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THIRTIETH ANNUAL REPORT

OF THE

STATE BOARD OF HEALTH

OF

MASSACHUSETTS.

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1899.

MEMBERS OF THE BOARD.

1898–1899.

HENRY P. WALCOTT, M.D., *Chairman*, ...	of Cambridge.
GERARD C. TOBEY, Esq., ...	of Wareham.
JAMES W. HULL, ...	of Pittsfield.
CHARLES H. PORTER, ...	of Quincy.
JULIAN A. MEAD, M.D., ...	of Watertown.
HIRAM F. MILLS, C.E., ...	of Lawrence.
FRANK W. DRAPER, M.D., ...	of Boston.

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Engineer.

X. H. GOODNOUGH, C.E.

Pathologist.

THEOBALD SMITH, M.D.

Chemist.

H. W. CLARK.

Consulting Chemist.

THOMAS M. DROWN, M.D.

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GENERAL REPORT.

The following report of the State Board of Health comprises the general work of the Board during the year ending Sept. 30, 1898, and of the special work relating to food and drug inspection during the same period, also of that which relates to water supply and sewerage for the calendar year 1898.

The first portion of the volume, paged in Roman numerals, contains a condensed account of the work done under the provisions of the laws defining the duties of the Board.

The regular work of the Board is performed mainly under the provisions of three separate acts and the necessary appropriations for their execution, — an organic act of 1869, establishing the Board; an act for the inspection of food and drugs, of 1882; and an act for the protection of the purity of inland waters, of 1886, with the amendments to these acts.

The second part of the report, paged in Arabic figures, contains the fuller details of the work of the Board, under the acts relating to water supply and sewerage, food and drug inspection and the general acts relating to the work of the Board.

The following members comprised the Board in 1898: —

HENRY P. WALCOTT, *Chairman.*

FRANK W. DRAPER.	GERARD C. TOBEY.
HIRAM F. MILLS.	CHARLES H. PORTER.
JAMES W. HULL.	JULIAN A. MEAD.

No changes have taken place in the membership of the Board during the year.

Dr. Charles P. Worcester died Oct. 9, 1898, after ten years of service as assistant analyst and as chief analyst of the Board in its department of food and drug inspection.

The character of Dr. Worcester as a chemist was recognized throughout the Commonwealth as of the highest order. He was careful, thorough and painstaking in every line of his official duty, and won the respect and esteem of all with whom he came in contact. In the laboratory, in court, in his daily relations with men, he impressed every one with the absolute sincerity, honesty and trustworthiness of his character. In his death the service of the Commonwealth has sustained an irreparable loss.

Infectious Diseases.

The year 1898, as indicated by definite information in the possession of the Board, was notable for its greater freedom from epidemics than any other year, with one or two exceptions, in the past half-century. So far as can be learned at the date of writing this report, the death-rate of the State, which has usually varied but little from 19.5 per 1,000 during the past twenty-five years, fell to less than 18 in 1898. The most notable factor in this improvement appears to have been the decrease in the mortality from certain infectious and preventable diseases, and especially from diphtheria, scarlet-fever and consumption.

The tendency of legislation in regard to the management and control of those infectious diseases to which human beings are liable is usually toward a better protection of the public health. The laws of to-day are much more specific and definite than those which were enacted in the early half of the century.

Even as late as the publication of the volume of the Public Statutes, in 1882, no specific legal mention was made of the diseases now known as *diphtheria*, *scarlet fever*, *typhoid fever* or *measles*. The principal terms employed in the statutes before that date to denote infectious diseases were the words *small-pox* (P. S., chap. 80, §§ 2, 82, 83, and chap. 86, § 25), *plague* (P. S., chap. 80, §§ 40, 44), *hydrophobia* (P. S., chap. 102, § 83). The more indefinite terms having relation to the same subject, "other diseases dangerous to the public health" (P. S., chap. 80, §§ 2, 75, 78, 79, etc.), "an infectious distemper" (P. S., chap. 80, § 68), "severe epidemic" (P. S., chap. 80, § 14), "articles capable of conveying infection" (P. S., chap. 80, § 18), placed in the power of local health authorities considerable latitude of interpretation.

During the past sixteen years additional and more specific laws have been enacted for the restriction of the spread of diphtheria and scarlet fever (1884, chap. 98, § 1; 1885, chap. 198, § 1; 1890, chap. 102; 1891, chap. 188), typhoid fever (1883, chap. 124, § 2), syphilis (1891, chap. 420, §§ 1, 2), measles (1898, chap. 496, § 11). By the laws authorizing the appointment of a Cattle Commission the diseases known as tuberculosis, glanders and rabies, common to man and to animals, are also recognized; and by the statute authorizing the establishment of a State Hospital for Consumptives provision is also made for the isolation and treatment of persons suffering with consumption, now properly classed among the infectious diseases.

It has been the custom, in each of the reports of the past twelve years, to present a condensed statement relative to the prevalence of the principal infectious diseases, having special reference to those which are mentioned in the statutes.

Small-pox.

Although small-pox prevailed quite generally in many of the eastern and central States of the Union during 1898, Massachusetts fortunately escaped with a very small number of outbreaks, and among those attacked there were fortunately no deaths in 1898.

The entire number of cases reported to the Board during the year under the provisions of chapter 138 of the Acts of 1883 was twelve. These occurred in two outbreaks, nearly a year apart, the latter in a paper-mill village.

Early in January a young man employed in Greenfield took a pleasure trip of several hundred miles, returning to Greenfield soon afterward. He was then boarding in a hotel near the railroad station, where he was taken ill with what proved to be small-pox in a modified form. Two other young men had access to his room during his illness, and before the character of the disease had been made known with certainty. These two young men were also taken ill, and all three were sent to a temporary hospital. The hotel was closed to the public and its inmates were quarantined. General vaccination was ordered. The persons attacked were seen by the secretary of the State Board, and the cases were pronounced to be small-pox. One other case occurred in another part of the town in March and also one in Westfield in February, the cause of the latter being unknown.

During the month of March three cases occurred in the Reformatory for Women at Sherborn, all of them being colored women employed in the laundry, where the clothing of persons living outside of the prison was washed and ironed. It was also known that the young man referred to as No. 1 in the accompanying table, and who lived at Greenfield, was acquainted with one of the officers of the prison, and had visited there during the winter months.

The second attack, at Russell, occurred in a paper-mill town, the first person attacked being, as is often the case, an operative who was employed in the rag-sorting room of the mill. The next persons attacked were her child and her nephew.

Cases of Small-pox reported to the State Board of Health in 1898 under the Provisions of Chapter 138 of the Acts of 1893.

Number	Date of Report.	Place of Occurrence.	Nationality of Patient.	Occupation.	Age.	Sex.	Previously Vaccinated.	Number of scars.	Deaths.
1	Feb. 8,	Greenfield, .	United States,	Salesman (father a street cleaner).	22 years.	M.	-*	1	-
2	Feb. 20,	Westfield, .	Irish, . .	- -	6 years.	M.	-*	1	-
3†	Feb. 23,	Greenfield, .	United States,	Jeweller's clerk, . .	20 years.	M.	-*	2	-
4†	Feb. 28,	Greenfield, .	United States,	Car inspector, . .	21 years.	M.	-‡	-	-
5	Mar. 2,	Sherborn,§ .	United States negro.	Laundry operative, .	22 years.	F.	-‖	2	-
6	Mar. 14,	Sherborn,§ .	Negro, . .	Laundry operative, .	22 years.	F.	-¶	2	-
7	Mar. 14,	Greenfield, .	United States,	Housewife (husband a baker).	32 years.	F.	-**	1	-
8	Mar. 30,	Sherborn,§ .	United States,	Laundry operative, .	18 years.	F.	-††	1	-
9	Dec. 22,	Russell, . .	United States,	Paper mill (rag room),‡‡	21 years.	F.	-§§	1	-
10	Dec. 22,	Russell, . .	United States,	Child of No. 9, . .	1½ years.	F.	-‖‖	3	-
11	Dec. 22,	Russell, . .	United States,	Nephew of No. 9, .	6 years.	M.	-¶¶	1	-
12	Dec. 22,	Russell, . .	French Canadian.	Father in paper mill, .	11 years.	M.	Yes.	-	-

* In infancy. † Boarded in same hotel with No. 1. Was in his room while No. 1 was ill.
‡ Unvaccinated. § Convict at reformatory. ‖ In childhood.
¶ One and one-half years since. ** Fifteen years ago. †† Two years ago.
‡‡ Domestic rags. §§ Nine years ago. ‖‖ Not till mother's illness.
¶¶ Six months ago.

In paper-mill towns the appearance of small-pox does not ordinarily produce as much disturbance in the community as it does in other towns, since it is a matter of more common occurrence in such towns. Its source is usually the rags, which have come from some infected place, or family in which small-pox existed. A law such as exists in England, providing that the wilful sale of rags, clothing or other material worn by or used in connection with persons who have suffered with small-pox shall be regarded as a criminal offence, and liable to a penalty, would probably afford additional protection against small-pox.

In most cities and towns the occurrence of one or more cases of small-pox creates much alarm and consternation in the community, — a fact which is due mostly to the rarity of its occurrence, since there are many other diseases of common occurrence which are more fatal and more dangerous, and less amenable to the ordinary means employed for the prevention of disease. Fortunately, vaccination has in the past century shorn this disease of its terrors, and, as a consequence, the thoroughly vaccinated nation or people enjoys an immunity from this disease that is not known in unvaccinated communities. As an illustration of this fact, the German nation presents an example of a thoroughly vaccinated people. The German law enacted in 1874 requires that every child shall be vaccinated before the September of the year following its birth. All scholars in public and private schools must be vaccinated in their twelfth year.

The following figures, from the most recent report received from the Imperial Board of Health of Germany, are significant of the protection afforded by this law. Almost the only deaths which now occur in Germany are those of persons who have brought the disease with them from neighboring countries across the border, or, in a few instances, infants who were attacked before being vaccinated.

Deaths from Small-pox per Million Inhabitants in Certain Countries in 1896.

The German Empire,	.2	France,	117.6
Austria,	17.7	England,	2.3
Switzerland,	1.7	Holland,	14.7
Belgium,	5.7		

From recent information received as to the condition of certain towns in Massachusetts, it appears that vaccination is greatly neglected, and all the conditions prevail for spreading a serious epidemic of small-pox whenever the infection of this disease becomes implanted in such a community. It is therefore far preferable to provide the only adequate protection for such communities at once by thorough vaccination than to await the coming of an epidemic before taking such measures.

During the year there were reported to the Board, under the provisions of the Toronto Interstate Resolutions of 1886, 470 cases of small-pox scattered throughout the country in the following States and provinces: New York, Pennsylvania, Ohio, Indiana, Illinois, Michigan, Minnesota, North Carolina, South Carolina, West Virginia and the provinces of Ontario and Quebec. This did not comprise the whole number, since in several instances the number attacked was indefinitely expressed ("many" or "several"). Cases were reported in every month of the year except August.

Small-pox was also reported by the United States Commissioner of Immigration at New York as having occurred on board the following steamers, bringing immigrants destined for Massachusetts: "Carlsruhe," "Moravia," "Augusta Victoria," "Gallia," "Spaandam," "La Normandie" and "Pretoria." Upon these steamers there were 206 immigrants destined for cities and towns in Massachusetts. Upon receipt of definite information from the Commissioner in regard to these immigrants, their names and destination were immediately forwarded by the Board to the health officers of those towns and cities, in order that they might be kept under surveillance.

Typhoid Fever.

In the reports of the last four years a table has been introduced in which were presented the number of deaths and the death-rates from typhoid fever in each of the cities of the State. Another table, published in the report of 1896, page 779, showed quite conclusively that the death-rate from this disease has diminished with considerable uniformity, as public water supplies have been introduced. Another table (twenty-ninth annual report, 1897, page 495) shows what has been accomplished in reducing the death-rate from this disease by improving the water supply of a single city.

In the following tables the deaths and death-rates from this disease are presented in groups of five years, except those for 1896, 1897 and 1898, which are presented singly: —

Deaths and Death-rates per 10,000 Inhabitants from Typhoid Fever in Massachusetts Cities, 1871–95.

	1871-1875.			1876-1880.			1881-1885.			1886-1890.			1891-1895.	
Holyoke,	157	23.3	Holyoke,	77	8.1	Holyoke,	159	12.8	Lowell,	396	11.2	North Adams,	74	8.4
Springfield,	214	14.8	Lawrence,	122	6.6	Chicopee,	48	8.4	Lawrence,	233	11.2	Lawrence,	187	7.7
Chicopee,	63	12.6	Chicopee,	35	6.5	Lowell,	243	7.9	North Adams,	64	8.9	Lowell,	294	7.3
Lawrence,	190	11.9	Fall River,	152	6.4	North Adams,	43	7.6	Chicopee,	43	6.7	Chicopee,	50	6.6
Lowell,	221	9.8	Malden,	31	5.4	Lawrence,	144	7.4	Fall River,	209	6.4	Woburn,	33	4.8
Fall River,	176	9.8	Springfield,	86	5.3	Fall River,	174	6.6	Holyoke,	105	6.6	Newburyport,	29	4.1
Pittsfield,	56	9.6	Worcester,	131	4.9	Springfield,	117	6.6	Marlborough,	32	5.2	Springfield,	97	4.1
Brockton,	43	9.2	Haverhill,	40	4.8	Taunton,	59	5.3	Quincy,	37	5.1	Quincy,	37	4.0
Chelsea,	86	8.7	Salem,	61	4.6	Lynn,	109	5.2	Pittsfield,	40	5.0	Salem,	63	3.9
Northampton,	46	8.7	Newburyport,	31	4.6	Haverhill,	52	5.2	Haverhill,	59	4.8	Fall River,	154	3.8
New Bedford,	99	8.4	Pittsfield,	29	4.5	Boston,	952	5.1	Taunton,	58	4.7	Holyoke,	72	3.8
Worcester,	176	7.8	Lowell,	117	4.3	Pittsfield,	34	4.9	Springfield,	88	4.3	Haverhill,	49	3.4
Lynn,	118	7.8	Quincy,	21	4.3	Brockton,	41	4.8	Salem,	59	4.0	Marlborough,	24	3.3
Boston,	1,145	7.7	Marlborough,	20	4.3	Quincy,	27	4.8	Newton,	44	4.0	New Bedford,	77	3.2
Somerville,	69	7.6	North Adams,*	16	4.3	Salem,	66	4.7	Boston,	818	3.9	Boston,	722	3.1
Salem,	87	6.9	Lynn,	72	4.1	Northampton,	29	4.6	New Bedford,	71	3.8	Somerville,	65	2.8
Taunton,	65	6.7	Boston,	690	3.9	New Bedford,	62	4.1	Brockton,	46	3.8	Brockton,	41	2.7
Haverhill,	46	6.6	New Bedford,	50	3.8	Marlborough,	20	3.8	Woburn,	24	3.8	Malden,	36	2.7
Marlborough,	27	6.4	Gloucester,	34	3.8	Cambridge,	103	3.7	Cambridge,	116	3.6	Medford,	17	2.7
Gloucester,	51	6.3	Chelsea,	36	3.4	Gloucester,	38	3.7	Malden,	33	3.3	Worcester,	120	2.6
Cambridge,	124	5.7	Medford,	12	3.4	Everett,	9	3.6	Fitchburg,	31	3.3	Cambridge,	91	2.4
Woburn,	26	5.7	Taunton,	34	3.3	Newton,	31	3.4	Everett,	14	3.3	Chelsea,	35	2.4
Malden,	25	5.5	Northampton,	19	3.3	Worcester,	106	3.3	Northampton,	22	3.2	Everett,	18	2.4
Fitchburg,	32	5.4	Beverly,	13	3.3	Somerville,	45	3.3	Worcester,	109	2.8	Lynn,	64	2.2
Beverly,	18	5.2	Newton,	25	3.0	Newburyport,	22	3.2	Somerville,	49	2.8	Taunton,	29	2.2
Quincy,	19	4.6	Somerville,	33	2.8	Chelsea,	37	3.1	Chelsea,	35	2.6	Newton,	28	2.2
Newburyport,	29	4.5	Fitchburg,	17	2.8	Malden,	21	3.0	Newburyport,	17	2.5	Northampton,	17	2.1
Everett,	6	4.1	Brockton,	14	2.3	Waltham,	20	3.0	Lynn,	56	2.2	Beverly,	11	1.9
Medford,	11	3.6	Cambridge,	55	2.2	Fitchburg,	18	2.6	Gloucester,	25	2.2	Fitchburg,	22	1.8
Newton,	20	2.8	Woburn,	10	2.0	Medford,	11	2.6	Medford,	11	2.2	Waltham,	18	1.8
Waltham,	13	2.7	Waltham,	8	1.5	Woburn,	14	2.5	Waltham,	17	2.0	Gloucester,	18	1.3
			Everett,	2	1.0	Beverly,	10	2.3	Beverly,	10	2.0	Pittsfield,	25	1.3
Total,	3,458	-	....	2,093	-	....	2,864	-	....	2,971	-	....	2,617	-
Means for the cities,	-	8.2	....	-	4.2	....	-	5.1	....	-	4.6	....	-	3.4
THE STATE,	-	8.2	....	-	4.5	....	-	5.0	....	-	4.1	....	-	3.2

* North Adams not incorporated till 1878.

Deaths from Typhoid Fever in Massachusetts Cities (1896, 1897 and 1898).

	1896.		1897.		1898.			1896.		1897.		1898.	
	Deaths.	Deaths per 10,000 Living.	Deaths.	Deaths per 10,000 Living.	Deaths.	Deaths per 10,000 Living.		Deaths.	Deaths per 10,000 Living.	Deaths.	Deaths per 10,000 Living.	Deaths.	Deaths per 10,000 Living.
North Adams, .	12	6.08	9	4.42	10	4.77	Holyoke, . .	7	1.69	6	1.42	9	2.07
Pittsfield, . .	7	3.31	4	1.83	8	3.53	Fitchburg, .	4	1.46	3	1.06	6	2.04
Boston, . .	169	3.33	160	3.09	185	3.50	Everett, . .	6	2.91	5	2.19	5	1.97
Quincy, . .	8	3.70	5	2.22	8	3.40	Medford, . .	3	1.98	1	0.63	3	1.82
Beverly, . .	7	5.83	4	3.28	4	3.23	Somerville, .	28	5.09	10	1.72	11	1.80
Waltham, . .	5	2.34	2	0.92	7	3.14	Northampton, .	1	0.58	3	1.72	3	1.69
Taunton, . .	7	2.55	8	2.88	8	2.84	Lawrence, .	14	2.60	14	2.52	†9	1.57
Lowell, . .	38	4.43	17	1.95	24	2.71	Cambridge, .	32	3.80	13	1.50	14	1.56
Salem, . .	5	1.42	6	1.66	10	2.71	Malden, . .	8	2.56	4	1.22	5	1.44
Springfield, .	10	1.88	19	3.47	15	2.65	Woburn, . .	2	1.40	2	1.38	2	1.37
New Bedford, .	19	3.24	24	3.84	17	2.56	Newburyport, .	8	5.45	7	4.73	2	1.34
Newton, . .	7	2.47	4	1.38	7	2.36	Worcester, .	16	1.57	15	1.43	13	1.20
Lynn, . .	29	4.55	18	2.76	15	2.25	Brockton, . .	8	2.32	10	2.79	3	0.80
Chicopee, . .	6	3.55	7	4.03	4	2.24	Gloucester, .	9	3.10	2	0.67	2	0.65
Haverhill,* .	17	5.52	16	4.38	8	2.15	Marlborough, .	2	1.31	1	0.65	0	0.00
Fall River, .	27	2.92	40	4.17	21	2.11	Totals, .	526	-	445	-	445	-
Chelsea, . .	5	1.56	6	1.83	7	2.09	Means, .	-	3.13	-	2.56	-	2.50

* Bradford annexed to Haverhill, Jan. 1, 1897.

† Careful inquiry shows that the number of deaths from typhoid fever in Lawrence in 1898, stated on a later page as 8, should be 9.

NOTE.—For the years 1896 and 1897, the figures are taken from the registration reports for those years. For the year 1898, the figures are furnished by the local boards of health.

The figures presented in the foregoing table show that the typhoid fever mortality in the cities of the State has fallen from a rate of 8.2 per 10,000 living in the five-year period 1871–75 to 3.4 in the five-year period 1891–95, and still further to 2.5 in the year 1898, or less than one-third of its former proportions. With the exception of a very slight increase in the period 1881–85, the diminution has been quite uniform.

The death-rate from typhoid fever in the cities was slightly less than that of the previous year, 2.50 per 10,000 in 1898, as compared with 2.56 in 1897.

Among the ten cities having the highest death-rates from this cause during the three years, North Adams has maintained the highest average. Beverly and Haverhill held the second and third positions for the three-year period, but each of these had improved since 1896. Pittsfield, Boston, Quincy, Waltham, Lowell and Salem had higher rates in 1898 than those of 1897.

Fear having been manifested during the summer of 1898 lest the returning of a considerable number of troops from the West Indian campaign and from the various camps in other States should tend to spread this disease at a time when its prevalence is most severe, the Board reissued its circular upon typhoid fever, with such modifications as were deemed necessary, as follows: —

Suggestions for the Prevention of Typhoid Fever.

[A Circular from the State Board of Health. — Revised October, 1898.]

Typhoid fever is an infectious disease, and a specific bacillus is constantly present in the lesions and in the fecal discharges.

Typhoid fever prevails throughout the year in New England, and is usually more prevalent in the autumn months than at other seasons of the year. Of 36,012 deaths from this disease, occurring in Massachusetts during the thirty-six years ending with 1896, 19,037, or more than half, occurred in the months of August, September, October and November.

It is common to all ages, cases occurring in infancy and in old age. It occurs more commonly in persons from 15 to 30 years of age than in the younger ages and those of middle life. The following figures represent the death-rates in Massachusetts per 10,000 living at each age period during the twenty years ending with 1895: —

0–5 years,	2.29	40–50 years,	2.92
5–10 years,	2.38	50–60 years,	2.83
10–15 years,	3.34	60–70 years,	3.77
15–20 years,	6.82	70–80 years,	5.97
20–30 years,	6.40	Over 80 years,	6.04
30–40 years,	3.96		

Mode of Propagation.

Typhoid fever is undoubtedly communicable, even from person to person, though not positively contagious, in the restricted sense of personal contact. The infection of typhoid fever is conveyed from the sick to the well through the medium of the fecal discharges, and such is the most common method of its transmission. The vehicle of communication may be the air or the drinking-water, more commonly the latter. Its conveyance by food has also been demonstrated, especially by milk and by several species of shell-fish. The difficulty of discriminating between water and milk as media of transmission in certain cases is recognized, especially in large cities.

Prevention.

The *purification and protection of public and private water supplies from pollution* is one of the best measures for the prevention of this disease. The Caterham epidemic, which occurred in England in 1878, in which 352 cases and 21 deaths followed the pollution of a public water supply by the typhoid excrement of a single person, and more recently, the epidemic at Plymouth, Pa., which was still more destructive, and where a similar origin was distinctly traced, were noted examples of the pollution of public water supplies. The continued prevalence of this disease in the cities of this State which used the water of the Merrimack River for domestic purposes furnished abundant proof of the mode of transmission of the disease; and the results of filtration of the public water supply at Lawrence also have given proof of the efficiency of this method of purification as a means of its prevention.

Single cases and detached groups of cases are more commonly traced to private wells as their source, in consequence of proximity of the wells to cesspools, vaults, barn-yards, pig-styes and other contaminating sources. Hence, isolated farm-houses, thinly settled districts, as well as small but compact villages, without a public water supply, are more liable to the occurrence of the disease than cities having a public supply. In Massachusetts, for the five years 1871–75, the number of deaths per 10,000 of the population from typhoid fever was 8.2. During the five years 1886–90 the death-rate from this cause had fallen to 4.2 per 10,000. During this time the number of cities and towns having public water supplies had increased from 20 (1870) to 137 (1890).

The source of many cases has been explained by the large and increasing numbers of people who are in the habit of visiting seashore and summer resorts, picnic and camp grounds, where the sanitary conditions are of a doubtful character.

The great value of pure water supplies and efficient drainage systems of municipalities in the reduction of this disease is shown by the experience of English cities and towns, in nearly all of which a very decided reduction in mortality from typhoid fever followed the introduction of such works.*

Duties of Local Authorities with Reference to Typhoid Fever.

1. To investigate the source or origin of the disease, and to take measures to prevent the further use of well waters (if such be shown to be its mode or medium of communication), until the source of infection is remedied.

* Ninth Report of the Privy Council, England, 1866. Sixth Annual Report of the State Board of Health of Massachusetts, 1875. Senate Document No. 4, January, 1896.

2. Isolation of the sick. While the separation of the sick from the well is desirable, it is not essential that the same restriction as to intercourse should be required as is necessary in the case of small-pox or scarlet fever, since there is no evidence that this disease is conveyed from the sick to the well through the medium of a third person.

3. *Disinfection of the discharges of persons sick with the disease should be required*, as well as of vaults and other appliances used by them, and also of bedding, clothing and apartments used by the sick, especially when soiled.

4. *Notices of all cases should be required* from attending physicians in compliance with the provisions of the Public Statutes. Such notice should contain the name, age and residence of the patient, the name of the disease, the date of the first visit and the name of the reporting physician. Postal-cards or blank forms may conveniently be used for this purpose.

Attention is called to the following statutes, which provide definite and specific requirements in relation to disease dangerous to the public health : —

[P. S., Chap. 80, § 78; Acts of 1884, Chap. 98, § 1; Acts of 1890, Chap. 102.]

When a householder knows that a person within his family or house is sick of small pox, diphtheria, scarlet fever or *any other infectious or contagious disease dangerous to the public health*, he shall immediately give notice thereof to the board of health of the city or town in which he dwells, and upon the death, recovery or removal of such person, such of the rooms of said house and such of the articles therein as, in the opinion of the board of health, have been subjected to infection or contagion shall be disinfected by such householder to the satisfaction of said board of health. Any person neglecting or refusing to comply with either of the above provisions shall be punished by a fine not exceeding one hundred dollars.

[P. S., Chap. 80, § 79; Acts of 1884, Chap. 98, § 2; Acts of 1891, Chap. 188.]

When a physician knows that a person whom he is called to visit is infected with small pox, diphtheria, scarlet fever or *any other disease dangerous to public health*, he shall immediately give notice thereof in writing over his own signature, to the selectmen or board of health of the town; and if he refuses or neglects to give such notice he shall forfeit for each offence not less than fifty nor more than two hundred dollars.

[Acts of 1884, Chap. 98, § 3.]

The boards of health in the several cities and towns shall cause a record to be kept of all reports received in pursuance of the preceding sections; and such record shall contain the names of all persons who are sick, the localities in which they live, the diseases with which they are affected, together with the date and the names of the persons reporting any such cases. The boards of health shall give the school committee immediate information of all cases of contagious diseases reported to them according to the provisions of this act.

[Acts of 1884, Chap. 98, § 4.]

The secretary of the Commonwealth shall furnish the boards of health with blank books for the record of cases of contagious diseases as above provided.

As an additional measure in the same direction, the Legislature of 1893 enacted the following law, requiring that the contagious diseases reported to the local boards of health shall, in turn, be reported by them to the State Board of Health : —

[Acts of 1893, Chap. 302.]

(1) When the board of health of any city or town has had notice of the occurrence of a case of small pox or any other disease dangerous to the public health in such city or town, such board of health shall, within twenty-four hours after the receipt of such notice, notify the State board of health of the same.

(2) If the board of health of the city or town, in which a case of small pox or any other disease dangerous to the public health has occurred, refuses or neglects to send a notice as required in section one, such city or town shall forfeit its claim upon the Commonwealth for the payment of any expenses which may be incurred as provided in section eighty-three of chapter eighty of the Public Statutes.

Disinfection.

The following are recommended as the most efficient disinfectants for use in connection with this disease : —

For the Disinfection of Excreta. — A solution of chloride of lime, in the proportion of 4 parts of the chloride to 100 of water (from $\frac{1}{4}$ to $\frac{1}{2}$ a pound of the chloride to a gallon of water). Quick-lime slaked with water in the form of common whitewash or milk of lime, liberally used. The mixture of the disinfectant with the excreta should be thoroughly stirred, to ensure contact with all parts of the mass.

For the Disinfection and Deodorization of Masses of Organic Material in Privy Vaults, etc. — Chloride of lime in powder.* Quick-lime slaked with water in the form of common whitewash, or milk of lime, freely used.

For Clothing, Bedding, Linen, etc. — Burning, if the articles are of little value. Boiling, for at least half an hour. Immersion in a solution of bichloride of mercury, of a strength of at least 1 part to 2,000 of water, for at least four hours (one-half drachm of the bichloride of mercury to a gallon of water). Immersion in a 2 per cent. solution of carbolic acid for four hours ($2\frac{1}{2}$ ounces of carbolic acid to a gallon of water).

For the Person, Hands or Other Portion of the Body liable to be soiled. — Solution of chlorinated soda, 1 part to 10 of water (1 gill of the solution to $2\frac{1}{2}$ pints of water). Solution of carbolic acid, 3 parts to 100 of water (4 ounces of carbolic acid to a gallon of water).

For the Bodies of the Dead. — Wrap in a sheet saturated with a solution of chloride of lime, 4 parts to 100 of water (from $\frac{1}{4}$ to $\frac{1}{2}$ a pound of the chloride to a gallon of water), or of bichloride of mercury, 1 part to 500 of water (2 drachms of bichloride of mercury to a gallon of water), or of car-

* The chloride of lime for this purpose may be diluted with nine parts of plaster of Paris, or the same proportion of clean, dry sand.

bolic acid, 5 parts to 100 of water (6 ounces of carbolic acid to a gallon of water).

For the Sick Room, after the Death or Recovery of the Patient. — The washing of surfaces with a solution of bichloride of mercury, 1 part to 1,000, or of carbolic acid, 3 parts to 100 of water, and the use of formaldehyde as a gaseous disinfectant.

As it has been conclusively demonstrated that the fecal discharges of the sick are the chief vehicle of communication in this disease, their disinfection should be carefully and thoroughly performed, and especially should care be taken as to their disposal, so that no portion of them can gain access, either directly or indirectly, by surface drainage, percolation, filtration or otherwise, to any water supply.

If the number of reported cases of typhoid fever is taken as an index of its prevalence, there is shown to have been a slight increase over those of the previous year.

The following table indicates the number of cases reported to the State Board of Health in each week from the whole State during the different weeks from Sept. 1, 1897, to Dec. 31, 1897, and for a corresponding period of 1898. This period is selected as the period of the highest prevalence of the disease, as well as the period which was most liable to have been influenced by the return of troops from the south.

The number of cities and towns which reported cases of typhoid fever in these months of 1897 was 85, and those in the corresponding months of 1898 were 95. There were, however, 22 cities and towns which appear in the list for 1897 but not in 1898, and 32 in 1898 which do not appear in the list of 1897. This fact is partly due to a marked improvement in the matter of reporting in 1898, and partly due, undoubtedly, to the absence of the disease in some of the smaller towns.

The cities and towns reporting in 1898, which reported in that year but not in 1897, contained about 210,000 inhabitants, and those which reported in 1897 but not in 1898 contained about 75,000, so that the reporting population of the later year had about 135,000 more inhabitants than that which reported in 1897. For the purpose of comparison, therefore, only those places are selected which reported in both years, the total population being about one and three-fourths millions.

The reported cases in these months in 1897 were 1,076, and for the corresponding months in 1898, 1,134. The difference (58) is but little greater than may be accounted for by the usual increase of population in one year.

Reported Cases of Typhoid Fever in Massachusetts in September, October, November and December, 1897 and 1898, for the nearly Corresponding Weeks in those Months.

For the week ending —			For the week ending —		
Sept. 4, 1897,	78		Sept. 3, 1898,	58	
11, 1897,	96		10, 1898,	84	
18, 1897,	60		17, 1898,	91	
25, 1897,	77	311	24, 1898,	83	316
Oct. 2, 1897,	72		Oct. 1, 1898,	95	
9, 1897,	97		8, 1898,	87	
16, 1897,	89		15, 1898,	109	
23, 1897,	83		22, 1898,	75	
30, 1897,	62	403	29, 1898,	72	438
Nov. 6, 1897,	57		Nov. 5, 1898,	57	
13, 1897,	54		12, 1898,	61	
20, 1897,	48		19, 1898,	53	
27, 1897,	43	202	26, 1898,	41	212
Dec. 4, 1897,	34		Dec. 3, 1898,	25	
11, 1897,	40		10, 1898,	46	
18, 1897,	32		17, 1898,	36	
25, 1897,	26		24, 1898,	56	
Jan. 1, 1898,	28	160	31, 1898,	5	168
Total for 18 weeks,		1,076	Total for 18 weeks,		1,134

Diphtheria and Croup.

Diphtheria and membranous croup are here considered as identical. From this cause nearly 60,000 children have been swept away within the past forty years; but present indications appear to show that the introduction of better methods of treatment are beginning to limit the fatality of diphtheria in a manner which may justly be compared with the effect of vaccination upon the fatality of small-pox at a period nearly a century earlier, and parents having families of young children now feel a security against these two diseases which was unknown to former generations.

The following condensed statement, from a later page in this report (see Section II., of the Statistical Summaries), illustrates the changes which have taken place since the general introduction of the use of antitoxin, and of more systematic methods of diagnosis and disease notification: —

Pre-antitoxin Period. — 1891-94 (Four Years).

Reported cases,	13,332
Deaths in the same town,	3,768
Fatality (per cent.),	28.3

Antitoxin Period. — 1895-98 (Four Years).

Reported cases,	28,740
Deaths,	4,446
Fatality,	15.6

Consumption.

The classification of diseases which was conventionally adopted by the medical profession of Massachusetts nearly a half-century ago was that which was drawn up by Dr. William Farr, and presented at a statistical congress which met in Paris in 1855. But, while the classification as employed in England, where it originated, has undergone careful revision every ten years, and appears in the report of the Royal College of Physicians, that of Massachusetts has never been carefully revised, and is now entirely out of date, and not in accord with the progress of medicine. The almost meaningless term "zymotic" is still retained; and under the term "constitutional," which also has little significance, the diseases known as "tubercular" are still retained.

Tuberculosis or consumption is a disease regarding which so much has been learned, both by observation and by experiment, during the past quarter of a century or more,* as to make it a necessity to transfer it to the group of diseases known as "infectious."

One of the most noticeable points in regard to this disease, not only in Massachusetts but almost everywhere, where records are kept, is its steady and uniform decrease from year to year.

In the annual report of the Board for 1896, page 787, a table was presented showing steady diminution in the relative incidence of this disease upon the population, from a death-rate of 4,272 per million in 1853 to 2,194 in 1895, while the records of 1896 and 1897 and the partial returns which have already been received for 1898 indi-

* Dr. H. I. Bowditch, the first chairman of the State Board of Health, expressed his belief in the infectious character of consumption as early as 1864, and still more decidedly in 1869.

cate a still further decrease. The causes of this remarkable change are undoubtedly of a similar character with those which have affected nearly the entire class of infectious or preventable diseases; namely, a better knowledge on the part of the people of the art of prolonging life, a growing appreciation of the value of sanitary measures, as shown in the better organization and equipment of local health authorities, and the more vigorous enforcement of those measures which are essential to success in the campaign against infectious diseases.

Another means which has recently been adopted is the establishment of a special State hospital for the isolation and treatment of persons afflicted with tuberculosis, — a plan which has already been followed in other States, and one which has the advantage of isolating the consumptive from the crowded populations in which he has been living, and placing him under conditions where he will have better treatment than he could have at home, and, in addition, will not constitute a danger to the community.

These conditions are such as will undoubtedly favor the continuous lessening of the mortality from tuberculosis in the future.

Dysentery.

Mention was made in the report of last year (page xvii) of the reappearance of dysentery during 1896 and 1897. In neither of these years, however, did the disease assume such destructive proportions as were experienced in the early periods of registration, from 1845 to 1875. In the matter of locality, also, its recent prevalence has been extremely limited, the greater number of cities and towns having experienced no increase of the disease.

The only instance in which the Board was called upon to investigate its prevalence was at Leominster, during the winter of 1897 and 1898. The seasonal prevalence was here unusual, the epidemic, if it could properly be called an epidemic, having occurred in winter, and not in summer, its usual season of prevalence. The cases occurred chiefly in January and February, 1898.

The early symptoms in most of the cases resembled those of influenza, but none of the characteristic bacilli of influenza were found on examination. No common source of the disease could be found. Examinations of the water and milk were made, without avail. The water supply of the town is one of more than ordinary purity.

The following conclusions are from the report of Dr. O. Richardson, who made bacteriological examinations of the excreta in several of the cases of persons who were ill: —

It is evident that the *bacillus Coli Communis* must have been a predominant organism in the intestines of the individuals attacked with this "epidemic dysentery," as the cultures, with the exception of a very few colonies of *Cocci*, were pure cultures of this organism. The organism is characterized by its very rapid growth in bouillon, with the formation of a scum over the surface of the medium within twenty-four hours, and by its motility, which is greater than this organism usually possesses. The interesting fact in regard to the organism, however, is its virulency. Three guinea pigs were killed from two doses of 20 minims each and one from a dose of 10 minims of pure bouillon culture of the organism. They all died within twenty-four hours after inoculation, from septicæmia.

There were no deaths in this epidemic, so that the direct connection of this organism, as cause for it, could not be made, owing to lack of autopsies.

Notification of Infectious Diseases.

The law requiring physicians to report cases of infectious diseases to the local authorities was enacted in 1827, but it was practically inoperative until within the past twenty years; partly on account of its indefinite phraseology and partly in consequence of a general indifference to the importance of public-health measures.

This law was amended in 1884 by introducing the words "diphtheria and scarlet fever," and later by another amendment requiring a written notice signed by the attending physician.

Still later it was required that the local board of health should notify the State Board of the occurrence of cases of disease dangerous to the public health. The summary of the results of the operation of this law will be found in the Statistical Summaries, Section III.

The operation of this law has proved of much value, since it has given early notice of the prevalence of epidemics to the State Board and has thus enabled the Board to trace the origin and cause of such epidemics while they were still in progress, and in some instances to take measures which have prevented their further spread.

It is difficult to estimate the exact degree of compliance with the provisions of the law requiring notification to be made. Local boards of health throughout the State began to appreciate the usefulness of notification as early as 1890 or 1891, and subsequent legislation has still further lent its assistance in improving this important measure for preventing the spread of disease.

Another condition, which has already been alluded to in these reports, is the organization of an Association of Boards of Health, which meets at stated intervals and gives excellent opportunity to local health authorities to meet each other to consider the value of sanitary measures, and to strengthen each other in the adoption of new and more efficient modes of combating the different forms of infectious disease which are constantly occurring not only in densely settled communities, but also in a more limited manner in the rural districts.

The number of notices of cases of infectious diseases received at the office of the State Board of Health, in compliance with the law of 1893, had increased from 15,595 in 1894 to 27,925 in 1897. We are not, however, to understand that this means a nearly twofold increase in the prevalence of these diseases in the State, since the yearly prevalence of certain diseases is extremely variable. The number of cases of measles reported in 1897, for example, was more than twice as great as those reported in 1896.

It is also difficult to select any single disease as an index of the extent to which notification is made, by a comparison of the number of notified cases with the actual deaths which occurred as known from the registration of the cities and towns.

The recognized modification which has taken place in the mortality from diphtheria vitiates the calculation so far as that disease is concerned, and the irregularity in the annual death-rate from scarlet fever and especially from measles also similarly affects any estimate in regard to those diseases.

Typhoid fever, however, is a disease which has presented a much more uniform though steadily diminishing death-rate. In order to eliminate the effect of epidemic years, we have selected the two years 1891 and 1892, and the two years 1896 and 1897 for comparison.

The number of reported cases of typhoid fever in the cities and towns in which notification was enforced in 1891 and 1892 was 4,306. The number in such towns in 1896 and 1897 was 5,167 (see page 629, twenty-ninth annual report, 1897).

