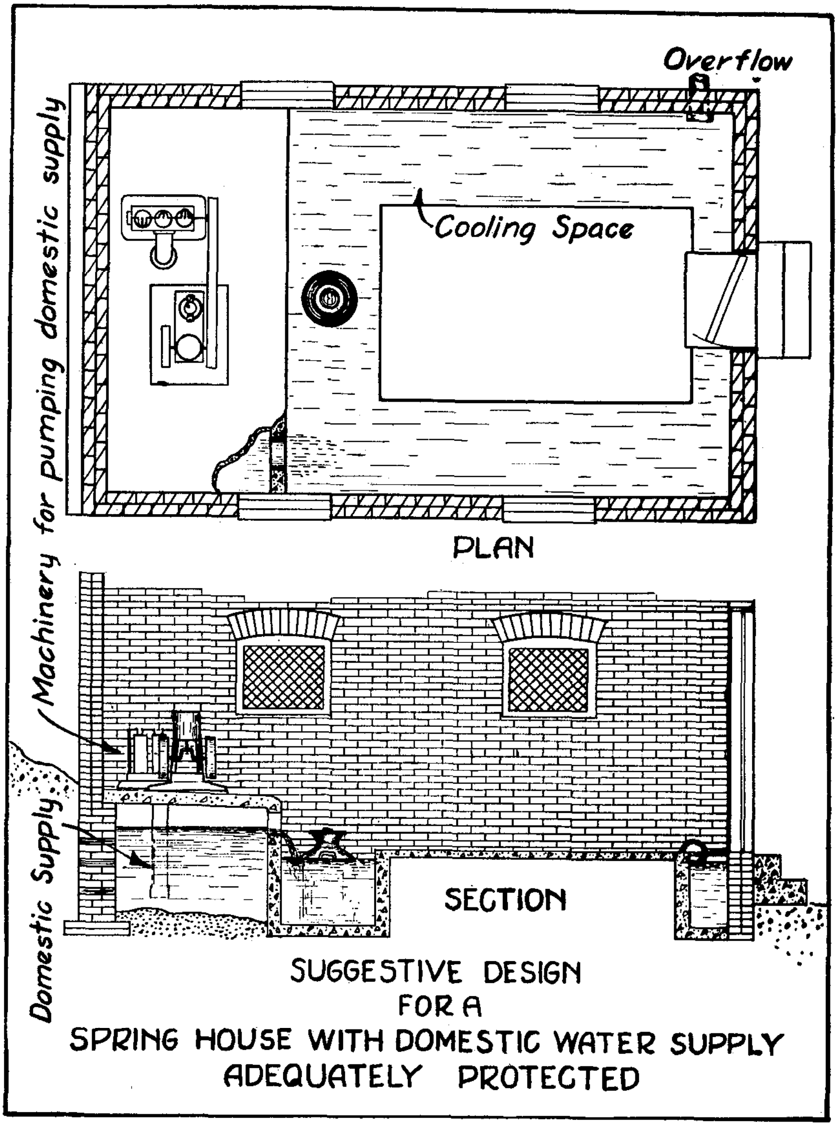


Fig. VII.—Suggestive Design for a Spring House.

tion of a water ram and, therefore, a gasoline engine with pump attached is shown. If dairying operations are conducted in the spring house it would be quite practicable to use the same engine for operating the cream separator and churn.

In developing springs it is always of the highest importance to ascertain from which direction the flow comes and to adequately protect the watershed so as to prevent contamination. This is due to the fact that spring waters are ordinarily derived from shallow depths and are particularly subject to the influence of surface conditions.

Development of the Water Supply: The development of a water supply for farm uses is a matter that does not need the consideration of the sanitary engineer except insofar as to point out the broad general principle that the water shall at no point in the course of its handling be exposed to the possibility of contamination. Aside from the gravity system of delivering water from an elevated source through pipes, the problem involves a selection of some means of pumping and storing the water. With reference to storage, there are three systems, known respectively as the elevated tank system, the hydro-pneumatic system and pneumatic system. The first involves the storage of water in an elevated tank placed either in the top part of the house or on a specially constructed tower. Such towers are sometimes combined with windmill towers. The second involves the storage of water in an enclosed tank under pressure at or below the ground level, the pressure being produced by a cushion of air maintained in the tank. Such tanks may be located in cellars or buried in the ground. For structural reasons there are always made of steel, whereas the elevated tanks may be made of wood. The third or pneumatic system, strictly speaking, does not store the water at all excepting insofar as it may be stored in the well or cistern. The same effect is secured by the storage of a large quantity of air under pressure, which, upon opening a faucet, forces water out of smaller tanks or pneumatic cylinders located below the water level at the source. With any of these systems power may be furnished by windmill, a gasoline engine, an electric motor, or any other actuating device that proves convenient or economical. The water ram is adapted to use with the elevated tank system only. The gasoline engine seems to be coming into general favor.

The several systems, including the pumping equipment, have their advantages and disadvantages. For example, the elevated tank system is relatively cheap and furnishes reliable service, but it renders the water unpalatable by permitting it to become warm through exposure to the sun's heat in the tank, and when the tank is within the house it does not give good fire protection. The hydro-pneumatic system is somewhat complicated and costs more, but furnishes excellent fire protection and maintains the water reasonably cool and palatable, unless, of course, the storage tank is placed in a heated cellar. The pneumatic system is in certain respects less complex than the hydro-pneumatic system, but costs more. It has a distinct advantage in that the engine or motor and other parts that should be kept under cover may be remote from the well, even when water must be drawn from a great depth. The principal objection results from leaky air pipes. For details of design and cost of distributing systems for farm water supply, reference must be made to those who have given special study to farm machinery.

DISPOSAL OF SEWAGE AND LIQUID WASTES.

Primitive Conditions: But a few years ago farmhouses with a complete plumbing equipment was a rarity, and even today the great majority of farmhouses depend upon primitive methods for water supply and the disposal of their liquid wastes. It is not probable that the laborious carrying of water necessitated by the old-fashioned farm well and the inconvenience and unhealthfulness of the outdoor privy will be abandoned on all farms for many years to come, and it, therefore, becomes necessary to give some attention to the best method of disposing of human wastes under these primitive conditions.

The liquid wastes of an ordinary farm household comprise drainage from the kitchen sink, laundry water, and comparatively small quantities of water used for washing and bathing. These liquids are, as a rule, thrown out upon the surface of the ground, and if reasonable care is observed not to water-log the ground, this method of disposal of such wastes is entirely satisfactory. The privy constitutes a different problem, however, and in this connection the principal requirement is to so construct this device as to prevent soil pollution, the entrance of flies, and further to render it readily accessible for cleaning purposes. This may be accomplished by the use of water-tight receptacles, such as half barrels placed at or above the surface of the ground in a dry and well-screened compartment with a large door provided for accessibility.