The number of actual registered deaths from this cause in the State in 1891 and 1892 was 1,648; but in 1896 and 1897 it was only 1,330. The reported cases in 1891 and 1892 were, therefore, only

2.6 times as many as the actual deaths, while in 1896 and 1897 they were 3.9 times as many (the ratio of 4,306 to 1,648, and of 5,167 to 1,330). But the actual ratio of cases to deaths from the average statement of many observers is about 6 to 1, the fatality being about 15 to 18 per cent.

The ratio of 3.9 to 2.6 (or about 50 per cent. greater) may be taken therefor approximately as the improvement in notification in comparing the two periods in question. But not until this ratio approaches nearly to a ratio of five or six fold in the case of typhoid fever can the work of notification be regarded as complete.

Bacteriological Department.

The bacteriological department of the Board was organized in 1894 for the purpose of facilitating the study of infectious diseases and for aiding local boards of health in cities and towns where the maintenance of a laboratory is impracticable.

The work of the department has comprised several different lines or branches: —

1. The production of antitoxin, which has included the preparation of 12,491 packages in the year ended March 31, 1899.
2. The examination of 1,591 cultures of matter suspected of containing germs of diphtheria.
3. The examination of 414 specimens of material suspected of containing the bacilli of tuberculosis.
4. The examination of slides of blood of patients living in malarial districts.
5. Examination of blood of typhoid patients.
6. Preparation of a considerable quantity of tetanus antitoxin for use in several cases scattered throughout the State.
7. A comparative study of the bacillus of tuberculosis in man and animals.
8. Studies upon the toxin of diphtheria.

By means of the organization of this department the Board has initiated and carried into effect a plan by which every part of the State, from Berkshire to Cape Cod, has been directly benefited.

The production of antitoxin has been continued throughout the year, and it has been distributed to every city and town from which calls for this valuable therapeutic agent have been received. The lessening of the fatality from diphtheria can be satisfactorily explained in no other way than by the extensive and thorough use of antitoxin, which has been encouraged and promoted by its free distribution. Fuller details upon this subject may be found on later pages of the report.

The examinations which have been made to determine the character of material sent to the Board from patients suffering with symptoms of diphtheria, tuberculosis, malarial fever and other diseases have rendered substantial service to local boards of health and physicians throughout the State by making the diagnosis of disease more certain, and thus dispelling the doubts which often hinder the efficient work of sanitary authorities.

The Board has established places of deposit in the cities and large towns for supplies of antitoxin, culture tubes and sputum jars so that they may be obtained for immediate use.

On account of the rarity of cases of *tetanus* and the consequent small demand for tetanus antitoxin, no special mention was made in the report of last year of the fact that the Board had kept constantly on hand a supply of serum for immediate use, and it is doubtful whether the limited demand for this serum would warrant the continuance of its production.

In consequence of this limited and irregular demand the distribution was made direct from the laboratory. This serum should be furnished only on condition that full detailed reports of its use are returned to the Board as soon as possible. In consequence of the great variety of lesions which lead to the occurrence of tetanus, the variations in the period of incubation and in the severity of the symptoms, it has not been deemed best to issue a formulated series of questions but to allow each observer to state the case in his own language.

Supplies of tetanus serum have been furnished to the Massachusetts General Hospital as follows: —

In April, 1898,	1,000	cubic	centimeters.
In June, 1898,	2,720	"	"
In July, 1898,	800	"	"
In Sept., 1898,	900	"	"
In Nov , 1898,	1,000	"	"

To the Boston City Hospital.

In July, 1897,	360	cubic	centimeters.
In Aug., 1897,	360	"	"
In Sept., 1897,	600	"	"
In May, 1898,	200	"	"
In June, 1898,	140	"	"
In Sept , 1898,	500	"	"

To Waltham Hospital.

In Aug., 1898, ...	700 cubic centimeters.

To Salem Hospital.

In April, 1898, ...	200 cubic centimeters.
In Jan., 1899, ...	620 " "

To Lowell Hospital.

In Feb., 1899, ...	500 cubic centimeters.

To the Board of Health of Marblehead.

In Aug., 1898, ...	500 cubic centimeters.

To the Hospital Ship "Bay State."

In July, 1898, ...	1,380 cubic centimeters.

To Private Physicians in Brookline and Boston.

In July and Dec., 1898, ...	2,200 cubic centimeters.

Applications having been made from parties living outside of the State for the products of this laboratory, it should be stated that the Board has no authority to supply such products to citizens of other States.

Offensive Trades.

Under the provisions of chapter 80 of the Public Statutes certain noxious and offensive trades (slaughter-houses, rendering establishments or other trades attended by "noisome and offensive odors") are made amenable to the action of the court and of the State Board of Health. The local board of health has the power to assign places for carrying on such business, or may prohibit the exercise of such trades.

It is also necessary for persons carrying on such trades to obtain a license from the mayor and aldermen or from the selectmen, and under a recent law this license must be renewed annually.

The State Board has also jurisdiction in such cases upon a petition for a hearing, and may "order any person to cease and desist from carrying on such trades" if in its judgment the public health or comfort or convenience so require.

No petitions have been received by the State Board for its action or interference under this statute since 1894, such cases having usually been settled by the local boards of health.

Food and Drug Inspection.

This important department of the work of the Board has now been conducted without interruption for a period of sixteen years, and when the results of the first and last years' work are compared, a decided improvement is apparent in the quality of the food supply of the State.

A great loss was sustained during the past year in the death of the chief analyst in this department, Dr. Charles P. Worcester.

The work of the Board during the past year comprises the examination of 10,797 samples of food and drugs, of which number 6,247 were samples of milk obtained by the inspectors in different parts of the State.

The total number of samples collected and examined since the beginning of the work under the food and drug acts is 97,950, of which number 51,198 were samples of milk.

The number of prosecutions conducted during the year ended Sept. 30, 1898, was 64, of which number 62 resulted in conviction.

The details of the work of this department may be found at page 677.

Health of Towns.

With the exception of Rhode Island, Massachusetts is the most densely settled State in the Union, its population, according to the census of 1895, having an average density of a little more than 300 per square mile. It had, by the same census, 39 cities and towns each having a population of more than 10,000, and more than 80 per cent. of its population were living in towns of more than 5,000 in each.

Such a degree of density and the consequent aggregation of the people in close proximity are usually accompanied with an increase in the existence of unsanitary conditions, nuisances and in the prevalence of infectious diseases, unless great pains are taken by the local authorities to counteract these depressing conditions by the vigorous application of sanitary measures. It is a matter of congratulation that the death-rate of Massachusetts has not increased, notwithstanding the fact that its density of population has doubled in the past twenty-five years. It remains to be seen whether another quarter of a century of sanitation and another doubling of the population will find the death-rate the same as at present.

Constant improvements in sanitary methods are being made, but there is abundant room for more. It is desirable that local boards of health and the State Board should work together as far as possible for the common good. In those cities and towns where facilities for careful investigation are not accessible, the State Board can supply the means for sanitary investigation, which its well-equipped laboratories and experts furnish. For the purpose, therefore, of facilitating the investigation of sanitary questions in cities and towns, and of aiding the work of local health authorities, the State Board has organized a new department of health of towns and of correspondence with local boards of health, and has appointed Dr. F. L. Morse as its medical and sanitary inspector, who will have his office at the State House, and under the direction of the Board will be ready to assist the local health officers of cities and towns in making such investigations as may be necessary, especially in regard to the prevention of the spread of infectious diseases.

Manual of Health Laws.

Beginning with 1882, the Board has issued at intervals a compilation of statutes relating to public health which had been enacted up to the date of publication.

At first this compilation was issued about once in four years, but the demand for it has considerably increased in consequence of the wider range of topics included in its pages. Its chief use is as a manual for reference for local boards of health and other sanitary officials, but the increasing importance attached to the legislation relative to water supplies, systems of sewerage, pollution of streams, food and drug inspection, the registration of vital statistics and other special sanitary topics has created a much greater demand for the manual than had heretofore existed.

In addition to the laws contained in it, the manual also presents a digest of all the decisions of the supreme court upon sanitary questions up to the date of its publication. It also contains the regulations of the State Board of Health in regard to food and drug inspection, and a digest of the powers and duties of the State Board under the general laws relating to health.

The edition of 1897 was very soon exhausted, and another has been issued containing the additional health statutes of 1897 and 1898. The last editions have been stereotyped.

Water Supply and Sewerage.

The operations of the Board under the provisions of chapter 375 of the Acts of the year 1888, entitled "An Act to protect the purity of inland waters and to require consultation with the State Board of Health regarding the establishment of systems of water supply, drainage and sewerage," have increased considerably over those of previous years, and have formed a very large share of the official work of the Board.

The portion of the work which comprises the advice of the Board to cities and towns, under the provisions of section 3 of this act and under the provisions of acts of the Legislature requiring special action of the Board relative to the approval of plans of water supply and sewerage, together with the action of the Board upon various petitions for the taking of land for the purification and disposal of sewage under the provisions of the general law of 1890, chapter 124, has already been reported to the Legislature in Senate Document No. 4, and the abstracts of replies of the Board are also given in this report, pages 4–128.

During the year 1898, 75 applications were officially made to the Board for its advice under the provisions of the act referred to, or for the approval of plans of water supply and sewerage, or the taking of land, making in all 583 such applications since the beginning of this work in 1886. In connection with many of these matters the Board has given public hearings in cases where hearings were required.

The examinations of public water supplies and rivers have been continued as in former years, and many samples of water from the sources of public water supply in the State and from many of the rivers have been analyzed at the laboratory of the Board in the State House. The year 1898 was one of extraordinary rainfall in Massachusetts, and the effect of the pollution of streams has not been as noticeable as in drier seasons. The chemical analyses of the public water supplies and rivers are presented in the usual form, excepting that in some cases, especially of ground waters which changed but little in character during the year, only an average of the results of analyses is presented. A limited number of biological examinations have also been given in cases where these analyses are of special importance in judging of the character of a water.

The usual tables of water supply statistics are given, showing the number of towns supplied and the quantity of water used in cities and towns where the quantity is measured, together with a summary of the records of rainfall and flow of streams which are necessary in considering the results that are presented of analyses of water supplies and rivers. One of the tables presented shows the population of cities and towns having public water supplies and cities and towns which are not provided with such supplies. From an examination of this table it will be seen that the cities and towns which are provided with public water supplies contain over 90 per cent. of the total population of the State; and while in many cases the public water supply is not available to all of the inhabitants of a city or town, the table, nevertheless, gives a fair indication of how large a proportion of the people of the State depend for their supply of water upon public water works.

The results of the investigations carried on at the Lawrence Experiment Station upon the purification of sewage and various kinds of manufacturing wastes, as well as the filtration of water, are presented as usual. The continuance of these experiments has furnished much new and useful information upon the practicability of purifying sewage at rapid rates and with various materials, which is of value in many sewage-disposal problems, where land suitable for the purification of sewage cannot be obtained. A considerable portion of the work at the station during the year has consisted of the investigation, by means of experiments, of proposed plans for the purification of sewage and manufacturing wastes concerning which reliable information is not available.

Investigations as to lead poisoning by the use of water drawn through lead service pipes and the action of water on pipes of lead and other metals have been carried on through the year, and in the present report, Mr. H. W. Clark, chemist of the Board, presents the results of these investigations and the methods used in analyzing the water.

In several of the cities and towns of the State, some of them containing a large population, works for the purification of sewage by intermittent filtration through beds of sand and gravel have now been in successful operation for several years, and the results of analyses of sewage and effluent from these systems have been presented in the annual reports of the Board from time to time. During the year 1898 a much more thorough examination of the various systems has been made than before, to obtain information as to the practical working of these systems. The results of these investigations are presented by the engineer of the Board.

Lead Poisoning.

Investigations as to the action of water of various public water supplies upon pipes of lead and other metals used in the conveyance and distribution of water have been continued, and, as already indicated, a description of the results of the investigations and the methods of analysis used are presented in a paper by the chemist of the Board. It has been found that many waters, when brought into contact with lead services, as in lead distribution pipe, dissolve lead from the pipes, and the water thus becomes dangerous to those who drink it. While the quantity of lead dissolved may be small, and a single dose might not seriously harm the user of the water, the continued use of water containing lead is harmful, because lead is a cumulative poison. The exact amount of lead which may be taken into the system without producing harm is not definitely known and may vary with different people, but it is known that the continuous use of water containing quantities of lead as small as .05 of a part per 100,000, or about $\frac{1}{33}$ of a grain per gallon, has caused serious injury to health.

Attention has already been called in previous reports to the occurrence of lead poisoning in the towns of Kingston, Milford and Fairhaven.

In addition to these places, many cases of a serious character have been reported from the city of Lowell among persons using the city water, and several communications have been addressed to the authorities of this city with reference to abandoning the use of lead pipes.

The Board is continuing its investigations upon this subject, and hopes that any appearance of similar trouble in other places may be reported to it without delay.

Private wells, even more than public water supplies, are subject to the same danger when lead pipe is used for the conveyance of the drinking water. Several instances of this character have come to the notice of the Board in the past year.

The history of the harmful effects of lead pipes upon well waters has, in this country, been closely connected with the city of Lowell.

In the year 1842 a special committee of this city, appointed at the instance of its leading physicians, made a report upon the subject, and the committee noted with especial emphasis the readiness with which the Lowell ground waters dissolve lead in dangerous quantities, and warned the inhabitants of the city against the use of lead pipes for the conveyance of drinking waters.

So far as we know, this public document of the city of Lowell is the earliest, as it is one of the best, statements of the peculiar danger from the unnecessary use of lead pipe.

The symptoms of chronic lead poisoning, such, for example, as are liable to ensue after the continuous use of water containing small quantities of lead, are as follows : —

The symptoms are usually slow in their progress. There is usually a rapidly developing anæmia, with a consequent anæmic pallor of the skin. There is often constipation and indigestion, with a feeling of depression at the outset. Then there may be a loss of appetite, an unquenchable thirst, a constant unpleasant metallic taste, and a foul odor in the breath. The countenance becomes dull and appears anxious. There is rarely any fever and the pulse is usually natural. The respiration is often rapid. There is frequently abdominal hardness and pain, the pain increasing as the case progresses, colic being the most common symptom. But little urine is usually passed, and there is dysuria.

Far more commonly, lead paralysis is manifested. It may occur after a single attack of chronic lead poisoning, but is more often the result of a series of attacks, and occasionally occurs without being preceded by any attack. The upper extremities, and especially the extensor muscles, are most commonly attacked, those of the hand and forearm first suffering.

The chief diagnostic sign is the blue line upon the gums at the margin of the teeth. This is due to the formation, in the capillaries of the gums, of sulphide of lead. It is not invariably present. The presence of lead in the urine constitutes a valuable diagnostic symptom.

In mild cases the prognosis is usually favorable when the exciting cause has been removed. But in severe cases, and especially where paralysis exists as a consequence of lead poisoning, the injury may be permanent, and occasionally proves fatal.

Routine Work of the Board.

During the year ending Sept. 30, 1898, the Board held meetings at least once in each month. Meetings of such of the standing committees as were necessary for the transaction of business were also held from time to time, as well as joint sessions with such other boards or commissions as were prescribed by the Legislature.

The office of the Board has been open throughout the year, as prescribed by the Public Statutes, chapter 21, section 10,* for the transaction of its authorized business.

Advice has been very frequently given at the office and by mail to local boards and to individuals in regard to sanitary matters, and many visits have been made by the secretary, the engineers and other experts to cities and towns for the purpose of making investigations and giving advice.

The bacteriological work undertaken by the Board for the benefit of such communities in the State as possessed no facilities for such methods of investigation and diagnosis, together with the production and distribution of antitoxin for the treatment and prevention of diphtheria, has very materially increased the work of the office, which acts as a general and central station for the distribution of antitoxin and of the various culture tubes, receptacles and other means employed for the diagnosis of disease.

The work of antitoxin production especially had more than doubled since the previous year, as will be seen by reference to the report upon antitoxin production.

The statistics of mortality compiled from the weekly postal-card returns from the registering authorities of cities and towns have been published weekly during the year in the form of a bulletin, which also contains, once in each month, a report of the work done in the line of food and drug inspection, together with the prosecutions made under the food and drug acts, and other important information relative to the work of this department. In addition to these items there is also published in the same bulletin a weekly report of the number of cases of infectious diseases reported by the local boards to the State Board of Health, under the provisions of chapter 302 of the Acts of 1893.

* Office hours, 9 A.M. to 5 P.M.; Saturdays, 9 A.M. to 2 P.M.

The laboratories for water analysis and for food and drug inspection are located on the fifth floor of the State House, the former at Room 502 and the latter at Room 501, each of which is open during the usual working hours.

The following table presents certain statistical data relative to the routine work of the Board: —

Statistical Table for the Year ending Sept. 30, 1898.

Whole number of samples of foods and drugs examined during the year,	10,797
Samples of milk examined (included in the foregoing),	6,247
Whole number of samples of food and drugs examined since beginning of work in 1883,	97,590
Whole number of samples of milk examined since beginning of work in 1883,	51,198
Number of prosecutions against offenders during the year,	64
Number of convictions during the year,	62
Amount of fines imposed during the year,	$2,060 98
Number of packages of antitoxin issued to cities and towns,*	12,491
Number of bacterial cultures made for the diagnosis of diphtheria in cities and towns,*	1,591
Number of examinations made for diagnosis of tuberculosis,*	414
Number of examinations of blood made for diagnosis of malarial infection,*	132
Number of notices of cases of infectious diseases received and recorded under the provisions of chapter 302, Acts of 1893,†	14,331
Number of postal card returns of mortality for cities and towns received and recorded,†	1,953
Number of annual reports of cities and towns received under the provisions ‡ of Acts of 1894, chapter 218,†	88

Force employed in general work of Board at central office, State House: —	
Secretary,	1
Clerks,	2
Messenger,	1
Total,	4

Force employed at central office, State House, Boston, for food and drug inspection, chemists and assistants,	2
At Amherst,	1
Inspectors,	4
Total,	7

* For the year ending March 31, 1899. † For the calendar year 1898.

‡ Towns having a population of over 5,000 inhabitants in each.

Force employed at laboratory (Bussey Institute): —	
Pathologist,	1
Assistants,	3
	4

UNDER THE PROVISIONS OF CHAPTER 375, ACTS OF 1888.

Applications for advice from cities, towns and others: —	
Relating to water supply,	38
Relating to ice supply,	6
Relating to sewerage and drainage,	22
Relating to pollution of streams,	9
Total,	75

Number of samples of water examined chemically and microscopically at the laboratory, Room 502, State House,	3,458
Number of samples of sewage and effluent from sewage purification works examined chemically at the laboratory, Room 502, State House,	626
Number of samples of sewage and water examined chemically and bacterially at the Lawrence Experiment Station,	2,171
Number of samples of sand examined chemically and bacterially at the Lawrence Experiment Station,	610
Number of samples of sand examined mechanically at the Lawrence Experiment Station,	610
Additional samples examined bacterially at the Lawrence Experiment Station,	6,770
Total number of samples examined,	14,245

Force employed at central office: —		
Chief engineer,	1	
Assistant engineers,	4	
Stenographers and clerks,	2	
Messenger,	1	
	—	8
At laboratory, Room 502, State House: —		
Chemists,	1	
Assistant chemists,	4	
Biologist,	1	
	—	6
At Lawrence Experiment Station: —		
Chemists,	2	
Bacteriologists,	2	
Other assistants and laborers,	4	
	—	8
Total ordinary force employed under chapter 375, Acts of 1888,		22
Total ordinary force in all departments,		37

The number of applications for advice under the provisions of the acts relating to water supply and sewerage, received since July, 1886, when these acts first went into operation, is a follows : —

1886,	8	1894,	53
1887,	22	1895,	52
1888,	28	1896,	65
1889,	38	1897,	59
1890,	23	1898,	75
1891,	53		
1892,	56	Total,	583
1893,	51		

Recommendations.

The following recommendation was made to the Legislature at the beginning of the session of 1899 : —

The Board recommends the continuance of its investigations now being carried on, as authorized by the provisions of chapter 375 of the Acts of 1888.

For this purpose, and to make the necessary investigations in order to advise cities, towns, corporations and individuals in regard to the best methods of assuring the purity of intended or existing water supplies and the best method of disposing of sewage, and to carry out the other provisions of chapter 375 of the Acts of 1888, the Board estimates that the sum of $30,000 will be required.

Expenditures.

The expenditures in 1898 under the foregoing appropriations were as follows : —

General Expenditures Sept. 30, 1897, to Sept. 30, 1898.

Salaries,	$5,599 75
Travelling expenses,	628 95
Stationery,	335 48
Printing,	1,185 73
Books, subscription and binding,	424 64
Advertising,	24 15
Express charges,	192 14
Extra services,	272 77
Messenger services,	30 00
Postage and postal orders,	421 98
Telephone and telegraph messages,	79 00
Typewriting supplies,	7 85
Special investigations,	780 39
Amount carried forward,	$9,982 83

Amount brought forward,	$9,982 83	
Printing report upon cerebro-spinal meningitis,	1,530 29	
Expense of collecting samples of water,	19 59	
Sundry office supplies and incidental expenses,	220 65	
		$11,753 36

Expenditures at Bacteriological Laboratory.

Salaries,	$2,473 84	
Travelling expenses,	25 52	
Purchase of animals,	28 12	
Board of horses,	1,255 62	
Food for animals,	72 94	
Apparatus, chemicals and laboratory supplies,	1,424 52	
Express charges,	13 35	
Ice,	9 80	
Postage,	1 96	
Stationery,	3 95	
Rental of telephone,	168 00	
Telegrams,	1 00	
		5,478 62
Total,		$17,231 98

Expenses under Chapter 375 of Acts of 1888 (Protection of Purity of Inland Waters) for Calendar Year 1898.

Salaries, including wages of laborers at Lawrence Experiment Station,	$24,052 02
Apparatus and materials,	2,305 83
Rent of Lawrence Experiment Station,	150 00
Travelling expenses,	1,617 31
Express charges,	877 41
Use of tools and office, Lawrence Experiment Station,	216 97
Books, stationery and drawing materials,	411 64
Maps and blue prints,	125 48
Postage stamps,	41 00
Printing,	184 44
Messengers, telegrams and telephone messages,	17 56
Total,	$29,999 66

For Food and Drug Inspection for Year ending Sept. 30, 1898.

Salaries of analysts	$4,595 00
Salaries of inspectors,	4,000 00
Travelling expenses and purchase of samples,	1,838 83
Apparatus and chemicals,	299 48
Amount carried forward,	$10,733 31

Amount brought forward,	$10,733 31
Printing,	20 34
Index cards,	27 50
Special investigation,	14 94
Special services (milk case),	10 00
Extra services for inspection,	154 00
Services (cleaning laboratory),	82 00
Bottles and stoppers,	10 21
Sundry small supplies,	10 38
Total,	$11,062 68

HENRY P. WALCOTT,
GERARD C. TOBEY,
JAMES W. HULL,
CHARLES H. PORTER,
JULIAN A. MEAD,
HIRAM F. MILLS,
FRANK W. DRAPER,
State Board of Health.

WATER SUPPLY AND SEWERAGE.

ADVICE TO CITIES AND TOWNS.

ADVICE TO CITIES AND TOWNS.

Under the provisions of chapter 375 of the Acts of 1888, entitled "An Act to protect the purity of inland waters, and to require consultation with the State Board of Health regarding the establishment of systems of water supply, drainage and sewerage," the Board is required

"from time to time to consult with and advise the authorities of cities and towns, or with corporations, firms or individuals either already having or intending to introduce systems of water supply, drainage or sewerage, as to the most appropriate source of supply, the best practical method of assuring the purity thereof or of disposing of their drainage or sewage, having regard to the present and prospective needs and interests of other cities, towns, corporations, firms or individuals which may be affected thereby. It shall also from time to time consult with and advise persons or corporations engaged or intending to engage in any manufacturing or other business, drainage or sewage from which may tend to cause the pollution of any inland water, as to the best practicable method of preventing such pollution by the interception, disposal or purification of such drainage or sewage: *provided*, that no person shall be compelled to bear the expense of such consultation or advice, or of experiments made for the purposes of this act. All such authorities, corporations, firms and individuals are hereby required to give notice to said Board of their intentions in the premises, and to submit for its advice outlines of their proposed plans or schemes in relation to water supply and disposal of drainage and sewage; and all petitions to the Legislature for authority to introduce a system of water supply, drainage or sewerage shall be accompanied by a copy of the recommendation and advice of the said Board thereon."

During the year 1898 the Board has given its advice to the following cities, towns, corporations and individuals who have applied for such advice under the provisions of the general act of 1888, or under special acts relating to water supply and sewerage.

Replies were made during the year to applications made from the following sources for advice relative to water supply: Agawam (Mittineague), Arlington (the Robbins' Spring Water Company), Billerica (two replies), Cheshire, Cohasset, Enfield, Fairhaven, Groton, Harvard, Haverhill, the Gale Shoe Manufacturing Company of Haverfor drinking and other domestic purposes to be analyzed. The results of these analyses show that the water of four of the springs was of good quality at the time that the examination was made, though there was evidence that some of the water had at some time been polluted and subsequently thoroughly purified in its passage through the ground. The water of the remaining spring, numbered 4 on the plan, contained a small quantity of free ammonia, contained a larger quantity of chlorine and nitrates than was found in the water of any of the other springs, and the hardness also was somewhat greater. The poorer quality of the water from this spring may possibly have been partially due to the manner of collecting the sample, since there seems to be no good reason why the water should not be of as good quality as that of spring No. 5, which is located close by.

A portion of the area from which the water of the springs appears to be derived is controlled by your company, but other portions are not so controlled; and there are already a few dwelling-houses within the apparent water-shed of the springs, and these lands are liable to be used for building purposes before many years. The region appears to be building up rapidly; and, if the number of dwelling-houses in the region above the springs and from which their supply is derived increases, and sewage is disposed of by discharging it into or upon the ground, it is probable that the sewage would unfavorably affect the quality of the water of the springs, and possibly render it unsafe for drinking.

The town is provided with a sewerage system, however; and, if all sewage is removed from houses in the territory in question by discharging it into the sewers, the danger of pollution of the springs would be greatly reduced, especially if the sewers are made tight, or are laid below the level of the ground water.

The best method of protecting the purity of the spring water would be for the company to acquire control of the land above the springs within the area from which the water of the springs is apparently derived, and prevent its occupation for building; and, if it is feasible to do so, the Board would advise that the control of the land be secured by the company, and that it be kept free from buildings.

It is important that the springs be kept covered, so as to exclude the light and to keep out such contamination as might be thrown into them, and surface water should also be carefully excluded.

BILLERICA. The water commissioners of Billerica applied to the Board, Dec. 10, 1897, for its advice under the general act of 1888, chapter 375, and the special act of 1897, relating to a water supply for the town. The Board replied as follows: —

JAN. 27, 1898.

The State Board of Health received from you, on Dec. 17, 1897, an application for the advice of the Board, under the authority of chapter 375 of the Acts of 1888 and chapter 471 of the Acts of 1897, with reference to a proposed water supply for the town of Billerica, in which you state that it is proposed to obtain a supply of ground water from land on the west side of the Concord River, known as the Hutchins Meadow, by means of a large well, supplemented when necessary by tubular wells, or by the use of tubular wells alone. You also submitted the results of your investigations of this territory by means of tubular test wells, and the results of pumping tests made by connecting several wells with a steam pump, and pumping from them for a period of several days. During these tests samples of the water drawn from the wells collected by you and by agents of the Board have been analyzed.

The first pumping test was begun on November 15 and continued until November 24, seven wells, numbered 11, 12, 13, 42, 49, 48 and 26, being connected with the pumps. During the whole of this test the water drawn appears to have had a strong odor of sulphuretted or carburetted hydrogen, which, however, disappeared very quickly when the water was exposed to the air; and the analyses showed the presence of iron in considerable quantity, a small amount of which precipitated out of the water on standing. In view of this condition, and the probability that the quantity of iron would increase with continued pumping of such a quantity of water as would be necessary to supply the town of Billerica, the suggestion was made that you continue your investigations, to determine whether it was feasible to obtain in this neighborhood water that was free from iron.

Subsequently, on December 3, a second test was begun by pumping from a group of seven wells, numbered 12 (*a*), 22, 24, 25, 53, 34 and 52, situated at the southerly side of the meadow, a short distance south-west of those first connected with the pump. This test was continued from December 3 to December 11, water being pumped during this period at the rate of about 430,000 gallons in twenty-four hours. Analyses of samples of water collected at frequent intervals through this test showed that it was soft, free from odor, nearly colorless, and contained only an insignificant amount of iron, and that it was in other respects of excellent quality for the purposes of a public water supply.

The wells from which the last test was made were located as stated above, at the southerly side of the meadow; and, while some of them are not far distant from the wells used in the previous test, which were nearly all located in the meadow, the quantity of iron present showed no tendency to increase during the test. It is very desirable, however, in selecting the final location of the collecting works, to place them at as great a distance as is feasible from the places where the ground water is found to contain an excess of iron.

The daily quantity of water pumped during each of these tests was much in excess of the quantity that is likely to be needed for the supply of Billerica; but, while the tests have shown that water could be pumped freely from the ground in large quantities at this season of the year, when the ground is full of water, the yield is likely to be much smaller in the summer season, when the water in the river and in the ground in its vicinity is lower, and when water is being pumped constantly for the supply of the town. Nevertheless, it is probable that a sufficient supply of good water for Billerica can be obtained from the ground in this locality, if the works are extended so as to draw water from a large area.

The tests, on the whole, indicate that a system of collecting works in this locality can be so located and arranged that a suitable water supply for the town of Billerica can be obtained at this place; and there does not appear, from your investigations, to be any other available source where the conditions for obtaining a suitable supply are as favorable, unless at a considerably greater expense for the works. Moreover, if works are constructed here, and the quantity of water shall be found too small at some future time, it will be practicable, without great cost, to increase the supply by filtering the water of the Concord River through a filter prepared for the purpose, or, perhaps, by discharging it upon the ground, where the material is favorable for filtration, in the vicinity of the collecting works.

The Board, therefore, advises and recommends that ground water, taken from the ground at the southerly side of the Hutchins Meadow, proposed in your application, is a suitable source of supply for the town of Billerica.

Billerica. A request was received, May 22, 1898, from the water commissioners of Billerica, for the opinion of the Board relative to the use of lead service pipes in connection with the public water supply of the town. The Board replied to this request as follows: —

June 7, 1898.

The State Board of Health has considered your request, contained in a letter of your engineer to the chief engineer of this Board, for opinion relative to the use of lead service mains for the distribution of the water from tubular wells which it is proposed to use for the supply of Billerica.

It is not possible for the Board to determine, without suitable tests, the probable effect that this water would have upon lead pipes. Investigations in regard to this matter are now being made; and while, in some cases, certain waters do not appear to dissolve lead from the pipes, in most cases it is found that lead is taken up by the water from such pipes, and it has been found in some late investigations by the Board that severe cases of lead poisoning have been caused by the use of water from public water supplies drawn through lead pipes.

Under the circumstances, the Board would advise that you avoid the use of lead pipe, either for mains or services, in connection with the proposed system of water supply of the town of Billerica.

CHESHIRE. An application was received, Feb. 7, 1898, from the Cheshire Water Company, for the advice of the Board relative to a proposed additional water supply to be taken from Kitchen Brook in that town. The Board replied to this application as follows: —

APRIL 7, 1898.

The State Board of Health received from you, on Feb. 7, 1898, an application for advice with reference to a proposed additional water supply for the town of Cheshire, which you propose to take from Kitchen Brook, also called West Brook, in that town.

The Board has caused an analysis of a sample of water from this source to be made, and finds that at the present time it is of good quality, its quality being about the same as that of your present source of supply, which is drawn from a tributary of Kitchen Brook known as Thunder Brook. Whether its quality is materially different at other seasons of the year from what it was found to be at the present time, cannot be predicted with certainty, but it seems probable that it will be considerably harder in the summer season. Its water-shed, however, lies between the water-sheds of Bassett Brook on the north and of Thunder Brook on the south; and the results of analyses of samples of water from these sources, taken at regular intervals through two years, show that, while the water becomes considerably harder in the summer season than it is in the early spring, the hardness has not been excessive, and it is reasonable to expect that the quality of the water of Kitchen Brook will not differ materially in this respect from that of the other sources mentioned.

The water-shed of Kitchen Brook, at the point at which water would naturally be taken for the supply of the town, is much larger than that of Thunder Brook; and, so far as can be learned, its flow is well maintained in the summer season, so that it is probable that it will furnish an ample additional supply for the town; and, owing to its situation with respect to your present source, it is the most economical source from which an additional water supply can be obtained.

It has not been feasible for the Board to have a thorough examination made at this season of the year of the water-shed of the brook, with reference to danger of pollution of the water from dwelling-houses thereon; but a further examination will be made at a later date, and the Board will advise you with reference to precautions that may be necessary to avoid danger of pollution of this source.

COHASSET. An application was received, March 21, 1898, from the Cohasset Water Company, for the advice of the Board with reference to a proposed additional source of water supply for that town, to be taken from wells in the Ellms Meadow in that town. The Board replied to this application as follows: —

JULY 7, 1898.

The State Board of Health received from you, on March 21, 1898, an application for advice with reference to a proposed source of water supply for the town of Cohasset, to be taken from tubular wells in the Ellms Meadow, so called, in that town, and has caused the locality to be examined by its engineer and samples of the water of the wells to be analyzed.

Since the application was received, a pumping plant has been installed and water has been pumped from a group of seven tubular wells in this meadow for periods of a few days at a time, at a rate nearly sufficient for the supply of the town.

The results of analyses of samples of the water from the wells show that at the present time it is clear, nearly colorless, and otherwise of good quality for the purposes of a public water supply, and is of better quality than the water of your present sources, in that it is much softer and is free from an excessive amount of iron.

With regard to the quantity of water which the proposed source will furnish, it may be said that, while the yield for the short periods during which the pump has thus far been operated has been nearly sufficient for the supply of the town, it is probable that with continued pumping in a very dry year the yield will be considerably smaller than it is at present. Nevertheless, this source will probably form a material addition to the supply of the town.

The proposed new source is located much nearer the thickly settled portion of the town than is desirable, and the water may deteriorate when a large quantity is pumped continuously from the ground; but, in view of the need of an additional source of supply and the difficulty of obtaining a suitable additional supply in the vicinity of the town, the Board believes that it is advisable, under the circumstances, to use all of the water that the proposed source will yield, while its quality remains satisfactory, and advises you to cause the water to be analyzed from time to time, in order to detect any deterioration in its quality which would render it unsuitable for domestic use.

ENFIELD. An application was received, March 4, 1898, from the committee on water supply of the town of Enfield, for the advice of the Board with reference to the taking of certain springs in that town as sources of water supply. The Board replied to this application as follows: —

APRIL 7, 1898.

The State Board of Health has considered your application relative to a proposed water supply for the town of Enfield, to be taken from springs on the Randall and Shearer farms, and has caused an examination of the locality to be made by its engineer and samples of water to be analyzed. It appears that the town at present owns a spring upon the Randall farm, from which water is drawn for the supply of a drinking fountain, hotel and two houses in the village, and that it is proposed to use this spring as the source of supply, and increase its capacity by diverting into it the water of a small spring in the southwest corner of the Shearer pasture.

Samples of the water of both these springs have been analyzed, and the results show that the water is nearly colorless, very soft, and otherwise of excellent quality for the purposes of a public water supply; and there is no reason to expect that, if the water is kept from exposure to light, its quality will differ materially at other seasons of the year from what it is found to be at the present time. The water-shed of these springs, however, is so small that it is not probable that enough water could be obtained from them for the supply of the town of Enfield, should water be generally introduced in both villages, or even in the main village only. The Board, therefore, does not advise the construction of works for taking a supply of water for the town from these springs, but would advise that the matter be given further consideration, and a source of supply secured that will not only furnish a water of good quality, but also of ample quantity to provide for the needs of the town.

In this connection the Board has caused analyses to be made of samples of water from several other sources that appear to have been under consideration in the past, and finds that water of good quality can probably be obtained from Wood's Springs, so called, Thurston's Brook, or the brook flowing from Quabin Hill. There are indications that either of the first two sources mentioned might be developed so as to furnish a sufficient supply of good water for the town; but there is much doubt as to whether the last-mentioned source — the brook flowing from Quabin Hill — could be made to yield a sufficient supply.

The Board will be pleased to furnish you with information collected by its engineer with reference to possible sources of water supply for the town, and will give you further advice in this matter when you have any further plans to present.

FAIRHAVEN. In the last report of the State Board of Health (29th annual report, 1897, p. 10) reference is made to the action of the Board in relation to the action of the water of the Fairhaven water supply upon lead pipes. Further examinations in the same direction were made by the Board during the past year, and the results of the investigation were communicated to the board of health of Fairhaven, as follows: —

JUNE 20, 1898.

The State Board of Health has made further examinations of water drawn from faucets in several houses in the town of Fairhaven which had not previously been examined, and found an excessive quantity of lead in nearly all cases. One of the houses from which samples were collected was that of J. G. Murray, located on Green Street extension, one of the occupants of which is said to have recently been ill from lead poisoning. The sample of water from this house contained an excessive quantity of lead. The Board would suggest that you bring this matter to the attention of the persons who occupy the house referred to.

The best means of preventing danger to health from this cause is to remove the lead pipe, at least that portion of it through which water is drawn for drinking aud cooking, and to replace it with pipe made of material which does not contain lead.

The recent examinations by the Board, like those made previously, show that the Fairhaven water continues to dissolve large quantities of lead from lead service pipes, and the use of service pipes of this material is causing injury to the health of the people who use the water.

GROTON. An application was received, Dec. 30, 1897, from the Groton Water Company, for the approval by the Board under chapter 388 of the Acts of 1897 of the taking of sources of water supply and lands in that town. The Board replied to this application as follows: —

MAY 5, 1898.

The State Board of Health received from you, on Dec. 30, 1897, an application requesting the approval by this Board of the taking of sources of water supply and lands in the town of Groton. Subsequently, upon request of the Board for copies of plans and descriptions of the sources of water supply and lands taken by your corporation under the authority of chapter 388 of the Acts of 1897, you submitted a plan entitled, "Plan of Land in Groton Mass., Taken by the Groton Water Company, Scale 80 feet to the inch. Charles A. Allen, Chief Engineer, H. C. Hovey, Surveyor and Assistant Engineer. Surveyed, April, 1897." Attached to this map was the following communication, signed by H. C. Hovey, assistant engineer and addressed to the president of the water company: —

In accordance with your request of Jan. 18, 1898, for "plans and a description of the sources of the water supply and lands taken by the Groton Water Company," I send you herewith a plan of the land taken by the Groton Water Company at Baddacook Pond, which comprises all the land taken by the company (about 4.7 acres), that I am aware of. The land has no brook or springs upon its surface.

The source of supply is from a well 30 feet in diameter (inside) and about 16 feet deep below the surface of the surrounding ground and 19½ feet below the finished top of masonry wall. The bottom of the well is 10 feet below the surface of the pond, at medium heights of water in the pond. The centre of the well is about 50 feet from the high-water line on the shore of the pond, and has no connection by a pipe or other way with the pond; and I have never supposed that direct connection was contemplated, as the capacity of the well, as indicated by continuous pumping during construction, and measured by me at that time (by request of Mr. Allen, chief engineer), was 41,000 gallons per hour.

The Board has caused an examination of the source of supply to be made by its engineer and has caused samples of the water of the well to be analyzed. The water is found, upon analysis, to be soft, practically colorless, and in other respects of excellent quality for the purposes of a public water supply. With regard to the quantity of water which the well will yield, a definite estimate cannot be given; but, in view of the information as to the yield of the well up to the present time, it seems probable that it will furnish a sufficient quantity of water for the supply of the town of Groton.