Another type of privy which has given satisfaction is that recommended by the United States Public Health Service and comprises the use of one or more barrels filled with water. These barrels act very much as ordinary sewage tanks and serve to disintegrate the organic matters so that the final liquid effluent may be disposed of with small difficulty through drain tiles laid at a foot to 18 inches below the surface of the ground, or the overflow from the barrels may be collected in a suitable receptacle and carried away and disposed of on land where soil pollution will not endanger wells. This form of privy requires very little attention, though it is liable to produce bad odors in its vicinity. These odors, however, are certainly no worse than result from the ordinary outdoor privy as commonly built.

With plumbed houses and the water carriage system for removing wastes there is produced a sewage which is similar to that coming from the sewer outfalls of small residential communities. This liquid is large in volume, amounting often to about 50 gallons per capita. If permitted to flow into a drainage ditch or into a small, natural water course, it is very apt to create foul conditions and hence there must be provided special means for its final disposal.

The Principles Underlying Sewage Disposal: Sewage is merely a dirty water containing rarely over one part in a thousand of organic matter. This small quantity, however, is sufficient to impart to the liquid a very disagreeable odor, particularly when it is in a putrefying condition. The circumstance that renders sewage dangerous, however, is the fact that it may contain the germs of disease, and therefore special consideration must be given to its final disposal, so that it will not enter the water supply or contaminate the food intended for human consumption.

Practically all methods of sewage treatment are based upon the one central principle of oxidation and mineralization of the organic matters through the activitiy of microscopic organisms, principally bacteria. These organisms always present in sewage feed on the complex organic compounds found in sewage, constantly reducing them to simpler compounds until complete mineralization results. The same organisms do not function in all stages of the process, but each successive stage is produced by organisms that have vital requirements best adapted to the condition in which the organic matter is found at that particular stage of decomposition.

There are two distinct forms of decomposition, both of which are used in the art of sewage treatment. One relates to decomposition in the presence of an abundance of oxygen (aerobic decomposition) and is usually accomplished without the production of offensive odors. The other relates to decomposition in the absence of oxygen (anaerobic decomposition) and is commonly designated as putrefaction and is accompanied under ordinary conditions by very offensive odors. Where organic matter decomposes in the presence of insufficient oxygen for complete oxidation the first stages of the process are malodorous or of a putrefactive character, and complete mineralization does not result, though it is possible to secure a liquid of fairly stable character and compartively free from bad odor. If oxygen is available, however, or if the liquid is standing in contact with the atmosphere, it will soon begin to take up oxygen so that the final stages of the process will be on an aerobic basis.

Disposal by Dilution: The simplest form of sewage disposal is so-called disposal by dilution, in which the sewage is discharged into a water course with sufficient volume of flow and sufficient oxygen content to effect complete mineralization on the aerobic basis. Thus the process is unaccompanied by objectionable odors. For successful disposal by dilution a stream flow of 4 to 6 cubic feet per second is required for every thousand persons tributary to the sewers discharging at a particular point. If the dilution falls materially short of this amount anaerobic conditions will prevail and a nuisance will result.

Application to Land: Very often a stream of sufficient volume is not available for receiving the discharge of a sewer and it then becomes necessary to treat the sewage. This may be accomplished in various ways, the most primitive of which is direct application to the land. While this method is apparently simple, it nevertheless involves many difficulties if carried out in an inoffensive and sanitary way and on a large scale requires enormous areas and is very costly. Intensive methods have been gradually developed which for large installations furnish very economical methods of sewage disposal, but in the case of sewage disposal on the farm it becomes desirable to revert to some of the more primitive methods, though such may be modified to some extent by modern developments.

Tank Treatment: One of the modern developments that must generally be used in the final disposal of sewage, no matter how small the quantity of sewage, consists in giving the sewage a preliminary treatment in some form of tank. The object of this treatment is to hydrolize or disintegrate the solid matters, so that they can be more readily disposed of and to produce a liquid effluent comparatively free from suspended matter. Such effluent can be applied to subsequent treatment devices more readily than crude sewage, because difficulties due to clogging are greatly reduced.

The simplest form of treatment device that may be used for an individual farmhouse comprises merely a tank capable of holding the sewage produced in a period of 24 hours or longer, and provided with an inlet and outlet. Such a tank is shown in Figure 8. This tank, as will be seen, is very simple in construction and can be built for approximately $30.00.

The effluent from a tank of this character contains no coarse solids, is likely to be dark in appearance and upon close observation will be found to carry finely divided suspended particles. It may be discharged into a perennial stream of moderate size without producing objectionable conditions, but where no such stream is available some other method must be utilized.

With certain forms of secondary sewage treatment devices, and often where sewage is to be discharged into a water course, it is desirable to maintain the sewage in as fresh a condition as possible, that is to say, it is desirable to maintain the oxygen content of the sewage. To accomplish this there has recently been developed in the Emscher drainage district of Germany a two-story tank known as the Emscher tank, which utilizes a small compartment for sedimentation purposes and a lower compartment for the digestion of the solid matters. The solid matters, which are settled out in the upper compartments, gain access to the lower compartments through a narrow slot so trapped that the liquids in the two compartments

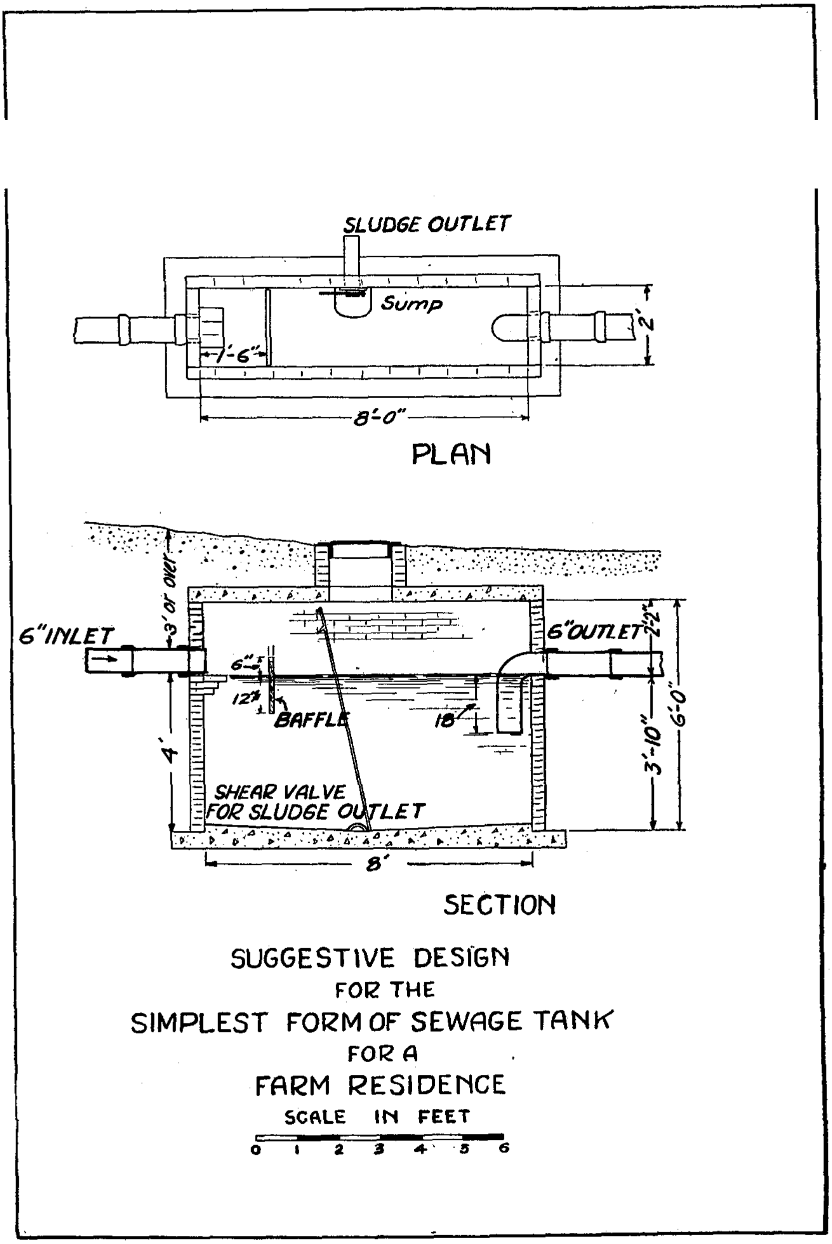


Fig. VIII.—Suggestive Design for the Simplest Form of Sewage Tank for a **Farm Residence.**

may not readily intermingle. The sedimentation chamber must be made very much larger than is customary in connection with municipal sewage treatment works for the reason that the very uneven rate of sewage flow from an individual residence would subject the sedimentation compartment to violent disturbances. For this reason an average period of 5 or 6 hours' sedimentation should be provided.

The Emscher tank has another advantage in that the sludge or solid matter is thoroughly digested and may periodically be discharged into some nearby depression without giving rise to objectionable odors. When dry it has the consistency of rich, loamy earth and may advantageously be spread on lawns and gardens. A modification of the Emscher tank adapted to the use of a household of ten persons is shown in Figure 9. The cost of such a tank would be about $60.00.

Subsurface Disposal: In a sandy or gravelly soil a tank effluent may best be disposed of by permitting it to flow into a system of open-jointed tile drains placed at a foot to 18 inches below the surface of the ground. The tile drain may be made up of 4-inch farm drain tile and should have a length of about 100 feet for every member of the household. The character of soil may materially vary the amount of tile necessary.

To get best results the liquid should be applied to the tiles in the form of a dose discharged rapidly within a few minutes once every 12 or 24 hours. This can be accomplished by building in conjunction with the tank a small dosing chamber equipped with an automatic discharge syphon, as shown in Figure 10. Syphons, however, are subject to derangements and in most cases should be omitted in favor of a more liberal use of tile.

A typical arrangement for a subsurface sewage disposal system of tile drains is shown in Figure 11. This assumes the necessity for a system of distribution pipes and a system of collector pipes, but, as a matter of fact, the collector pipes can generally be omitted.

Where the soil is of a finely divided character and capable of absorbing large quantities of moisture, as is characteristic of most of the glacial drift throughout Illinois, the same system may be utilized, but can be relied upon to adequately take care of the sewage only during periods of small rainfall. This, however, often proves to be all that is needed, for in wet weather the sewage may be discharged directly into a stream which will then have flow enough to provide the dilution necessary for inoffensive oxidation. Sufficient dilution may even obtain within the drain tile itself. It thus sometimes happens that the discharge of the effluent into the upper end of an existing long tile drain accomplishes all that is required, for in dry seasons the sewage will soak into the ground, while in wet seasons it will be carried to the outlet of the drain along with a sufficient quantity of water to render the liquid inoffensive.