The Board advises and recommends that this well is a suitable source of water supply for domestic purposes, and approves the taking by the Groton Water Company of the land, including this source, shown upon the plan submitted to this Board, Feb. 7, 1898, entitled "Plan of Land in Groton, Mass., taken by the Groton Water Company. Scale, 80 feet to the inch. Charles A. Allen, Chief Engineer, H. C. Hovey, Surveyor and Assistant Engineer. Surveyed April, 1897."

HARVARD. An application was received from the board of health of Harvard, Sept. 27, 1898, for advice relative to the quality of the water of a public well in that town used for drinking purposes, especially by the pupils in one of the public schools. The Board caused the water to be examined and replied as follows: —

DEC. 2, 1898.

The State Board of Health received from you, on September 27, an application requesting that an examination be made of the town well, so called, in Harvard, which you state is used for public purposes, and especially by the children of your public schools.

The Board has caused the well and its surroundings to be examined by one of its engineers, and samples of the water collected on October 18 and November 7 to be analyzed. The results of these analyses show that the water has a disagreeable odor, and contains an excessive amount of organic matter and iron. The quality of the water appears to vary considerably from time to time; and, since the indications are that it is in some way polluted by sewage, it cannot be regarded as a safe source of drinking water.

Under the circumstances, the Board advises that the use of the water of this well be prevented.

HAVERHILL. Early in the fall of 1897 the attention of the Board was called by the board of health of Haverhill to the unusual prevalence of typhoid fever in that city, and the State Board caused an investigation to be made, the results of which were embodied in the following communication to the Haverhill board of health: —

JAN. 21, 1898.

Early last fall you called the attention of this Board to the presence of an unusually large number of cases of typhoid fever in the city of Haverhill, and the Board has since caused a thorough investigation to be made, with a view to discovering the probable cause of the epidemic. Investigations already made by your board, through Mr. Bryant, your agent, were of great assistance in locating the cases, and furnished a large amount of necessary information relative to the sources of water, milk and ice supplies, the occupation and movements previous to illness of persons attacked with the disease, and much other information.

An examination of the records of cases of typhoid fever in Haverhill for several years past shows that the disease has prevailed in an excessive degree since about the beginning of November, 1895. In the months of November and December, 1895, 21 cases of the disease were reported, which is three times as many as is usual in these two months. Of these 21 cases, it is reasonably certain that 16 used Crystal Lake water more or less regularly. These cases resulted in 6 deaths in December, which is a larger number of deaths than occurred from this disease in any one month in the past ten years, and six times the average number of deaths from this disease in December.

The number of cases during the first five months of 1896, while not numerically large, was about twice the number of cases that might have been expected to occur if the prevalence of this disease had been no greater than usual, and the mortality during this period was exceedingly high, being 50 per cent. of the total number of cases. In June, 1896, there was a sudden increase, the total number of cases reported being 32 for that month; and for the months from July to November, inclusive, the number ranged from 11 to 19 per month. The total number of cases in six months was 100, showing an excessive prevalence of the disease; while the total number of deaths was 9, the same as the number of deaths in the first five months of the year, when the whole number of cases was 18. From December, 1896, up to and including July, 1897, a period of eight months, the number of cases ranged from 3 to 5 per month, and averaged 3.5, which was about twice the number which might have been expected to occur in Haverhill during this period under usual conditions. In August, 1897, the number of cases reported rose to 16, and in September to 41, the greatest number that had occurred in the city in any one month for at least ten years. Since that time the number of cases in each month has gradually decreased, but has remained much above the number which it is reasonable to expect will occur in a city of this size when the inhabitants are exposed to no extraordinary source of infection.

For the purpose of this investigation, August 5 was assumed as the date of the beginning of the epidemic of 1897, because at that time the number of cases of typhoid fever in the city increased with much greater rapidity than was usual at that season of the year. From that time until November 12, 85 persons became ill with typhoid fever in Haverhill. Of this number 2 cases were undoubtedly imported, the persons returning to Haverhill ill with typhoid fever after an extended absence. Four of the cases were those of persons engaged in attendance upon others who were ill with the disease, and it is probable that they were infected from the persons upon whom they were in attendance. Of the 79 remaining cases, it was found that 71, or 90 per cent. of the whole number, used Crystal Lake water for drinking purposes more or less constantly; while the number of cases in which the patient had not used Crystal Lake water is not greater than usual for districts containing a population equal to that in Haverhill outside of the Crystal Lake district.

An investigation was also made to determine whether it was probable that the presence of the many cases of typhoid fever was due to the milk supplies or ice supplies of the city; but many of the patients used no ice at all, and the milk supply of the various patients came from so many different sources, which appeared to be entirely independent of each other, that there was no evidence that the epidemic was due either to infected ice or milk.

An examination was also made of a spring water which is sold to a large extent in the city; but there is no evidence that this supply could have been contaminated by sewage, and, moreover, a great many of the cases of typhoid fever were those of persons who had used no spring water.

Examinations were also made of various semi-public water supplies in the city, taken for the most part from tubular or other wells, but in some cases drawn from the Merrimack River. Nearly all of the well waters were found to be highly polluted by sewage, and there is no question of the danger of drinking water directly from the Merrimack River, but it could not be determined that any cases were due to the use of these waters.

The circumstances indicate very strongly the infection of the part of the water supply of the city that is drawn from Crystal Lake. This lake, which is one of the main supplies of the city of Haverhill, has an area of about 145 acres and a drainage area of 2.95 square miles, exclusive of the area of the lake, as measured from the State maps. The lake is divided into two basins by a natural bar, at a narrow place about 2,000 feet from its lower end, and the small basin below this bar is very shallow. From this basin about 800 feet from the outlet of the lake the intake pipe of the Haverhill water works begins. In very dry seasons the water falls so low in the small basin that it is necessary to pump water from the main portion of the lake over the low bar into this basin, in order to obtain a sufficient supply for the city. A careful examination of the water-shed of the lake, however, shows at present no actually existing case of sewage pollution, nor any definite evidence of the cause which produced the increase of typhoid fever in 1895. It is found that the water in the shallow basin at the lower end of Crystal Lake was very low during the latter part of 1895, and it was necessary to pump water from the main portion of the lake into the portion from which the pipe line begins; and it appears that, while an engineer and a fireman were employed here for a period of more than two months, no provision was made for the disposal of excrement and other wastes from this place, or from camps along the shore used at various times, especially in the summer season. During 1896 and 1897 it does not appear that any pumping has been done at the lake, but it is probable that the lake was infected from the several camps and places about the shores to which people resort for fishing, boating, etc.; and it does not appear that any supervision is exercised by the city authorities over the use of the pond or its shores by visitors, to protect it from danger of pollution.

A careful investigation was also made of the other sources of water supply of the city, including Kenoza Lake, Lake Pentucket, Lake Saltonstall and Johnson's Pond, the source of supply of the Bradford district. The result of this investigation shows the existence of possible sources of pollution on Kenoza Lake and Johnson's Pond, but the most serious danger of contamination by sewage is found in the vicinity of Lake Saltonstall. It is understood, however, that this lake has been used to supply drinking water on only one or two occasions now for nearly two years.

In view of all the circumstances, the Board would advise that it is their judgment that the recent excessive sickness and mortality from typhoid fever have been due to the pollution of the water supply, principally of that from Crystal Lake; and it becomes necessary that all possible sources of pollution within the water-shed of Crystal Lake, and of all other sources of public water supply of the city, be cut off, and that hereafter all access to the shores of the lakes and ponds from which the supply of any portion of the city is drawn be under the supervision and control of a board having authority if necessary to exclude all persons, and that such measures be taken that the city authorities can feel sure that all danger of contamination from visitors or others has been provided against.

The Board would also call attention to the poor quality of the water of several wells in the city which are accessible, in some of the large manufacturing establishments, for drinking. Nearly all of the wells in the thickly settled portion of the city that have been examined by the Board have shown evidences of a high degree of pollution by sewage; and while, in most cases, the water has been subsequently purified to a considerable degree in its passage through the ground, it is, nevertheless, an unsafe water for drinking purposes. While it may be said that no case of typhoid fever in the city in 1897 was traced directly to the use of water from wells in the densely populated part of the city, it is not improbable that injury has been done to the health of those using it, because these waters are very hard, while the water supply of the city is very soft. It is known that the use of hard water by those whose usual supply is soft, or *vice versa*, may be productive of stomach and bowel disturbances which may render the patient susceptible to other and more serious forms of illness.

In the course of the investigation it was found, as already stated, that Merrimack River water, drawn from the shore of the river a short distance below sewer outlets, was accessible in some of the factories for drinking. The Merrimack River water from any point in the vicinity of Haverhill is a dangerous water for drinking; and the Board would advise that you make every effort to prevent its being made accessible for this purpose, or if it is not feasible to do this, that you warn the people to whom it may be accessible of the danger involved in its use.

Should you desire to examine the details obtained in this investigation, they will be shown to you at this office.

HAVERHILL (the Gale Shoe Manufacturing Company). A request was received, Jan. 27, 1898, from the Gale Shoe Manufacturing Company of Haverhill, for the opinion of the Board relative to the quality of the water of a well on the premises of the company. The Board replied to this request as follows: —

MARCH 4, 1898.

The State Board of Health has caused an examination to be made of the surroundings of the well referred to in your communication of January 27, which is used as a source of water supply for your factory, and has caused a sample of the water to be analyzed. The results of this analysis, and of an analysis of a sample collected last fall, show that the water has been greatly polluted by sewage which has not been thoroughly purified in the passage of the water through the ground, and that its hardness is so excessive that it would generally be regarded as unfit for use in boilers.

The well is located in a densely populated part of the city, and, considering its location and the character of the water, as shown by the analyses, the Board is of the opinion that it is a dangerous water for drinking.

The Board is informed that you have warned your employees not to drink the water, but that it is still accessible for drinking; and, in view of the circumstances, the Board would advise that you remove all opportunity for obtaining this water for drinking, or, if this is not practicable, that you post notices warning those to whom it is accessible of the danger involved in its use.

HAVERHILL. An application was received from the board of health of Haverhill, May 10, 1898, requesting the State Board of

Health to examine the water of certain wells used as sources of water supply at the birthplace of Whittier in Haverhill, those wells being largely used by visitors to that place. The Board made the examination and replied as follows: —

Aug. 8, 1898.

The State Board of Health received from you, on May 10, a communication requesting an examination of certain wells on the premises known as "Whittier's Birthplace," on the Amesbury Road, Haverhill; and in response to this request the Board has caused the locality to be examined by one of its engineers, and samples of water from the wells on the premises to be analyzed.

It appears that in the course of the year the place is visited by large numbers of people, and there are two wells on the place from which water is used by visitors for drinking, one of the wells being located near the house and the other on the side of the highway near the barn.

The water of the well nearest the house, when first analyzed in May last, was found to be nearly clear, only slightly colored and free from odor. The quantity of organic matter was, however, considerably larger than is found in a good ground water. A sample analyzed in June showed that the water had deteriorated somewhat, as compared with its condition at the previous time. The results of an analysis of a sample of the water collected in July, when apparently the quantity of water being drawn from the well was much greater than in the former months, shows a very great increase in the quantity of organic matter present in the water, which had also become decidedly turbid and had an offensive odor. There is a privy and sink drain located in close proximity to this well; and, in view of all the circumstances, the Board is of the opinion that the well is a very dangerous source from which to take water for drinking, and advises that further use of this water be prevented.

Analyses of samples of water from the well at the side of the highway near the barn show that the water has been considerably polluted, probably by drainage from the barn, and subsequently well purified in its passage through the ground. While the water of this well, so far as these analyses show, may not be unsafe for drinking, a change in the conditions affecting the well, such as the use of a larger quantity of water from it than was being used at about the time these samples were collected, might cause a deterioration in its quality such as was observed in the well near the house.

Under the circumstances, the Board is of the opinion that it is very desirable that a new and safe source of drinking water supply be provided for the use of visitors at this place, so that the use of the well near the barn may also be discontinued.

HINGHAM. An application was received, Jan. 11, 1898, from the water board of Hingham, relative to the question of improving the water of Accord Pond, which is subject at times to a disagreeable taste and odor. A request was also made for an examination of the pond and its surroundings, to determine whether anything could be done to prevent a recurrence of the same trouble in the future. The Board replied as follows: —

MARCH 4, 1898.

The State Board of Health received from you, on Jan. 11, 1898, an application for advice as to whether there is any means of improving the quality of the water in Accord Pond, which you state is causing serious annoyance to the users of the water, owing to the disagreeable taste and odor due to the organism *Uroglena*. You also request that a thorough examination be made of the pond and surroundings, to determine what, if anything, can be done to prevent a recurrence of the same trouble in the future.

The Board has carefully considered your application, and has caused an examination of the pond and its surroundings to be made by its engineer and samples of the water to be analyzed.

So far as our observations of this organism have shown, it is usually present only in the colder months of the year, between October or November and April or May, though it is sometimes found in June and late in September, but only in very small numbers. In some ponds and reservoirs in which its presence has been observed it has returned in each winter season for several years consecutively, though it appears to be present in smaller numbers and to affect the character of the water less seriously in some years than in others, while in other ponds it is present only at intervals of several years.

The water of Accord Pond has now been used for the supply of Hingham for nearly eighteen years, and the quality of the water appears to have been objectionable on account of a bad taste and odor in several years since it was first used, the most serious complaints, hitherto, occurring in the latter part of the spring or early in the summer. The cause of complaint as to the quality of the water in June, 1894, was the subject of investigation by this Board, at your request; and the results of the investigation made at that time showed that the taste and odor of the water were due principally to the presence of the organism *Anabœna*, which was found in great abundance, either distributed through the water of the pond or floating upon the surface as green scum. It is probable that the occurrence of similar trouble in other years was due to the presence of some variety of microscopical organism in large numbers.

The cause of the presence and growth of organisms in the water of Accord Pond is not known; but it seems probable that the presence of mud and organic matter on the bottom and sides of the pond, especially the portions which were flowed by raising the dam, and from which the soil and vegetable matter were not removed, may cause or help to cause the growth of these organisms.

With reference to a possible method of improving the quality of the water of this pond, with the information at present available the Board can advise you only in a general way. It is possible that the removal of the soil and organic matter from the bottom of the pond to the extent to which it may be removed when the pond is drawn low would lessen the amount and frequency of the growths of organisms in this pond; but it may not be practicable or desirable to reduce the level of the water of this source for several years to such an extent or for such a time as to enable you to do this work. It is possible that the water of Accord Pond could be effectually purified by filtration near the pond; but such information as is available as to the purification by filtration of a water of this sort, containing large numbers of organisms, has not been sufficient to enable the Board to advise you as to the size of filters that might be required. Moreover, owing to the small amount of head at present available for supplying the town by gravity, pumping would probably be necessary; and there might be much difficulty and expense in the operation of filters in the winter season, when the trouble from the presence of *Uroglena* usually occurs.

From a general examination of the land along the shores of Accord Pond, near the outlet, it appears probable that the soil is in many places largely composed of coarse sand or gravel, and the large amount of leakage from the pond in the vicinity of the outlet is a further indication that the soil, in this vicinity at least, is porous. If this is the case, it is probable that, if wells or filter-galleries should be constructed along the shores of the pond, and water could be drawn from them in large quantities, water from the pond would filter through the soil in these works, and a large portion, if not all, of the yield of the pond might be obtained in this way, as is done at several other places in the State. In this way a water free from color, taste or odor would be obtained, if the collecting works were placed at such a distance from the shore of the pond that the water would become thoroughly purified in its passage through the ground. Experience with other works of this sort has shown that, in order to obtain satisfactory results, it is desirable to place such works as much as 100 feet from the shore of the pond.

Under the circumstances, the Board would advise that you cause an investigation to be made, to determine the character of the soil in the vicinity of Accord Pond; and, if from these tests the conditions are found to be favorable to obtaining a large quantity of water from the ground near the pond, the Board would recommend that you make a further test by setting up a temporary pumping plant, and pumping from wells or other works for such a time as may be necessary to determine the probable quantity of water to be obtained in this way, and that you cause analyses to be made of samples of the water, to obtain information as to its quality.

These investigations should be made under the direction of an engineer of experience in such matters, and the Board will assist you by making the necessary analyses of water, and will give you further advice in the matter when you have the results of investigations to present.

HINGHAM. A further application was received from the Hingham Water Company, May 20, 1898, for the advice of the Board relative to the improvement of the water supply of that town by means of a system of wells in the neighborhood of Accord Pond. The Board replied to this application as follows: —

JULY 7, 1898.

The State Board of Health has considered your application for further advice in regard to the improvement of the water supply of the town of Hingham, and has examined the information received with reference to investigations in the vicinity of Accord Pond by means of tubular wells. Several samples of water sent in by you from these wells have been analyzed. The results show, in general, that the material on the north-westerly side of the outlet of the pond is too fine to furnish any considerable yield of water. The conditions for a large yield of water are much better in the immediate vicinity of the dam, but the test wells in this vicinity show that the water contains an excessive amount of iron which would make it objectionable for many domestic uses. At the south-easterly end of the dam, and between the gravel ridge which borders the shore of the pond at this place and the cut-off dam, so called, constructed on the north-westerly side of this ridge to intercept the leakage from the pond, water which was free from an excess of iron was obtained from several test wells, but the indications are that the yield of the wells would amount to but a small proportion of the yield of the pond. The results, as a whole, indicate that the conditions are not favorable for obtaining a large proportion of the yield of Accord Pond from the ground in this region, except by the use of water which will contain such an excessive amount of iron as to make it objectionable for many purposes.

An estimate of the probable yield of your present sources of supply, when compared with the records of water used in Hull and an estimate of the probable quantity used in Hingham, indicates that the consumption of water is probably already in excess of the capacity of your sources of supply in a dry period, and an additional supply will soon be needed. Moreover, it is understood that greater pressure is desirable in the mains in the central portion of Hingham.

In response to a previous application for advice with reference to a proposed additional water supply for Hingham, which it was proposed to take from Accord Brook, the Board advised that, owing to the swampy character of this water, it was of the opinion that the water would not be of suitable quality for domestic use unless it should be efficiently purified. The plan for purifying the water which seemed likely to give the most satisfactory result was by filtering it slowly through gravelly land in the vicinity of Accord Pond or Fulling Mill Pond; and the Board advised that investigations be made to determine whether there was high porous land near Fulling Mill Pond, or the brook which feeds it, where filter beds might be constructed to which the water of Accord Brook might be conveyed by gravity, but it is understood that no such investigations have been made. You have found, however, that by constructing a filter basin near the shore of Fulling Mill Pond a large amount of filtered water can be obtained.

In view of all the circumstances, the Board would advise that you take into consideration the question of increasing your sources of water supply and of improving the quality of the present supply, by conveying the water of Accord Brook to the vicinity of Fulling Mill Pond and filtering it there through the natural gravel beds, and that you also consider the feasibility of filtering the water of Accord Pond in this vicinity when the water is of unsatisfactory quality, owing to the presence of organisms. It will be very desirable to collect the filtered water in covered conduits or galleries, where it will be kept from exposure to light and consequent danger of deterioration. It will also be necessary to provide pumping capacity sufficient to supply all the needs of both Hingham and Hull from these sources whenever required, though water may be taken directly from Accord Pond, as at present, when its quality is satisfactory. It is desirable, however, to use the full capacity of Accord Brook and Fulling Mill Pond, so as to keep the water of Accord Pond for use in the drier portion of the year.

An examination of the present conditions in the vicinity of Fulling Mill Pond indicates that a considerable quantity of ground water flows from the meadow on the easterly side of the pond; and, if an examination shows that this water is of good quality, it would probably be of advantage to include the collection of this water with any system of filtration which may be constructed in the vicinity of this pond.

The Board will assist you in these investigations by making such analyses of samples of water as may be necessary, and will again advise you with reference to the purification of your water supply when you have the results of further investigations to present.

Hudson. An application was received, Feb. 7, 1898, from the water commissioners of Hudson, for the advice of the Board relative to a proposed additional water supply for Hudson. The Board replied to this application as follows: —

MARCH 3, 1898.

The State Board of Health received from you, on Feb. 7, 1898, an application for advice with reference to a proposed additional water supply for the town of Hudson, to be obtained by diverting into Gates Pond, your present ource of supply, the water of Fosgate Brook, so called, the water-shed of which lies contiguous to that of Gates Pond on the north.

The application was accompanied by a report and plans by your engineer, Mr. Burton R. Felton, showing the location and a profile of the proposed pipe line, about 1,650 feet in length, from the brook to a point within the water-shed of the pond, where it is proposed to discharge the water into an open channel, through which it will flow into the northerly end of the pond. A topographical plan of the water-shed of Fosgate Brook was also submitted, showing the location and area of swamps within the water-shed of Fosgate Brook. From this plan it appears that there is an area of about 15 acres of swamp land on the southerly branch of the brook, in which the mud is in several places more than 13 feet in depth; and there is also a small swamp on the northerly branch of the brook, having an area of about three-quarters of an acre. A proposed method of draining the swamps was shown in this plan, but the plan was subsequently modified, and a new plan submitted on Feb. 23, 1898. By this plan it is proposed to construct drainage channels around the larger swamp, to intercept water flowing toward the swamp and the water of the brook near the upper end of the swamp, and convey it to the channel of the brook below the swamp, in order to prevent the water from acquiring a high color and an excessive amount of organic matter from contact with mud and vegetable matter in the swamp, which, under present conditions, makes the quality of water of this source very unsatisfactory.

It is proposed to place the drainage channels about the swamp at such an elevation that swamp water will not flow into them unless the swamp is flooded to a considerable depth; and, in order to remove the water which will collect on the swamp and prevent it from entering the proposed drainage channels or finding its way into Gates Pond, it is proposed to lay a six-inch pipe from the lower end of the swamp to convey this water to a point of discharge in the water-shed of the brook below the point at which it is proposed to divert the water into Gates Pond. By this plan, the area of the water-shed of the brook above the proposed point of diversion will be reduced from 125 to about 108 acres. In order to drain the small area of swamp on the north branch of the brook, it is proposed to lower the surface of the water by deepening the channel of the brook through the swamp and below it.

The Board has carefully considered the proposed plan, and concludes that it is an appropriate one for increasing the water supply of the town of Hudson; and, if carried out as proposed, and the entrance of water which has been standing in the large swamp on the south branch of the brook into Gates Pond is prevented, the water of Fosgate Brook will not be likely to have an unfavorable influence upon the quality of the water of Gates Pond. The diversion of the water of this brook into Gates Pond will increase materially the quantity of water which this pond will furnish to the town of Hudson, and there appears to be no other source from which a material addition to the supply can be obtained without pumping.

It is proposed to discharge the water of the brook into the northerly end of the pond, near the outlet gate-house; but it may be found desirable to discharge the water into a portion of the pond more remote from the gate-house, in order that it may derive benefit from longer storage in the pond.

HUNTINGTON. The water commissioners of the Huntington fire district applied to the State Board of Health, Aug. 22, 1898, for its approval, under chapter 344 of the Acts of 1898, of plans for a proposed system of water supply for the district. The Board replied to this application as follows: —

SEPT. 17, 1898.

The State Board of Health received from you, on Aug. 25, 1898, a communication submitting your proposed plans for a system of water supply for the Huntington fire district, which you describe in your application as follows: —

We propose to take the waters of Cold Brook, so called, substantially in conformity with a plan of Louis E. Hawes, a civil engineer, accompanying a report by him, made April 7, 1898. The plan contemplates an intake reservoir of a capacity of 1,250,000 gallons, situated at a distance of about one and one-half miles from the center of Huntington Village, the dam to be of rubble masonry and earth work, and of suitable dimensions to secure the above capacity. The surface of the ground flowed and for a distance of 25 feet beyond the flowage line is to be cleaned of all trees, brush, stumps, roots, muck and vegetable matter. The main conduit is to be of ten-inch pipe and the branches of eight, six and four inch pipe, according to the needs of the locality to be supplied.

We also ask your approval of plans showing proposed sources of supply and methods of utilizing them, submitted by E. E. Davis, Aug. 2, 1898. These provide for the possibility of increasing the capacity of the present proposed source by uniting the waters of Gold-mine Brook, so called, with those of Cold Brook, and the building of a large storage reservoir on Cold Brook. Not being a part of our plan at the present time, we have not caused detailed specifications for their development to be prepared.

You have also submitted a plan by Louis E. Hawes, C.E., showing the location of the proposed intake reservoir on Cold Brook and the system of piping in the village; and plans by E. E. Davis, C.E., showing details of construction of the proposed intake reservoir and possible methods of increasing the supply, — one by diverting the water from Gold-mine Brook into Cold Brook, and the other by the construction of a storage reservoir on a tributary of Cold Brook.

The Board has carefully considered the proposed plans, and has caused the proposed source of supply and the sources and methods by which it is proposed to increase the supply when necessary to be examined by its engineers, and samples of the water of these and other sources to be analyzed.

The results of analyses of samples of the water of Cold Brook, collected at the point at which it is proposed to locate the intake reservoir, indicate that the water is soft, has but little color, and is otherwise of good quality for the purposes of a public water supply.

With regard to the quantity of water which this source will furnish in the drier portion of a dry season, it is very difficult to make an estimate, since no records are obtainable of the flow of the streams in such a season. So far as can be judged with present information, it seems probable that, with an intake reservoir having a capacity of 1,250,000 gallons, as proposed, the supply from this stream will be adequate for the needs of the town in an ordinary summer, but that the capacity of this source will be inadequate in a very dry season, after the water comes into general use.

Your plans show that it is feasible to enlarge the supply by diverting the water of Gold-mine Brook, at a point where this stream flows close to the water-shed of Cold Brook and at a higher level, into the latter water-shed, at a comparatively small expense, and thus increase considerably your supply of water. Analyses of the water of Gold-mine Brook show that at the proposed point of diversion it has a much higher color and contains a much greater amount of organic matter than the water of Cold Brook, or even of Gold-mine Brook at a point lower down stream. The color and organic matter are doubtless due to contact of the water with vegetable matter in swamps, and the quality of the water might possibly be improved by draining the swamps. The water of this brook would be objectionable for many domestic uses, and the Board does not advise the use of water from this brook in its present state for the supply of Huntington.

Another proposed plan of increasing the supply is by constructing a storage reservoir upon the head waters of Cold Brook. By the construction of this reservoir a large increase to your supply could be made, though the water-shed of the reservoir will be comparatively small. No investigations appear to have been made at the site of this reservoir to determine the probable cost of constructing and preparing it in a suitable manner for the storage of water, but the indications are that the expense would be large.

Examinations made under the direction of the Board of other possible sources in the vicinity indicate that it is feasible to divert the waters of Black Brook into the water-shed of Cold Brook at no very large expense, and thus furnish an additional supply nearly as great as would be obtained if the waters of Gold-mine Brook were used. Analyses of samples of water collected from Black Brook at the point at which it might be diverted show that the water is of about the same quality as that of Cold Brook, having but little color and containing only a small amount of organic matter.

The indications are, that, if the works are constructed for supplying the fire district from Cold Brook, and the supply should be found to be inadequate, it can be increased without special difficulty by one of several methods; and, in view of all the circumstances, the Board hereby approves the taking of the waters from Cold Brook at the point shown upon the plan entitled "Huntington Water Works. Proposed Plan Showing Sources of Supply, Reservoir, Distribution Pipes, Gates and Fire Hydrants, 1898," by Louis E. Hawes, civil and hydraulic engineer, Boston, Mass., and the water sources and water rights connected therewith and pertaining thereto; but the Board does not at present approve the proposed plan of increasing the supply by taking water from Gold-mine Brook and diverting it into the water-shed of Cold Brook, nor can it advise at present that the construction of the proposed storage reservoir on Cold Brook will be the best method of increasing the supply when necessary; but advises that a survey be made to determine the feasibility of diverting the water of Black Brook into the water-shed of Cold Brook, and the probable cost of the work.

It is very essential that the intake reservoir be thoroughly prepared for the reception and storage of water by removing all muck and vegetable matter from its bottom as proposed.

With regard to the sizes of pipe to be used in the construction of the works, the Board is unable to advise you with the limited information presented.

There are located at present upon the water-shed of Cold Brook, near its extreme upper limits, a very few farm-houses. It will be essential that you enforce such methods of disposing of sewage and other refuse matters from these houses as may be necessary to prevent danger of pollution of your sources of water supply.

Lawrence. An application was received from the water board of Lawrence, March 5, 1898, for advice with reference to increasing the capacity of the Lawrence city filter. The Board replied to this application as follows: —

Sept. 19, 1898.

The State Board of Health received from you, on March 5, 1898, the following request for advice with reference to improving the capacity of the Lawrence city filter: —

The Lawrence water board respectfully represents that the municipal filter does not furnish sufficient water for the demands upon our system.

We are led to believe, from limited experiments showing the loss of head, that portions of the filter are clogged. We desire your Board to advise us in regard to the proper method to be adopted to restore the filter to its proper capacity, also to co-operate with us and advise what further experiments may be necessary to determine what portion needs to be renewed.

The Board has examined the available data as to the operation and management of the filter and the consumption of water as furnished from the records kept by your Board, and has made investigations to determine the quality and condition of the sand in the filter, and the condition of the underdrains as compared with their condition when first placed in the filter five years ago. The Board has also made many experiments to determine the cause of the reduced capacity of the filter and the best method of relief.

Analyses of many samples of sand collected from all parts of the filter show that, while the effective size of the sand is probably slightly finer than when first placed in the filter, on account of silt carried by the river water, the increase in the fineness of the sand is not sufficient to cause a very material reduction in the quantity of water that would pass through the filter.

A careful examination of the height of water in the sand of the filter while it was being drained showed that, while the portion nearest the pumping station, amounting to approximately half the area, for the most part drained down rapidly, the water in the easterly half of the filter did not drain down readily, and in some portions of it remained, after several hours of draining, but little below the surface of the sand.

Excavations were made through the whole depth of the sand and into the gravel forming and surrounding the underdrains. The sand was found to be clean and unobstructed throughout its full depth, and in the portion of the filter near the pumping station the gravel under the sand was found where examined to be in good condition, and the water appeared to drain freely through it. More attention was given to the easterly portion of the filter, where, as has been stated, the water did not drain readily from it. Here, as elsewhere, the sand was found in nearly all parts of it to be clean and unobstructed down to the gravel; but within the gravel and between the stones surrounding the drain pipes and in the joints of the drain pipes was found a deposit of gelatinous iron rust, together with some *Crenothrix*, a plant which grows in water containing iron, which deposit allowed very little water to enter the drain pipes. This deposit was more dense in the middle and upper portion of the layer of gravel, where air has entered this layer from the underdrains when the water in the pump well has been drawn below the top of the underdrains.

It is evident from the character of this deposit that air is essential to its formation; and the only way to prevent its formation in the future is to run the filter, as it was intended to be run from the time of construction, with the water in the pump well always above the top of the underdrains, or not below the level of 31 feet on the scale of heights.

This portion of the filter can be rendered efficient by excavating trenches 10 feet wide across the filter, in line of and over the underdrains, removing the gravel for this width, washing and relaying the pipes, and at the same time extending the lines of four-inch pipes a distance of about 50 feet from their present termination and placing clean gravel about them, as it was originally placed, adjacent to such pipes; then filling the trench above the gravel to a depth of 2 feet with the washed sand which you have upon the bank, and filling above this and over the present top of the filter between the nearest carriers with the remaining sand from the excavation. This process should be continued over so much of the filter as does not allow the water to drain from the sand freely, which includes a large part of the easterly half of the filter and a small portion of the remainder.

When the filter was constructed, you were advised that the whole surface should be cleaned once a month, and that certain portions should be cleaned oftener in times of freshets. Your records show that the easterly portion of the filter has been allowed to remain uncleaned in the cold season a much longer time, even reaching a period of four or five months, while the portion nearer the pumping station has been cleaned more frequently. To this fact is probably due the larger deposit of iron in the gravel of the easterly portion, and the Board regards it important that the original instruction in regard to cleaning the filter should be carried out in order to maintain its efficiency. To accomplish this, it is, in the opinion of the Board, necessary that the filter be covered, to effectually prevent the formation of ice upon its surface.

Upon completing the relaying of the underdrains and upon restoring the filter bed to its original depth, it should hereafter be maintained at that depth; and, to keep it in the most efficient condition for purifying the water, it should be run intermittently, as originally designed.

You have found the filter delivering an abundant supply of water during the past four months, but from this you cannot conclude that it will continue to do so, for during the season of the formation of ice the sand will allow only about two-thirds as much water to pass through it as in summer. Your experience of last winter shows that it is necessary to act promptly.

By entering upon the work of covering the filter with a roof to prevent freezing and of removing the gravel clogged with iron without delay, it is probable that enough work can be done before the beginning of winter to insure a sufficient supply of filtered water for the city.

Lenox. A communication was received from the Lenox Water Company, May 6, 1898, requesting that its reservoir be examined, "and such suggestions made as may lead to an improvement of the water and the curing of any defects in the system of water supply adopted by the company." The Board replied to this application as follows: —

JUNE 3, 1898.

The State Board of Health has considered your application for advice with reference to the improvement of the quality of the water supplied to the town of Lenox, and has caused an examination of the sources of supply to be made by its engineer and has analyzed several samples of water collected at various times since the early portion of last November.

The results of the analysis of a sample collected from the storage reservoir on Nov. 9, 1897, show that the water, while it had only a slight color, contained a large amount of organic matter, the quantity of albuminoid ammonia being several times as great as has been found in the samples analyzed since that date. The microscopical examination of the sample collected in November showed the presence of a very large number of the organism *Dinobryon*, which has been known to cause disagreeable tastes and odors in the water of other reservoirs when present in large numbers. The microscopical examinations of the other samples showed the presence of very few organisms, and in some cases none were found. The presence of microscopic organisms in the water of a pond or reservoir affects the appearance, taste and odor of the water, rather than its healthfulness, so far as can be judged from our present information.

An examination of the bottom of the reservoir at the time it was drawn down recently showed the presence of considerable mud covered with a plant growth, which upon analysis was found to be a variety of Algæ known as *Chara*. This organism is quite common in the water of ponds and reservoirs, and when present in very large quantities may impart a taste and odor to the water. It may also produce a condition of the water which is favorable to the development of microscopic organisms, but it is not known to have an unfavorable effect on the health of those who may drink the water.

The cause of the growth of the organisms found in the reservoir is not definitely known, but it is probably largely due to the presence of mud and vegetable matter on its bottom; and it seems probable that, by thoroughly cleaning the bottom and sides of the reservoir so as to remove all soil, mud and vegetable matter, leaving a clay or gravel bottom practically free from organic matter in contact with the water, the growths of organisms could be greatly reduced and perhaps prevented; and the Board would advise that the bottom of the reservoir be thoroughly cleaned, and precautions taken to prevent mud and organic matter being washed into the reservoir from the sides or through the smaller streams which enter it.

There are two houses with barns and out-buildings in such close proximity to the stream upon which the reservoir is situated that there is some danger of the pollution of the reservoir by these places. It appears that a careful supervision of the disposal of the drainage and other refuse from these places is exercised by the water company; and it is important, in order to prevent pollution of the water supply, that, if these houses and buildings are to continue in use, this supervision be not relaxed, and that the chance of polluting matters entering the water supply be prevented at all times.

THE LYMAN SCHOOL FOR BOYS. The superintendent of the Lyman School at Westborough applied to the Board, March 11, 1898, for the opinion of the Board with reference to the quality of the water supply of the institution. The Board replied to this application as follows: —

MAY 5, 1898.

In response to your communication of March 11, 1898, stating that you had reason to be suspicious of the quality of the water of Sandra Pond, and requesting an investigation of this source, the Board has caused an examination of the ponds used as sources of water supply of the town of Westborough to be made by its engineers, and has carefully examined the results of numerous analyses of samples of water sent in by the water works authorities from time to time for several years.

It appears that the supply is drawn partly from the upper basin of Sandra Pond, so called, which is an artificial storage reservoir of small depth, a portion of the bottom of which is covered with mud and organic matter, and partly from the lower basin, so called, which receives water from the upper basin both by direct flow over the dam and by filtration through the dam and the gravelly land which surrounds it.

A comparison of the results of analyses of samples of water collected from the lower basin with those collected from the upper basin shows that the quality of the water of the lower basin is much better than that of the upper basin, which at times contains enormous numbers of organisms of a kind which cause disagreeable tastes and odors when present in large numbers in the water. If the supply could be drawn wholly from the lower basin, and water from the upper basin kept from running directly into it, a water of much better quality than that supplied at present could be furnished to consumers; but the yield of the lower basin is not, under present conditions, sufficient for the supply of consumers at all times.

The water-shed of the basins contains only a small number of inhabitants, and the water does not appear to be exposed to serious danger of pollution by sewage. The presence of a large amount of organic matter found in the water of the basins affects its appearance, taste and odor, rather than its healthfulness, so far as can be judged from our present information.

The Board cannot advise you as to any practicable method by which you can improve the quality of the water supplied to you, unless the town will take steps to provide sufficient filtered water to avoid drawing water directly from the upper basin, which seems to be practicable, or unless you can obtain an independent supply from some suitable source.

LYNN. The State Board of Health having observed that the number of cases of typhoid fever in Lynn had increased in a marked manner in recent years, and that there was a further increase in the early portion of the present year, caused a thorough investigation to be made, with a view to discover the probable cause of the excessive prevalence of this disease in the city. The Board after completing the investigation addressed the following communication to the board of health of Lynn: —

JUNE 3, 1898.

It having been observed by the State Board of Health that the number of cases of typhoid fever in the city of Lynn had increased in a marked manner in recent years, and that there was a further increase in the early portion of the present year, the Board has caused a thorough investigation to be made, with a view to discover the probable cause of the excessive prevalence of this disease in the city.

In this connection an examination has been made of the statistics of typhoid fever in Lynn, and records have been obtained of the annual number of cases of the disease and the number of deaths therefrom since the year 1881. It is found that the returns of cases of this disease were probably not, for several years after 1881, as complete as they have been in recent years. No information which appeared to be of great value relative to the number of cases of typhoid fever for the years previous to 1881 has been found.

It appears that the death rate from all causes in Lynn has been materially reduced during the past eighteen years. Beginning with 1880, the death rate per 10,000 of the population by three-year periods has been as follows: —

PERIOD.	Death Rate from All Causes per 10,000 Living.	PERIOD.	Death Rate from All Causes per 10,000 Living.
1880-82, ...	201.2	1889-91, ...	168.7
1883-85, ...	179.6	1892-94, ...	170.6
1886-88, ...	177.0	1895-97, ...	167.7

A study of the death rate from infectious diseases during the past nine years, from 1889 to 1897, considered in a similar manner, shows a noticeable increase in the number of deaths due to infectious diseases as compared with the deaths from all causes. These facts appear in the following table: —

PERIOD.	Average Annual Number of Deaths from Infectious Diseases per 10,000 Living.	Percentage (of Deaths from All Causes) due to Infectious Diseases.
1889-91, ...	28.6	17.0
1892-94, ...	30.2	17.7
1895-97, ...	31.9	19.0

A study by three-year periods of the death rate from typhoid fever per 10,000 living shows an increase similar to that which was found to exist in the death rate from all infectious diseases during the same years from 1889 to 1897. The average annual death rate from typhoid fever and the relation of the deaths from this disease to the total number of deaths from all causes during each of the three-year periods are as follows: —

PERIOD.	Average Annual Number of Deaths from Typhoid Fever per 10,000 Living.	Percentage (of Deaths from All Causes) due to Typhoid Fever.
1889-91, ...	1.7	1.0
1892-94, ...	2.0	1.1
1895-97, ...	3.1	1.9

It appears from the foregoing table that the death rate from typhoid fever during the past three years has been 55 per cent. higher than that of the years from 1892 to 1894, and over 82 per cent. higher than during the period from 1889 to 1891. Moreover, it will be seen that the relation of the number of deaths from this disease to the total number of deaths from all causes during the three years from 1895 to 1897 was 73 per cent. higher than the average of the three-year period next preceding, and 90 per cent. greater than that of the years from 1889 to 1891.