In certain forms of clayey soil any attempt to cause the sewage

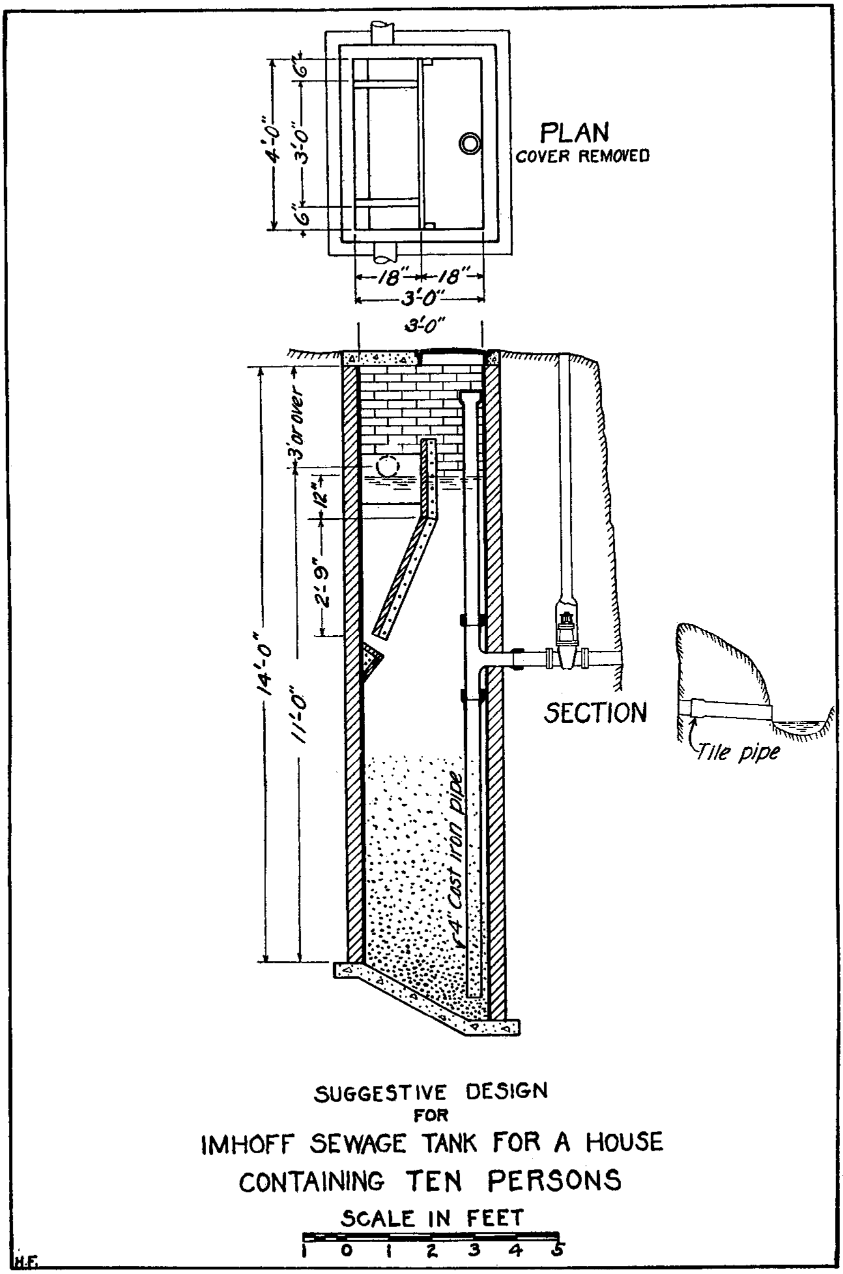


Fig. IX.—Suggestive Design for Imhoff Sewage Tank.

to soak away into the ground will prove futile, but this difficulty may be overcome by artificially placing beds of sandy or gravelly material about the tile. When this is done it is necessary to place subdrains for carrying off the more or less purified liquid after it has passed through the sand or gravel. This arrangement constitutes the principle of a well-known proprietary device for sewage treatment and can be counted upon to produce satisfactory results so long as a sufficient quantity of porous material is used. For large installations, however, it would prove costly and uneconomical.

It is difficult to lay down any hard and fast rules relative to

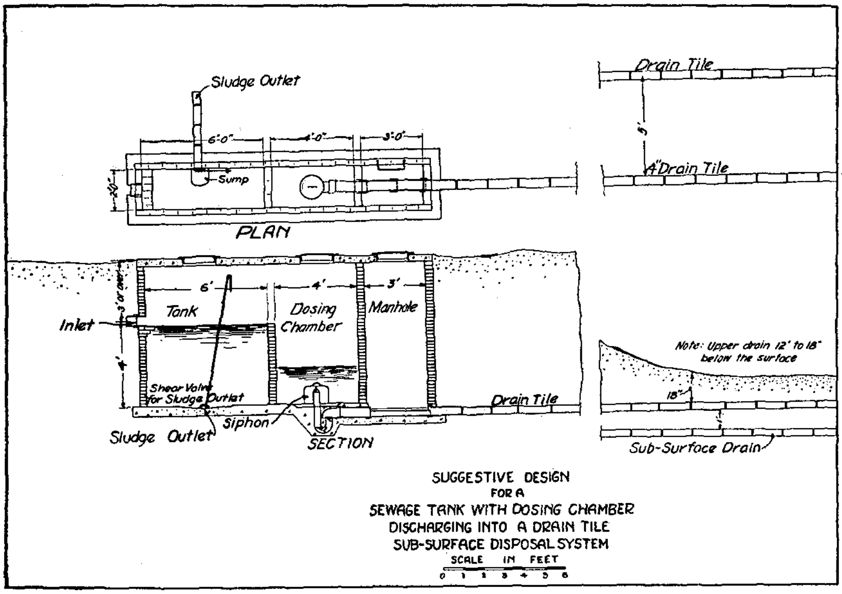


Fig. X.—Suggestive Design for a Sewage Tank with Dosing Chamber.

the design and arrangement of subsurface sewage disposal systems. The proper length of drain tile, the necessity of collector drains and the desirability of surrounding the drains with porous material must under many conditions be determined by the method of cut and try. Where the system is applicable, however, it is certainly the simplest, least offensive and easiest to maintain.

Iowa Agricultural College Method: Where simple tank treatment or subsurface drainage cannot be utilized, a system successfully experimented with at the engineering experiment station of the Iowa State College may be adopted. This consists of a preliminary sedimentation tank and a sand strainer of 6 inches in thickness placed above a coarse-grained trickling or percolating filter. The whole is covered over with a roof and suitably ventilated to promote aerobic decomposition. The structural material consists of bricks, easily removable concrete slabs, vitrified pipes, wood and the filtering materials. The construction is so simple that derangements cannot readily occur. The sand strainer no doubt needs the most frequent attention, as this will from time to time become clogged. A description of this method of sewage treatment by Professor Anson Marston will be found in a bulletin of the Iowa Agricultural College.

Intermittent Sand Filtration: On large country estates, or for

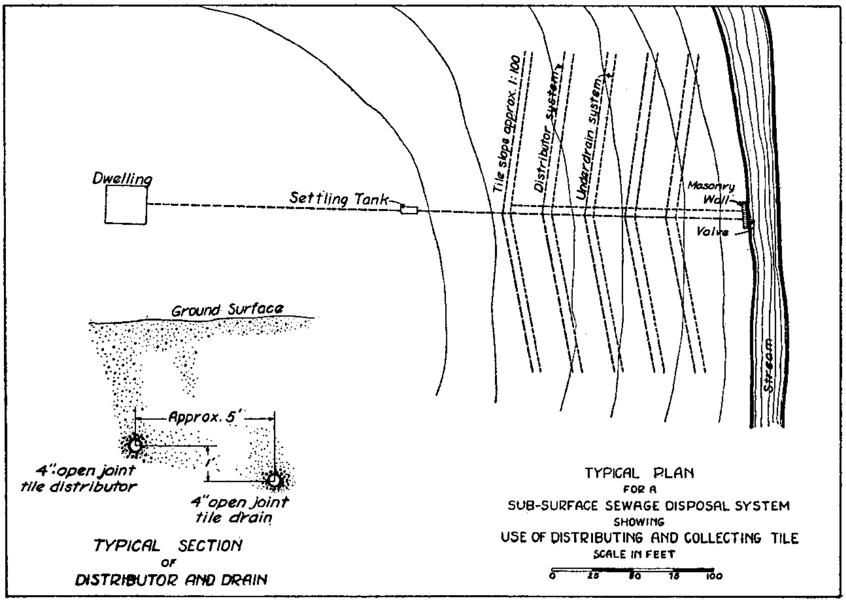


Fig. XI.—Typical Plan for a Sub-surface Sewage Disposal System.

isolated institutions, such as almshouses, asylums, sanitaria, etc., perhaps the most economical and highly efficient system is so-called intermittent sand filtration. Figure 12 shows a plant for an intermittent sand filter plant that will adequately care for the sewage of about fifteen persons. Generally they should not be built for populations of less than twenty-five. The filters are shown as being used in conjunction with an Emscher tank and a dosing chamber. Each filter comprises a bed of sand 3 feet in thickness, resting upon a carefully constructed underdrain system, consisting of drain tile and graded gravel. The area of the installation is figured on the basis of one acre for every 750 persons tributary to the sewers.

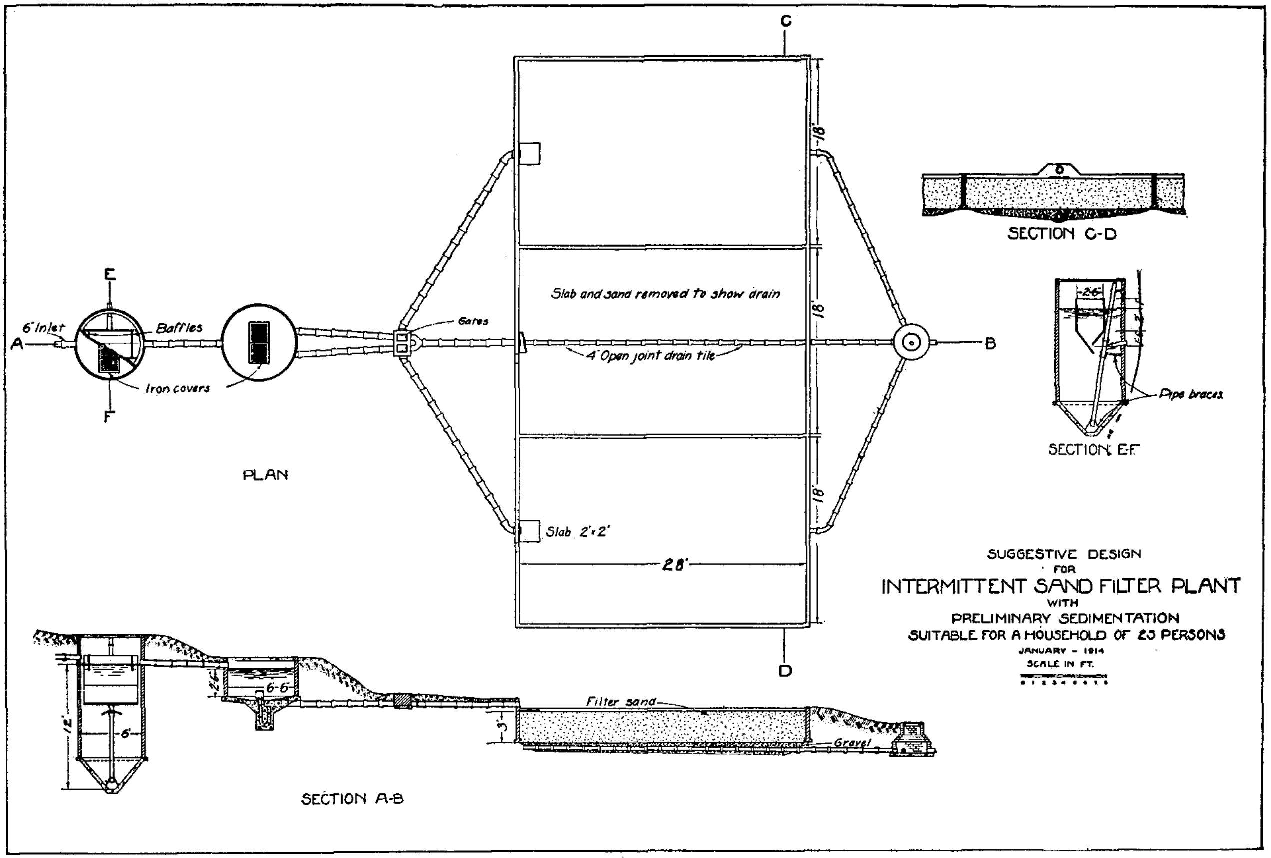


Fig. XII.—Suggestive Design for Intermittent Sand Filter Plant.

For a household of fifteen persons there would be required 0.02 acre or 870 square feet. As the name intermittent sand filtration implies, the sewage is applied to the filters intermittently, and this is accomplished by the dosing chamber, which is of such capacity that a single dose will cover one filter bed to a depth of 2 inches. The filter area is divided into three beds for convenience. This permits two beds to be used alternately and a third bed to be out of service for cleaning or repairs, or for a protracted resting period, which is necessary from time to time to secure best results with this method of sewage treatment. It would be possible to build a plant comprisnig but two filters, but never less than this. The automatic dosing apparatus is so arranged that it will automatically discharge upon first one bed and then the other, and valve arrangements are such that any two beds may be maintained in service. The above arrangement has another superiority over the two-unit arrangement in that the dosing chamber may be built smaller and discharge more frequently and thus get the sewage to the beds in a fresher condition.

Intermittent sand filters will not operate without attention, and they should be visited at least once every few days to see that all parts are in proper working order and to keep the sand beds free from weeds. At greater intervals, perhaps once per month, it becomes necessary to rake or scrape the sand lightly so as to break up the surface mat formed by the solid matter in the sewage, but with proper care this process should result in but very slight loss of sand. During the winter in cold climates it is necessary to furrow or mound sand beds in such way as to cause the formation of a sheet of ice resting upon the top of the furrows. This will effectively prevent the freezing of the sewage as it passes along the troughs of the furrows underneath. The automatic dosing apparatus requires attention, as already noted, but with a well-settled sewage and siphons of reliable make derangements will be infrequent.

Contact Beds: A somewhat more intensive method of sewage treatment and one which is especially adaptable to very large farmhouses, country clubs and institutions and for use in locations where the production of odors is not permissible is treatment in so-called contact beds. An installation comprising double contact beds is shown in Figure 13. It is assumed that the contact treatment will be preceded by sedimentation.

Contact beds are merely water-tight basins filled with gravel, broken stone, hard-burned cinders, broken brick or any other material which presents a fairly rough surface and which is not easily disintegrated. The size of the material should not average less than ½ inch in diameter or be greater than 1½ inches in diameter. Means are provided for permitting the sewage to flow into this bed and to fill the interstices of the material which it contains, where it may remain in contact for a definite period of time. This feature of hold-