The death rate from typhoid fever per 10,000 living during each of the past three years, 1895-97, has been, respectively, 2.1, 4.4, 2.9. It will be seen that the mortality from the disease in 1896 was about 2.1 times that of the previous year, and during 1897 was about 1.4 times that of 1895. The death rate from typhoid fever during 1896 was higher than that of any year since 1884, and during 1897 was greater than during any other year, except 1896, since the year 1887.

The records of the number of reported cases of typhoid fever and deaths therefrom during the past seventeen years show that this series of years may be divided into three periods. The first extended from 1881 to 1887, covering a period of seven years; the second, from 1888 to 1893, embracing six years; and the third, from 1894 to March 24, 1898, covering about four and a quarter years.

It is evident that typhoid fever was prevalent in Lynn in an excessive degree during the period of years first mentioned, from 1881 to 1887. The probable number of cases occurring during each of the years in question, estimated from the number of deaths actually reported upon the basis of 20 per cent. mortality and of the present population, has been found to be as follows: —

YEAR.	Cases.	YEAR.	Cases.
1881, ...	196	1885, ...	99
1882, ...	212	1886, ...	121
1883, ...	159	1887, ...	115
1884, ...	147		

During the period from 1888 to 1893 the number of cases of typhoid fever reported each year was fairly uniform, and was lower than in any period since records have been kept; so that this period may reasonably be taken to represent what, for purposes of comparison, may be considered as the normal prevalence of typhoid fever in Lynn when there are no unusual causes of infection. The annual number of cases of the disease, estimated upon the basis of present population, from the number of cases actually reported, for each of the six years from 1888 to 1893, is as follows: —

YEAR.	Cases.	YEAR.	Cases.
1888, ...	74	1891, ...	69
1889, ...	70	1892, ...	58
1890, ...	69	1893, ...	69

The average number of cases of the disease per 10,000 inhabitants was 10.5 and the average number of deaths 1.9.

Very early in the year 1894 the number of reported cases per month began to be considerably greater than the average monthly number during the period from 1888 to 1893. The conditions of the year 1894 were peculiar, in that the number of cases was not as great as usual during the late summer and the autumn months, but was very much greater than usual during the winter and spring months. The average annual number of cases during the past three years, 1895 to 1897, upon the basis of present population, was 100.2; which is 47 per cent. larger than the average number for the period of six years from 1888 to 1893. The current year, 1898, has been marked by an excessive prevalence of the disease during the months of February and March.

During the entire period from Jan. 1, 1894, to March 24, 1898, there was reported to your board a total number of 390 cases of typhoid fever, 77 of which have resulted in death. Assuming that the cases of typhoid fever and deaths therefrom during the period from 1888 to 1893 represent usual conditions, there has been an excess, in the interval between Jan. 1, 1894, and March 24, 1898, of about 156 cases, resulting in about 35 deaths.

From Jan. 1, 1895, to March 24, 1898, there was reported a total number of 336 cases of typhoid fever; and in 269 of these a careful investigation has been made of each individual case, and information has been obtained relative to the occupation and movements for about two months prior to the date of illness of persons having the disease, together with as complete information as possible relative to the water, milk, ice and food supplies used in each case during that period. In the study of these cases a large portion of the information was collected through your sanitary inspectors, who were detailed by you to do this work. The remaining 67 (or about 20 per cent.) were not investigated, because no satisfactory information concerning them could be obtained, the large majority of those persons sick with the disease during the years 1895 and 1896 having removed from the city.

Of the 269 cases investigated, 12 were undoubtedly imported, 7 others may reasonably be attributed to infection derived elsewhere than in Lynn, and 13 cases followed somewhat closely upon others occurring in the same families, and it is possible that the infection may have been derived from direct personal contact and association with those first coming down with the sickness. Excluding the cases which were imported, and 2 others, all are known to have been provided with the public water supply at the house from which they were reported. Only 17 individuals of the 257 cases investigated, excluding as before the imported cases, are believed to have used at their homes any other water than that from the public water works. One hundred and fifty-four persons (or 60 per cent.) of all the cases investigated, excluding the 12 cases known definitely to have been imported, are believed to have used no water for drinking purposes other than the public water supply of Lynn, during a period of two months previous to coming down with the disease.

A study of the relation of the use of spring waters to the cases of typhoid fever occurring in Lynn during the period from Jan. 1, 1895, to March 24, 1898, has given no evidence that the infection in any instance was derived from the use of a spring water. There is evidence, however, that the water of several of these springs has been at some time greatly polluted by sewage and subsequently well purified in its passage through the ground; and, while no case of typhoid fever was traced to the use of water from these springs, some of the waters are excessively hard, and it is not improbable that the hardness has an injurious effect upon the health of those using these waters. Moreover, there is danger that the purification of the water in its passage through the ground may at some time be less thorough, and thus endanger the health of those who use it.

An examination of the relation of the cases occurring during the period above noted to the milk supply indicates that several cases coming down in September, 1896, may have been due to infection received from the use of milk supplied by one of the largest dealers in Lynn. A careful investigation of other cases of typhoid fever, relative to the use of milk and a general study of the milk supply of Lynn, has failed to give any further evidence of infection derived from the use of this article of food.

In the course of the investigation it was learned that about 70 per cent. of the people of the city used ice in connection with food or drinking water; while, of the total number of cases of typhoid fever investigated, it was found that a somewhat smaller percentage of those who contracted the disease had used ice in this way for a period of several weeks prior to the date of illness. Considering the fact that the most excessive prevalence of the disease occurred in the months from December to April, inclusive, when the use of ice in contact with food and water is far less common than at other seasons, it is unreasonable to attribute the excessive prevalence of the disease during these years to the use of ice.

An examination into the system of public water supply of the city of Lynn has revealed a most serious pollution by sewage of that portion which has been taken from the Saugus River above Howlett's dam. The use of this source appears to have been begun in the latter part of the year 1893, or early in the year 1894. Throughout the past four years typhoid fever has been more or less prevalent upon the water-shed of this stream, under conditions which at times must have caused the infection of the river water with the germs of the disease, since there are many cesspools which overflow into the stream, and there are privies situated either directly over the water or in its immediate vicinity. It has been found that practically coincident with the first use of this river water for the purposes of a public supply in Lynn typhoid fever began to be prevalent to a degree greatly in excess of its prevalence during the preceding six years, when the water supply is believed to have been in no part drawn from this source.

In addition to the statistical evidence which has been presented, many facts have been brought out by personal studies of the individual cases of typhoid fever which make it impossible to arrive at any other conclusion than that nearly all of the excess in the prevalence of typhoid fever in Lynn during the years from 1894 to 1897 has been due to the use of the polluted waters of the Saugus River and of Birch Pond, and perhaps Breed's Pond, which have been contaminated therefrom. It appears probable that some of the cases of typhoid fever occurring during the present year have been due to temporary infection of the water of Hawkes reservoir.

In addition to the examination which was made of the water-shed of the Saugus River, a careful investigation was made of the water-sheds and the condition of the various other sources of public supply of the city. It appears that the water-sheds of Breed's, Birch, Walden and Glen Lewis ponds are largely embraced in a tract of land known as the Lynn woods, which is public property used for the purposes of a public park. There is no evidence that injury to the quality of the water of the ponds has been caused by the use of these lands by the public up to the present time.

In view of all the circumstances, the Board is of the opinion that a large portion of the sickness and mortality from typhoid fever in the city of Lynn in the past four years has been due to the pollution of the portion of the water supply drawn from Saugus River and from Birch and Breed's ponds, to which this water is supplied. The sickness and mortality caused by the pollution of the public water supply of the city are, in the opinion of the Board, unnecessary and preventable; and the Board would, therefore, advise the city of Lynn that, on account of the large population situated upon the water-shed of the Saugus River, the water from this stream should not be taken into the city until it has been thoroughly purified by filtration. While it does not appear that the public use of the Lynn woods, so called, has caused pollution of the ponds about which these lands are situated, it is, nevertheless, important that the use of these lands in the vicinity of the ponds and streams be continually under careful supervision, in order that all danger of the pollution of these sources of water supply of the city may be prevented.

The Board would also advise that measures be taken to prevent the use, for domestic purposes, of ice from polluted sources. A careful supervision should also be exercised over the spring waters sold in the city, in order that the sale of such waters as are dangerous or injurious to health may be prevented.

With these conditions established, we see no reason why the city of Lynn may not return to the enviable condition existing from 1888 to 1893, when deaths from typhoid fever were less than in nearly all the cities of the State.

Should you desire to examine the details obtained in this investigation, they will be shown you at this office.

MARBLEHEAD. A communication was received from the water commissioners of Marblehead, Dec. 20, 1897, asking the opinion of the Board as to the cause of a reddish color in the public water supply of the town, sometimes accompanied by a bad taste and odor. They also requested advice as to the best remedy for the same. The Board replied as follows: —

JULY 7, 1898.

The State Board of Health received from you, on Dec. 20, 1897, a communication relative to the quality of the water supply of the town of Marblehead, which you state is objectionable on account of a reddish color, which stains materials with which it comes in contact, and also on account of a somewhat disagreeable taste and odor; and you request information as to the cause of the trouble and advice as to a remedy therefor.

The Board has caused an examination of the present sources of supply to be made by its engineer, and finds that the supply of the town is at present drawn chiefly from two large wells, one known as Well No. 1, located near the pumping station and not far from Loring Avenue in Salem, and the other known as Well No. 2, located about 800 feet south-east of the pumping station. The water in the latter well stands at a considerably higher level than the water in Well No. 1, and is drawn into Well No. 1 by gravity. A system of thirty-nine tubular wells, situated mostly in a marsh near the salt water north-east of the pumping station, has been used occasionally in connection with the other sources. Numerous samples of the water supplied to the town from these sources have been analyzed since the works were first constructed, the results of which show that the water is affected by the presence of an excessive amount of iron, causing the reddish appearance and probably also the taste and odor of the water to which you refer in your application.

Examinations of the separate sources of supply show that the water of Well No. 2, which furnishes the greater portion of the water supplied to the town, contains a very large amount of iron. It has not been practicable to obtain samples from Well No. 1 except at times when it was affected by the presence of water from Well No. 2; but the mingled water of the two wells, as drawn from Well No. 1, contains a considerably smaller quantity of iron than the water of Well No. 2, and it seems probable that the water which drains naturally into Well No. 1 is not at present affected by an excess of iron.

Examinations of the water of the tubular wells show that this water also is affected by an excess of iron, and, moreover, the quality of the water appears to deteriorate rapidly when any considerable amount is drawn from these wells, on account of a marked increase at such times in the hardness and in the quantity of salt present in the water.

With regard to the best means of improving the quality of the water of

Well No. 2, the Board has caused experiments to be made with water taken from this well, the results of which have shown that by first aerating the water and subsequently filtering it through a sand filter at a rate of about 10,000,000 gallons per acre per day, the iron can all be removed, and a clear and colorless water can be obtained which is free from taste and odor.

In constructing a filter to filter all of the water of Well No. 2, it would be desirable to provide for a smaller rate of filtration than that at which the experimental filter was operated, and the depth of sand should not be less than 24 inches. The filter should be so designed and constructed that it can be operated without difficulty at the rate proposed, and provision should be made for cleaning. The filter should be covered, to prevent difficulty of operation in cold weather.

Should you desire to construct a filter for the improvement of your water supply, the plans should be prepared by a competent hydraulic engineer, and the Board will, upon application, give you advice with reference to any plans which you may wish to present.

The consumption of water in the town is increasing, and in connection with plans for the filtration of water from your present sources the Board would suggest that you consider the question of the possible necessity for an additional supply.

Medford. An application was received, Oct. 18, 1898, from the water commissioners of Medford, for the advice of the Board relative to the proposed use of the water of Wright's Pond as a source of water supply during the cold weather. The Board replied to this application as follows: —

Dec. 2, 1898.

The State Board of Health received from you, on October 18, an application requesting the advice of the Board with reference to the use of water from Wright's Pond for the supply of the city of Medford during cold weather.

The Board has caused the pond and its water-shed to be examined by one of its engineers, and a sample of the water collected on November 4 to be analyzed. This analysis shows that the water at that time had considerable color and a somewhat unpleasant odor when heated; and the quantity of organic matter present, as shown by the free and albuminoid ammonia, was large. The water of the pond does not appear to be exposed to danger of pollution by sewage, but it will be liable to be objectionable for drinking and other uses on account of its appearance and disagreeable taste and odor; and on this account the Board would advise that you avoid the use of water from this pond, if a better source is available.

Natick. The water commissioners of Natick applied to the Board, Feb. 15, 1898, for its advice relative to a proposed water supply for the town, to be taken from gravel beds lying between the Worcester road, the Saxonville branch of the Boston & Albany Railroad and Lake Cochituate, and distant about one and one-half miles from the railroad station in Natick. The Board replied to this application as follows: —

March 17, 1898.

An application was received from you, on Feb. 15, 1898, requesting the advice of the State Board of Health with reference to a proposed water supply for the town of Natick, containing the following outline of your proposed plans: —

It is proposed to obtain a supply of ground water from the gravel beds underlying land owned by the town of Natick and lying between the Worcester Road (old turnpike), the Saxonville branch of the Boston & Albany Railroad and Lake Cochituate, said land being located in the town of Natick and distant about one and one-half miles from the railroad station in Natick, and is the territory referred to in the communication of your Board to the water commissioners of Natick, dated Nov. 4, 1897.

It is proposed to obtain this water by driven wells of large diameter arranged in clusters and connected with each other and a main suction pipe by pipes of appropriate diameter, such wells to be located at such points and driven to such depths as convenience in construction and quantity of water available may indicate.

Or, by an excavated well of large diameter, to be retained with heavy stone work, laid dry, and lined inside with water-tight brick work laid in American Portland cement, this well to be covered with appropriate roof to exclude sunlight.

Or, the above methods may be used in combination; in such case the large well to serve as a storage reservoir to meet the demand for rapid pumping.

The water obtained by either or both of the above plans is to be pumped into a stand-pipe, to be constructed on an appropriate elevation within the town limits, such stand-pipe to be of most modern construction, and to have a tight roof to exclude sunlight and air and reduce the danger of freezing in cold weather. In such stand-pipe the ground water is to be delivered at or near the high-water mark at the top of the structure.

Or, the water may be pumped through the present system of piping in the town into the present reservoir on Broad Hill; in such case the reservoir is to be covered over by an appropriate and durable design in construction in order to preserve the quality of the water.

The opinion and advice of the Board is desired as to the sufficiency and quality of the proposed supply and its desirability in comparison with the water now drawn by the town from Dug Pond.

You also submitted the results of your investigations as to the character of the soil in the territory referred to in the application by means of tubular test wells, and the results of a pumping test made by connecting several of these wells and pumping from them nearly continuously with a steam pump for a period of thirteen days, from January 19 to Feb. 1, 1898. During this test samples of water drawn from the wells, collected by you and by the Board, have been analyzed.

The source from which it is proposed to obtain the supply is the same as that referred to in your application of last year, concerning which the Board advised that the conditions appeared to be favorable, and suggested that further investigation be made in its communication of November 4. The character of the soil, as shown by the material taken from the wells, appears to be coarse and porous, but the soil taken from one of the wells driven in the bottom of the small shallow pond known as Snake Pond was quite fine.

The wells from which water was drawn were located in the immediate vicinity of Snake Pond, and several other test wells were driven near the shore of the southerly basin of Lake Cochituate and one near the southerly shore of the middle basin of the lake. The average daily quantity of water pumped during the test was considerably in excess of the quantity now used for the supply of Natick; but, nevertheless, the water in the ground in the vicinity of the wells, as shown by your observations, rose considerably during the test, following closely a rise in the level of the water of Lake Cochituate. The tests as a whole indicate that a quantity of water much in excess of the present needs of the town of Natick can be obtained from the ground at this place, under conditions similar to those which existed when the pumping test was made. The lake may, however, be drawn down much lower at times than its level at the time this test was made, and the amount of water which the ground would yield would be smaller when the level of the water in the lake is lower, and it is not feasible to tell definitely the probable quantity of water that could be obtained from the ground when the lake is drawn down near low-water level; but it appears to be practicable to increase the yield of the wells, if it should become necessary, by pumping water from the lake upon the surface of the ground in their vicinity.

Analyses of several samples of the water of the test wells collected at intervals throughout the test show that this water was clear, colorless and otherwise of good quality for the purposes of a public water supply; and, if the location of the wells in soil containing organic matter beneath the small pond is avoided, and the wells for permanent use are located at a sufficient distance from the lake to avoid danger of imperfectly filtered water from that source finding its way into them, there appears to be no reason to expect a deterioration in the quality of water, if a quantity sufficient for the supply of Natick should be drawn continually from the ground at this place, provided the water is kept from exposure to light, as is proposed in your present plan.

In view of the results of the investigation, the Board is of the opinion that the source proposed by you is an appropriate one for the supply of the town of Natick, and is much more desirable than Dug Pond, your present source, the capacity of which is little in excess of the present needs of the town in dry years. Moreover, as stated in the previous communication of the Board with reference to this subject, Dug Pond is not a safe source from which to take water directly for domestic uses, on account of the large population located along its main feeder, which discharges into the arm of the pond from which its supply for the town is drawn.

The Board would, therefore, advise that the new works be constructed with a view to supplying the town wholly from the new source, in order that the use of water from Dug Pond may be abandoned as soon as practicable.

NEEDHAM. An application was received, Sept. 23, 1898, from the Needham water board, giving notice of their intention to increase the water supply of that town, and requesting the advice of the State Board of Health relative to the same. The Board replied to this application as follows: —

Nov. 17, 1898.

The State Board of Health received from you, on Sept. 23, 1898, an application under the authority of chapter 375 of the Acts of 1888, giving notice of your intention to increase the system of water supply for the town of Needham, and giving an outline of your proposed plan for adding to the supply by providing further means for securing ground water from the water-shed of your present supply, as follows: —

To accomplish this it is proposed to sink another well or provide filter-galleries or conduits, or both, in the sand and gravel basin between the present well and the pumping station.

To aid in keeping the ground saturated about the supply well, it is proposed to construct a storage basin either above the location of the wells in the valley of the brook or below the wells near the pumping station in the sandy basin before mentioned.

The latter location seems preferable, inasmuch as considerable spring water now wasted would be intercepted; the water table in the near vicinity of the wells would be maintained higher; more water would pass through the reservoir, creating a better circulation; and there would be a large body of water near the pumping station, which, although not to be used direct, its presence would give an added sense of security in considering the possibility of a conflagration coincident with an empty stand-pipe and low water in the wells. The reservoir would be excavated to uniform depths and protected against impure surface water by a sand filter dam where the brook enters.

Subsequently a plan was submitted by your engineer, showing the proposed location of a well in the valley of the brook about 440 feet southwest of your present well, between the present well and the pumping station, together with the location of the proposed dam across the brook a short distance above your pumping station, but below the location of the present and proposed wells, and the approximate outlines of the reservoir which would be created thereby.

From this plan it appears that the shores of the pond will be at the nearest place within about 225 feet of your present well, and that, to avoid flooding the ground in the immediate vicinity of your proposed new well, it is proposed to raise the level of the ground so that the line of flowage in the pond will be at least 90 feet from the well.

The consumption of water in Needham has increased very rapidly in the last few years, and there are indications that the supply from the present source would prove inadequate for the supply of the town in a dry season, and a suitable additional supply should be provided without delay.

The Board has carefully considered the proposed plans, and has caused the locality to be examined by its engineer and a sample of the water from the test well at the location of your proposed new well to be analyzed. It appears that a test well at the site of your proposed new well yields water freely at a rate of about 60 gallons per minute when pumping with a hand pump; and the results of the analysis of a sample of the water sent in by you from this well indicate that its quality at the present time is good, being about the same as that of your present source of supply. Observations upon the height of water in the test well and in your present well show that, when pumping from the present source, the level of the water in the test well is affected to a considerable extent, showing that the ground water in the vicinity of your proposed well is already influenced by pumping from your present source. No test has been made to determine the probable quantity of water that can be obtained from the ground in the vicinity of this test well, in addition to the quantity now obtained from your present well.

The proposed well would be located close to the edge of the water-shed of the brook, on its southerly and westerly sides, while on the north-westerly and northerly sides tests of the ground have shown that ledge comes to within 9 feet of the surface in places. It also appears that ledge was encountered in the test well at a depth of 16 feet beneath the surface, and the indications are that the stratum of porous material from which water can be obtained is not of considerable depth or extent.

It is a part of your plan, however, to create a small pond near the wells, by means of which it is expected to saturate the ground and thus increase the yield of these sources. It is impossible to determine beforehand to what extent the water of your proposed pond would filter through the ground to these wells; but, even if a large portion of the flow of the brook should enter the wells through the ground, it is doubtful whether the yield of the wells would be sufficient to supply the requirements of the town of Needham if a dry year should occur in the immediate future. It may also happen that imperfectly filtered water from the pond may enter the wells and have an unfavorable influence upon the quality of the water, causing it to contain an excess of iron or organic matter, and making it objectionable for many uses.

In view of all the circumstances, the Board does not at present advise the adoption of the method now proposed for increasing the water supply of the town of Needham, but would advise a further investigation, with a view to obtaining a larger quantity of water than would probably be made available by the proposed new well.

It is desirable to increase your supply, if possible, by further works in the vicinity of your present well. A single test well in a small valley east of your present well indicates that porous soil may be found in that vicinity at a considerable depth beneath the surface; and, under the circumstances, it seems desirable to make further tests in this valley, to determine whether any considerable additional supply of ground water may be obtained there.

It is also desirable to make a careful examination along the Charles River, near your present pumping station, to see whether a suitable additional supply may not be obtained near that stream.

The Board will co-operate with you in such further investigations as you may decide to make, by making such analyses of samples of water as may be necessary, and will, upon application, give you further advice in this matter when you have the results of further investigations to present.

NORTH ANDOVER. An application was received from the water commissioners of North Andover, April 20, 1898, for the advice of the Board relative to taking the water of Great Pond in that town as a source of public water supply. The Board replied to this application as follows: —

MAY 6, 1898.

The State Board of Health received from you, on April 20, 1898, an application for advice with reference to a proposed source of water supply for the town of North Andover, to be taken from Great Pond in that town, at a point near its southerly end, and has caused an examination of the proposed source to be made and a sample of the water of the pond to be analyzed.

The results of this analysis, and of analyses of two samples made in previous years, indicate that the water is soft, generally only slightly colored, and is in other respects of good quality for the purposes of a public water supply. The limited number of examinations thus far made are not sufficient to make it possible to determine whether its quality would be satisfactory at all times; but the indications are that the water will generally be satisfactory, but that it may at intervals be affected by the presence of large numbers of microscopic organisms, which may impart to the water a noticeable taste and odor.

The quantity of water which the pond will furnish is many times in excess of the quantity which would be required for the supply of the town of North Andover.

The water-shed of the pond contains a considerable number of dwelling-houses, in connection with most of which there are barns and out-houses; and it will be necessary to prevent danger of the pollution of the pond from these places. The pond is also used to a considerable extent as a summer resort, and it is likely that the number of summer visitors will increase from year to year. There are, moreover, several buildings around the shores which are said to be used as places of resort in the summer season, one of which is not far from the proposed intake.

Recent investigations in the cases of other ponds used as sources of public water supply indicate that there might be much danger to the health of the inhabitants of the town should water be drawn directly from the pond, unless the use of the pond is under such control and supervision as to prevent its pollution; and the Board would advise that such control and supervision is necessary to protect the health of those who may use the water.

At a later date, Sept. 23, 1898, the same board applied to the State Board of Health, requesting an opinion as to the probable effect of the water of Great Pond upon lead or lead-lined pipes, as affecting the water for domestic use. The Board replied to this letter as follows: —

Oct. 7, 1898.

The State Board of Health has considered your communication of Sept. 23, 1898, in which you inquire whether anything was found in the analyses of Great Pond water that would make the use of lead or lead-lined pipe undesirable for street services to dwellings.

It is not possible for the Board to determine, from the analyses of Great Pond water that have been made by the Board, whether the water would take up lead if supplied through pipes of that metal, or, if so, to what extent. Investigations thus far made with regard to this subject have shown that, while in some cases certain waters do not appear to dissolve lead from the pipes, in most cases it is found that lead is taken up by the water from such pipes. The quantity taken up is in many cases quite minute; but in some cases investigated by the Board it has been found that water dissolves lead from lead pipes in large quantities, and severe cases of lead poisoning have been caused by the use of water from public water supplies drawn through lead pipes.

Even if tests should show that Great Pond water would not take up lead in passing through lead pipes at the present time, it is possible that in the future some change might occur in the character of the water which would cause it to attack the pipe, or a supply of water of a different character might, at some time, be introduced from another source, which might be unfavorably affected by passing through lead pipes.

Under the circumstances, the Board would advise that you avoid the use of lead either for mains or services in connection with the proposed system of water supply of the town of North Andover.

NORTHFIELD. An application was received, March 4, 1898, from the Northfield Water Company, for the advice of the Board relative to a proposed water supply from Minot Brook and Warwick Brook, "for domestic use and for the better protection of the town from fire." The Board replied to this application as follows: —

APRIL 8, 1898.

The State Board of Health received from you, on March 4, 1898, an application for advice with reference to a proposed water supply for the town of Northfield, in which you state that the supply is to be obtained from a brook running between Hemlock and Round mountains, known as the Minot Brook. You also state that, should it be necessary at a later date to increase this supply, you propose to use so much of the water of Warwick Brook, so called, as may be necessary.

The Board has caused an examination of the proposed sources of supply to be made by one of its engineers, and has had samples of the water of each of these sources analyzed. The water of Minot Brook is found from this analysis to be nearly colorless, soft, and of excellent quality for the purposes of a public water supply; and, while its quality may be found to be somewhat different at other seasons of the year, it is not probable that the difference will be material. The water-shed of the brook is free from dwelling-houses, and its waters do not appear to be exposed to any danger of sewage pollution.

With regard to the quantity of water that can be obtained from this source, it is difficult to form an estimate from an examination made at this season of the year, since the flow in the drier portion of a dry season would be very much smaller than at the present time; but, so far as can be learned, the flow of this brook appears to be well maintained in the summer season, and it is probable that by the construction of a small reservoir, capable of holding a few weeks' supply for the town, a sufficient quantity of water can be obtained from this source for the supply of the town for several years, at least, if the growth is no greater than it has been in the past.

Warwick Brook would probably furnish an ample supply of water at all times without storage, but its water has considerable color and would be of less satisfactory quality than that of Minot Brook; moreover, there are several houses located near this stream above the place at which it would naturally be taken for the supply of Northfield, and there would be great danger that, if this source should be used for the supply of the town, the health of the people would be endangered by sewage entering the stream from these houses. It does not appear to be practicable, except at a large expense, to prevent the danger of pollution of this stream by sewage, and the Board therefore does not advise its use as a source of water supply for Northfield.

There appear to be other sources in this region which, like Minot Brook, are not exposed to pollution from population upon their water-sheds, and from which it may be practicable to obtain by gravity a further supply of water of good quality in connection with Minot Brook. Possibly the brook draining the westerly slope of Hemlock Mountain and north of the Minot Brook drainage area would furnish a suitable and satisfactory additional supply for the town. The Board would recommend that a further examination be made, with a view to selecting a source of suitable quality in case the yield of Minot Brook should prove insufficient for the supply of the town.

The Board will, if you so request, assist you in any further investigations you may wish to make by making analyses of samples of water, and will give you further advice in the matter when you have the results of further investigations to present.

PEPPERELL. An application was received from the selectmen of Pepperell, Oct. 26, 1897, for the advice of the Board relative to a proposed water supply for the town to be taken from wells in the valley of Sucker Brook. The Board replied to this application as follows: —

MARCH 17, 1898.

The State Board of Health received from you, on Oct. 26, 1897, an application for advice with reference to a proposed water supply for the town of Pepperell, with which you submitted a report relative to tests of the ground in the valley of Sucker Brook in the Sartelle Meadow and above, by means of tubular wells, and requested the advice of the Board with reference to taking a supply of water for Pepperell from the ground in this vicinity.

The Board has caused an examination of the locality to be made by its engineer, and has caused a sample of the water collected from one of the wells to be analyzed. The results of this analysis do not differ materially from the analysis of a sample of water collected from another well in this region three years ago; they show, as stated in a previous reply, that the water is of good quality except for its hardness, which would render it unsatisfactory for some of the purposes of a public water supply.

The source now under consideration is one of those proposed by you in your application of three years ago, the plan proposed at that time being to construct a well near the right bank of the Nissitissit River, just below the mouth of Sucker Brook, and to lay a pipe with open joints from that point to the vicinity of Sartelle Meadow, where it was proposed to construct a second well to supplement the supply. It was suggested at that time, in case a sufficient supply should not be obtained from the valley of the brook, that the source might be further supplemented by drawing water from the valley of Gulf Brook, the water-shed of which lies north-west of that of Sucker Brook. The results of tests of the ground in the valley of Sucker Brook made at that time and at a subsequent time showed that ledge was found so near the surface near the mouth of Sucker Brook that it was impracticable to obtain water from the ground at this place, except possibly in very small quantity; and the tests further up the valley showed that the conditions for obtaining water freely from the ground were not favorable at any place below the Sartelle Meadow.

The recent tests were made by driving seven wells in the valley of the brook, one being located in the Sartelle Meadow and the others between the meadow and a road which crosses Sucker Brook about a quarter of a mile above the meadow. The tests show that water could be obtained freely from the well in Sartelle Meadow, and with considerable freedom from three of the other wells nearest the meadow; but from the upper three wells no water could be obtained, on account of the fineness of the material, and in nearly all of the wells ledge was found at no very great depth beneath the surface of the ground.

The results of these tests tend to confirm the opinion of the Board, expressed in a previous reply, that the quantity of water which could be obtained from the ground in the valley of Sucker Brook would not be sufficient for the supply of the town in the drier portion of a dry year after the water supply system comes into general use; and it does not appear to be practicable to supplement the supply from any other source without maintaining and operating two pumping plants.

In the previous reply of the Board with reference to this subject it was suggested that you make further tests in the valley of Unquetenasset Brook, by driving wells along the valley of the brook to determine whether porous soil is found beneath the surface in the valley at any place from which water of good quality could be drawn with freedom from the ground; and it appears, from information submitted by you, that tests were made in this valley in the spring of 1897, between the railroad crossing near the mouth of the brook and the Dunstable Road; but the conditions appear from the report submitted by you to be unfavorable to obtaining water from the ground in this region, though, judging from the location of the test wells, the area covered does not include all of the valley of the brook in which the conditions may be favorable to obtaining water in large quantity from the ground. On account of the snow, it has not been possible to make a satisfactory examination of this territory recently, to determine whether further investigation in this valley is desirable.

In view of the circumstances, the Board does not at present advise that you attempt to secure a water supply from the valley of Sucker Brook, but advises that you continue your investigations, and that you secure the aid in this matter of an engineer of experience in matters relating to water supply. It is desirable that these investigations include a consideration of the feasibility of obtaining a ground-water supply in the vicinity of Baddacook Pond; and it may be found advisable to make further tests in the valley of Unquetenasset Brook, for a distance of at least a mile above the place where the previous tests were made.

The Board will give you further assistance in this investigation by making such analyses of the water as is necessary, and will, upon application, give you further advice when you have the results of further investigations to present.

PEPPERELL. The Board received another application from the selectmen of Pepperell, Aug. 11, 1898, for advice relative to the introduction of a public water supply for that town. The Board replied to this application as follows: —

SEPT. 1, 1898.

The State Board of Health received from you, on Aug. 11, 1898, an application for advice with reference to a proposed water supply for Pepperell, accompanied by a report giving a description of certain tests made by means of tubular wells in the valley of Unquetenasset Brook. From this report it appears that ten test wells were driven in the valley of the brook, at various places between the point where it is crossed by the Dunstable Road and the road which crosses near Cummings' Mill, about one and one-half miles further up stream, but that none of these wells reached a stratum which would furnish water in any considerable quantity. Further tests by means of wells located in the vicinity of a road which crosses the brook about three-fourths of a mile above Cummings' Mill and two and one-half miles south-east of the village of East Pepperell were more favorable. At this place five wells were driven, three of which penetrated a gravel stratum of a considerable depth, from which water could be pumped freely with a hand pump.

The Board has caused the latter locality to be examined by its engineer, and samples of the water from three of these test wells to be analyzed.

The results show that the water is quite soft, but the samples contained an excessive amount of iron, which would render this water objectionable for many domestic uses. A general examination has been made of the land in this valley for a long distance up the brook, and the surface indications appear to be favorable to the absorption by the ground of a large portion of the water which falls upon its surface, and there are several large springs in the low land in the valley. An analysis of a sample of water collected from one of these springs showed that the water was clear and nearly colorless and was also quite soft, the hardness of this water, as well as that of the test wells already referred to, being much less than that of the water obtained from wells in the valley of Sucker Brook, where your previous investigations were made. While the water of the test wells contained an excessive amount of iron, the quantity of iron found in the spring water was insignificant, and it is therefore evident that ground water free from an excess of iron can be obtained in this valley.

So far as the Board can judge from the information which has thus far been submitted, the conditions for obtaining a suitable supply of good ground water are more favorable in this valley than at any other place within an equal distance of Pepperell; and the Board would advise that thorough tests be made here, to determine definitely the feasibility of obtaining a suitable supply of water for the town. Such tests should be made under the direction of an engineer of experience in the design and construction of works for the collection of ground water.

If by further examinations a gravel stratum of large depth and extent is found, it will be very desirable to connect together several wells, and test them by pumping continuously for a period of several days, at a rate at least as great as would be likely to be required for the supply of Pepperell after water comes into general use, and to note the effect of such pumping upon the elevation of the water in the ground, in order to obtain information as to the probable quantity of water that the source will yield. Samples of water should also be collected to determine its quality before pumping, and what changes, if any, take place in the course of the test.

The Board will, if you so request, assist you in further investigations by making such analyses of samples of water as may be necessary, and will, upon application, give you further advice when you have the results of further investigations to present.

ROWLEY. The board of health of Rowley applied to the State Board of Health, April 16, 1898, for its advice in regard to the quality of the water of certain wells used by the operatives in shoe factories in that town. The Board replied to this application as follows: —

JUNE 3, 1898.

The State Board of Health received from you, on April 16, a communication relative to three wells in the town of Rowley, the water of which you state is used extensively by the public for drinking, and you desire the advice of the Board as to the quality of the water.

The Board has caused the location and surroundings of these wells to be examined by one of its engineers, and has analyzed two samples of the water from each well, one on the 1st of March and the second on April 30, 1898.

The water of the first sample, collected from the Burke well, so called, was found to be clear, colorless and free from odor, and the quantity of organic matter present was not large. The chlorine, however, appears to be above the normal for the region, and a considerable quantity of nitrates was present in the sample. These results indicate that the water has at some time been polluted by sewage and subsequently well purified in its passage through the ground. The sample collected on April 30 was slightly turbid and colored, but free from odor, and the quantity of organic matter, as represented by the free and albuminoid ammonia, was the same as in the first sample. The chlorine and nitrates, however, were considerably higher and the water was much harder. So far as chemical analyses show, there is no indication that the water of this well is, in its present state, injurious to the health of those who use it for drinking or cooking purposes; but, considering the comparatively small depth of the well and the nearness of several of the sources of pollution, there is danger that at some time polluting matter may enter the well without complete purification, and this well cannot, therefore, be considered a safe source of drinking water.

A sample of water from the Pickard well, so called, collected on March 1, was found to be slightly turbid and colored, but free from odor. The water was hard, and contained several times as much mineral matter as the Burke well and a much larger quantity of organic matter. The quantity of chlorine and nitrates was also excessive. The second sample, collected on April 30, was found to be decidedly turbid and more colored than the first sample. It also contained a considerably larger quantity of organic matter, though the chlorine and nitrates were slightly smaller than in the previous sample. An examination of the surroundings of the well shows the presence of several privies and sink drains in its immediate vicinity, and the analyses show that the water has been highly polluted and has not been fully purified in its passage through the ground to the well. In the opinion of the Board, this well is a dangerous source from which to take water for drinking or other domestic purposes, and its further use should be prevented.

The third well is known as the Armitage well, which is said to have been in use for many years. Its surroundings are similar to those of the other wells, but the analyses show that the water is very hard and is even more highly polluted than that of the other wells; and, in the opinion of the Board, this well also is a dangerous source from which to take water for domestic uses, and its use should be prevented.

SHEFFIELD. A communication was received, Nov. 13, 1897, from the Sheffield Water Company, calling attention to an unusual outbreak of illness in one of the schools of that town, and stating that the illness had been attributed by some persons to the new public water supply, and at the same time requesting an examination of the water by the State Board of Health. The Board caused an examination to be made, and replied as follows: —

MARCH 4, 1898.

The State Board of Health received from you, on November 13, a communication calling attention to cases of illness in one of the schools of Sheffield, which appears to have been attributed by some persons to the water supplied from the new system of works installed last fall.

The Board, upon receipt of your letter, caused an examination to be made of the sources of water supply of the town and of the locality in which the schools were situated, and from this examination it appeared that the school children in the two school buildings located in the centre of the village were all supplied with water from the public works by the same pipe; but the cases of illness were practically all confined to the children in the room occupied by the primary school, while there was only one case in the other room in this building, and none at all among those in the other building near by, which, as already stated, was supplied with water through the same pipe. These conditions point to infection of the children of the primary school from some cause which affected the condition of the children of the other room in this building but slightly, and had no effect at all on those of the grammar and high schools.

Since there appeared to be some doubt as to the exact nature of the disease, which was thought to be malarial, the Board has sought further evidence on this point, but none has been obtained.

The sources of water supply were examined, and no evidence was found of the possible infection of the source from which the supply was then being drawn. It does not appear to the Board that there is any evidence that the disease was due to infection of the water supply.

SOUTH HADLEY. The water commissioners of the fire district of South Hadley Falls applied to the Board, July 25, 1898, for advice relative to a bad taste and odor in their water supply, and the best method of improving the quality of the water. They also asked whether the condition of the water would make it injurious to the health of persons using it. The Board replied as follows: —

Sept. 2, 1898.

The State Board of Health received from you, on August 4, a communication stating that the water of Leaping Well reservoir has a strong odor and bad taste, and requesting the Board to make an examination of the water and to advise you as to means by which the quality of the water may be improved. You also request information as to whether there is any thing in this water that would affect or be injurious to the health of the community.

The Board has caused the reservoir and its surroundings to be examined by one of its engineers, and has caused samples of the water of the reservoir and of the water of the brook which feeds it to be analyzed, both chemically and microscopically. The results of these analyses, taken in connection with the results of similar examinations of water from this source made in previous years, show that the quality of the water is unfavorably affected, especially in the summer season, by the presence of large numbers of microscopical organisms, of kinds which are known to impart to water a disagreeable taste and odor. The cause of the recent bad taste and odor of the water has evidently been the presence of large numbers of the organism *Anabœna*. While the presence of such organisms in large numbers often renders a water disagreeable for drinking and other domestic uses, it is not known that waters affected in this way are injurious to health.

An examination of the water-shed of the reservoir shows that the soil is sandy, and the indications are that a large proportion of the water falling upon the surface sinks into the ground, and, after percolation through the soil, enters the reservoir, or the brook which feeds it, in the form of springs. An analysis of a sample of the water of the brook which appears to form the main feeder of the reservoir shows that the water is practically clear and colorless, and contains only a very small amount of organic matter, as compared with the water which has been standing in the reservoir. It is well known that ground water, such as that which enters the reservoir, very quickly deteriorates when exposed to the action of the sunlight by storage in an open reservoir; and, judging from experience with such sources, the water of the Leaping Well reservoir is likely to continue to give trouble at times from disagreeable tastes and odors for an indefinite period.

The appearance of the surface of the ground in the vicinity of the reservoir indicates that the soil may be coarse and porous to a considerable depth; and, if this is the case, it may be practicable, by constructing filter-galleries or similar works in the vicinity of the shores of the reservoir, to obtain a large proportion, if not all, of the yield of this source by filtration through the ground, and at the same time to secure a water free from color, taste or odor, which will not deteriorate if kept from exposure to light, and which can probably be conveyed to the town through the present system.

In view of all the circumstances, the Board would advise that you cause tests to be made in the vicinity of the reservoir, by means of tubular wells, to determine the character of the soil and the probable quantity of water to be obtained from the ground. If the material is very coarse and porous, it is desirable that works for collecting ground water be located as much as 100 feet from the shore of the reservoir, to reduce as much as possible the danger of imperfectly filtered water from the reservoir finding its way to the collecting works. It is very desirable that investigations and plans for improving the quality of the water be made under the direction of an engineer of experience in such matters.

The Board will assist you in these investigations, if you desire, by making analyses of samples of water, and will, upon application, give you further advice in the matter when you have the results of further investigations to present.

WAREHAM. An application was received, Jan. 17, 1898, from Mr. Joseph K. Nye, for the advice of the Board relative to a proposed extension of the water supply of Onset to that part of the town of Wareham known as the Narrows, using for the purpose the water of Sandy Pond, also known as Jonathan's Pond, in that town, the present source of supply of Onset. The Board replied as follows: —

FEB. 3, 1898.

The State Board of Health received from you, on Jan. 17, 1898, an application for advice with reference to a proposed water supply for a portion of the town of Wareham, in which you state that it is proposed to extend the present works of the village of Onset in that town into the portion of the town known as Wareham Narrows, using, as the source of supply, Sandy Pond, also known as Jonathan's Pond, the present source of supply of the village of Onset.

Several chemical analyses of the water of Jonathan's Pond have been made since the works for supplying the village of Onset were constructed, in 1894, and the results have shown that the water has been very soft, and otherwise of good quality for the purposes of a public water supply.

The works for supplying the village of Onset have been in use for a period of four years, and the quantity of water used during the year just ended, according to information furnished by you, averaged only 13,000 gallons per day. While, as already stated in a previous communication of the Board with reference to this subject, the limits of the territory which contributes to the supply of Jonathan's Pond, either by direct flow over the surface or by filtration under ground through the sandy territory in which the pond is situated, are not well defined, the indications are, that, considering the small quantity of water used by Onset at present, the yield of the pond will be sufficient to supply both Onset Village and the territory to which you now propose to extend the works for several years in the future. There appear to be other sources in this region which might furnish a larger supply of good water; but it will probably be best, on the whole, to use the present works as long as the supply proves sufficient for the purpose, rather than to take water from a new source.

In view of all the circumstances, the Board is of the opinion that Jonathan's Pond is a suitable source from which to take, for the present, a supply of water for both Onset and the village of Wareham Narrows, to which you now propose to extend the works.

WESTON. An application was received, Feb. 14, 1898, from Mr. C. W. Hubbard of Weston, for the advice of the Board relative to a proposed water supply for a small part of Weston, at the same time suggesting that the supply be taken from the existing water works of Wellesley. The Board replied to this application as follows: —

MARCH 4, 1898.

The State Board of Health has considered your communication of February 14, relative to a water supply for a small district in the southeasterly portion of Weston, in which you suggest taking a supply from the works of the town of Wellesley, one of the main pipes of which works, you state, extends to within less than 1,000 feet of the boundary line between Wellesley and Weston, in the vicinity of the district which you propose to supply. You state, also, that your water tower holds 100,000 gallons, and was built at an even level with the Wellesley reservoir.

Under these conditions it is possible that a sufficient supply for your works would flow to the stand-pipe from the works of the town of Wellesley, if the consumption from the Wellesley main is not such that there is a large loss of head in the passage of the water through the Wellesley mains and the main leading to your stand-pipe. The water furnished by the filter-gallery and the well of the Wellesley water works at Williams Spring, so called, is of good quality for drinking and other domestic uses, but the quantity of water which these sources have furnished in the past has been insufficient for the supply of the town at all times. It is understood, however, that the town of Wellesley has recently completed additional works for obtaining water from the ground, and that a new covered reservoir has also been built. Under the circumstances, it may be practicable for the town to furnish you an adequate supply of good water in addition to the amount that is needed for the supply of its present system; and, if this is the case, the Board can see at present no objection, if mutually satisfactory arrangements can be made, to the plan of supplying the portion of Weston referred to from the works of the town of Wellesley, and is of the opinion that the proposed source would be an appropriate one for the portion of Weston which it is proposed to supply from it.

WEST SPRINGFIELD. An application was received from the water commissioners of West Springfield, Nov. 12, 1897, for the advice of the Board relative to increasing their supply. The Board replied to this application as follows: —

FEB. 4, 1898.

The State Board of Health received from you, on Nov. 12, 1897, an application for advice as to increasing the water supply of West Springfield, in which you state that, application having been made by the Boston & Albany Railroad Company for a supply of water for its use, an increase of the capacity of the town's water plant will be necessary in order to furnish a permanent supply, and that you are considering the plan of taking either Hyde Brook or the Massasoit (also known as Bear Hole) Spring, and connecting the new source with the present reservoir. You also state that, if the water is satisfactory, probably Hyde Brook would be the most practical source, under existing conditions. It is understood that the quantity of water that will be required to supply the Boston & Albany Railroad may be in the vicinity of 200,000 gallons per day.

No records of the consumption of water in the town are kept, and it is not practicable to determine definitely the capacity of the present sources of supply, but, owing to the small size of the water-sheds, it is not probable that they will furnish enough water to supply the town in the drier portion of a dry year.

The Board has caused the proposed sources of supply and other possible sources in the neighborhood to be examined by one of its engineers, and samples of the water of these sources have been analyzed. The water of Hyde Brook is somewhat colored; and it is not feasible to tell from these examinations, which were made at times when the flow of the brook was high, what the quality of the water may be in the drier portion of the year, though, so far as can be judged, they indicate that the quality of the water is likely to be fairly good, and the source does not appear to be exposed to pollution by sewage at the present time. This source has the advantage that its water could be used in connection with the present source by gravity; but the flow of the stream is not known, though, judging from the small size of its water-shed, as measured from the State map, it is not probable that it would furnish a sufficient additional supply for the town, if water is also supplied to the railroad, as proposed, without storage. From a general examination of the water-shed, there does not appear to be a favorable site for a large storage reservoir.

The water of Massasoit Spring is of excellent quality, and, while it is somewhat hard, its hardness might not be very objectionable if the water be mixed with that of the present source. The water of Bear Hole, or Black Brook, which flows near this spring, and forms also the outlet of Ashley Pond, one of the sources of supply of the city of Holyoke, may be of suitable quality for water supply purposes, though it is not practicable to make a definite statement with regard to the quality of this source, from the limited investigations thus far made. No measurements of the flow of the spring or brook in the drier portion of the year have been made, but it is possible that careful investigation would show that a sufficient additional supply for West Springfield could be obtained from these sources, though it might be found less expensive to pump the water than to supply it by gravity.

Examinations have also been made of Pepper Brook, the water-shed of which is contiguous to that of Hyde Brook on the south, and of Block Brook, the water-shed of which lies between the water-shed of Darby Brook, your present source, and Bear Hole or Black Brook, already referred to. Pepper Brook would probably furnish a water of similar quality to that of Hyde Brook, though somewhat harder, and its water could probably be used in connection with that of Hyde Brook by gravity; but, in the absence of any knowledge as to the quantity of water flowing in this brook in the drier portion of the year, it is not feasible to tell whether it would furnish, in connection with Hyde Brook, a sufficient additional supply for the town and railroad at all times, though, judging from the small size of the water-sheds of these brooks, it is not probable that they would furnish all the water required, unless additional storage can be provided.

Block Brook appears to be at such an elevation that its water could be turned into the water-shed of Darby Brook, your present source, by gravity, and the area of its water-shed at the place where it might be diverted is twice as large as those of Hyde and Pepper brooks combined. But there appear to be considerable areas of swampy land within the water-shed of this brook, and analyses of samples of its water show that it is highly colored and contains a large amount of organic matter, so that its water would probably be objectionable for domestic uses.

In order to determine which will be the most economical and otherwise satisfactory source or sources of additional supply for the town, it is necessary that you make further investigations, in order to determine the probable quantity and quality of water that the various sources may be depended upon to yield in connection with the present works, and the probable cost of works for obtaining a sufficient additional supply of water for the town from the sources which are found to be available. In order to obtain such information as is necessary to determine the best practicable method of increasing your water supply, the Board would advise that you employ an engineer of experience in matters relating to water supply to make the necessary investigations.

The Board will, upon application, assist you in such further investigations as you may decide to make, by making analyses of samples of water, and will give you further advice in the matter when you have the results of further investigations to present.

West Springfield. The Board of Health of West Springfield applied to the State Board of Health, March 17, 1898, requesting the opinion of the Board with reference to a proposed plan of using the water of the Agawam or Westfield River in that town, in case of necessity, for extinguishing fires, the water to be pumped into the pipes of the public water supply. The Board replied to this application as follows: —

April 7, 1898.

The State Board of Health received from you, on March 19, 1898, a communication requesting the opinion of the Board as to the advisability of making a connection between a pump in a paper mill in the village of Mittineague and the water supply pipes in that village, in order that at times of fire an extra supply of water may be obtained and greater pressure secured than is furnished by the present system, by pumping water from a canal leading from the Agawam or Westfield River into the water pipes in the village.

The Westfield River now receives the sewage of all of the thickly settled portions of the town of Westfield, which, at the last census, had a population of 10,663. The sewage is discharged, directly into the river, without treatment, chiefly at a point about 7 miles above the village of Mittineague, and the water of the river at the place at which it is proposed to take it would be very dangerous for drinking. If the proposed connection should be made, it might be found necessary or desirable to use the water at times for periods of several hours, and in consequence of this use the river water might flow through a considerable portion of the pipe system, and be used for drinking by many of the people of the village at such times. Moreover, contamination from this source might remain in the pipes for a considerable time, even if they should be thoroughly flushed after the necessity for pumping water from the canal had passed.

The Board, therefore, advises that the introduction of water from the Westfield River into the water supply pipes of the town should be avoided, by all means.

West Springfield. An application was received from the water commissioners of West Springfield, May 8, 1898, for the advice of the Board in relation to the quality of the public water supply of that town. The Board replied to this application as follows: —

June 3, 1898.

The State Board of Health received from you, on May 8, a communication requesting an investigation and advice as to the quality of the water supplied to the town of West Springfield from the present works.

In response to this request the Board has caused an examination of the sources of supply to be made by one of its engineers, and has examined the results of several analyses of samples of water.

The results of analyses of samples of water from the reservoir show that the water is slightly colored and that it often has a vegetable and sometimes a disagreeable odor, and that it contains at some seasons of the year a considerable amount of organic matter. This organic matter is largely in suspension in the form of microscopical organisms, and an examination of the reservoir shows that many of the larger Algæ also grow in this water.

A large quantity of ground water is diverted into the reservoir from a spring in another water-shed, and it is probable that a considerable quantity of ground water enters it from its own water-shed. It is known that organisms of various sorts thrive in ground water when exposed to light in an open reservoir, and it is probable that to this cause is due a large portion of the organic growths in this reservoir.

The presence of such organisms as have been found in this water makes it very objectionable in appearance, taste and odor, but it is not known that these organisms have an injurious effect upon the health of those who may use the water for drinking or cooking purposes. The reservoir does not appear to be exposed to pollution by sewage.

If the soil about the shores of the reservoir is of gravel or coarse sand, it might be possible to construct filter-galleries or wells near the shores of the reservoir, and secure in this way practically all of the water which this source is capable of yielding; but the capacity of the present works is insufficient to meet all requirements, and it is understood that investigations are at present being made with reference to an additional water supply for the town. Under the circumstances, it will probably be best, in selecting a source of supply, to secure one which will furnish a sufficient quantity of water to make it possible to avoid the use of the present reservoir, excepting at times when the quality of the water is satisfactory.

Analyses of samples of water collected from the well used to supply the village of Mittineague show that this water has at some time been polluted by sewage and subsequently well purified in its passage through the ground, so that the water, as shown by these analyses, is of good quality for the purposes of a public water supply. The pollution is probably due to houses and barns located at a considerable distance from the well, the drainage from which probably finds its way into the well. If proper care is exercised in the disposal of sewage from these buildings, and there is no considerable increase in population in this region, it is not probable that the buildings will cause any material injury to the water of the well.

WEST SPRINGFIELD. Another application was received from the water commissioners of West Springfield, Aug. 23, 1898, for the advice of the State Board of Health with reference to the protection and enlargement of the sources of water supply of the town. The Board replied to this application as follows: —

SEPT. 22, 1898.

The State Board of Health received from you, on Aug. 23, 1898, a communication requesting its advice with reference to the protection and enlargement of the sources of water supply of the town of West Springfield, in which your proposed plans are outlined as follows: —

The town by vote at a recent meeting referred the matter of "protection of sources of present water supply" to the commissioners. The board has decided on a plan to recommend to the town for adoption. A line has been run out around the land we propose taking, also the outline for another reservoir above the present one. A plan and description of same is nearly completed by the engineers. We ask that your Honorable Board will send an agent to view the premises as soon as convenient, that your Board may take as early action on the matter as possible. We desire a report from your Board before calling a special meeting of the town to act on our report. If your recommendations are satisfactory all around, it is desirable to begin the work at the earliest possible time, that the town may receive the benefits in the spring.

You have also submitted a plan showing the outline of your present reservoir, the outline of a new reservoir which you propose to construct upon Darby Brook by building a dam at the roadway which crosses the brook at the head of your present reservoir, and the outline of lands which you propose to take about the new reservoir. You also propose to enlarge your present reservoir by increasing the height of the dam so as to raise the surface at high water 4 feet above its present level.

The Board has caused the locality to be examined by its engineer, and has carefully considered the proposed plans.

It is evident that your present sources are inadequate to supply the large amount of water used for mechanical purposes, in addition to the quantity required for ordinary domestic and public uses and that an additional supply is necessary.

The quality of the water of your present reservoir is at times objectionable for drinking and other uses, on account of disagreeable tastes and odors; and, in response to a request made by you, in May of the present year, for an investigation and advice as to the quality of your water supply, the Board replied as follows: —

The results of analyses of samples of water from the reservoir show that the water is slightly colored and that it often has a vegetable and sometimes a disagreeable odor, and that it contains at some seasons of the year a considerable amount of organic matter. This organic matter is largely in suspension in the form of microscopical organisms, and an examination of the reservoir shows that many of the larger Algæ also grow in this water.

A large quantity of ground water is diverted into the reservoir from a spring in another water-shed, and it is probable that a considerable quantity of ground water enters it from its own water-shed. It is known that organisms of various sorts thrive in ground water when exposed to light in an open reservoir, and it is probable that to this cause is due a large portion of the organic growths in this reservoir.

The presence of such organisms as have been found in this water makes it very objectionable in appearance, taste and odor, but it is not known that these organisms have an injurious effect upon the health of those who may use the water for drinking or cooking purposes. The reservoir does not appear to be exposed to pollution by sewage.

If the soil about the shores of the reservoir is of gravel or coarse sand, it might be possible to construct filter-galleries or wells near the shores of the reservoir, and secure in this way practically all of the water which this source is capable of yielding; but the capacity of the present works is insufficient to meet all requirements, and it is understood that investigations are at present being made with reference to an additional water supply for the town. Under the circumstances, it will probably be best, in selecting a source of supply, to secure one which will furnish a sufficient quantity of water to make it possible to avoid the use of the present reservoir, excepting at times when the quality of the water is satisfactory.

By the plan you now propose, a larger quantity of water would be stored in reservoirs exposed to the light than is the case at present, and the water would be exposed to the light for a longer time. There would be, by this plan, no material change in the character of the water entering the reservoirs, and, under the circumstances, it is probable that the water of these sources would be affected by the presence of large numbers of organisms, and would be objectionable at times on account of disagreeable tastes and odors. Moreover, while the construction of the proposed new reservoir and the raising of the height of your present reservoir would increase considerably the available supply from Darby Brook, it is not probable that, even with this increase, the quantity of water which these sources would furnish in a dry year would be sufficient to supply all of the water that the town will require if you continue to supply water for other than ordinary domestic and public uses.

Under the circumstances, the Board does not at present advise the enlargement of your supply by the construction of a new reservoir and the increase in the storage capacity of your present reservoir, as you now propose.

In reply to an application with reference to increasing your water supply, under date of Feb. 4, 1898, the Board advised that, in order to obtain such information as is necessary to determine the best practicable method of increasing your water supply, you employ an engineer of experience in matters relating to water supply to make the necessary investigations. There appear to be several sources in the vicinity of West Springfield from which a large supply of good water may be obtained, and, in the opinion of the Board, it will be for the interests of the town, before making a large outlay for increasing and protecting its sources of water supply, to determine beforehand, as definitely as possible, the most appropriate source from which a further supply of water can be obtained, having in view the present needs and probable future requirements of the town; and the Board would again urge, before any steps are taken for enlarging the supply, that a thorough investigation be made, under the direction of an engineer of experience in matters relating to water supply.

The Board would again state that it will assist you in such an investigation by making any further analyses of the various possible sources of supply that may be necessary, and will, upon application, give you further advice when you have the results of further investigations to present.

WHITMAN. An application was received from the water commissioners of Whitman, Nov. 18, 1898, for the advice of the Board relative to the propriety of taking the water of Maquam Pond as a source of supply for the town, instead of the present source. The Board replied to this application as follows: —

JAN. 5, 1898.

The State Board of Health received from you, on Nov. 18, 1898, an application for advice with reference to a proposed source of water supply for the town of Whitman, in which you state that you propose to take water from Maquam Pond, located in the town of Hanson, about 5 miles from Whitman. You also state that, while Maquam Pond is not large, you believe that it will furnish a supply of water for Whitman for many years in the future, and that it can be supplemented, when necessary, by other sources at a greater distance from the town. It appears that the average daily consumption of water in Whitman during 1898 has been less than 150,000 gallons, and that the population of the town may be about 6,500. The proposed new supply will take the place of the sources now used, which furnish water which is not only of very poor quality, but is unsafe for drinking, on account of pollution by sewage.

The question as to whether Maquam Pond is a suitable source of water supply for Whitman was considered by this Board in response to an application from your board in 1893; and on May 4, 1893, after an examination of this pond and other sources in the vicinity, the Board advised as follows with reference to the capacity of Maquam Pond: —

It is not feasible to tell, from the information at present available, whether or not Maquam Pond will furnish sufficient water to meet the requirements of the town of Whitman even in the near future, and this source should not, therefore, be adopted in any case without making provision for supplementing the supply from some other source when necessary. In order to form an opinion as to whether this pond will furnish enough water to warrant taking a supply from it in the beginning, it would be necessary for you to ascertain by surveys the size of the water-shed from which its supply is derived, and to make investigations to determine how much, if any, water is liable to be lost by filtration through the ground into other ponds.

The quantity of water used by Whitman increased considerably for three years after the last reply was made; but during the last two years the use of water from the public supply has fallen off greatly, due, probably, in a considerable degree, to the poor quality of the water supplied from the public works.

The Board has caused a further examination of Maquam Pond and its surroundings to be made by its engineer, and has caused several samples of the water to be analyzed. The results of these analyses give practically the same indications as to the probable quality of the water as the results of the analysis made by this Board in response to your former application. They show that the water of Maquam Pond is very soft, practically colorless, and in most respects a very satisfactory pond water. The sample analyzed in 1893, and one of the samples collected recently, were found, however, to contain a considerable number of organisms, of kinds which impart to water a disagreeable taste and odor. It is not practicable to tell, from the limited number of examinations thus far made, whether troubles from this cause are likely to be of frequent or regular occurrence, though it seems hardly probable that in a pond of this character such troubles will be serious or long continued.

With regard to the quantity of water that this source will yield, it does not appear that any further information has been obtained since the matter was last considered by the Board; and such further investigations as it has been practicable for the Board to make are insufficient to show at all definitely the probable quantity of water which this source will yield. The pond is situated at a considerably higher elevation than other ponds in the vicinity, and it is surrounded by gravelly soil; so that the conditions appear to be favorable for the filtration of water from the pond through the ground toward other ponds at lower levels, and there is some evidence that a large amount of water is lost from the pond in this way. It is reasonable to expect that, with the introduction of an ample supply of soft, clear and nearly colorless water, a marked increase would occur in the use of water from the public works in Whitman; and, judging from the information at present available as to the capacity of Maquam Pond and the size of its water-shed, it is doubtful, in the opinion of the Board, whether the yield of the source would be sufficient for the supply of the town, even if no considerable quantity of water is lost by filtration, should a series of dry years occur in the near future. The only way in which the capacity of this pond can be determined is by making a survey to learn the extent of the water-shed, and by making investigations to determine how much, if any, water is lost by filtration through the ground to ponds at lower levels, as advised in the previous reply of the Board.

With regard to supplementing the supply from other sources, as suggested in your application, the investigations by the Board indicate that it is practicable to obtain an ample additional supply from Oldham Pond, which is distant at the nearest place about 1,900 feet from Maquam Pond. Monthly analyses of the water of Oldham Pond, made during the year 1898, indicate that it is at times highly colored and contains a large quantity of organic matter; but in the latter part of the winter and in the spring the water had only a moderate color, and was in other respects of good quality. By pumping water from Oldham Pond into Maquam Pond during the winter and spring seasons, when the quality of the water of Oldham Pond is at its best, and by discharging this water into Maquam Pond at some place remote from the place from which the water is drawn out, thereby allowing the water to mingle thoroughly with that of Maquam Pond and receive all the benefit practicable from storage in Maquam Pond, an ample supply of water for Whitman could undoubtedly be obtained, and it is not likely that the quality of the water of Maquam Pond would be affected in any noticeably unfavorable degree by the introduction into it of water from Oldham Pond.

In selecting a new source of water supply, it appears to the Board desirable for you to consider the feasibility of obtaining a supply from, or in connection with, the towns of Abington and Rockland, which at present take their supply of water from Big Sandy Pond.

The water of Big Sandy Pond has always been of good quality, and that pond is capable of supplying considerably more water than is now used by the three towns of Rockland, Abington and Whitman. The main pipe which supplies Abington and Rockland passes near the town of Whitman; and, if these works are capable of furnishing a suitable supply of water to Whitman, in addition to the other towns at all times, the town of Whitman might obtain a satisfactory water supply from these works at less expense than in any other way.

While the need for a new water supply in Whitman is urgent, owing to the great danger to the health of the inhabitants of the town from the use of the present sewage-polluted sources, and while considerable time may be consumed in making further investigations, the Board is, nevertheless, of the opinion that it will be for the best interests of the town to make such investigations as are necessary to determine the best source of supply available for the town, before deciding upon its future source of water supply.

The Board would, therefore, advise the town of Whitman to investigate the feasibility of obtaining a supply from, or in connection with, the towns of Abington and Rockland; and that at the same time you cause an investigation to be made, with the assistance of an engineer of experience in matters relating to water supply, to determine the area of the water-shed of Maquam Pond, the probable quantity of water, if any, that may be lost by filtration therefrom, and the probable cost of obtaining a supply of water from Maquam Pond, supplemented, when necessary in the future, by water pumped from Oldham Pond into Maquam Pond. It is important, also, that frequent analyses be made of the water of Maquam Pond.

A good ground-water supply, owing to its freedom from color, taste and odor, would be more satisfactory than a surface-water supply; and the conditions appear to be very favorable for obtaining a ground-water supply from the vicinity of Maquam Pond, and there are indications that it may be possible to obtain such a supply from the ground near Oldham Pond. In view of these conditions, the Board would advise that you include in your investigations an examination of the ground in the vicinity of Maquam and Oldham ponds, and, if the conditions are found to be favorable for obtaining a satisfactory supply in this way, that you cause an estimate to be made of the probable cost of obtaining a supply of water for Whitman from the ground in the vicinity of one of these ponds.

The Board will assist you in these investigations by making such analyses of samples of water as may be necessary, if you will collect the samples, and will, upon application, give you further advice in this matter when you have the results of further investigations to present.

WHITMAN (the Commonwealth Shoe and Leather Company). An application was received, Nov. 29, 1898, from the Commonwealth Shoe and Leather Company of Whitman, for the advice of the Board relative to the use of the water of certain wells which had been driven upon the premises of the corporation. The Board replied to this application as follows: —

JAN. 5, 1899.

The State Board of Health has carefully considered your application for advice as to whether the water drawn from seven driven wells located at the northerly side of your factory in the village of Whitman is suitable for drinking.

The Board has caused the locality to be examined by its engineer, and several samples of water have been collected from the wells for analysis. The results of the analyses show that, at the time these samples were collected, the water was nearly clear and colorless and free from odor, but that it was hard, and contained an excessive amount of nitrates and chlorine, showing that much of the water entering the wells has at some time been highly polluted by sewage, and it is evident that the water has not been wholly purified in its passage through the ground to the wells.

The town of Whitman has no sewerage system, and the sewage from buildings in the region about the wells is collected in cess-pools and similar receptacles, or discharged upon the ground, thus greatly polluting the ground water. Experience with wells in similar situations indicates that the quality of the water is likely to deteriorate with continuous use.

Under the circumstances, these wells cannot be regarded as a safe source from which to take water for drinking, and the Board would advise that the use of the water for this purpose be avoided, and that water of known purity be supplied to the employees of your factory for drinking.

Wilmington. An application was received from the board of health of Wilmington, Nov. 17, 1898, requesting that an examination should be made of the water of a well intended for use as drinking water in a new school-house being erected in that town. The Board replied to this request as follows: —

Jan. 5, 1899.

The State Board of Health has considered your application for advice with reference to the quality of the water of a well newly dug and intended to supply drinking water for a new school-house in the north district of Wilmington.

The Board has caused an examination of the well and its surroundings to be made and a sample of the water to be analyzed. The water of the well had a very strong and offensive odor at the time the sample was collected, and the analysis indicates that the water entering the well has been considerably polluted by sewage, and has not yet been purified in its passage through the ground.

The indications are that the pollution comes from a drain which passes under the road near the well, since the waters of this drain appear to receive pollution from buildings situated not far from the well.

In view of the circumstances, this source must be regarded as a dangerous one from which to take water for drinking, and the Board would advise that the use of water from this source for drinking be prevented.

Sewerage and Sewage Disposal.

The following is the substance of the action of the Board during the past year in reply to applications relative to sewerage and sewage disposal: —

Andover. The sewer commissioners of Andover applied to the Board, March 19, 1898, for its approval, under chapter 386 of the Acts of 1895, of a system of sewerage and sewage disposal for that town. The Board replied to this application as follows: —

May 7, 1898.

The State Board of Health received from you, on March 21, 1898, an application requesting the approval of a proposed plan of sewerage and sewage disposal for the town of Andover, under the authority of chapter 375 of the Acts of 1888, and chapter 386 of the Acts of 1895. The plan proposed by you is described in your application as follows: —

The system proposed is the separate system, *i. e.*, for sewage only. The entire system includes about 23.9 miles. The proposed outlet is into the Merrimack River, at or near the mouth of the Shawsheen River.

A general description of the system is as follows: starting at the Merrimack River, at or near the mouth of the Shawsheen River, thence through private land, in a general south-westerly direction, along the southerly side of the Shawsheen River to Haverhill or Lowell Street in Andover. Said line passes through a part of North Andover and Lawrence, thence in a westerly direction on Haverhill or Lowell Street to Main Street, thence in a southerly direction on Main Street to the top of the hill at the Andover Seminary. A branch sewer enters the main sewer at Marland Street. This branch sewer is described as follows: starting at the junction of Main and Marland streets, thence in a general southerly direction through Marland and Mineral streets and private land to Ballardvale.

Into this main and branch sewer lead the lateral sewers, in sizes from 6 to 12 inches.

The main sewer from the Merrimack River to a point on Main Street near the Shawsheen River is a 24 inch pipe. The remainder is 20, 15, 12, 10 and 8 inch. The Ballardvale sewer is a 15 and 12 inch pipe. The plans submitted show the sizes of pipes and direction of flow of the sewage. The 24 inch has a grade of 1 foot in 1,000 feet. The lateral sewers have good grades.

A plan is submitted, showing the size of pipes and direction of flow.

The town of Andover, through its sewer commissioners, hereby ask your approval of the proposed plan for a system of sewerage, as required under chapter 386 of the Acts of 1895.

The blue lines on the said plan show the part of the system the town proposes to build in 1898, about 7 miles.

The town proposes to construct a settling tank and filter beds at a point on the Shawsheen River near where the Boston & Maine Railroad crosses said river, and to discharge the purified sewage or water into the Shawsheen River at said point; this outlet and method to be temporary. Plans showing in detail the proposed settling tank, filter beds and outlet, will be submitted to the State Board of Health. The town of Andover, through its sewer commissioners, hereby petition the State Board of Health for permission or license to drain temporarily into said Shawsheen River, said permit to contain such restrictions as said Board of Health may see fit to impose. . . .

The application was accompanied by a plan, showing the proposed system and the portion of it which it is proposed to construct in the beginning. Plans were also submitted, on a subsequent date, showing the proposed temporary settling tank and filter beds on the southerly bank of the Shawsheen River, just east of the Boston & Maine Railroad.

The system as designed provides for collecting the sewage of all of the thickly settled portion of the town, for which sewerage facilities are likely to be necessary, into a main sewer in the valley of the Shawsheen River in the vicinity of Frye Village, from which it is proposed to continue the main sewer along the easterly side of the Shawsheen River to a place of discharge into the Merrimack River, just below the mouth of the Shawsheen River. It is proposed in the beginning to construct this main sewer down to a proposed temporary filtration area near the place where the Boston & Maine Railroad crosses the Shawsheen River, and to purify it there by means of a settling tank and filter beds, and discharge the effluent into the Shawsheen River.

The Board has carefully considered the plans submitted, and has caused the examination of the locality to be made by its engineers.

In the course of examinations in this region, it appeared that good soil for the filtration of sewage could be found on higher land on both sides of the river in the vicinity of the proposed temporary disposal works; and it was suggested that a further investigation be made, to determine whether there was a sufficient area of suitable land in this vicinity for the disposal of all of the sewage of the town. Subsequently, a plan was submitted showing the contour of the land that appeared to be available for sewage-disposal purposes, and your engineers also submitted samples of the soil from many test pits upon this area, together with estimates of the cost of disposing of the sewage of the town by pumping it to filter beds upon this area, as compared with the estimated cost of conveying the sewage to a point of discharge into the Merrimack River.

According to the estimates of cost submitted, it appears that the cost to the town of disposing of the sewage by pumping it to filter beds upon the area of higher land near the Shawsheen River would probably be less for many years than the cost of conveying the sewage to the Merrimack River; but these estimates indicate that, if a longer period is taken into consideration, it might be cheaper to adopt in the beginning the plan of conveying the sewage to the Merrimack River.

It appears to the Board that, with the growth of population in the valley of the Merrimack River and the consequent pollution of the stream from the many cities, towns and factories upon it which discharge sewage into the stream, the time is likely to come when some method of purification of the sewage will have to be adopted; and, in estimating upon the probable future cost of the Merrimack River outlet, the possibility that Andover may still in time find it necessary to purify its sewage, even if conveyed to the Merrimack River, should be taken into consideration, especially as there is a section in its sewerage act providing for the prevention of a nuisance from the discharge of its sewage into the river in the vicinity of North Andover. Under the circumstances, it is probable that, even in the long run, it will be more economical for the town to purify its sewage in the beginning.

The estimates of cost of disposing of the sewage by filtration are based upon a plan which provides for conveying all of the sewage by gravity through a sewer in the valley of the Shawsheen River to a point near the filtration area, and there pumping it to the height necessary for disposing of it upon the area. It appears to be possible, from a general examination of the territory, to collect the sewage from nearly all of the town that is said to require sewerage facilities at present, and to convey it to the possible filtration area near the Shawsheen River by gravity at such an elevation that nearly all of the best portions of the area would be available for the disposal of sewage without pumping. If this plan is feasible, its adoption might effect a considerable saving of cost to the town in disposing of its sewage. It would still be necessary, however, to provide some means of disposing of the sewage from the lower levels in the town. Two methods appear to be practicable; one by constructing a sewer in the valley of the Shawsheen River, to discharge upon artificial filter beds constructed on the lower portions of the filtration area, and the other by providing a pumping plant for pumping the sewage from the lower levels in the town into the high-level main sewer. It is understood that sewerage facilities are not required at present by the village of Ballardvale or by Frye Village; and, if this is the case, the quantity of sewage which would have to be disposed of from the low levels would be likely to be very small, in the beginning at least.

In view of all the circumstances, the Board does not at present approve the plans submitted, but advises that you give the matter further consideration, to determine whether it will not be more satisfactory and economical for the town to dispose of its sewage by filtration within its own limits than it would be to construct a sewer to convey the sewage to the Merrimack River. The Board will give the matter prompt consideration when you have the results of further investigations to present.

On May 18, 1898, the sewer commissioners again applied to the Board for approval of a system of sewerage and sewage disposal, involving filtration of the sewage upon a tract of land near the Shawsheen River, and east of the Boston & Maine Railroad in that town. After a public hearing, duly advertised, had been held, on June 2, 1898, as required by chapter 124 of the Acts of 1890, the Board replied to the application of the Andover sewer commissioners as follows: —

June 8, 1898.

The State Board of Health received from you, on May 20, 1898, an application giving notice of your intention to introduce a system of sewerage in the town of Andover, and submitting your proposed plans for the advice and approval of this Board, under the authority of chapter 375 of the Acts of 1888 and chapter 386 of the Acts of 1895. You also request the approval of the Board, in accordance with the provisions of chapter 50, section 1, of the Public Statutes, as amended by chapter 124 of the Acts of 1890, of the taking of certain lands within the limits of the town of Andover for sewage-disposal purposes.

The plans provide for a system of sewers, designed to take sewage only, connecting with a main sewer which will convey the sewage by gravity to a proposed filtration area located on the easterly side of the Boston & Maine Railroad, and on both sides of the Shawsheen River, just south of the boundary line between the town of Andover and the city of Lawrence. A portion of the main village and the villages of Ballardvale and Frye Village are situated at so low a level that the sewage from these districts cannot be discharged into the main sewer by gravity. It is proposed to collect the sewage of these districts at a pumping station to be located on Main Street on the easterly side of the Shawsheen River, and to pump the sewage from this place into the main sewer. In connection with this pumping station it is proposed to provide an overflow or waste pipe leading to the Shawsheen River in the vicinity of Main Street, in order to discharge sewage into the Shawsheen River in case of emergency. It is understood that this overflow or discharge pipe is to be used only in cases of emergency, such as an accident to pumps, pumping station or force main, and it is not for frequent or regular use.

The route of the proposed main sewer from the town to the filtration area lies across a valley. From the corner of High Street and Pray's Road to the filtration area, a distance of about 5,467 feet, the sewer is to be laid in the form of an inverted siphon, and is to be constructed of iron pipe. At the lowest point in this siphon it is proposed to construct a blow-off, for the purpose of emptying the pipe if necessary; and it is proposed to take a small area of land and to construct a filter bed at this place, to receive the sewage that may be discharged from this blow-off. At the filtration area the main sewer is to discharge into a settling tank, in connection with which it is proposed to provide a flush tank to discharge the sewage intermittently upon the filter beds.

It is proposed to prepare twenty filter beds in the beginning, covering an area of 4 acres, and to provide underdrains beneath those beds to collect the effluent and convey it to pipes leading to a small brook which flows through the proposed filtration area and discharges into the Shawsheen River. It is also proposed to prepare about 2 acres along the side of a steep hill, with ditches from 10 to 20 feet apart, along the sides of the hill, into which sewage can be discharged when necessary. It is proposed to provide a system of underdrainage for this bed similar to that of the beds referred to above, and to discharge the effluent into the brook. Two sludge beds are also to be prepared, to receive sludge from the settling tank. It is understood that, aside from the proposed overflow or discharge pipe at the pumping station already referred to, which may be used in case of emergency, no crude or unpurified sewage is to be discharged into the Shawsheen River, or any stream or water course tributary thereto.

The Board has considered the proposed plans, and concludes that they are, in general, adapted to the disposal in a satisfactory manner of the sewage from the districts in the town of Andover for which it is proposed to provide sewerage facilities. It appears that only a limited portion of the lower districts in the town are likely to require sewerage for several years; and the proposed method of disposing of the sewage from these areas by collecting it at a pumping station on Main Street, near the Shawsheen River, and pumping it into the main sewer leading from the town to the filtration area, is probably, under the circumstances, the best that it is practicable to adopt. If it becomes necessary in the future to materially extend the sewers in these districts, it may be found desirable to change somewhat the proposed plans; but the consideration of other possible methods of disposing of the sewage from these districts may properly be omitted until there is need of much more extensive sewerage facilities than it is proposed to provide in this region in the beginning.

The Board hereby approves the proposed plan of sewerage and sewage disposal for the town of Andover, as herein described, under the provisions of chapter 386 of the Acts of 1895.

It is very important that all storm water be kept out of the sewers; and, by providing underdrains beneath the sewers to carry off ground water, as proposed, the quantity of sewage to be disposed of can be made smaller than would otherwise be the case, and a smaller area of filter beds will be required.

The velocity of flow through the inverted siphon may not be sufficient, in the beginning at least, to prevent deposits; but the proposed blow-off at the lowest point in this siphon will make it practicable to flush out the siphon from time to time, if it becomes necessary. There would be more certainty of the satisfactory operation of the siphon at all times, if means were taken to prevent the entrance of large substances which might tend to clog it.

In response to the request contained in your application for the approval of the Board of the purchase or taking of certain lands for sewage-disposal purposes, described in your application and shown upon a plan submitted, the State Board of Health gave notice that a public hearing upon this matter would be given at its office on June 2, 1898, as required by chapter 50, section 1, of the Public Statutes, as amended by chapter 124 of the Acts of 1890. At this hearing no person appeared to oppose the taking of the lands referred to for sewage-disposal purposes; and the Board hereby approves the purchase or taking by the town of Andover, for the purification and disposal of the sewage of the said town, of land bordering the easterly side of the Boston & Maine Railroad, just south of the boundary line between the town of Andover and the city of Lawrence, and of another lot of land located in the vicinity of the proposed blow-off from the main sewer and adjoining land now owned by the town of Andover, as shown upon a plan submitted, May 20, 1898, entitled, "Plan of Proposed Siphon and Filter Area of Andover, Mass., May 12, 1898. McClintock & Woodfall, Civil Engineers," said land being described in your application as follows: —

The main area for filtration is described as follows: beginning at a point in the easterly line of the location of the Boston & Maine Railroad, thence running parallel to the Lawrence city line and 5 feet southerly therefrom S. 68° 16′ E — 2,118.0 feet; thence S. 25° 19′ W — 601.2 feet; thence S. 59° 13′ W — 789.9 feet to the aforesaid easterly line of the Boston & Maine Railroad; thence following said easterly line of the Boston & Maine Railroad northerly 2,015.9 feet to the point of beginning.

The area for filtration at the blow-off of the siphon line is described as follows: beginning at the south-easterly corner of said area, at a point where the line of the proposed sewer crosses the boundary wall between land of George Mander and land of the town of Andover, thence running in a westerly direction along the line of said wall 175 feet to the boundary wall between the aforesaid land of George Mander and land of David Middleton, thence running in a northerly direction along said wall 161 feet, thence running in an easterly direction 174 feet to the aforesaid line of proposed sewer, thence in a southerly direction 195 feet to the point of beginning.

ATTLEBOROUGH. The selectmen of Attleborough applied to the Board, June 24, 1897, for its advice relative to a proposed system of sewerage and sewage disposal for that town, to which the Board replied as follows: —

JAN. 27, 1898.

The State Board of Health received from you, June 25, 1897, an application for advice with reference to a proposed system of sewerage and sewage disposal for the town of Attleborough, in which you refer to a report and plans made by engineers employed by the town, which you submitted with the application.