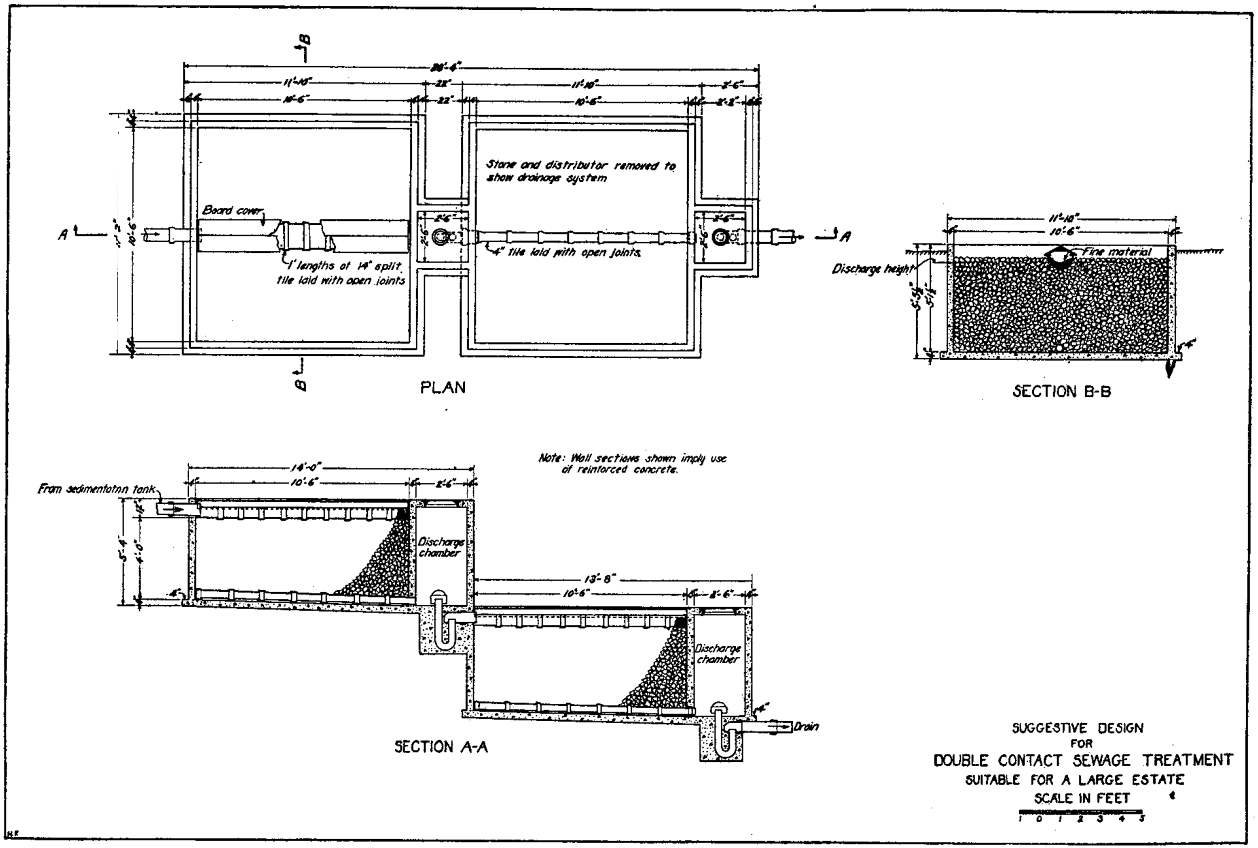


Fig. XIII.—Suggestive Design for Double Contact Sewage Treatment.

ing the sewage in contact with the material gives rise to the name of the device. The bed is emptied and the period of contact is regulated by means of an automatic device which embodies the principle of the siphon.

In the design as shown on Figure 11 the effluent from the first contact bed passes into another contact bed of exactly similar construction. Upon emerging from the second contact bed, the liquid will be fairly clear in appearance and will have no offensive odor, thus rendering it suitable to be discharged into a water course of even the smallest size. For the purpose of minimizing odors, a specially constructed inlet arrangement to the bed is provided which prevents the sewage from being exposed to the atmosphere. This device consists simply of short half tile 14 to 18 inches in diameter and laid with large open joints. Within the invert of this half tile is placed fine broken stone or gravel and over the top is placed a readily removable roof. The device also has another advantage in that it localizes all clogging in the fine material within the half tile. When this becomes clogged so that it will not readily permit the entrance of the sewage into the bed, it may be easily shoveled out and replaced with new material.

Sprinkling Filters: At institutions and on large estates, especially where intelligent labor is available, the so-called sprinkling filters which are now being almost universally designed for large installations may be utilized. A sprinkling filter comprises a bed of coarse material such as broken stone, varying in size from that which will pass a ¾-inch ring to that which will pass a 1½-inch ring. Generally a coarser stratum is placed at the bottom of the bed. The minimum thickness should be about 6 feet, and it is preferable to use a thickness of 7 feet to 9 feet. Suitable means for spraying the sewage onto the surface of the filtering material and withdrawing the effluent from the base of the bed complete the device. The sewage may be applied continuously, but generally speaking it is more practicable to apply it intermittently in small doses at frequent intervals. The most effective means for small installations comprises a sprinkling nozzle, such as is available on the market for use with this type of filter, and an equalizing chamber so shaped that with each dose the spray from the nozzle will expand and contract in such a manner as to apply approximately the same quantity of sewage to each unit of area of the filter surface. Sprinkling filters cannot be used without preliminary tank treatment and for this purpose the Emscher tank, already described, is most adaptable. Also because of the tendency of the filtering material to flake off accumulated humus matter, it is desirable to give a final sedimentation to the effluent. Because of the necessity of spraying the sewage in the air, a sprinkling filter is liable to produce some odor and it is, therefore, always desirable in connection with small installations to cover the filter by means of a suitable superstructure. This not only prevents the dissemination of odor, but protects the bed and particularly the sprinkling nozzle against depredations.

Other Methods: There are a few other methods of sewage treatment which, however, are rarely applicable to the farm or to estates. The most important of these other methods, perhaps, is disinfection of the sewage, and this may be desirable in connection with certain institutions, but its applicability to the small plant is so infrequent that it is not deemed advisable to dwell upon it at this point, other than to state that calcium hypochlorite (commercially known as bleaching powder) is the disinfectant most commonly used and may be relied upon if of normal strength to disinfect a good tank effluent with the application of about ¼ pound per 100 gallons of effluent treated. The chemical is always applied in the form of a solution, generally not exceeding 5 per cent in strength.

SUMMARY.

By way of summary, it may be pointed out that the dweller on the farm now has at his command all of the household conveniences of the city dweller, and moreover he can be fortified in the same degree, or even to a greater degree, against a contaminated water supply or offensive and insanitary final disposal of sewage, and this without excessive cost. It is impossible in speaking of sanitation on the farm, especially as it relates to water supply and disposal of sewage, to lay down hard and fast rules which may be followed blindly. On the contrary, it will be necessary in arranging for any of the conveniences outlined in the foregoing to take full cognizance of the influence of local factors. The problems presented are not, however, difficult or at all complex, and with a moderate amount of study the up-to-date and intelligent farmer can with but moderate assistance from the agricultural engineer design and install water supplies, sewerage systems, plumbing systems, heating and ventilating systems, and all that is necessary of a material nature to render the comfort of life on the farm complete and even luxurious.