The plan first proposed provided for disposing of the sewage from the present sewers in Union and County streets, by pumping the dry-weather flow of the County Street sewer into the Union Street sewer, and extending the latter sewer to a tract of low land having an area of about 10 acres in the vicinity of the Ten-mile River near Tiffany Street, upon which area it was proposed to dispose of this sewage by filtration. Upon an examination of this land, however, it was found that the soil consisted of a deep layer of loam and subsoil, beneath which the material was a very fine sand, so that the disposal of any considerable quantity of sewage upon this area would be impracticable; and a further plan was then prepared and submitted to the Board on Jan. 1, 1898. By this plan it is proposed to collect the sewage from the Union Street and County Street sewers, together with other sewage from the district, at a location between the railroad and the river about opposite the end of Manchester Street, and to pump the dry-weather flow to a proposed filtration area in the vicinity of Tiffany Street, adjoining the area already referred to, but situated at a higher elevation.

The works now proposed are intended to form a part of a general system of sewerage for the town of Attleborough. One of the essential features of this system is the collection of the sewage from several proposed sewer districts in the town, by means of sewers converging at the lowest point in each district, from which it is to be pumped into a force main leading to the proposed filtration area near Tiffany Street. It is proposed in the beginning to pump only the dry-weather flow of the sewers now built, which drain an area which will form a part of District No. 1 of the proposed plan, to the proposed filtration area, allowing the excess of flow of mingled sewage and water at times of rains or thaws to discharge into the river.

It is also proposed at first to provide only a limited pumping capacity, but to construct a force main having a diameter of 12 inches, which is large enough to provide for removing a much larger quantity of sewage than the dry-weather flow of the present sewers, which is thought to be about 150,000 gallons per day, though it is understood that the dry-weather flow has not been definitely determined.

The Board has examined the proposed plans, and has caused an examination of the land which it is proposed to use for filtration purposes to be made by one of its engineers, and finds that it is well adapted to the purpose, both in its location and in the character of the soil, which is excellent for the disposal of sewage by intermittent filtration, and that the area is of such size as to be capable of providing for the disposal of the sewage of Attleborough for many years in the future.

The rate at which you propose to pump sewage through the force main appears to be so small that deposits are likely to occur in the pipe and cause serious trouble, nor does it appear to be feasible to secure a greater velocity through the pipe at any time for flushing purposes. It is very desirable that such change be made in the plan as will avoid this difficulty.

With regard to the other features of the proposed plan, no details have been submitted showing the proposed method of construction and operation of the force main, storage reservoirs, ejector or pumping stations or other essential features, nor have plans been submitted showing the proposed systems of street sewers.

The present sewers, as already stated, receive both sewage and storm water from a large district, and it is proposed to pump only the dry-weather flow of these sewers, allowing the excess at times of storms and thaws to discharge into the stream. This is a very objectionable feature of the proposed plan, since, if this plan is used, a considerable quantity of sewage will still be discharged into the stream at times of storms or thaws; and, in order to be sure of pumping the maximum dry-weather flow of the sewage at all times, and avoiding the discharge of sewage under ordinary conditions into the stream, it will be necessary at other times to pump considerable quantities of storm water, thus increasing the cost of pumping. Moreover, the disposal of the mingled sewage and storm water will require a larger area of filter beds than will be required if sewage only is discharged upon them, and there would be more difficulty in disposing of the sewage upon the beds, especially in cold weather, when its temperature is reduced by the admission of storm water.

The information furnished as to the method of construction and operation of the proposed system of sewerage for the town of Attleborough is not sufficient to enable the Board to advise as to whether this plan is the most economical and otherwise appropriate for the town of Attleborough to adopt. In the opinion of the Board, however, it is very desirable that, whatever plan be adopted, the storm water be kept separate from the sewage in making future extensions, and that sewers for conveying sewage only be constructed to receive the sewage which is now discharged into the existing storm water sewers.

The Board would advise that, before constructing partial works, as proposed, the whole matter be given further consideration, in order that the most feasible and economical plan may be selected, having in view both the present needs and probable future requirements of the town in the matter of sewerage, drainage and sewage disposal.

THE BROCKTON HOSPITAL COMPANY. An application was received from the Brockton Hospital Company, Aug. 19, 1898, for the advice of the Board relative to a proposed plan of sewage disposal for that institution. The Board replied to this application as follows: —

SEPT. 1, 1898.

The State Board of Health received from you, on Aug. 19, 1898, an application for advice with reference to a proposed system of sewage disposal for the Brockton hospital, accompanied by a plan and general description of the proposed works. The present method of disposing of the sewage is by means of cess-pools, and it is not satisfactory, on account of the character of the soil, which is fine and compact. Owing to the distance of the hospital from the thickly settled portion of the city, it is not practicable, under present conditions, to dispose of the sewage in connection with the general system of the city.

Your proposed plan provides for collecting the sewage in a storage and flush tank having a capacity of about 2,000 gallons, which will discharge its contents automatically upon four filter beds, having an aggregate area of about 2,000 square feet, which are to be constructed upon the hospital grounds, of sand to be hauled from a sand bank about one mile away.

The proposed filter beds are to have a depth of 4½ feet, and the effluent is to be collected in underdrains, which will discharge through a single pipe into a small pond near the filter bed. The quantity of sewage at present produced by the hospital is not definitely known, but is probably somewhat less than 2,000 gallons per day.

The Board has caused the locality to be examined by one of its engineers and has carefully considered the proposed plans.

Examinations of the sand in the sand bank from which it is proposed to take the material for the construction of the filter beds indicate that material of excellent quality for this purpose can be obtained from this sand bank, and, if the most suitable material is used, the proposed filter beds will be of sufficient size for the disposal of the sewage of the hospital, even though the quantity of sewage becomes somewhat greater than it appears to be at present.

The proposed method of disposing of the effluent from the underdrains beneath the filters, by discharging it directly into a small pond near the filter beds, might foster large growths of Algæ and similar organisms in this pond, which would make it unsightly and perhaps objectionable under the circumstances. It appears to be practicable to lay a pipe to convey the effluent to a small stream below the ponds on the hospital grounds, or possibly to drain these ponds by constructing a suitable drainage channel leading to a stream a short distance away, and the Board would recommend that the effluent be discharged into the stream in the valley below the lower pond unless the ponds are suitably drained.

The Board is of the opinion that the plan in general, with the modifications suggested as to the disposal of the effluent, is a suitable one for the disposal of the sewage of the Brockton hospital, under the present circumstances.

Concord. A communication was received, June 30, 1898, from the sewer commissioners of the town of Concord, giving notice of their intention to construct and maintain a system of sewerage in that town, under the authority of chapter 151 of the Acts of 1895; at the same time submitting plans and a general description of the proposed system and the location of land to be taken for sewage disposal, for the consideration and approval of the State Board of Health. The Board replied to this communication as follows: —

AUG. 10, 1898.

The State Board of Health received from you, on June 30, 1898, a communication giving notice of your intention to construct and maintain a system of sewerage in the town of Concord, and you have submitted plans and a general description of the proposed system, and the location of lands to be taken for the purpose of sewage disposal, for the consideration and approval of the State Board of Health, under the authority of chapter 151 of the Acts of 1895. The description of the proposed system submitted by you is as follows: —

Outline of Concord Sewerage System accompanying Plans submitted to the State Board of Health by the Concord Sewer Commissioners.

The general arrangement of pipe sewers for the town of Concord is clearly set forth on the plan entitled "Preliminary Plan of Sewerage System for the Town of Concord, Mass." Briefly outlined, the system can be described as follows: —

The pipe sewers cover three general districts, the first, the north-easterly portion of the town, comprising all of that portion of the town lying to the north and east of the junction of Main Street and Sudbury Road, and of Stow Street and Hubbard Street. The sewers of this district are all tributary to the main 10-inch sewer running through Lowell Road from Main Street to the pumping station lot near the Boston & Maine Railroad track, and discharge into the main storage well and screen chamber opposite the pumping station.

The second district comprises the central portion of the town, lying south of the Sudbury River, west of the junction of Main Street and Sudbury Road and of Stow Street and Hubbard Street, and east of the junction of Main Street and Elm Street. This entire district is tributary to the 10-inch sewer running through Nashawtuc Road from Main Street to a collecting chamber on the southerly side of the Sudbury River, just east of Nashawtuc bridge.

The third district comprises the territory west of the junction of Main and Elm streets, and is tributary to the 8-inch sewer running from the junction of River and Elm streets westerly along Elm Street to the collecting chamber on the east side of the Sudbury River and north of the Elm Street bridge.

It may be said, in general, in regard to the pipe-sewer system, that it is a separate system, with minimum grades of 1 per cent. on 6-inch lines and ½ per cent. on 8-inch lines, flush tanks being placed at the heads of lines with grades flatter than 2 per cent.

The collecting chamber and river crossing at Elm Street is clearly set forth in the detailed plan therefor, the collecting chamber having a capacity of approximately 1,700 gallons. By means of a flush tank it will be automatically discharged intermittently.

The collecting chamber and river crossing east of Nashawtuc bridge is also clearly set forth in the detailed plan therefor, which provides for a chamber of approximately 7,400 gallons capacity, discharging intermittently. The river crossing near the Boston & Maine Railroad bridge is also shown in detail.

A detailed plan shows the general arrangement of the screen chamber and storage well to be built opposite the pumping station. Briefly stated, the storage well is a circular well, 60 feet internal diameter, with 24-inch brick walls laid in Portland cement mortar, covered by a concrete groined elliptical arch roof with a Portland cement concrete segmental groined arch bottom, draining toward the screen well, from the bottom of which runs the suction pipe leading to the pumps in the pumping station. The two pumps of 1,000,000 gallons capacity per twenty-four hours each, placed in said pumping station, will discharge the sewage through a 10-inch cast-iron force main laid along the line of the Boston & Maine Railroad location upon sand filtration beds, to be constructed upon the land at the easterly end of the Lang estate, a plan of which is submitted herewith.

Of the filtration lands shown upon the accompanying plans, it is proposed to acquire not less than 10 acres that shall be suitable for filtration purposes, upon which shall be prepared and constructed for present use such filter beds of about one acre net area each as the proper treatment of the sewage shall require.

The plans submitted for the consideration and approval of the Board show a system of pipe sewers designed to collect the sewage of the thickly built up portion of the main village of Concord upon the separate plan, and convey it to a proposed collecting well or reservoir to be located between the Lowell Road and the Sudbury River, and close to the southerly side of the Boston & Maine Railroad, from which the sewage is to be forced by means of a pump, to be located in a building near the reservoir, through an iron pipe 10 inches in diameter to land situated on both sides of the Boston & Maine Railroad, about one mile north-east of the main village of Concord, which it is proposed to use for the purpose of sewage disposal. It is understood to be a part of the plan submitted that all the sewage is to be conveyed to the proposed filtration area and there purified, and that no unpurified sewage is to be discharged into the Sudbury or Concord rivers, or any other stream, pond or water course, from any sewer or other part of the proposed works.

The Board has carefully considered the proposed plans, and has caused the territory to be examined by its engineer and samples of the soil from test pits on the land which it is proposed to take for the purposes of sewage disposal to be analyzed.

The location selected for the pumping station is such that it will be at a considerable distance from dwelling-houses, for the present at least; but its proximity to the highway and a railroad station will make it necessary, in order that there may be no odor from it in the neighborhood, to make provision for thorough ventilation, into the chimney connected with the boiler house, of the sewers, screen chambers, reservoir and any other places from which an odor of sewage might escape. The station and its appurtenances can be so constructed and operated that no odor of sewage will ever be noticed from it in the neighborhood.

The lands which it is proposed to take for the disposal of the sewage are well situated for the purpose, and are located in a thinly populated region, there being no dwelling-houses in their immediate vicinity. Examinations of the soil of these lands by means of a limited number of test pits indicate that the material beneath the surface soil is generally a very fine sand; and, while there is coarser material underneath this sand, the depth of the fine sand is such that it will not be practicable to remove it, from a large portion of the area at least, except at great cost. The fine sand is, however, suitable for the disposal of sewage if the beds are properly prepared for the purpose, though more care will be necessary in the proper operation of filters consisting of this material than would be the case with the coarser sand, and the quantity that can be purified will be smaller.

The system as a whole is adapted to the collection and disposal of all of the sewage of the portion of the town of Concord which it is proposed to make tributary to it, according to the plans submitted, provided that surface water is excluded from the sewers as proposed, and care is taken to prevent the entrance of ground water so far as practicable.

The State Board of Health, acting under the authority of chapter 151, section 2, of the Acts of 1895, approves the proposed system and the location of the lands to be taken for the purpose of sewage disposal, as outlined in your description previously quoted and shown upon the plans submitted with your application; the lands being in the town of Concord, and bounded, measured and described as follows: —

Description for Taking of Land now or lately of Estate of Catherine (alias Kate) Lang, on North Side of Boston & Maine Railroad.

Beginning at a point on the north line of the Boston & Maine Railroad (formerly Middlesex Central Railroad) location at its intersection with the division line between land supposed now or lately to belong to the estate of Catherine (*alias* Kate) Lang and land containing gravel pit and supposed to belong to the said Boston & Maine Railroad, thence running along the north line of said railroad location south seventy-two degrees and twenty-five minutes west (S 72° 25′ W) magnetic, about one thousand and thirty-nine (1,039) feet to a point; thence deflecting to the right and running approximately north one degree and forty-five minutes west (N 1° 45′ W) about seven hundred and ninety-three (793) feet to a point in the division stone wall between lands supposed to belong to the said Lang estate and to John S. Keyes, respectively; thence deflecting to the right and running in a generally easterly direction along said division wall about seven hundred and ninety-three (793) feet to an angle in said wall; thence deflecting to the right and running approximately south eleven degrees and nine minutes west (S 11° 9′ W) about seventy-nine (79) feet along said wall to its intersection with the fence and wall between said lands supposed to belong to the said Lang estate and to John S. Keyes respectively; thence deflecting to the left and running approximately south eighty-one degrees and sixteen minutes east (S 81° 16′ E) about two hundred and thirty-five (235) feet along said fence and wall to a point in the division fence between the said lands supposed to belong to the Lang estate and the said land containing gravel pit and supposed to belong to the Boston & Maine Railroad; thence deflecting to the right and running approximately south one degree and forty-five minutes east (S 1° 45′ E) about three hundred and fifty-three (353) feet along said division fence to the point of beginning, comprising an area of fourteen and thirteen hundredths (14.13) acres, more or less.

Description for Taking of Land of John S. Keyes.

Beginning at an angle or corner where land supposed now or lately to belong to the estate of Catherine (*alias* Kate) Lang, and land containing gravel pit and supposed to belong to the Boston & Maine Railroad (formerly Middlesex Central Railroad), and lands supposed to belong to John S. Keyes, respectively, meet, and distant about three hundred and fifty-three (353) feet northerly from the north line of the location of the said Boston & Maine Railroad measured along the easterly line of said Lang estate; thence approximately north one degree and forty-five minutes west (N 1° 45′ W) magnetic, in prolongation of said easterly line one hundred and twenty (120) feet to a point; thence deflecting to the left through an angle of ninety (90) degrees and running approximately south eighty-eight degrees and fifteen minutes west (S 88° 15′ W) about two hundred and fourteen (214) feet to an angle in the division stone wall between lands supposed to belong to said Lang estate and to John S. Keyes, respectively; thence deflecting to the left through an angle of approximately seventy-seven degrees and six minutes (77° 6′) and running approximately south eleven degrees and nine minutes west (S 11° 9′ W) about seventy-nine (79) feet along said wall to its intersection with the division fence and wall between said lands supposed to belong to the said Lang estate and to John S. Keyes, respectively; thence deflecting to the left through an angle of approximately ninety-two degrees and twenty-five minutes (92° 25′) and running approximately south eighty-one degrees and sixteen minutes east (S 81° 16′ E) about two hundred and thirty-five (235) feet along said division fence and wall to the point of beginning, comprising an area of forty-nine hundredths (0.49) of an acre, more or less.

Description for Taking of Land now or lately of Estate of Catherine (alias Kate) Lang, on South Side of Boston & Maine Railroad.

Beginning at a point on the south line of the Boston & Maine Railroad (formerly Middlesex Central Railroad) location at its intersection with the division line between land supposed now or lately to belong to the estate of Catherine (*alias* Kate) Lang and land supposed to belong to Patrick W. White, said point being about forty-one (41) feet from the south rail of the track of said railroad; thence running approximately south one degree and forty-five minutes east (S 1° 45′ E) magnetic, along said division line about one thousand and eighty (1,080) feet to land supposed to belong to Enoch Garfield; thence deflecting to the right and running approximately south eighty-eight degrees and fifteen minutes west (S 88° 15′ W) along the division line between the lands supposed to belong to said Lang estate and to said Garfield, respectively, five hundred (500) feet to a point; thence deflecting to the right and running north one degree and forty-five minutes west (N 1° 45′ W) two hundred and ninety-five (295) feet to a point; thence deflecting ninety (90) degrees to the right and running approximately north eighty-eight degrees and fifteen minutes east (N 88° 15′ E) one hundred (100) feet to a point;

thence deflecting ninety (90) degrees to the left and running approximately north one degree and forty-five minutes west (N 1° 45′ W) about six hundred and sixty-nine (669) feet to a point on said south line of the Boston & Maine Railroad location; thence deflecting to the right and running approximately north seventy-two degrees and forty-one minutes east (N 72° 41′ E) about four hundred and fifteen (415) feet along said railroad location to the point of beginning, comprising an area of ten and nine hundredths (10.09) acres, more or less.

Danvers. The trustees of the Danvers Lunatic Hospital applied to the Board, Aug. 1, 1898, for its advice with reference to a plan of sewage disposal for that institution upon land belonging to that institution. The Board replied to this application as follows: —

Aug. 4, 1898.

The State Board of Health received from you, on Aug. 1, 1898, an application for advice with reference to certain proposed modifications in the details of the plan of sewage disposal for the Danvers Lunatic Hospital which was considered by the Board last year.

With regard to the plan presented at that time, the Board advised that, if properly carried out, the plan was the best that it appeared to be feasible to adopt; but it was suggested that the filtration area might with advantage be divided into a larger number of beds, and that the size of the flush tank might be reduced.

You now state that you have secured a more direct route for the main sewer from the hospital to the filtration area, by which the construction of a portion of the main sewer in the form of an inverted siphon at a place where the line crossed a valley between the hospital and the filtration area is avoided; and, in connection with the proposed change in the location of the main sewer, it is proposed to change the position of the flush tank and to locate it upon the proposed filtration area.

In accordance with suggestions of the Board in its last reply, it is proposed to reduce the size of the flush tank and to divide the filtration area into a larger number of beds.

The present plan provides for ten beds, eight of which, having an area of about a quarter of an acre each, are to be constructed of the coarsest material available, and the remaining two, having an area of about half an acre each, are to be constructed of the finer material. It is proposed to use a portion of the sewage for the irrigation of crops on land through which the main sewer is to pass.

The Board has carefully considered your application and the proposed modifications in your plans, and concludes that the changes proposed are desirable in the interest of economy and facility of operation of the plant; and, if the plans are carried out as proposed, they will provide satisfactorily for the disposal of the sewage of the Danvers Lunatic Hospital, provided the size of the institution is not materially increased.

It will be necessary, in using the sewage for irrigating purposes in the growing of crops, to avoid danger of any portion of the unpurified sewage finding its way into a water course.

GLOUCESTER. An application was received Aug. 19, 1898, from the committee on sewerage of Gloucester, for the advice of the Board relative to a proposed system of sewerage for that city. The Board replied to this application as follows: —

SEPT. 23, 1898.

The State Board of Health received from you, on Aug. 19, 1898, an application giving notice of your intention to introduce a system of sewerage in the city of Gloucester; and the Board is informed that you propose to make use of the drain which at present discharges into the outer harbor opposite Mansfield Street as a main sewer, and change the point of discharge of this drain from its present location to a point in the Gloucester canal.

The application was accompanied by a plan entitled "Sketch showing Proposed Extension of Main Drain through Western Avenue to Gloucester Canal," which shows the line of the proposed extension from the present drain at the place where it crosses Western Avenue through Western Avenue to the Gloucester canal.

The Board has caused the locality to be examined by its engineer and has carefully considered the proposed plan. The plan appears to resemble closely a plan submitted to this Board in 1888, which provided for the collection of the sewage of a large district in Gloucester which would naturally be tributary to the present drain, and the discharge of this sewage into the canal in the vicinity of Cut bridge. The opinion of the Board, as expressed at that time, was as follows: —

It would not be advisable to admit sewage to the drain now receiving brook and storm water, and discharging upon the beach near Western Avenue. A satisfactory outlet for the sewage of a large part of the city will not be provided by building the proposed sewer in Western Avenue to carry the contents of the existing drain to the waterway known as the "Cut."

The city has grown considerably in the past ten years, and the proposed sewer outlet would be in the immediate vicinity of a thickly populated portion of the city, and upon a shore which appears to be used as a place of resort by many people in the summer season. Under the circumstances, the Board can see no reason for changing the opinion expressed at the previous time with reference to the use of the existing drain as a sewer and the disposal of the sewage by discharging it into Gloucester canal, or the "Cut," and is of the opinion that all sewage should be kept out of the "Cut" and away from the shores in the neighborhood of its outlet.

It appears that the drainage discharged from the drain has at times an offensive odor, and that the present place of disposal of the drainage is objectionable, especially when discolored water from the streets is discharged after a heavy rain. It is possible that much of the objection to the discharge of drainage at the present outlet would be removed by extending a pipe from the bottom of the present drain to a place of discharge at some distance beyond low water, so that, except in very heavy rains, little or no drainage would be discharged close to the shore; but the Board is of the opinion that in any case it is important to keep sewage from entering the present drain or any of its tributaries.

The Board would advise that the whole question of sewerage for the city be again considered, with a view to beginning the construction of a system on some satisfactory plan.

HATFIELD. An application was received, Oct. 20, 1898, from the Board of Health of Hatfield, for the advice of the Board relative to the proposed construction of certain sewers in that town intended to convey the sewage of certain houses to the Mill River. The Board replied to this application as follows: —

DEC. 1, 1898.

The State Board of Health has considered your application for advice with reference to the construction of two sewers in Hatfield, to discharge sewage from certain houses into the Mill River at two points in the village, and has caused the localities to be examined by its engineer.

One sewer is to be laid in School Street, and will provide for the collection of the sewage of four houses on that street. It is proposed to discharge this sewer into a drain which crosses the highway near land of Jacob Carl, and runs through private land in a southerly direction to Mill River. At the place where this drain will discharge the stream has a sluggish current, owing to a dam below, and solid matters from the sewage will naturally tend to deposit upon the sides and bottom of the stream. While there are no houses in the immediate vicinity of the stream near the outlet of the drain, the main portions of the village are not far distant, and, in the opinion of the Board, it is not desirable to discharge sewage at this place continually, even in small quantity.

The other sewer mentioned in the application is to be constructed in Elm Street, and it is proposed to discharge the sewage into the Mill River just below the last dam. This outlet is less objectionable from a sanitary point of view than the one farther up stream; but if any considerable number of houses should be connected with this sewer, the discharge of sewage at this place might become objectionable at times when the river is low.

It is very desirable, in the opinion of the Board, not only to keep sewage from entering Mill River and polluting it in the vicinity of the village, but also to avoid the creation of numerous sewer outlets into the streams near the village, on account of danger that local nuisances will thereby be created. In the opinion of the Board, it would be best for the interests of the town that, before any sewers are constructed, a general plan of sewerage should be prepared, by which a satisfactory disposal of the sewage may be effected. All sewers hereafter constructed might then be made to conform to this plan, so that they might all ultimately form a part of the completed system.

The Board would therefore advise that you cause a plan to be prepared for the collection and disposal of the sewage of the main village of Hatfield. The Board will render you such assistance as it may in any investigation as to the disposal of sewage that you may desire to make, and will upon application advise you as to any plan for the sewerage of the village which you may wish to present.

HINGHAM. An application was received, Oct. 14, 1898, from the board of health of Hingham, for the advice of the State Board of Health relative to a proposed sewer for a small district in that town known as Crow Point. The Board replied to this application as follows: —

DEC. 1, 1898.

The State Board of Health received from you, on Oct. 14, 1898, an application for advice with reference to the disposal of sewage from a small summer settlement in the town of Hingham, known as Crow Point, accompanied by a plan showing the lines of the proposed sewers and the proposed location of the sewer outlet. It is understood to be a part of your plan that each house is to be provided with a cess-pool, and that the sewers are to receive the overflow from these cess-pools, but are not to receive storm water.

The Board has caused the locality to be examined by its engineer, and has carefully considered the proposed plan. The proposed system of sewers, with such extensions as can be made, will provide for collecting sewage from nearly all of the houses on Crow Point, and for houses which may be built on high land to the west of the point.

The quantity of sewage that is likely to be discharged from the proposed system of sewers will probably be very small for several years, and it is not likely that any serious trouble will be caused by the discharge of sewage at the place proposed at all times. If the population in this region should increase considerably, and a much larger number of houses should be connected with the sewers, it might be desirable to provide an outlet into the main channel; and for this reason it would be desirable to so construct the sewers that the sewage can, at some future time, be carried further to the east, along the northerly side of Crow Point, and discharged into the main channel well out from the entrance of Hingham harbor.

With the modification suggested, the Board is of the opinion that the plan is a suitable one for the disposal of the sewage of this small portion of the town of Hingham.

HOLYOKE. An application was received, June 18, 1898, from the board of public works of Holyoke, for the advice of the State Board of Health relative to a proposed system of sewerage and sewage disposal for a district of Holyoke lying in the northerly part of the city above the dam. The Board replied to this application as follows: —

OCT. 6, 1898.

The State Board of Health received from you, on June 18, 1898, an application for advice with reference to a proposed system of sewerage and sewage disposal for a district in the north-westerly part of the city of Holyoke. Subsequently, on August 24 and September 22, plans were received showing outlines of a proposed sewerage and drainage district, its relation to the present sewerage system of the portion of the city in that vicinity, and the location, sizes and grades of a proposed system of domestic sewers and a system of storm-water drains to serve the new district.

The district shown upon the plans is bounded by the city limits on the north and approximately by Pleasant Street on the east, Lincoln Street on the south, and a line about 1,500 feet west of Northampton Street on the west. A separate system of pipes to receive storm water includes the portion of the district lying between Lincoln Street on the south, Morrill Avenue on the north, Pearl Street on the east, and a line about 1,500 feet west of Northampton Street on the west. It is proposed to discharge the storm water from this system of pipes into the upper end of the Dingle, so called, through which it will flow to the Connecticut River.

The plan for the sewerage of the district provides for a system of pipe sewers discharging into a trunk sewer in Jefferson Street near the upper end of the Dingle, from which the course of the sewer is northerly through Jefferson Street and private land and down through a deep ravine to the Connecticut River, into which it is proposed to discharge the sewage directly without treatment. You propose to include in the new sewer district a small portion of the district which at present discharges into the Walnut Street sewer system, which drains a district lying south-west of the new district. The sewers in the Walnut Street district are constructed upon the so called combined plan, and in the portion of the Walnut Street district which it is proposed to divert into the new district, one of the sewers will, by the proposed plan, continue to receive storm water, in addition to the sewage. You also propose to receive into the main trunk sewer the storm water from the area bounded by Dartmouth Street on the south, Princeton Street on the north, Pleasant Street on the east and the trunk sewer on the west. In addition to the storm water from these areas, you propose to receive into the sewer system the roof water from the whole district.

The Board has caused the locality to be examined by its engineer, and has carefully considered the plans submitted.

The storm-water sewers as designed appear to be of sufficient size for the reception and removal of all of the storm water which would naturally be tributary to them from the district which they are designed to serve; and the Board is of the opinion that the discharge of this water into the Dingle, so called, is a satisfactory method of disposal of this water, from a sanitary point of view.

The system of sewers designed for the reception of sewage and roof water, together with storm water from a portion of the district, is of smaller capacity than desirable; and, if all of the roof water is to be admitted to them, there is much danger that they will prove inadequate to carry off all of the water at all times, if the number of houses in the district becomes as large as it seems reasonable to anticipate. While there might be some advantage in discharging roof water into the sewers designed for the reception of house sewage, it appears to be entirely practicable to discharge this water into the storm-water sewers, and the latter system, as designed, is probably of sufficient capacity to receive this water, in addition to the remaining storm water from the district which it is designed to serve. By discharging the roof water into the storm-water sewers, it will be practicable to considerably reduce the size of the proposed sewers for the reception of sewage. Moreover, it is very desirable to keep all storm water and ground water separate from the sewage, since the cost of the final disposal of the sewage may be considerably reduced thereby. The Board would therefore advise that all roof water and all storm water be kept out of the sewers designed for the reception of domestic sewage, and that the sizes of these sewers be made no greater than is necessary for the removal of the house sewage and the probable leakage into them, estimated upon a liberal basis.

The disposal of the sewage by discharging it directly into the Connecticut River, about 1¾ miles above the Holyoke dam, might not cause any serious harm for the present at least, if the sewage is discharged as much as 100 feet from the shore of the river at low water. The Board is of the opinion, however, that no large amount of sewage can safely be disposed of in this way, owing to the conditions that prevail in this vicinity and below, where there is a large population near the river and the canals leading therefrom. There is evidence that considerable numbers of people use the river and its banks in the region of the proposed sewer outlet and between this place and the Holyoke dam as a place of resort in the summer season, and it is probable that the use of the river in this way will increase in the future. Under the circumstances, it is desirable to keep crude sewage out of the river in this vicinity.

In this connection, it may be said that the attention of the Board has been called to the discharge of sewage into the river near Walnut Street, about a quarter of a mile above the entrance to the canals of the Holyoke Water Power Company, where the conditions are such that much of the time all of the sewage discharged from the sewer probably passes into the canals. There is evidence, also, that much sewage from the mills is discharged directly into the canals in their course through the city. These conditions are very objectionable from a sanitary point of view; and the public interest requires that the sewage from the Walnut Street sewer be diverted to a more suitable place of disposal, and that sewage be prevented from entering the canals.

The indications are that it is feasible to convey the sewage from the proposed new district to the Walnut Street outlet, and dispose of it in connection with the sewage from the Walnut Street sewer, and this method of disposal might ultimately be the most satisfactory to adopt; but it does not appear that any plan for the diversion of the sewage from the Walnut Street outlet to a more suitable place of disposal has yet been prepared, and considerable time would probably be required to prepare a suitable plan. It is understood that sewerage facilities are somewhat urgently needed in the district for which the plans under consideration are intended to provide; and, under the circumstances, it is probably best not to complicate the problem of disposing of the Walnut Street sewage by conveying the sewage from the new district to the Walnut Street outlet, for the present at least.

An examination of the land in the region in which it is proposed to construct the new sewer system indicates that a suitable area for the disposal of the sewage of this system for a considerable number of years in the future may be found in the vicinity of Jones' Pond, so called, near the bank of the river south of the proposed sewer outlet. The area of filter beds required to purify the sewage from the present population would probably not exceed three acres, provided all storm water, and, so far as practicable, ground water, should be kept out of the sewers.

If suitable filter beds can be constructed at this place for the purification of the sewage at a reasonable cost, this would probably be the most satisfactory method of sewage disposal to adopt; and, in view of all the circumstances, the Board would advise that, before constructing the proposed system of sewerage, you investigate the feasibility and probable cost of conveying the sewage to the land referred to near the Connecticut River south of Jones' Pond, and purifying it there by filtration.

The Board will, if you so request, assist you in this investigation by making all necessary analyses of soil, and will give you further advice in the matter when you have the results of the investigations to present.

Lee. The State Board of Health was informed that it was proposed to build certain sewers in the town of Lee, having their outlet into the Housatonic River. The State Board, therefore, sent a communication to the selectmen of Lee, as follows: —

Nov. 17, 1898.

The State Board of Health is informed that it is proposed to construct sewers in the village of Lee in accordance with a plan which has been submitted to your board, and it is understood that the sewage is to be disposed of by discharging it into the Housatonic River. The evidence before this Board would indicate that the plan of sewerage in question is one which should be submitted to this Board for advice, in accordance with the provisions of chapter 375 of the Acts of 1888. If it is intended to construct a sewer or sewers discharging into the Housatonic River or any other stream, you will, of course, wish to comply with the provisions of the act referred to, and a blank form of application is accordingly enclosed. Upon receipt of an application, the Board will give the matter prompt attention.

Leicester. The attention of the Board was called, July 26, 1898, by the water commissioners of Worcester, to the imperfect purification of the sewage at the disposal beds at the Leicester Poor Farm, and the possibility of the pollution of the water supply of Worcester as a consequence. The State Board of Health made an investigation of the matter, and sent the following communication to the selectmen and overseers of the poor of Leicester: —

Sept. 1, 1898.

The results of chemical analyses made by this Board of the effluent from the sewage filter beds at the Leicester Poor Farm show that it contains at times a large proportion of unoxidized organic matter, indicating that the action of the filters is at times inefficient in the purification of the sewage; and an examination of the filters by one of the engineers of the Board indicates that they are not operated in the manner necessary to produce the best results. It appears that the sewage has been allowed to flow upon one of the beds continuously for a period of several days, thereby preventing the necessary air from entering the filter and effecting the purification of the sewage. If all of the beds were used, and the sewage changed frequently from bed to bed, satisfactory purification could be effected, provided the filters were given the necessary attention, and were kept in proper condition by scraping or raking from time to time.

The effluent from the filter beds finds its way into one of the feeders of the water supply of the city of Worcester, and the discharge of unpurified or partially purified sewage from these beds will cause a pollution of this water supply, and is contrary to existing statutes.

The Board would therefore urge that the necessary steps be taken without delay to provide that sewage be applied at proper intervals and in such a manner as to insure a purified effluent from the filter beds at the Leicester Poor Farm. It may be found that, even with proper application of the sewage, satisfactory purification may not result in winter, on account of freezing. If this should be found to be the case, the difficulty can be avoided by protecting the filtering area by a cover which will prevent freezing.

Lexington. An application was received from the sewer commissioners of Lexington, March 24, 1898, under the general act of 1888, chapter 375, and chapters 504 and 520 of the Acts of 1897, for the advice of the Board with reference to a proposed system of sewerage and sewage disposal for the town of Lexington. After a hearing, as required by the provisions of chapter 504, section 17, Acts of 1897, at which the sewer commissioners of Lexington and the water commissioners of Arlington were present, the Board replied to the application as follows: —

April 16, 1898.

The State Board of Health received from you, on March 24, 1898, an application, under the authority of chapter 375 of the Acts of 1888 and chapters 504 and 520 of the Acts of 1897, dated March 22, 1898, giving notice of your intention to introduce a system of sewerage in the town of Lexington, Mass., and submitting a plan of your proposed system for the approval of this Board. In this application your proposed plans are set forth as follows: —

A general description of the system of sewerage proposed is given in the report of McClintock and Woodfall, civil engineers, dated Jan. 18, 1897, contained in the printed pamphlet submitted herewith, the discharge of the sewage to be into the metropolitan sewer as extended to the dividing line between Arlington and Lexington, under chapter 520 of the Acts of 1897. (Disregard cancelled portions of pages 8, 9, 10, and 11 of said report.)

The sizes, directions of flow and approximate locations of the several sewers proposed to be built for house drainage are shown on the map accompanying said report, and entitled "Plan Showing Proposed System of Sewers for the Town of Lexington, Mass. Designed by McClintock and Woodfall, Civil Engineers, 15 Court Square, Boston, Mass., 1897."

The grade of the main and intercepting sewer is to be at no place less than 1 foot in 1,000 feet. Following is a general description of said sewer: A sewer 20 inches in diameter, starting at the dividing line between the towns of Arlington and Lexington, and extending through Massachusetts Avenue to the junction thereof with Flint or Curve Street; thence running easterly and northerly through portions of Flint or Curve Street; thence north-easterly across private lands to and across the Arlington Branch Railroad; thence northerly or north-westerly in and along the location of said railroad, about 2,000 feet; thence running nearly parallel with the north-easterly line of the location of said railroad about 1,500 feet to a point near Munroe's station; thence continuing as an 18-inch pipe in a line approximately parallel with the north-easterly side of said railroad location, about 1,100 or 1,200 feet; thence an 18-inch pipe in a northerly direction across the head of Munroe's Meadows and private lands to and across Woburn and Vine streets to a point about 165 feet northerly from Vine Street; thence a 15-inch pipe across private lands to the lane at the base of Granny Hill leading to the Hayes house.

Into this main and intercepting sewer will be connected at sundry places the several sewers leading from the Centre and East villages.

Such portions of the main and intercepting sewer between the junction of Pleasant Street and Massachusetts Avenue and Vine Street as the State Board of Health shall require, and so much of each lateral sewer within the water-shed of the Arlington water supply as shall lie between a level even with the top of the main or intercepting sewer at the place where such lateral sewer connects therewith and the place of connection will be constructed of iron pipe with carefully made lead joints. Similarly, where any sewer crosses a stream or brook which is tributary to the Arlington water supply, iron pipe with leaded joints will be used at such crossing, and for a distance of about 12 feet on either side thereof.

Surface water is not to be conducted into the sewers; but sub-drains have been planned to take care of such water, and drain low-lying and wet parts of the town, the discharge to be into natural water courses, as may be approved by said Board of Health.

At the hearing upon the foregoing application, plans prepared by said McClintock and Woodfall will be submitted, showing in detail the work to be done in constructing said system.

In accordance with the provisions of chapter 504 of the Acts of 1897, the State Board of Health, upon receipt of your application, gave notice to the board of water commissioners of the town of Arlington of a hearing upon your application, as required by section 17 of said chapter 504, to be held at the rooms of the Board, at the State House, on April 7, 1898, at eleven o'clock. At this hearing there were present the board of water commissioners of the town of Arlington with their engineer and your board with your engineers; and plans were presented by you, showing in detail the work to be done in constructing a system of sewerage for the town of Lexington, which is designed to discharge into the metropolitan sewer as extended to the dividing line between Arlington and Lexington, under chapter 520 of the Acts of 1897.

It appearing that some modifications with a view to further protection of the water supply of the town of Arlington were deemed desirable by the water commissioners of that town, it was suggested that your board confer with the water commissioners of the town of Arlington, and subsequently submit such amendments to your plan as might, after the consultation suggested, seem desirable; and subsequently, on the same day before said hearing was closed, you presented the following modifications of your proposed plan : —

In the matter of the application filed by the sewer commissioners of Lexington, March 22, 1898, for an approval of a system of sewerage for that town, which application, after due notice to the board of water commissioners of the town of Arlington, is now being heard by your Board, the undersigned ask leave to modify the application and plans as below set forth : —

In the next to the last paragraph, the words, "take care of such water and" are stricken out, so that the paragraph as amended reads : "Surface water is not to be conducted into the sewers; but sub-drains have been planned to drain low-lying and wet parts of the town, the discharge to be into natural water courses, as may be approved by said Board of Health."

If required by the water board of Arlington, cut-off dams of concrete 1 foot thick will be constructed at the three several places shown on the accompanying plan, marked : "Plan of Proposed System of Sewers for the Town of Lexington, Mass., designed by McClintock and Woodfall, 1897." These dams are to be 2 feet wider than the sewer trench (*i.e.*, overlapping 1 foot on either side), and are to extend from a point 2 feet below the ground's surface to a point 6 inches below the bottom of the sewer, or the underdrain, as the case may be.

If a permanent sub-drain is constructed in the East Village, it shall empty into Brown Brook, just below the present outlet of the Brown Brook conduit, so called.

Any sub-drain in the East Village made for use only during or in connection with the construction of the sewer, may enter into Brown Brook at any point, but in case of any such temporary sub-drain, so emptying, its outlet shall be filled up immediately after the sewer shall have been constructed.

The town of Lexington, in contracting for the construction of its sewers, will cause to be inserted in the contract substantially the following provisions : —

The contractor at his expense shall provide proper sanitaries.

No sanitary to be located within 100 feet of any brook tributary to the Arlington water supply.

The engineer may designate the position of the sanitaries.

Sanitaries shall be left in one location as short a time as possible, and on removal all foul matter shall be removed to such location as the engineer designates, and there buried.

The contractor must see that the men employed on the work use the proper sanitaries provided for them.

No sanitary to be put over the sewer trench within the territory tributary to Arlington's water supply.

Accompanying this communication was a statement signed by the water commissioners of Arlington and the sewer commissioners of Lexington, as follows : —

The several matters discussed before your Board this morning are disposed of to our mutual satisfaction, except that we differ as to the necessity of any requirement to be made by your Board with reference to the policing of the sewer district, and also as to the necessity of any requirement with respect to disposing of water pumped out of the sewer trenches during the period of construction.

These two matters are left to be determined by your Board. You are to incorporate in your order of approval such provisions on these matters, if any, as you shall think necessary and proper.

It is understood that no provision is to be made therein with regard to diverting or disposing of the waters of "Village Brook."

The Board has carefully considered your proposed system of sewerage, with the modifications referred to, and the plans submitted, and concludes that, in general, they are appropriate for the sewerage of the town of Lexington, and that the disposal of the sewage in connection with the metropolitan sewerage system is the best method of disposal for the town to adopt.

The disposal of water collected by the proposed underdrains beneath the sewers, by discharging it into Vine Brook and into Brown Brook below the lower end of the Brown Brook conduit, as indicated upon the plans submitted, does not appear to be objectionable.

With reference to policing the district in which sewers are to be constructed during the period of construction, the Board is of the opinion that, under the circumstances, extra precautions should be taken by the town of Lexington to prevent danger of polluting the sources of the Arlington water supply, in consequence of the operations carried on by the town of Lexington, by providing sanitaries, so called, in suitable places not over the sewer trenches, by requiring the use of the sanitaries by the persons engaged upon the work, by making provision for the removal and proper disposal of all matters deposited therein, by preventing the encampment of laborers within the water-shed of the Arlington water supply in the town of Lexington, and by policing the district in case other safeguards shall not prove effectual in preventing contamination of the sources of water supply of the town of Arlington within the limits of the town of Lexington.

With regard to the disposal of water pumped out of the sewer trenches during the period of construction, it may be said that if, by providing proper sanitaries and by other precautions before mentioned, all pollutions are kept out of the trenches, it seems to the Board that there should be no danger in the disposal of this water by discharge upon the ground in the vicinity of the trenches.

In this matter and in that of policing the district and in such other matters not specially mentioned, where conditions might arise that could endanger the healthfulness of the water supply of the town of Arlington, the State Board of Health assumes and expects that the sewer commissioners of the town of Lexington wlll take every precaution to protect that water supply that they would take if it were the water supply of their own town.

The Board hereby approves the proposed system and plans, as outlined in your communications of March 22, 1898, and April 7, 1898, and shown upon plans submitted and filed upon the latter date, and requires that all portions of the main and intercepting sewer which lie between the junction of Pleasant Street and Massachusetts Avenue and Vine Street shall be constructed of iron pipe with carefully made lead joints.

LONGMEADOW. The selectmen of Longmeadow applied to the Board, April 22, 1898, for its advice with reference to the sewage disposal of that town. The Board replied to this application as follows: —

MAY 5, 1898.

The State Board of Health received from you, on April 25, 1898, an application for advice with reference to disposing of the sewage of the town of Longmeadow, and subsequently a plan was received showing a proposed system of sewerage for the extreme northerly portion of the town. It is proposed to collect the sewage into a sewer in Lewis Street, in the valley of Cooley Brook, and to convey it to a point of temporary discharge in the vicinity of the westerly end of Lewis Street, and you desire advice as to the best method of disposing of this sewage.

To discharge the sewage untreated into Cooley Brook would undoubtedly create a serious nuisance, and there appear to be only two methods by which the sewage from this sewer can be satisfactorily disposed of; one by constructing a sewer to discharge the sewage into the Connecticut River, and the other by constructing filter beds near the outlet of the sewer and purifying the sewage thereon.

The Board has not at present sufficient information with regard to the probable cost of either of these plans to be able to advise you definitely as to which plan is the most appropriate one for the town to adopt. The Board would, therefore, advise that you cause a careful investigation of both of these plans to be made by your engineers, and careful estimates of the cost to be made; at the same time, the whole question of the sewerage of your town should be carefully considered, in order that the portion of the system which you now propose to construct may bear a proper relation to the sewerage of the remainder of the town when it may become necessary, thus possibly effecting a considerable saving in the ultimate cost of the works.

The Board will, upon application, give you further advice in this matter when you have the results of further investigations to present.

A subsequent application was made by the same authorities for the approval by the Board of a certain tract of land in Longmeadow for the purpose of sewage disposal; and after a public hearing, as required by chapter 124 of the Acts of 1890, the Board transmitted the following reply to the selectmen of Longmeadow: —

JULY 28, 1898.

The State Board of Health received from you, on June 22, 1898, an application for the approval by the Board of the taking of certain lands in the town of Longmeadow, as shown upon the plan submitted with your application, for the purification and disposal of sewage.

In response to this application, the State Board of Health gave notice that, in accordance with the requirements of chapter 50, section 1 of the Public Statutes, as amended by chapter 124 of the Acts of 1890, a public hearing relative to the taking of the land in question for the purification and disposal of sewage would be given at its office on July 7, 1898. At this hearing no person appeared to oppose the proposed taking of the land referred to, and the Board voted to approve the purchase or taking by the town of Longmeadow, for the purification and disposal of sewage, of land now or formerly of the estate of W. O. Emerson, situated north-westerly of Riverview Street, nearly opposite its junction with Lewis Street in said town, and shown upon a plan submitted by you, entitled, "Proposed filter bed for the town of Longmeadow, Mass.; Durkee, White and Towne, Engineers. June, 1898. Scale thirty feet per inch," the land being bounded, measured and described as follows: —

Beginning at a monument at the south-west corner of land now or formerly of James H. Lewis, and running thence along the westerly line of land of said Lewis, N. 8° 57′ E. 203.39 feet to a monument. Thence along the westerly line of said Lewis N. 0° 21′ W. 141.25 feet to a monument. Thence along the land of W. G. Emerson Est. N. 1° 46′ W. 27.22 feet to a monument. Thence along land of Wm. F. Emerson N. 59° 9′ W. 209.24 feet to a monument. Thence along the land of Wm. G. Emerson Est. S. 19° 21′ W. 392.00 feet to a monument. Thence along land of Wm. G. Emerson Est. S. 69° 49′ E. 300.38 feet to a monument at the place of beginning. Containing 2.25 acres of land.

Upon the plan submitted are shown a settling basin and two distributing basins, but no further details of the proposed method of purifying the sewage are presented. It is understood, however, that suitable filter beds are to be prepared upon the land as needed.

When you have prepared further plans for the disposal of the sewage upon the land, the Board will give you further advice in the matter, if you so request.

LUDLOW. An application was received, June 13, 1898, from the Ludlow Manufacturing Company, for the advice of the Board relative to a plan of sewerage and sewage disposal for the village of Ludlow, the system being designed to receive both sewage and storm water. The Board replied to this application as follows: —

JULY 7, 1898.

The State Board of Health received from you, on June 13, an application for advice with reference to a proposed system of sewerage for the village of Ludlow, which is located principally in the town of Ludlow and partly in the town of Wilbraham and in the city of Springfield. The application was accompanied by a map, showing the location of the proposed sewers and their outlets. It is understood that the sewers are to be designed to receive both sewage and storm water.

For the portion of the village on the northerly side of the river it is proposed to provide two main sewers, one to receive the sewage from the portion of the village between the Athol branch of the Boston & Albany Railroad and the Chicopee River, and the other to receive sewage from the thickly settled portion of the village north of the railroad. It is proposed to discharge the sewage from both of these main sewers into the tail-race, or waste-way, below the last mill. As indicated upon the plan, the sewage from the district nearest the river would be discharged into the waste-way about 600 feet from the point where the waste-way joins the main river, while the sewage from the district north of the railroad would be discharged into the waste-way about 200 feet from the point where it joins the main river. It is proposed to discharge the sewage from the portion of the village south of the Chicopee River into a cove a short distance below the lower dam.

The Board has carefully considered the proposed plans, and has caused the locality to be examined by its engineer. The proposed method of disposing of the sewage, by discharging it in a crude state into the Chicopee River, appears to the Board to be permissible, under present conditions.

The proposed plan of discharging the sewers into the tail-race, or waste-way, below the mill on the northerly side of the river, might not be seriously objectionable if there were a flow through this waste-way at all times; but when the mills are shut down it appears that there is no flow in this channel, and, under the circumstances, a local nuisance is liable to be created if the sewers are discharged into it. It appears to be feasible to convey the sewers to a point of discharge into the river below the outlet of the waste-way, and the Board would recommend that this be done.

The proposed sewer outlet on the south side of the river is so located that it will not be likely to cause offense for several years at least; but the water in this cove is quite still, and matter from the sewage may collect along the shore and cause an odor at times of low water in the river. A more thorough dilution of the sewage could be obtained by placing the outlet in the river near the lower end of the rapids below the lower dam, and the Board would suggest that you consider the feasibility of making the outlet at this place when the sewers are constructed.

While, in the opinion of the Board, it is permissible to discharge the sewage from the village in a crude state into the Chicopee River for the present, the time may come when it may be found desirable to divert the sewage from the river. Moreover, it appears to be practicable, without great cost, to dispose of the sewage upon land in the neighborhood of the village, where it can be used to great advantage as a fertilizer and for the irrigation of crops. If the time shall come when it is found necessary to remove the sewage from the river, or should it be decided to use it upon land in the beginning, it will be very desirable to keep the sewage separate from the storm water, so as to avoid unnecessary expense in pumping and disposing of the sewage; and, under the circumstances, it would probably be best to construct the sewers in the beginning upon the so-called separate plan, that is, to admit sewage only to the sewers, and remove the storm water and roof water by separate channels.

The sizes and grades of the proposed sewers have not been submitted, so that the Board is unable to advise as to their capacity for serving the proposed territory.

The Board will give you further advice in regard to this portion of your proposed plans, if you desire, and will, upon request, give you further information or advice, should you conclude to dispose of the sewage upon land.

Marlborough. An application was received, July 25, 1898, from the mayor of Marlborough, for the approval of the Board, under chapter 364 of the Acts of 1898, of plans for a proposed extension of the system of sewerage of Marlborough to the district bordering upon Lake Williams, for the purpose of protecting the purity of the water of that lake. The Board replied to this application as follows: —

Aug. 4, 1898.

The State Board of Health received from you, on July 25, 1898, an application giving notice of your intention to extend the sewerage system of the city of Marlborough by constructing sewers in the district about Lake Williams, and submitting plans of the proposed sewers and other works for the advice and approval of the Board, as required by chapter 375 of the Acts of 1888 and chapter 364 of the Acts of 1898.

In the application you state that the object of the plan is to preserve the purity of the water of Lake Williams, which is the principal source of water supply of the city, and you present the following outline of your proposed plans: —

At the present time there are about eighty-one houses on this shed. The most feasible way to handle the sewage from these houses at the present time seems to be to collect the sewage at a central point, and pump over the divide into our present system.

As outlined on the accompanying plans, we propose to sewer West Main Street, Lakeside Avenue, Williams Street, Lincoln Street, Winter Street, Elm Street and Bond Street. The sewage is to be collected at a well by the water works pumping station. The capacity of the well is to be 40,000 gallons, and will be below the surface of the water in the lake at nearly the entire time. We propose to have two pumps, of about 500,000 gallons capacity, to be operated every day, in lifting the sewage from the well and forcing it through an eight-inch iron pipe, to the junction of Broad and West Main streets, at which place it will flow by gravity through our present system, and be discharged at the filter beds now in use.

We propose to use iron pipe with calked lead joints throughout this proposed system. This will prevent ground water entering the pipe, and prevent possible leaks, that would cause pollution to the lake water.

The plans submitted show the location, size and grade of the proposed sewers, which are designed to convey the sewage of all of the thickly settled territory about Lake Williams to the proposed storage well, or reservoir, which is to be located at the westerly end of your present water works pumping station on the northerly shore of the lake. A general outline of the proposed storage well, or reservoir, and pumping station is shown on the plans submitted. From this it appears that the bottom and sides of the reservoir are to be constructed of concrete, with an inside lining of brick masonry and a layer of asphalt between the concrete and masonry. The roof is to consist of concrete arches, supported upon iron I-beams and brick piers. The proposed level of high water in this reservoir is to be three feet below the level of high water in Lake Williams, and its capacity is to be sufficient to hold the entire flow of sewage to be expected from the territory in which the sewers are to be built for a period of many hours under present conditions. It is proposed to dispose of the sewage by pumping it into one of the main sewers of the city, through which it will flow with the other sewage from the city to the present sewage-disposal area.

The Board has caused the territory to be examined by its engineer, and has carefully considered the proposed plans. There is no doubt that the population upon the water-shed of Lake Williams is a very serious menace to the purity of your drinking-water supply, and that provision should be made for removing all sewage from this district. The proposed plans are well adapted for the collection of this sewage in such a manner as to cause the least danger of an escape of any of the sewage by leaks in the pipes. The location of the proposed reservoir close to the water works pumping station should not be a menace to the quality of the water, if, in constructing the reservoir, care is taken to prevent any danger of overflow from it or leakage at a time when the lake is drawn down below the level of high water in the reservoir. It is very important that all pumps, machinery and connections with the reservoir and force main should be in duplicate, so that, in case of injury to any part of the machinery or a suction pipe, duplicate works will be available without material delay.

Provision should be made for stirring up any sediment that may collect in the tank, and removing it with the sewage so as to avoid the necessity of removing it by means of carts or other receptacles, from which some of the polluting matters might escape and find their way into the lake; and it will be necessary to avoid any danger of polluting the water supply in the operation of cleaning the screens and disposing of matters removed from the sewage.

The plans as a whole are suitable for the disposal of the sewage of the territory which they are designed to serve, and, in accordance with the provisions of chapter 375 of the Acts of 1888 and chapter 364 of the Acts of 1898, are hereby approved.

Measurements of the quantity of sewage flowing upon the filter beds used to purify the sewage of the city of Marlborough show that the quantity of sewage is larger than the present area of beds is capable of receiving and purifying at all times, and the Board is informed that unpurified sewage is at times allowed to escape into the stream in the vicinity of the filter beds. While the increase in the quantity of sewage that will be due to the construction of sewers in the Lake Williams district will be comparatively small, it is nevertheless very desirable that a larger area of filter beds be prepared as soon as practicable.

Metropolitan Sewerage Commission. The Board received an application from the Metropolitan Sewerage Commission, July 13, 1897, requesting the advice and approval of the Board concerning plans for automatic overflows and regulators at certain connections with the metropolitan sewer in the Neponset valley; and on Aug. 13, 1897, another application was received from the same board for advice and approval of a proposed overflow from a fifteen-inch branch on the northerly side of the metropolitan sewer in Business Street, at the junction of Barry Place in Hyde Park. To these applications the Board replied as follows: —

March 4, 1898.

The State Board of Health received from you, on July 13, 1897, an application requesting the advice and approval of the Board concerning automatic overflows and regulators at certain connections with the metropolitan sewer in the Neponset valley, as follows: —

The board of sewer commissioners of the town of Hyde Park have made application to the Metropolitan Sewerage Commissioners for permission to make connections with the Neponset valley intercepting sewer at five points, as follows: —

By 12-inch branch on the westerly side of the metropolitan sewer in Fairmount

Avenue, between the New England Railroad and Neponset River, Hyde Park. (Section No. 1.)

By 12-inch branch on the northerly side of the metropolitan sewer in Hyde Park Avenue, near Factory Street, Hyde Park. (Section No. 2.)

By 15-inch branch on the westerly side of the metropolitan sewer in extension of Arlington Street and Metropolitan Avenue, Hyde Park. (Section No. 3.)

By 18-inch branch on the easterly side of the metropolitan sewer between Neponset River and New England Railroad, Hyde Park, opposite extension of Milton Avenue. (Section No. 4.)

By 20-inch branch on the southerly side of the metropolitan sewer in Hyde Park Avenue, being the outlet for sewerage section No. 8, Hyde Park.

It is the desire of the Metropolitan Sewerage Commissioners to require at these connections automatic overflows and regulators, so designed as to act only when the intercepting sewer is filled to its maximum flow line. Maps, showing the details of the proposed connections, as they are desired to be approved, are submitted herewith.

Your advice and approval is asked for these Hyde Park connections, as above outlined.

Subsequently, on Aug. 13, 1897, a similar application was received for the advice and approval of the Board concerning a proposed overflow from a 15-inch branch on the northerly side of the metropolitan sewer in Business Street, at the junction of Barry Place, Hyde Park.

Accompanying the applications were plans showing in detail the proposed connections with the proposed regulators and overflows. On each of these plans there is a note stating that the valve (by which the lateral sewer is shut off from the metropolitan) is designed to close when the metropolitan sewer is full.

It is understood that all the applications for connections with the metropolitan sewer in the Neponset valley thus far approved by your board have been approved with the distinct understanding that no surface, roof or ground waters from underdrains should be admitted to the sewers, and that this provision applies to the connections mentioned in the applications submitted to this Board.

The sewage discharged from all of the overflows proposed in your applications would enter the fresh-water portion of the Neponset River, or Mother Brook, in the midst of a large and rapidly growing population, where the streams have a sluggish current, on account of a dam below the outlets of the proposed overflows.

As stated in the previous reply relating to this matter, the Board believes it to be important to keep sewage from entering the fresh-water portion of the Neponset River, which, in the region in which it is proposed to make these overflows, is practically a mill pond, and that no opportunity should be afforded for the disposal of any sewage in this way, unless it may be absolutely necessary in order to prevent the danger of a greater nuisance elsewhere.

The size of the metropolitan sewer above a point in the vicinity of the boundary line between Hyde Park and Boston was designed to be sufficient to remove all of the sewage of the district which it is intended to serve until about the year 1930, at which time it is expected that the population will be several times as great as that now living in this district. Below this point the size of the sewer is much smaller down to the place where it joins the Dorchester intercepting sewer, but was considered when planned to be sufficient to remove the sewage which the larger sewer will bring to it until about the year 1905, or possibly longer, depending upon the growth of the population and the increase in quantity of sewage in the district. The Dorchester intercepting sewer, into which the metropolitan sewer discharges, is provided with overflows through which the sewage may discharge into tide water automatically, when the sewage in the Boston main drainage sewer rises above a certain height. It seems to the Board that the only condition which will make the overflows proposed in your present application necessary would be a flow of sewage in the metropolitan sewer, above the place where its size is reduced, much in excess of the capacity of the smaller sewer below the Hyde Park and Dorchester line, before the time that the high-level sewer is constructed.

No evidence has been submitted to show that the flow in the metropolitan sewer is likely to soon exceed the capacity of the sewer at any place, and it does not appear to the Board that it is necessary to provide at present automatic overflows for the proposed connections with the metropolitan sewer in Hyde Park; and the Board, therefore, does not approve the construction of overflows, as proposed in your applications.

If observations made at times of maximum flow of the height and flow of sewage in the metropolitan sewer, especially in the vicinity of the place where its size is contracted at the line between Hyde Park and Dorchester, shall show that the flow in the sewer is so great that there is danger that the capacity of the sewer, or any portion of it, is likely to be reached before any additional means of removing the sewage shall have been provided, and that the flooding of lateral sewers above the place where the sewer is contracted is threatened, or if from any other cause it would seem to you necessary to provide an overflow or overflows from the main sewer or its tributaries at any place, this Board will consider any information you may present showing the necessity or desirability of overflows, or any plans that you may submit with regard to measures for disposing of the excess of sewage; but, as already stated in a previous reply, the Board is desirous of avoiding the discharge of sewage into the Neponset River above any of the mill dams when not absolutely necessary.

The Metropolitan Water Board (sewerage system of Clinton). An application was received, Aug. 2, 1898, from the Metropolitan Water Board for the approval of the State Board of Health of a proposed system of sewerage for the town of Clinton, under the provisions of chapter 557 of the Acts of 1898. The Board replied to this application as follows: —

SEPT. 1, 1898.

The State Board of Health received from you, on Aug. 2, 1898, an application giving notice of your intention to introduce a system of sewerage in the town of Clinton, and submitting your proposed plans for approval by the Board, under the authority of chapter 557 of the Acts of 1898. The application was accompanied by plans of the proposed main sewers and other portions of the proposed system, and by the following statement relating to the plans for the disposal of the sewage of the town of Clinton: —

The preliminary examinations relative to the disposal of the sewage of Clinton were made for the Metropolitan Water Board by Messrs. Snow & Barbour, and they reported, as a result of gaugings and observations, that the quantity of sewage to be disposed of at the present time, including the wool wastes from the Bigelow Carpet Mills and the more objectionable wastes from the Lancaster Mills, equalled 780,000 gallons per day. We have not thought it necessary or desirable to attempt to pump and purify wastes which are merely discolored, and not offensive in odor or injurious to health. Should it be necessary to purify these comparatively unobjectionable wastes, the additional quantity to be purified will be about 1,000,000 gallons daily.

The sewage of the town is now discharged into the Nashua River through two main outlets, one which takes the sewage from the main valley of the Nashua River and is known as the Williams Street outlet, and the other which takes the sewage from the valley of Coachlace Brook and is known as the Allen Street outlet. It is proposed to build an intercepting sewer 20 inches in diameter, with a grade of .17 per 100, to convey the sewage from the Williams Street outlet to the Allen Street outlet, and thence to make the sewer 30 inches in diameter to the reservoir. The 20-inch sewer will receive less than half the sewage of the town, and will have a capacity, when full, of about 3,500,000 gallons daily. It is not expected that this capacity will be exceeded at any time. From the intercepting sewer the sewage will discharge into a small chamber between the reservoir and the pumping station. The sewage will first pass through a screen, and then can be turned, by means of gates, either directly into the pump wells or into the further end of the reservoir, so as to produce as much sedimentation in the reservoir as possible.

The reservoir is to be 100 feet in diameter, and up to its high-water mark, which is at elevation 247 above Boston city base, will hold 600,000 gallons. The high-water mark is placed sufficiently low to provide for the sewerage of the lowest parts of Clinton. An overflow from the reservoir is provided at the high-water level, to be used only in cases of emergency. Arrangements will be made for agitating the sediment in the tank and pumping it to the filter beds.

The pumping plant proposed is to consist of two pumping engines, one of which will have a capacity of 3,000,000 gallons daily, and two boilers, each having a sufficient capacity to supply steam to either engine.

From the pumping station the sewage will be forced through an 18-inch cast-iron pipe to the westerly corner of the area to be taken for sewage-disposal purposes, thence will be carried by a 24-inch vitrified pipe carrier to the filter beds.

It is proposed to construct at present twenty-five beds, having a total area of 23½ acres. From nineteen of these beds, which have a total area of 17¾ acres, all of the dark soil at the surface and of the subsoil will be removed, and the underlying sand and gravel will be properly graded to receive the sewage. From one bed, having an area of 1 acre, the dark soil only is to be removed before grading; and from five beds, having a total area of 4¾ acres, no soil is to be removed before grading.

The carriers for distributing the sewage to each bed will be vitrified pipes.

Two tiers of beds will be underdrained by running a vitrified pipe beneath them; but it is not proposed to drain the other beds unless it should be found necessary after trial.

Mr. Bigelow, of the Bigelow Carpet Company, has signified his willingness to construct duplicate settling tanks, in which to remove by sedimentation the solids in the wool-washing wastes.

The plans provide for a main intercepting sewer in the valley of the Nashua River, which is designed to collect the sewage from sewers which at present discharge into that stream, and convey it to a reservoir to be located on the westerly side of the river and on the easterly side of the road leading from Clinton to Lancaster Commons, from which the sewage is to be forced by pumps, through a cast-iron pipe 18 inches in diameter, to a proposed filtration area to be located on the easterly side of the road leading from Clinton to the village of Lancaster Commons, and about half a mile south-west of the latter village, and there purified by intermittent filtration.

The Board has caused the proposed system and the lands which it is proposed to use for sewage disposal to be examined by its engineers, and has carefully considered the proposed plans.

It is understood that in the construction of the present sewers in Clinton all storm water, and, so far as practicable, ground water, has been excluded, and it is also understood that in making extensions to the system in the future it is proposed to adhere to the so called separate system.

It appears that in certain manufacturing establishments in Clinton large quantities of water are used in the processes of scouring wool and dyeing wool and cotton. Information furnished by you shows that a small portion of this water, especially that which is used in the scouring of wool, becomes very highly polluted; and you propose to receive this sewage into the intercepting sewers, after removing a portion of the heavier matters by passing the sewage through settling tanks. The remaining water is used chiefly in the processes of dyeing and rinsing, and you propose to discharge this water into the river or its tributaries without treatment.

It is very important, in the opinion of the Board, that the proposed settling tanks be so operated as to remove as much of the solid matters from the sewage as it is practicable to remove by sedimentation, in order to avoid difficulty in operating the works, which would be caused by admitting such matters to the sewers.

Examinations of the effluent from the dyeing and rinsing processes show that, while it may be discharged into the river at the present time and possibly even after the construction of the reservoir above Clinton without causing a serious pollution of the stream, this effluent contains at present considerable quantities of organic matter; and it may be found desirable in the future, on account of an increase in the quantity of this organic matter or from some other cause, to remove it from the stream. It is possible that a portion of the water containing the greater portion of the organic matter can be separated, and thus the treatment of the whole of these waste waters be avoided. It is desirable, in designing the sewerage works, however, that they should be so arranged that they can be readily enlarged so as to admit of the purification of this manufacturing sewage; and it appears that such provision has been made, since the proposed sewers are of sufficient capacity to remove all of the manufacturing sewage, in addition to the domestic sewage, that seems likely to be produced for many years in the future.

The place at which it is proposed to locate the pumping station is a suitable one; and, by thorough ventilation, into the chimney at the pumping station, of the sewers, reservoir, pump wells and other places from which an odor of sewage might escape, there need be no danger of any objectionable odors in the neighborhood. In connection with the reservoir, the plans show an overflow or waste pipe through which sewage may be discharged into the north branch of the Nashua River, which at this place has a very sluggish current, owing to a dam a short distance below. By providing duplicate machinery at the pumping station, as is proposed, the necessity for such an overflow will be very slight, and this Board understands that the overflow or discharge pipe is to be used only in cases of emergency, such as an accident to the pumping station, machinery or force main, and that it is not for frequent or regular use.

The lands which it is proposed to use for sewage disposal, according to the plans, are located within the area prescribed by chapter 557 of the Acts of 1898. Examinations of the soil show that it is excellent for the purification of sewage, and the lands selected appear to be the most appropriate for the purpose that are to be found within that area.

The area of filter beds which it is proposed to prepare will be sufficient for the disposal of all of the sewage which is likely to be produced by the town of Clinton for the present and for a considerable time in the future; and it appears to be feasible to increase considerably the area of filter beds by using other lands in the prescribed area, if it should become necessary. It will be practicable to dispose of a greater quantity of sewage per acre on the beds from which all of the soil and subsoil has been removed than on the beds upon which the soil is allowed to remain, and less care in the operation of the beds will be required. The efficiency of the beds on which the soil is to be allowed to remain can be increased, however, when it becomes necessary, by removing the soil and subsoil. Should the limited amount of underdrainage that it is proposed to provide in the beginning be found inadequate for the proper removal of the effluent, further underdrainage can be provided without special difficulty.

The Board, having carefully considered the proposed plans, hereby approves them, under the authority of chapter 557 of the Acts of 1898.

Northampton. An application was received from the board of health of Northampton, Nov. 11, 1898, for the advice of the Board relative to the best method of disposing of the sewage of a mill in course of construction in that city. The Board replied to this application as follows: —

Dec. 2, 1898.

The State Board of Health received from you, on Nov. 11, 1898, a communication requesting advice as to the best way of disposing of the sewage of a new hosiery mill, the construction of which has recently been begun near the Mill River in Northampton. You state that the plan under consideration is to build a sewer to discharge the sewage of the factory into Mill River, at a point near the railroad bridge just below West Street. You also state that the only sewer in the vicinity of the proposed mill is a trunk line, indicated upon the plan submitted, which is so much higher than the land on which the mill is being built that you are informed that it is impossible to connect the building with it.

The Board has caused the locality to be examined by one of its engineers, and has carefully considered the proposed plan. It appears that the current in the river at the proposed sewer outlet is very sluggish during much of the time, owing to a dam across the river a short distance below, and that there is a large population in the vicinity of the river below the proposed point of discharge. Under the circumstances, the Board is of the opinion that no sewage should be discharged into the river in this vicinity.

It would probably be practicable, without great expense, to collect all the sewage in a small reservoir or tank, properly ventilated, and force it into the intercepting sewer. It is possible also, that, by preventing the construction of sinks, water-closets or other fixtures in the lower portion of the factory, a sewer can be laid in the vicinity of the railroad embankment to convey the sewage to the main sewer by gravity.

The Board advises that the matter be given further careful consideration, in order that the most feasible plan of disposing of the sewage into the present sewerage system may be selected.

SOUTHBRIDGE. A request was received from the town of Southbridge, Aug. 5, 1898, for the approval of the State Board of Health of certain lands in that town for the purpose of sewage disposal. A hearing was granted under the provisions of chapter 124 of the Acts of 1890, on Sept. 1, 1898, after which the Board replied to the application as follows: —

SEPT. 29, 1898.

The State Board of Health received from you, on Aug. 5, 1898, an application requesting approval by the State Board of Health of the taking by the town of Southbridge of certain lands in that town, now or formerly of the estate of G. W. Wells, situated for the most part on the northerly side of the Quinebaug River, in the vicinity of the Lensdale Dam, so called, for the purification and disposal of sewage.

In response to this application, the State Board of Health, in accordance with the requirements of chapter 50, section 1 of the Public Statutes, as amended by chapter 124 of the Acts of 1890, gave notice that a public hearing relative to the taking of the lands in question for the purification and disposal of sewage would be given at its office on Sept. 1, 1898. At this hearing no person appeared to oppose the proposed taking of the lands referred to, and the Board voted to approve the purchase or taking by the town of Southbridge of said lands for the purification and disposal of sewage. The said lands are shown upon a plan submitted by you on Aug. 5, 1898, signed by A. C. Moore, and are bounded, measured and described as follows: —

Beginning at a stone bound set on the east shore of Lensdale Pond, on the Quinebaug River, at line of land of Ellen J. Bartholomew; thence southerly and easterly on said river and pond about 2,000 feet to a pin near where the new channel of said river empties into the pond of the Southbridge Printing Company; thence southerly, crossing said river to a pin on the northerly line of Main Street; thence easterly on said Main Street about 280 feet to a pin at land of George W. Wells, known as the "Grant lot;" thence northerly by said Grant lot to the centre of said river; thence easterly on the centre of said river to land of said printing company; thence N. 4° 45′ E. by land of said printing company, E. T. Torrey and land formerly belonging to L. Travis, to a pin at a corner; thence S. 86° W. 364 feet to a pin at land of said Bartholomew; thence S. 4° 45′ W. 1,155 feet; thence S. 50° W. 247.5 feet; thence N. 68° W. 1,518 feet, all by land of said Bartholomew to the first-mentioned bound, containing 52 acres of land, more or less, a plan of which land is filed herewith and made a part of this petition.

SPRINGFIELD. An application was received, Nov. 3, 1897, from the mayor of Springfield, for the advice of the Board relative to the sewerage and sewage disposal of the Mill River valley in that city, and the propriety of discharging storm water into Watershop Pond and Mill River. The Board replied to this application as follows: —

June 3, 1898.

The State Board of Health received from you, on Nov. 3, 1897, an application for advice with reference to proposed plans for the disposal of sewage and storm water from the Mill River valley in Springfield.

Subsequently, new and detailed plans were submitted by the city engineer, one showing the areas from which the proposed Mill River intercepting sewer is designed to receive sewage and storm water, and the other showing the location and profile of the proposed intercepting sewer in the valley of Mill River. The proposed sewer is to begin at a point in Walnut Street near Hickory Street, north of the outlet of Watershop Pond, and, passing along the northerly side of Mill River, is to discharge into that stream a short distance below Fort Pleasant Avenue and above the third dam from the mouth of the river. This sewer is designed to provide for the disposal of the sewage from two districts. One of these districts includes chiefly the valley of Carlisle Brook, on the northerly side of Watershop Pond. In this district it is proposed to construct the sewerage system upon the so called separate plan, excluding from the sewers all storm water, and, so far as practicable, ground water, and to discharge the sewage into the intercepting sewer, while the storm water and ground water is to be disposed of by separate channels discharging into the brook or its tributaries, or into Watershop Pond. In the other district, a small portion of which lies north of Watershop Pond and Mill River and the remainder south of the pond and river, it is proposed to collect both sewage and storm water in one system of sewers, and to discharge them into the proposed intercepting sewer at several points, providing overflows at the points where sewers connect with the intercepting sewer, through which the mingled sewage and storm water may overflow into Mill River below Watershop Pond whenever the main sewer is flowing full.

The Board has caused the locality to be examined by its engineer, and has carefully considered the plans and other information submitted.

It is important to keep all sewage out of Watershop Pond, and for this reason no overflow or sewer from which sewage is discharged should be connected with this pond.

The proposed method of disposing of the sewage and storm water from the valley of Carlisle Brook seems to be the best that it is practicable to adopt.

In the other district, which it is proposed to connect with the intercepting sewer, sewers have already been constructed upon the combined plan, and it is probably best, in making future extensions in this district, to adhere to this system.

There are other areas in the valley of Mill River, at present very sparsely populated, from which the sewage can be taken into the intercepting sewer, if necessary, in the future; but it will be necessary to exclude storm water from the sewers in those districts, and it will also be essential, in order to avoid causing more frequent overflows of the Mill River sewer than are desirable or are contemplated in the present plan, to divert from this sewer some of the storm water which it is now proposed to discharge into it. If the necessity for reducing the quantity of storm water discharged into the main sewer arises, it can probably be accomplished by building a separate channel for the storm water in some portion of the district which it is now proposed to provide with sewers upon the combined plan; such, for instance, as the territory in the vicinity of Allen and White streets, and to dispose of the storm water by discharging it into Mill River.

The proposed intercepting sewer in the valley of Mill River, as designed, is of sufficient capacity to remove all of the sewage and storm water from the districts which it is designed to serve, excepting occasionally, at times of very heavy rain, when a small amount of mingled sewage and storm water may be discharged through overflows from tributary sewers at several points along the stream below Watershop Pond. It is not likely, however, that the sewage discharged at such times will have any very unfavorable effect upon the sanitary conditions of the stream, but it is very important that the quantity of sewage disposed of in this way be kept as small as possible.

It is understood that you propose to divert from the intercepting sewer at Locust Street so much of the sewage and storm water as the Locust Street sewer is capable of removing, and to discharge only the surplus through the Mill River intercepting sewer into Mill River.

From the information submitted, it seems probable that the Locust Street sewer will be capable of removing the dry-weather flow of the sewage from the Mill River intercepting sewer, as well as the dry-weather flow of sewage from sewers in Fort Pleasant Avenue and Belmont Avenue, which are connected with the Locust Street sewer. It seems likely that, in addition to the dry-weather flow of sewage from the sewers referred to, the Locust Street sewer will be capable of carrying off a small amount of storm water, so that in small storms there may be no flow in the Mill River intercepting sewer below Locust Street; but with larger storms and at times of thaws a portion of the mingled sewage and storm water will be discharged through the intercepting sewer into Mill River.

It is proposed to terminate the Mill River intercepting sewer in Mill River, just above the third dam from the mouth of the stream. If any considerable quantity of sewage should be discharged into the Mill River in this region, there is danger that a nuisance may be created; and the Board is of the opinion that it is very desirable to avoid the discharge of any considerable quantity of sewage into Mill River above any of the dams on the stream. There are, moreover, indications that the lower portion of the Mill River valley, in the immediate vicinity of the stream, is likely to be densely populated before many years, so that it will probably be necessary to extend the sewer to the Connecticut River, and it appears to be practicable to extend the sewer to that stream. It seems probable, however, that the quantity of sewage that will be discharged from the Mill River intercepting sewer will be small in the beginning, and the sewage coming from this sewer will probably be quite dilute.

Under the circumstances, the Board is of the opinion that it is desirable to extend the sewer in the beginning as far at least as some place below the lowest dam, though a temporary outlet at the point proposed may not cause any serious trouble for a time.

The plan as a whole, with the modifications suggested, is, in the opinion of the Board, a suitable one for the disposal of the sewage of the Mill River valley.

SPRINGFIELD. Another application was received from the mayor of Springfield, July 7, 1898, for the approval of certain sewers for a small district of Springfield having their outfall into the Connecticut River. The Board replied as follows: —

AUG. 8, 1898.

The State Board of Health received from you, on July 7, 1898, an application for advice with reference to the discharge into the Connecticut River of sewage and storm water from a proposed sewer to be built in Clinton, Fulton and Sargent streets, in Springfield. The plan shows a storm-water overflow at the Harbor Commissioners' line at the easterly bank of the Connecticut River, and a sewer leading downward from the bottom of the main sewer just above the outlet along the bottom of the river to a point of discharge 200 feet from the Harbor Commissioners' line.

The Board has caused the locality to be examined by one of its engineers, and, having given the matter careful consideration, concludes that the proposed method and plan of disposing of the sewage of the district under consideration are suitable for the purpose.

WAKEFIELD. A communication was received from the committee on sewerage of the town of Wakefield, requesting the approval of the Board, under chapter 124 of the Acts of 1890, of the purchase or taking of land for the purification and disposal of sewage, at the same time indicating certain tracts of land lying in the valley of the Saugus River as suited to the purpose. The Board replied to this application as follows: —

OCT. 6, 1898.

The State Board of Health received from you, on Aug. 31, 1898, a communication requesting approval by the Board of the taking of certain lands in the town of Wakefield for the purification and disposal of sewage, under the authority of chapter 124 of the Acts of 1890 and chapter 50 of the Public Statutes.

You state that it is proposed to utilize the property described in your application by filling upon the bottom and swamp land to the required depth with suitable material, some of which can be procured upon the land you propose to take, and the balance within 2,000 feet at the town farm, toward which place it is proposed to extend the filter area as necessity requires. Subsequently a plan was received, showing an outline of lands which you propose to take; and later a topographical plan of the area was submitted, showing the location of test pits.

The lands which you propose to use are located in the easterly portion of the town of Wakefield, adjoining the town of Saugus, and are bounded on the northerly and easterly sides by the Wakefield branch of the Saugus River and by the Saugus River.

The Board has caused the locality to be examined by its engineer, and has carefully considered the proposed plans and other information submitted.

In some parts of the proposed filtration area the soil appears to be suitable for the purification of sewage by intermittent filtration, but the aggregate area of these portions is much less than would be necessary for the purification of the sewage of the town of Wakefield. If the gravelly soil found on a part of the area extends to a sufficient depth, filter beds might be constructed with this material upon other portions of the area; but, even if filter beds should be constructed upon all portions of the area that appear to be suitable for that purpose, by using such suitable soil as is found upon the area, or by hauling sand or gravel from the town farm, if necessary, as suggested in your application, the Board is unable to conclude that a sufficient area could be prepared here for the disposal of all of the sewage of the town of Wakefield after a sewerage system shall have come into general use. Moreover, the cost of preparing filter beds, even upon the portions of this area best suited for the purpose, would be very large, as compared with the cost of constructing filter beds upon land better adapted to the purpose.

Under the circumstances, the Board is unable to approve the purchase or taking of the land referred to in your application for the purpose of the purification and disposal of the sewage of Wakefield.