REPORTS OF ASSOCIATIONS AND COMMISSIONS

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.

The Twenty-eighth Annual Report (1913) has been reviewed. Papers relating to water supply conditions in Illinois are abstracted in the following:

Increasing the Efficiency of Small Water Works and Sewage Treatment Plants. Paul Hansen. The substance of this paper is published elsewhere in this bulletin under the title Improved Management of Water Works.

Report of the Water Works Committee: Dabney H. Maury and Charles B. Burdick. Satisfactory progress is being made in water works methods. Supplies from surface sources are of necessity. becoming more numerous. The newer filtration plants are mostly of the rapid sand or mechanical type and the use of concrete has entered more largely in the construction. The use of hypchlorite of lime is perhaps the most notable of all modern developments in water purification.

There has been an advance in the use of reinforced concrete for reservoir construction. The cost of such reservoirs will range from $3,500 to $12,000 or more per million gallons storage capacity.

The output of electrical power in Illinois has greatly increased in the past few years. Water works with suitable reservoir capacity to tide over the usual peak in the load curves of the power company can secure electrical power for pumping that in many instances compares in cost very favorably with steam power.

The centrifugal pump is well adapted for use with electrical power. Manufacturers of these pumps are better able to meet requirements than formerly. Purchases should be made from leading manufacturers under suitable guarantees of capacity and efficiency.

There has been much improvement in the design of wells for gravel strata. Coarse strainers, which allow the fine particles to enter the well, are used. In this way a larger strainer of gravel is built up outside of the metal strainer. In some cases the strainer is made so large that the reduced velocity of flow into the well is too small to move the finest sand.

Report of the Committee on Sewers. The committee urges the keeping of accurate records in refuse disposal work. The problem is complex, and in order that a correct solution may be obtained, satisfactory both from the standpoint of sanitation and economy, it is necessary to inquire into the details and to have more definite facts and figures than are now available.

The removal or treatment of sewage is largely mechanical and does not require the supervision of one specially versed in medical science. Continued successful operation of such systems can best be controlled by engineers.

ILLINOIS WATER SUPPLY ASSOCIATION.

The fifth annual meeting of the Association was held at the University of Illinois March 11 and 12, 1913. The report of the secretary showed that the Association was making very satisfactory progress. The active membership showed an increase of 57 members, bringing the total to 240. The officers elected and a list of papers read are given below. 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.

LIST OF OFFICERS 1913-14.

President—C. H. Cobb, superintendent Water Works Company, Kankakee.

First Vice-President—H. M. Ely, superintendent Water Company Danville.

Second Vice-President—W. J. Spaulding, commissioner of public property, Springfield.

Third Vice-President—E. MacDonald, superintendent Lincoln Water and Light Company, Lincoln.

Secretary-Treasurer—Edward Bartow, director State Water Survey, University of Illinois, Urbana.

List of the papers read and published in the Fifth volume of the Proceedings of the Association:

Report of the Secretary-Treasurer.

Reports of Standing Committees—
- Legislation.
- Publication.

Program of Band Concert.

President's Address, R. R. Parkin, Chief Engineer, Water Department, Elgin.

Legal Aspects of Financing Municipal Water Works, E. V. Orvis, Commissioner of Public Property, Waukegan.

Water Required by a Railway System, C. R. Knowles, General Foreman Water Works, Illinois Central Railway, Chicago.

The Advantages of a Municipal Laboratory, Dr. W. E. Park, Commissioner of Health, Rockford.

A Water-Borne Typhoid Epidemic at Quincy, Illinois, Dr. Edwin O. Jordan, Professor of Bacteriology, University of Chicago.

The Study of Deep Well Drillings in Illinois, Dr. T. E. Savage, Assistant Professor of Geology, University of Illinois.

Conductivity as Applied to Water Analysis, C. C. Young and T. M. Godfrey, Kansas State Water Survey, Lawrence, Kansas.

Sterilization of Water by Ultraviolet Light, John R. Davies, Assistant in Chemistry, Northwestern University, Evanston.

The Use of Permutit in Water Softening, J. F. Garrett, Illinois State Water Survey, Urbana.

Notes on a Manganese and Copper Deposit in Water Mains, C. C. Young, Kansas State Water Survey, Lawrence, Kansas.

Effect of "Hypo" on Water-Borne Diseases at Evanston, Dr. W. L. Lewis, Assistant Professor of Chemistry, Northwestern University, City Chemist, Evanston.

Practical Methods for Obtaining High Efficiency in Water Works Pumping Plants, S. G. Pollard, Consulting Engineer, Cincinnati, Ohio.

The Safeguarding of an English Town Threatened with a Water-Borne Typhoid Outbreak, A. C. Jarvis, Water Engineer, Honor Oak Park, London, England.

Water Waste, W. D. Gerber, Consulting Engineer, Chicago.

The Rationale of Hydrotherapy, Dr. Frank P. Norbury, Alienist, State Board of Administration, Springfield.

Vital Statistics and Water Supplies, Paul Hansen, Engineer State Water Survey, Urbana.

Condition of Small Water Purification Plants in Illinois, Ralph Hilscher, Assistant Engineer, State Water Survey, Urbana.

The Effect of Artesian Water Upon Galvanized Steel Pipe, D. H. Stacks, Chief Chemist, Deere & Company, Moline.

The Rapid Preliminary Testing of Water for Sewage Contamination, Dr. Adolph Gehrmann, Bacteriologist, Columbus Laboratories, Chicago.

Methods of Bacterial Water Examination, Dr. Edwin O. Jordan, Professor of Bacteriology, University of Chicago.

Efficiency of Coagulating Basins, W. F. Monfort, Chemist, Water Department, St. Louis, Missouri.

Algae and the Treatment of the Quincy Reservoir, W. R. Gelston, Superintendent Citizens Water Company, Quincy.

Hypochlorite Disinfection vs. Typhoid Fever, C. A. Jennings, Superintendent Filtration, Union Stock Yards, Chicago.

Some Results from the Use of Gelatin and Agar, John Gaub, Chemist, Filtration Plant, Washington, D. C.

Biological and Chemical Conditions on the Upper Illinois River, Professor S. A. Forbes, Director, Illinois State Laboratory of Natural History.

Fire Streams from Small Hose and Nozzles, V. R. Fleming, Associate in Theoretical and Applied Mechanics, University of Illinois.

The Proposed Improvements at Moline Water Works, L. O. Jahns, Commissioner of Public Property, Moline.

Special Features of the Recent Water Works Improvements at Rushville, Illinois, F. H. Coult, Consulting Engineer, St. Louis Missouri.

Rockford and Her Water Works Problems (Illustrated), G. G. Crane, Superintendent Water Department, Rockford.

Uncalked Joints in an Intake Water Pipe Detected by Determining Solids and Sulfates, W. M. Cobleigh, Professor Chemistry, Montana State College, and Chemist State Board of Health, Bozeman, Montana.

Calcium Hypochlorite Treatment of Lake Water at Waukegan, W. J. Allen, Chief Engineer, Waukegan Water Works, Waukegan.

Calcium Hypochlorite Treatment of Lake Michigan Water at Winnetka, F. E. Herdman, Manager and Engineer Water and Light Properties, Winnetka.

Calcium Hypochlorite for Water Purification at Lake Forest, L. C. Trow, Engineer, Lake Forest Water Company.

Rock Island Filter Plant, R. W. Sharp, Superintendent Water Department, Rock Island.

Mt. Vernon Filter Plant, S. B. Severson, General Manager Mt. Vernon Gas and Electric Company.

Pana Water Works Extension of 1911, A. C. Stanfield, City Engineer, Pana

Notes on Water Supply Problems in the Canadian Prairie Provinces, R. O. Wynne-Roberts, Consulting Engineer, Regina, Canada.

The Flushometer Type of Water Closets, F. C. Amsbary, Manager Champaign and Urbana Water Co.

The Elimination of Taste in Lake Michigan Water Treated with Calcium Hypochlorite, Dr. Arthur Lederer and Frank Bachmann, the Sanitary District of Chicago.

Some Features of the Danville Water Works, H. M. Ely, Superintendent Danville Water Company.

The Appraisal of Water Works Properties, Douglas A. Graham, Consulting Engineer, Chicago.

SANITARY DISTRICT OF CHICAGO.

The Proceedings of the regular meeting of the Board of Trustees of February 5, 1914, contains a report by Langdon Pearse, Div. Engr., to Thos M. Sullivan, chairman of the Engineering Committee, relative to the present sanitary conditions in Chicago. The report discusses particularly statements in a recent report published by the drainage committee of the Chicago Real Estate Board. As regards water supply, the discussion may be summarized as follows:

The hygienic quality of the Chicago city water supply during the last few months (1913) has been good. Only storms of unusual severity agitate the bottom of the lake sufficiently to cause the water to appear turbid. The slight increase in the typhoid death rate in 1913 over that of 1912 was not due to the water supply. In order to reduce the number of preventable diseases, sanitation must tend toward improved health conditions, better surroundings, as well as better food and care.

It is believed the City Council, in starting agitation to prevent dumping impure material into the lake, has not appreciated the relation between muddy water and water impure from the standpoint of disease. Dumping as has been practiced does no great harm to the drinking quality of the water. The attitude of the district as regards the disposal of Chicago sewage in the future is discussed.

ILLINOIS STATE LABORATORY OF NATURAL HISTORY.

Studies on the Biology of the Upper Illinois River. Article X. Stephen A. Forbes and R. E. Richardson. Published in June, 1913.

The paper is intended as a preliminary summary of the principal conclusions, scientific and economic, from studies of the past few years and will be followed by a series of special papers on the various divisions of the work.

WESTERN SOCIETY OF ENGINEERS.

A journal is published monthly, excepting in July and August. The papers contained in Volume XVIII (1913) relating to water supply are reviewed below.

Chicago Water Works. John Ericson. A complete historical sketch since the beginning of the system in 1853 is given. The advisability of installing meters for the purpose of reducing waste is strongly urged. The present daily per capita consumption is 203 gallons, 57 per cent of which produces no revenue.

Water Purification in Illinois. Edward Bartow and Paul Hansen. This paper is published in full elsewhere in this Bulletin.

Improved Management of Water Works. Paul Hansen. This paper is published in full elsewhere in this Bulletin.

Permissible Dilution of Sewage. George W. Fuller. It is permissible to dispose of sewage by dilution, provided that complications can be prevented so far as disease germs are concerned, with further provision that offensive conditions to sight and smell do not result.

In some large streams, as in the lower Mississippi near New Orleans, sewage which is passed through coarse screens may with care be disposed of in a satisfactory way. In large lakes, tidal estuaries, moderate and small streams, it is important, if not necessary, for the success of maintaining "clean rivers" or "clean bodies of water" to free sewage from floating and settling solids.

Permissible dilution of sewage without treatment in water courses with fairly high velocities ranges apparently from about 3.5 to 7 cubic feet per second per 1,000 population, depending upon the manufacturing wastes in the sewage and the dissolved oxygen content of the diluting water. For well settled sewage, these limits become about 2.5 to 5 cubic feet per second per 1,000 population, according to present information.

The Yield of a Kentucky Watershed. George L. Thon and L. R. Howson. The maximum yield of a Kentucky watershed, similar to that of Little Hickman creek, during the dryest cycle of years to be expected once in 25 years, is about 425,000 gallons per day per square mile with an exposed water surface of 8 per cent of the drainage area and a reservoir capacity of 207,000,000 gallons per square mile available. The second dryest period in the record indicates a yield 20 per cent greater than the dryest period. Runoff records were available for a period of 26 years.

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PUBLICATIONS OF THE STATE WATER SURVEY.

No. 1. Chemical Survey of the Waters of Illinois. Preliminary Report. 98 pp., 3 pl., 1 map. 1897. (Out of print.)

No. 2. Chemical Survey of the Waters of Illinois Report for the years 1897-1903. XVI+254 pp., 55 Pl. 1905. (Out of print.)

No. 3. Chemical and Biological Survey of the Waters of Illinois. Report for year ending August 31, 1906. 30 pp., 5 cuts. 1906.

No. 4. Mineral Content of Illinois Waters. VIII+192 pp. 1908.

No. 5. Municipal Water Supplies of Illinois. VIII+123 pp. Map. 1907. (Out of print.)

No. 6. Chemical and Biological Survey of the Waters of Illinois. Report, September 1, 1906, to December 31, 1907. 88 pp., 3 cuts, 9 pl. 1908.

No. 7. Chemical and Biological Survey of the Waters of Illinois. Report for 1908. 204 pp., 4 cuts. 1909. (Out of print.)

No. 8. Chemical and Biological Survey of the Waters of Illinois. Report for 1909 and 1910. 150 pp., 28 cuts. 1911. Price 75 cents, cloth 90 cents.

No. 9. Chemical and Biological Survey of the Waters of Illinois. Report for 1911. 171 pp., 20 cuts. 1913. Price 85 cents, cloth one dollar.

No. 10. Chemical and Biological Survey of the Waters of Illinois. Report for 1912. 198 pp., 19 cuts. 1914. Price $1.00, cloth $1.25.

No. 11. Chemical and Biological Survey of the Waters of Illinois. Report for 1913. 473 pp., 106 cuts. Price, $1.00, cloth $1.25.

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