In response to an application from the authorities of the town of Wake field, made in 1892, for advice with reference to a proposed plan of sewerage and sewage disposal for the town, by which it was proposed to use land in the vicinity of the town farm for the purification and disposal of the sewage, the Board made the following statement: —

With regard to the best place for filtering the sewage, your engineer has shown in his report that the proposed disposal area has a decided advantage, in regard both to the cost of reaching it with the sewage and to the cost of maintenance, over any other available area. The character of the land at this place is also of excellent quality for filtration, so that, on the whole, these advantages may be said to outweigh the disadvantage that the tract contains two small houses and a school-house, and is not very far from settled portions of the town.

It does not appear that there has been any material increase in the population in the vicinity of the town farm in the last six years, so that the disadvantage referred to has not become materially greater; and it is probable that the necessary cost of purifying the sewage in the vicinity of the town farm would be less than by any other method of disposal that it is practicable to adopt. It is possible that there may be other suitable areas of land within the limits of the town, not known to this Board, which are suitable for the disposal of the sewage of Wakefield; and the Board is prepared to assist you in any further investigations you may conclude to make with reference to sewage disposal, by making such analyses of samples of soil as may be necessary, and to advise you as to any plan of sewerage or sewage disposal for the town which you may wish to present.

WAKEFIELD. Another application for advice was received from Wakefield, Nov. 8, 1898, with reference to the propriety of taking certain lands in Wakefield, under the authority of chapter 124 of the Acts of 1890. The Board replied to this application as follows: —

JAN. 5, 1899.

The State Board of Health received from you, on Nov. 8, 1898, a further application for advice with reference to the disposal of sewage of the town of Wakefield, in which you request the approval by this Board, in accordance with the requirements of chapter 124 of the Acts of 1890 and chapter 50 of the Public Statutes, of the taking of certain lands in the Woodville district in the town of Wakefield, comprising the Tyzzer, Edmunds and Buckman properties, and a portion of the town farm east of a brook which runs parallel with Farm Street about 500 feet easterly therefrom, for the purification and disposal of the sewage of the town, these lands being in addition to the Lynde and Hone lots described in a previous application. You also furnish a description of the lands you propose to take and a plan showing their location; but no plan has been presented showing definitely how the sewage is to be conveyed to these lands, or how they are to be prepared for the disposal of the sewage upon them.

The Board has given the matter of the disposal of the sewage of Wakefield further consideration, and has caused the lands described in your application to be examined by its engineer, and samples of soil from a limited number of test pits on these lands to be analyzed.

It is difficult, from the limited amount of information available with reference to the character of the soil of these lands, for the Board to determine at all definitely the area of the land within the lots mentioned in your application that is suitable for the construction of filter beds for the purification and disposal of sewage; but, so far as can be judged from the information available, there may be about 8 acres of land upon which it would be practicable to construct filter beds at a reasonable cost, which would be suitable for the disposal of the sewage of Wakefield. Judging from experience in other cities and towns, the area of land which is here suitable for filtration might be no more than sufficient to provide for the disposal of the sewage of Wakefield after the sewers had been generally extended through the town and become generally used.

The area of filters could probably be enlarged by taking some of the material from the higher portions of the gravelly areas, if the coarse material extends to a sufficient depth, and constructing filter beds artificially upon other portions of the land; but the cost of constructing filter beds in this way would be very large, as compared with the cost of constructing filters upon gravelly land naturally adapted to the purpose, where the material does not need to be moved.

It is understood that you propose, if it shall become necessary in the future, to use other portions of the town farm, located on both sides of Farm Street, for the extension of the filter beds; and, judging from the present indications, it would probably be necessary to extend the works for purifying the sewage within a few years after their construction; and, if the town farm lands are to be used at all, it would probably be less expensive for the town to use these lands in the beginning, because the indications are that the cost of conveying sewage to these lands and constructing filter beds upon them would, as indicated in the previous reply of the Board, be less than at the places proposed in your present application.

The attention of the Board has also been called, in this connection, to the lands north of Water Street and east of Montrose Avenue, where the character of the surface of the ground indicates that the soil over a considerable area may consist of porous sand or gravel. It is possible that further investigations might show that a sufficient area of suitable land for the disposal of the sewage of Wakefield exists here; and it is possible that these lands may be found, upon careful examination, to possess advantages as a place of sewage disposal which would make it desirable to select them for this purpose in preference to the other areas that have thus far been considered.

The information thus far presented with reference to the comparative advantages of the areas which appear to be available for the disposal of the sewage of Wakefield is not sufficient to enable the Board to arrive at definite conclusions as to which area or areas it would be for the best interests of the town to use for the disposal of its sewage. Under the circumstances, the Board does not at present advise that the land proposed in your application be selected as a place of disposal for the sewage of Wakefield, but would again advise that a further and more thorough investigation of the whole subject be made by the town, in order to collect all the available information with reference to the comparative advantages and suitability of the various areas for the disposal of sewage, and thus make it possible to determine which area it will be for the best interests of the town to use. These investigations should include such further surveys of the lands which appear to be available for sewage disposal as may be necessary to determine their elevation; the digging of a sufficient number of test pits in these lands to determine the character of the soil, the extent of areas containing soil suitable for sewage disposal, and the depth to ground water where necessary; and, finally, careful comparative estimates of the cost of constructing filter beds sufficient for the disposal of the sewage of the town for the present and for a reasonable time in the future, including a careful estimate of the probable expense for land damage in each case.

The Board will assist you in the investigations, if you desire, by making such analyses as may be necessary of samples of soil from test pits that you may excavate upon these areas, and will, upon application, give you further advice with reference to any plan of sewage disposal when you have the results of further investigations to present.

WALES. An application was received May 25, 1898, from the board of health of Wales, for the advice of the Board relative to the disposal of the drainage of certain houses in the village of Wales. The Board replied to this application as follows: —

JULY 7, 1898.

The State Board of Health received from you, on May 25, an application for advice with reference to the disposal of sink drainage from houses in the village of Wales. You suggest the possibility of preventing these nuisances by the construction of cess-pools.

The Board has caused an examination of the village to be made by its engineer, and finds that, owing to the contour of the land, many of the houses drain naturally toward the main street. Complaint is made of several sink drains which discharge upon this street, and particular attention was called to four of these drains. The construction of a sewer to remove sink drainage or other sewage seems impracticable, under the existing conditions; and, after careful consideration of the whole matter, the Board is of the opinion that, in general, the best method of disposing of the sink drainage which causes trouble in the village at present is by the construction of cess-pools. Care will have to be taken to locate cess-pools in such a manner that their contents may not find their way into any well or into the cellar or basement of any building.

Examination of each of the localities of which complaint is made at the present time indicates that it is practicable to construct cess-pools in the vicinity of the houses, to receive the drainage. One of the cases to which attention was called was that of a house located on the easterly side of the main street, south of the saw mill, the drain from which causes a serious nuisance in the street. It appears to be entirely practicable to divert the drainage to the rear of the house, where it may be disposed of either into a cess-pool or upon the surface of the ground, where it can probably be advantageously used as a fertilizer.

Pollution of Ponds, Streams and Other Bodies of Water.

The following is the substance of the action of the Board during the past year in reply to applications for advice relative to the pollution of ponds, streams and other bodies of water: —

Arlington. The attention of the State Board of Health was called by a communication from the Arlington water board to the existence of a slaughter house upon the water-shed of their source of supply, at the same time requesting the State Board "to take such action as the law allows to prevent further impairment or pollution of the water supply of the town of Arlington." The Board replied to this communication as follows: —

May 6, 1898.

The State Board of Health received from you, on April 12, 1898, a communication calling attention to a building used for slaughtering purposes and for the keeping of swine, which is drained into a small pond which is tributary to one of the sources of the Arlington water supply, and requesting this Board to take such action as the law allows, to prevent the pollution of the water supply of Arlington.

The Board has caused an examination of the building and of the locality to be made by its engineer, and finds that the building is used, as stated, as a slaughter house and for the keeping of swine, and there are evidences that drainage from it has recently flowed into one of the sources of the Arlington water supply. The drainage from this establishment is of a very foul character, and its discharge into the Arlington water supply should be discontinued as soon as possible.

By the provisions of chapter 491 of the Acts of 1894 and chapter 496 of the Acts of 1895, the proprietors of every slaughter house engaged in the slaughter of neat cattle, sheep or swine, any product of which is to be sold or used for food, shall annually, in the month of April, make application to the mayor and aldermen of the city or selectmen of the town where such establishment is located for a license to carry on such business. The

Board is informed that this establishment has not been licensed by the selectmen of Lexington, as required by the acts referred to.

Under the circumstances, it would seem that the selectmen of Lexington, upon presentation of the facts by the authorities of the town of Arlington, might refuse to grant a license, and thus prevent the continuance of the business at the present location or at any place where there would be any danger of causing a pollution of the water supply of the town of Arlington.

If a license is granted, it may be practicable for the person or persons who control the operations of the establishment in question to prevent polluting matters from escaping from it into the Arlington water supply. If this is not done, however, it seems possible for the town to prevent the pollution of its water supply from the operations carried on in and around this building, by acting under the authority of chapter 80, section 96 of the Public Statutes, which appears to cover such cases as the one under consideration; and the Board would advise that the necessary legal steps be taken, unless the pollution of your water supply from this source is discontinued.

Falmouth. An application was received, May 26, 1897, from the board of health of Falmouth, asking advice as to the best method "of abating a nuisance existing in State waters at the head of Little Harbor, so called, in Wood's Holl, and consisting of mud, seaweed and decomposed matter brought in by action of the wind and tide." The Board replied to this application as follows: —

March 4, 1898.

The State Board of Health has considered your application for advice with reference to the best method of abating a nuisance at the head of Little Harbor in the town of Falmouth, has caused an examination of the locality to be made by its engineer, and has carefully examined the plans proposed by you. These plans provide for the construction of a bulkhead across the north-easterly corner of the cove where the nuisance exists, and the filling in of the portion of the harbor thus cut off.

It is probable that, by constructing the bulkhead and making it tight enough to prevent the water passing out, and thus keeping the area covered with water at all times, much relief would be experienced from the odor now complained of, and the filling in of the area behind the bulkhead, as proposed in the application, would prevent all odor from this area; but whether, by this plan, permanent relief would be secured, seems doubtful, since it is possible that the seaweed would deposit outside of the bulkhead, and, gradually rising above the level of low water, again produce a nuisance such as is now complained of. It is also an objection to this plan that it would lessen the area of the harbor and reduce the quantity of tide-water coming in and going out of the harbor, thus changing somewhat the existing conditions which might possibly have an unfavorable effect upon the condition of some other portion of the harbor.

The indications seem to be that seaweed is carried to the north-easterly corner of the harbor, where the nuisance is now complained of, both floating upon the surface of the water and in suspension in the water below the surface, and perhaps also by movement along the bottom. If these masses could be arrested before entering the portion of the harbor where they are now deposited, and at the same time the tide water be allowed to pass into this place, the water, going out from behind a barrier arresting these masses, would tend to prevent them from being deposited, and the larger the area behind the barrier compared with the length of the barrier the more efficient would be its action.

In view of the circumstances, the Board would suggest, as a probable method of obtaining relief, the construction of a bulkhead perhaps 100 feet farther into the harbor than shown upon your sketch, if this distance would not interfere with the uses of the harbor; this bulkhead to be closed from high water down to near low water, below which to be composed of vertical strips of plank, two or three inches apart, covering half the area. The deposit in the rear of the bulkhead should be removed at least down to low water and deeper near the bulkhead, where the open work should present a water way as much as 4 or 5 feet in depth.

It is not known whether the Teredo operates to injure structures in this harbor, but the possibility of trouble from this organism should be taken into account in the construction of the work.

Middleborough. A petition was received by the State Board of Health, Oct. 6, 1898, from inhabitants of Middleborough, relative to the prevalence of malarial fever in a portion of that town, and alleging the pollution of the Nemasket River and the existence of certain nuisances caused by the sewage disposal of the town.

Accompanying this petition was a copy of another petition, addressed to the local board of health of Middleborough, dated Oct. 1, 1898, requesting that board to examine into the pollution of the Nemasket River and the cause of malarial fever, and to destroy, remove or prevent the same.

A supplementary petition was received, Oct. 20, 1898, by the State Board of Health, requesting a hearing, under the provisions of chapter 375 of the Acts of 1888; and representing that the disposal of sewage through the ditch into the Nemasket River, as alleged in the first petition, was begun in 1892, and that, contrary to the provisions of chapter 375 of the Acts of 1888, notice had never been given to the present State Board of Health or its predecessors by the present or any authorities of the town of Middleborough, at any time, of the intention of any of the said authorities as to disposing of their drainage and sewage in the manner alleged. The petitioners further stated that application had never been made for the advice and approval of the State Board of Health or its predecessors of the plans or schemes in relation to water supply and disposal of drainage and sewage proposed and practised, as alleged in the first petition; that is, by discharging it through a ditch into the Nemasket River opposite Mayflower Avenue; and that such omissions were and are contrary to the said act, and that such disposal and the pollution of the Nemasket River thereby have been and are contrary to the laws of the Commonwealth existing at any time during such disposal and pollution, and the Board was requested to bring such omission and pollution to the notice of the Attorney-General. In compliance with these petitions, the Board gave hearings to the petitioners, Nov. 3 and Nov. 17, 1898, and on Dec. 1, 1898, sent copies of the following communication to the petitioners and to the boards of health and selectmen of Middleborough: —

DEC. 1, 1898.

The State Board of Health received, on Oct. 6, 1898, a petition from inhabitants of the town of Middleborough, relative to the prevalence of malarial fever in a portion of the town, and alleging the pollution of the Nemasket River and the existence of certain nuisances in the disposal of the sewage of the town.

Accompanying this petition was a copy of a petition addressed to the local board of health of the town of Middleborough, dated Oct. 1, 1898, requesting the said board to examine into the pollution of the Nemasket River and the cause of malarial sickness, and destroy, remove or prevent the same.

On Oct. 20, 1898, a supplementary petition was received by the State Board of Health, requesting a hearing, under chapter 375 of the Acts of 1888, and representing that the disposal of drainage through the ditch into the Nemasket River, as alleged in the first above-mentioned petition, was begun in the year 1892; and that, contrary to chapter 375 of the Acts of 1888, notice has never been given to the present State Board of Health or its predecessors by the present or any authorities of the town of Middleborough at any time of the intention of any of the said authorities as to disposing of their drainage and sewage in the manner alleged; and that submission has never been made for the advice and approval of the present

State Board of Health, or its predecessors, of the plans or schemes in relation to water supply and disposal of drainage and sewage proposed and practised as alleged in the first petition, that is, by discharging it through a ditch into the Nemasket River opposite Mayflower Avenue; and that such omissions were and are contrary to the said act, and that such disposal, and the pollution of the Nemasket River thereby, have been and are contrary to the laws of the Commonwealth, existing at any time during such disposal and pollution; and the Board is requested to bring such omission and pollution to the notice of the Attorney-General of the said Commonwealth, as required by the said act.

The Board has carefully considered these petitions, and has given a hearing to the petitioners and the town authorities, and evidence relative to the matters referred to in the petitions has been presented to the Board. The Board has also caused the localities referred to to be examined by its engineer, and the prevalence of malaria to be investigated by one of its experts.

The Board does not at present express an opinion in regard to the claimed violation of the provisions of chapter 375 of the Acts of 1888, preferring to proceed immediately to the development of a practical way of removing such conditions as endanger the public health.

It is evident that malarial sickness has been increasing in the town of Middleborough in recent years, and that there has been a great increase during the present year, in which it appears that up to the first of November there have been as many as thirty cases of malaria in the town. Half of these cases have occurred in the village of Muttock, and, considering the small population of this village, the epidemic at that place has been a most serious one.

The Board finds that at the present time sewage from a large portion of the main village of Middleborough is discharged into the Nemasket River through two main sewers, one laid in Mayflower Avenue, so called, and the other in Water Street. The sewer in Mayflower Avenue ends at a point about 500 feet from the Nemasket River, where the sewage flows from the sewer into an open ditch and through this ditch to the river. The flow in the ditch is sluggish, and solid matters from the sewage are deposited upon the sides and bottom of the ditch, especially in the vicinity of the place where it joins the river. Moreover, the current of the river is also very sluggish in this vicinity, owing to a dam a short distance below, so that solids brought down in the sewer tend to deposit upon the sides and bottom of the stream and mill pond, portions of which, on account of the rise and fall of the river, are apparently alternately exposed to the air and covered with water.

The sewer in Water Street discharges into the raceway leading from the electric light works to the river. In the day-time, when the works are shut down, there is very little water running in the raceway to dilute the sewage, which spreads out over the stony bottom of the raceway in pools and small streams, and finds its way slowly toward the river, creating an objectionable local nuisance. In this case also there is a dam across the river a short distance below the sewer outlet, and solid matters from the sewage tend to collect on the sides and bottom of the mill pond, and make them offensive when exposed.

The dam at Muttock is an old one, and is in a ruined condition. The banks of the river in this vicinity are quite flat, and a considerable area appears to be alternately covered with water and exposed to the air by slight fluctuations in the level of the water in the river. It also appears that there has been complaint of an odor from the banks of the stream when exposed at times when the water is low, and an attempt has been made to keep them covered with water, but it does not appear that this has been done.

The present manner of disposing of the sewage of Middleborough is unsanitary, and may be among the causes of the large amount of sickness in the portion of the town which is nearest the river; and the conditions are certain to grow worse, because the quantity of sewage is likely to increase, while the flow of the river will grow smaller in the future, owing to the quantity of water withdrawn from the Middleborough ponds by the cities of Taunton and New Bedford for water-supply purposes.

The present method of disposing of the sewage of Middleborough is objectionable also, because the sewage pollutes the water supply of the State Farm, which is drawn from the Taunton River a short distance below the mouth of the Nemasket River.

It appears, from the evidence before the Board, that the discharge of the sewage in a crude state into the stream was not contemplated by the town as a permanent method of sewage disposal, but was a temporary expedient, which has, however, been continued in operation in the case of one sewer outlet for a period of at least thirteen years, and in the other for as many as six years. The sewerage plans of the town provide for an intercepting sewer in the valley of the Nemasket River, to collect the sewage from existing sewers and areas which may require sewerage in the future, and convey it to land in the valley of the river below the Star Mills, where it can be purified; but these portions of the works have not been constructed, and it does not appear that any thorough surveys or plans for works for collecting and purifying the sewage have been prepared, though a preliminary estimate, indicating the ultimate cost of the works, has been submitted.

In view of all the circumstances, the Board is of the opinion that the interests of the town of Middleborough and of the public require that the sewerage plans be carried out by constructing the works for collecting and purifying the sewage, and that the existing sewer outlets into the Nemasket River be closed, and the discharge of sewage through them be discontinued.

The Board would therefore advise that you cause an investigation to be made without delay, to determine the best available place for disposal and purification of the sewage, and the most feasible route for an intercepting sewer to convey the sewage from the present sewers and any other areas which are likely to require sewerage in the future to the proposed disposal area, together with careful estimates of the entire cost, and showing, among other things, the expenditure necessary for preparing sufficient land and for building presently so much of the intercepting sewer as will convey to that land the sewage now entering or soon to enter the Water Street sewer and the sewers down river therefrom.

Upon receiving such plans and estimates, the Board will advise further in regard to the portion of the work necessary to be first constructed. The Board will assist you in these investigations, if you desire, by making such examinations of the soil of available lands for filtration areas as may be necessary, and will, upon application, advise you as to any sewage disposal plan you may wish to present. It is also advised that in making investigations for the disposal of sewage you secure the assistance of an engineer of experience in such matters.

RHODE ISLAND. A communication was received from the State Board of Health of Rhode Island, July 28, 1898, with reference to the pollution of Ten-mile River by the sewage of Attleborough, that river being the source of water supply of the town of East Providence in Rhode Island. The assistance of the State Board of Health of Massachusetts was also requested in the removal of the sources of contamination. The Board replied to this communication as follows: —

Nov. 4, 1898.

The State Board of Health received from your Board, on July 28, 1898, a communication stating that, as a result of a recent inspection of the Ten-mile River made by your Board in the towns of Attleborough and North Attleborough, it was found that a number of factories and mills and the town of Attleborough were delivering their wastes, both from vaults and from the processes of manufacture, into the river, which is the source of water supply of the town of East Providence in Rhode Island. You request the assistance of this Board in the removal of these sources of contamination, and ask if any action can be taken by this Board in the matter, legally or otherwise. Accompanying your communication were memoranda of the inspection referred to.

The Board has caused an examination of the valley of the Ten-mile River to be made by its engineer, and has carefully considered the results of previous examinations of the stream and its water-shed. From the information recently collected, it appears that at the present time the sewage from as many as 4,500 people in the villages of Lebanon Mills, Kents Mills, Hebronville, Dodgeville, Attleborough, Robinsonville, Attleborough Falls, North Attleborough, Plainville and South Attleborough is discharged directly into the stream or its tributaries, and that large amounts of sulphuric acid, nitric acid, hydrochloric acid, ammonia, spent dyes and other substances used in the various manufactories are discharged into the river. Gas wastes, wastes from a rendering establishment at which dead animals are disposed of, and wastes from a tannery, also enter the stream.

Numerous chemical analyses of samples of water collected from this river at two points, one above North Attleborough and the other above Attleborough, were made several years ago, and the results were published in a special report of this Board, entitled "Examination of Water Supplies," published in 1890.

In this report it is stated that the pollution of the river at Attleborough was sufficient to render the water taken directly from the river unfit for drinking. No analyses of the water of the river below Attleborough were made at that time, but analyses made in more recent years have shown that the river is polluted to a much greater degree below the town than it is above.

The sewage discharged from the Attleborough sewers is the most serious pollution of the stream that exists at the present time; and the Board has already called the attention of the town of Attleborough to the objection to disposing of sewage by discharging it directly into the stream, and some action has been taken by the town, looking to the removal of the sewage from the river and its purification upon land. If, however, the sewage of the town of Attleborough should be purified before it is discharged into the river, while a great improvement in the sanitary condition of the stream will be effected, the stream would, nevertheless, continue to be, in the opinion of this Board, a very dangerous source from which to take water for drinking or other domestic uses. Moreover, on account of the large population within the water-shed of the stream and the numerous villages and mills widely scattered throughout this water-shed, it is impracticable, in the opinion of this Board, to prevent the pollution of the stream by sewage and manufacturing wastes to such an extent as to render the water safe for drinking.

The Board considers that the pollution of the river to the present degree is very objectionable, from a sanitary stand-point, and that, in the interests of the people of this valley, further pollution of the stream should be prevented; and the sewage of Attleborough, which is now discharged into the stream, should be removed therefrom and purified. The Board will urge the purification of the stream as rapidly as practicable; but, as already stated, it is not practicable, in its opinion, to render the water of the river below Attleborough suitable for drinking.

WESTBOROUGH. A communication was received from the selectmen of Northborough, stating that the sewage of Westborough was allowed to pass into the swamps near the filter beds without filtration, and that such disposal was a menace to the health of Northborough, at the same time requesting the State Board of Health to investigate the matter. The Board complied with this request, and sent the following communications to the selectmen of Northborough and to the sewer commissioners of Westborough. To the selectmen of Northborough, as follows: —

JAN. 5, 1899.

The State Board of Health received from you, on March 21, 1898, a communication relative to the Westborough sewer beds, stating that sewage was being turned directly into the swamps in the rear of the beds, and that the beds seemed to care for only a small portion of the sewage. You regard this as a menace to the health of the town, and request the Board to investigate, and take such action as shall seem for the best interests of all concerned.

The Board has caused examinations to be made from time to time since your application was received, to determine the quantity of sewage flowing from the town sewer, the character and condition of the filter beds and the quality of the water of the Assabet River, both above the filter beds and below them in the vicinity of Northborough and elsewhere.

The Board has found that much crude and partially purified sewage is being discharged into the Assabet River or small tributaries of that stream in the vicinity of the filter beds, — a method of disposal which was not contemplated in the plans for sewage disposal of Westborough, presented by the town to this Board under the authority of chapter 375 of the Acts of 1888, and which is inadmissible.

In 1893 the Board advised the town of Westborough relative to the purification of its sewage, and a considerable increase in the area of the filter beds has been made since that time; but the beds are nevertheless at present inadequate for the purification of the sewage. The Board has, accordingly, called the attention of the authorities of the town of Westborough to the need of constructing suitable works for purifying all of its sewage, and a copy of the communication is enclosed herewith.

The Board finds, as stated therein, that the Assabet River is being badly polluted by the sewage of the town of Westborough, and that the discharge of unpurified sewage into the stream is likely to prove a serious nuisance in the summer season, and the Board believes that the disposal of sewage in this way should be prevented.

It will not be practicable for the town of Westborough to make investigations or to construct works before next spring; and the Board would suggest that further action be deferred until an opportunity has been given for the town of Westborough to construct proper works.

The following communication was sent to the sewer commissioners of Westborough: —

JAN. 5, 1899.

The State Board of Health received a communication from the board of selectmen of the town of Northborough, in the early part of 1898, alleging that unpurified sewage was being discharged into the Assabet River, in the vicinity of the sewage filtration area of the town of Westborough.

The Board has caused examinations to be made, to determine the quantity of sewage flowing from the town sewer and the character and condition of the filter beds, and has also caused samples of the water of the Assabet River, both above the filter beds and at various points below the beds, to be analyzed.

As a result of these examinations, the Board finds that the quantity of sewage flowing from the town is often greatly in excess of the capacity of the filter beds for purifying the sewage, and that much crude and partially purified sewage is discharged into the Assabet River, or into small tributaries of that stream in the vicinity of the filter beds, and that the quantity so discharged is at times the greater portion of the flow of sewage. It also appears that a considerable quantity of sludge is separated from the sewage at certain periods of the year, and that part of it is discharged through a pipe directly into a meadow or swamp through which water flows to the Assabet River.

The plans for a system of sewage disposal presented to this Board by the authorities of the town of Westborough, under the provisions of chapter 375 of the Acts of 1888, provided for the purification of the sewage of the town of Westborough by intermittent filtration; and the discharge of unpurified sewage into the Assabet River or any of its tributaries has never been contemplated in any plan presented to this Board, and is inadmissible.

In the latter part of the year 1893 your Board requested the State Board of Health to examine your sewage-disposal works, and advise the town in the matter of sewage disposal. The Board advised you then, as on a previous occasion, very definitely as to how you should proceed to provide a proper system of sewage disposal, and offered to assist you in determining the suitability of materials obtained from test pits for filtering sewage, and to advise you as to any new plans you might present. It appears that since that advice was received you have constructed underdrains beneath the two filter beds then in use, and graded their surfaces, and that you have provided two additional filter beds. Recent examinations of the filter beds show that the two which were originally constructed consist now of a layer of coarse gravel at the surface, beneath which the soil is very fine, and that the fine material will not filter any considerable quantity of sewage, while the coarse material is found to be very badly clogged with organic matter; the other two beds are composed of such fine material that they are capable of purifying very little sewage, and are nearly worthless for the purpose for which they were constructed. In making the changes and enlargements of the works it does not appear that the advice of any person of experience in matters relating to sewage disposal was followed, nor was any further advice or assistance sought for from this Board.

Chemical analyses of the water of the Assabet River, made during the summer of 1898, when, however, the quantity of water flowing was much greater than is ordinarily the case in the summer season, have shown that the river is being badly polluted by the sewage of the town of Westborough, and the discharge of unpurified sewage into the stream is likely to prove a serious nuisance in the summer season.

Suitable filter beds of a sufficient area will have to be constructed in order to purify the sewage of Westborough, and the Board would advise you to proceed with the necessary work without delay.

A copy of the reply of the Board to the selectmen of Northborough is sent you herewith.

WINCHESTER. An application was received, Dec. 14, 1897, from the water board of Winchester, for the advice of the Board relative to the protection of the water supply of the town from pollution. The Board replied to this application as follows: —

FEB. 3, 1898.

The State Board of Health received from you, on Dec. 14, 1897, an application for advice with reference to protecting the purity of the water supply of the town of Winchester, which is at present furnished by three reservoirs, known as the north reservoir, middle reservoir and south reservoir. It is stated, in the annual report of the Winchester water board for 1894, that the water-shed of the middle and south reservoirs contains no dwelling-houses, and all of the land within the water-shed of these reservoirs, with the exception of about three acres of the water-shed of the middle reservoir, are within the Middlesex Fells park reservation. There appear to be no sources of pollution upon the water-sheds, and, if the use of these reservoirs and their water-sheds by visitors is restricted and properly supervised, there need be no danger of pollution from this cause.

The water-shed of the north reservoir is only partially within the park reservation, and at its upper end it includes a considerable portion of the village of Stoneham. The portion of the village that is within the water-shed is said to be partially provided with sewers; but the population appears to be increasing rapidly, and many of the houses are in the immediate vicinity of Dyke's Brook, the main feeder of the reservoir and its tributaries. Moreover, a considerable portion of the land within the water-shed but outside the reservation is said to be highly cultivated, and there is much danger of the pollution of the stream by manure used on these lands.

An examination of the results of chemical analyses of samples of the water of this reservoir collected during the past ten years show a very decided increase in the quantity of chlorine present, which is undoubtedly due to the increasing pollution by sewage of the main feeder of the reservoir, and the existence of these conditions endangers the health of those using the water; for, while under ordinary conditions the water of the brook, which enters the reservoir near its upper end, might be purified by long storage in the reservoir before reaching the supply main of the town, it is possible that, should a high flow in the stream occur when the water in the reservoir is low, the brook water would flow quickly to the lower end of the reservoir and enter the pipe, with but little improvement by storage.

The pollution of the brook can probably be prevented, to a considerable extent, by careful inspection of the water-shed; but it is not feasible, under the circumstances, to prevent wholly the pollution of the brook by this method, and the cost of inspection would be considerable. It is possible to filter the water of the brook before it enters the reservoir, and make it in this way a safe water for drinking; but the cost of suitable works for the filtration of the water at all times would be large.

Examinations made by your board in previous years indicate that it is feasible at small expense to divert all of the water of the water-shed of Dyke's Brook that is not within the park reservation into the stream below the north reservoir; and, while this would reduce considerably the yield of this source, this plan seems at present to be the most practicable and satisfactory method of preventing the pollution of this reservoir.

The Board would advise that measures be taken without delay to prevent the further pollution of the reservoir from the population at present living upon its water-shed.

Woburn. An application was received from the board of public works of Woburn for the opinion of the State Board of Health as to whether the water of Horn Pond is being polluted by the water flowing into it from Fowle Brook, one of the tributaries of the pond. The Board replied to this application as follows: —

June 3, 1898.

The State Board of Health received from you, on May 1, 1898, an application for advice as to whether the water of Horn Pond is being polluted by the water flowing into it from Put Fowle Brook, so called, one of the tributaries of the pond.

The Board has caused the water-shed of the brook and the water-sheds of its two principal branches, known as Cummingsville Brook and Gardner's Brook, to be examined by one of its engineers, and has caused samples of the water of the two last-mentioned streams to be analyzed. The results of these analyses indicate that the water of Gardner's Brook receives but little pollution, but that Cummingsville Brook is seriously polluted.

The water-shed of Gardner's Brook is sparsely populated, and there appears to be no serious source of pollution upon this water-shed. The water-shed of Cummingsville Brook includes a considerable population in the village of Cummingsville, and the stream is probably polluted to some extent by sewage from houses located close to the stream and its tributaries. A short distance south of the village there is a very large piggery located close to the brook, and it is evident that the stream receives a large amount of pollution from this establishment.

The water-shed of Put Fowle Brook below the junction of Gardner's and Cummingsville brooks appears to contain no sources of serious pollution.

The examinations made by the Board indicate that some of the other feeders of Horn Pond are seriously polluted.

The water supply of the city of Woburn is drawn from a filter-gallery located near the shore of Horn Pond. Analyses of samples of water from Horn Pond and from the filter-gallery indicate that about 90 per cent. of the water drawn from the filter-gallery comes from Horn Pond by filtration through the ground. Under these circumstances, it is very desirable to prevent the pollution of the waters of the pond or any of its feeders.

Should other means fail, the city authorities can probably prevent the pollution of Horn Pond or any of its feeders by taking action under the authority of chapter 80, section 96 of the Public Statutes.

Ice Supplies.

The following is the substance of the action of the Board during the past year in reply to applications for advice relative to sources of ice supply: —

Acton. An application was received, Nov. 26, 1898, from Mr. Freeman W. Robbins of Acton, for the advice of the Board relative to the use of ice from a pond in East Acton. The Board replied to this application as follows: —

Jan. 5, 1899.

The State Board of Health received from you, on November 26, an application for advice with reference to the use of ice from a small artificial pond in the village of East Acton, and has caused the pond and its surroundings to be examined by one of its engineers and a sample of the water to be analyzed.

The water does not at present contain any evidence of sewage pollution, and there appear to be no sources of sewage pollution upon the water-shed.

In the opinion of the Board, the source is a suitable one from which to take ice for domestic purposes. Owing to the nature of the pond, which is formed by flooding a meadow to a slight depth, it is desirable to avoid flooding it until the beginning of winter, as otherwise much organic matter of vegetable origin may be taken up by the water from the bottom of the pond.

HOLYOKE. An application was received from the water commissioners of Holyoke, Nov. 16, 1898, for the advice of the Board relative to the propriety of allowing ice to be cut from Ashley Pond, one of the sources of the city water supply. The Board replied to this application as follows: —

DEC. 2, 1898.

The State Board of Health received from you, on Nov. 16, 1898, a communication requesting advice as to the advisability of allowing ice to be cut from Ashley Pond, one of the sources of water supply of the city of Holyoke. Accompanying the application was a plan showing the water-shed of the pond, the place where the ice houses are to be located and the place where it is proposed to cut the ice.

The Board has caused the locality to be examined by its engineer, and has carefully considered the proposed plan. It appears that much improvement has been made in and about the shores of Ashley Pond; and it is understood that the water-shed of the pond is now controlled by the city of Holyoke, and that all sources of pollution have been removed therefrom. It is very desirable, in the opinion of the Board, that ice used for domestic purposes should be taken from sources free from sewage contamination; and it is probably safe to allow the cutting of ice upon Ashley Pond or one of its arms, provided that inspectors be employed to look after the interests of the city, and that other suitable precautions be taken to prevent pollution of the water.

The ice houses proposed in your application would be located within the water-shed of one of the tributaries of Ashley Pond, and drainage from the vicinity of these houses would flow naturally into the pond. It appears to be feasible to divert from Ashley Pond the portion of the water-shed upon which the proposed ice houses will be located, and thereby prevent any drainage from this region from entering the pond; but, in order to do this, it would be necessary for the city to deprive itself of the yield of about 100 acres of water-shed, which of course represents a considerable value.

In view of all the circumstances, the Board is of the opinion that, having secured control of the water-shed of this pond, — your principal source of water supply, — with the view of protecting it from pollution, it would not be wise to grant away any rights to its occupation, or to allow the construction or use of buildings within this water-shed.

LEXINGTON. An application was received from the water commissioners of Lexington, Nov. 14, 1898, for the advice of the Board relative to the propriety of allowing ice to be cut from the reservoir used by the town as a source of water supply. The Board replied to this application as follows: —

JAN. 5, 1899.

The State Board of Health has carefully considered your application for advice with reference to cutting and taking ice for domestic purposes from the reservoir of the Lexington water works, situated at the head waters of Vine Brook, and has caused the reservoir and its water-shed to be examined by one of its engineers.

It appears that the reservoir in question is not at present used for the supply of the town, and is not likely to be used except in the drier portion of the year, when the other sources of water supply may not yield a sufficient quantity of water for the town. It also appears that provision has been made whereby drainage from the only source of sewage pollution upon the water-shed can be diverted therefrom; and if this is done, this reservoir would be, in the opinion of the Board, a suitable source of ice supply.

The Board can see no objection to granting the privilege of cutting ice from this reservoir, under present conditions; but, in view of the possibility that this source may be drawn upon for water-supply purposes at any time, the Board would advise that the right to enter upon the reservoir and cut or remove ice therefrom be kept under the control and supervision of the water board, that any new buildings which may be necessary be kept off of the water-shed, and that inspectors be employed to prevent danger of pollution of the water by those engaged in any work connected with cutting or removing the ice.

NORTH ADAMS. An application was received from the board of health of North Adams, April 11, 1898, for the advice of the Board relative to certain ponds in that city used as sources of ice supply. The Board replied to this application as follows: —

MAY 5, 1898.

The State Board of Health received from you, on April 11, 1898, an application for advice with reference to the sources of ice supply in the vicinity of the city of North Adams, from which ice is harvested for domestic purposes, and has caused an examination of these sources to be made by one of its engineers and samples of the water and ice to be analyzed. The sources examined were as follows: Orr's Pond, or the Lower Pond in Flaggs Meadow, Zylonite Pond, Reservoir Pond, Blackinton Pond, Kemp's Pond, Hudson Brook Pond and Stamford reservoir.

Orr's Pond is so situated with reference to the south branch of the Hoosac River that at times the river water flows into the pond, even when the river is not at an extraordinarily high level. This stream receives domestic and manufacturing sewage from the town of Adams, situated on the stream above the pond. There are, moreover, several houses and stables on the water-shed of the pond, drainage from which enters one of the feeders of the pond. Under the present circumstances, this pond must be considered a dangerous source from which to take ice for household use, where it is to come in contact with food or drinking water.

Zylonite Pond is situated in the northerly portion of the town of Adams, near the works of the Zylonite Manufacturing Company, and ice from it is said to be sold in Adams and in North Adams. The pond receives its water chiefly from a small drainage area, upon which are located several dwelling-houses, three of which are quite close to the principal feeder of the pond, which is polluted by drainage from these sources. In its present state the source is not a suitable one from which to take ice for domestic use; but, if the pollution of the water of this pond from houses on the water-shed is prevented, the ice from this source could be used with safety.

The water of Reservoir Pond does not appear to be exposed to pollution by sewage, and there is no reason to think that ice cut from this source will be injurious to health.

Blackinton Pond is situated in Williamstown, just below the village of Blackinton, and is practically an arm of the Hoosac River, with which it is connected by a culvert beneath the Fitchburg Railroad, although the pond has a very small water-shed of its own. The water from the river flows through this culvert into the pond when the river rises, and in the opposite direction when the river falls. The Hoosac River above this pond receives all domestic and manufacturing sewage from Adams and North Adams and from the factories along its banks, and in its present state it is a highly polluted stream. Moreover, the small water-shed of the pond also contains several houses. Blackinton Pond is, in the opinion of the Board, a very dangerous source from which to take ice for domestic use.

Kemp's Pond is a very small artificial pond, situated in the easterly portion of North Adams, and the quantity of ice cut from it is said to be very small. The pond is exposed to pollution by one dwelling-house, situated about 60 feet from the shore of the pond; and, if the use of this pond as a source of ice supply for domestic purposes is to be continued, the drainage from this house should be prevented from entering the pond.

Hudson Brook Pond is a very small artificial reservoir, formed by a dam across Hudson Brook, one of the principal tributaries of the north branch of the Hoosac River. There are no immediate sources of pollution in the vicinity of the pond, but there are a few houses situated near the banks of the brook, and in connection with some of these houses there are stables situated very close to the brook. The pond would appear, however, to be a suitable source of ice supply, if care is taken to prevent its pollution from the few buildings situated in the immediate vicinity of the stream or its tributaries, above the pond.

Stamford reservoir is located at the head waters of the north branch of the Hoosac River, in the town of Clarksburg, and is the most important source of ice supply of North Adams. There is a considerable number of houses on the water-shed, a few of which are situated very close to the streams which feed the reservoir. If precautions are taken to prevent pollution of the reservoir from these houses, the source is a satisfactory one from which to obtain ice for domestic uses.

North Adams. An application was received, Nov. 10, 1898, from the board of health of North Adams, for advice relative to the propriety of using the Deerfield River, near the Hoosac Tunnel, as a source of ice supply. The Board replied to this application as follows: —

Dec. 2, 1898.

The State Board of Health received from you, on Nov. 10, 1898, a request for advice as to the use of the Deerfield River, near Hoosac Tunnel, as a source of ice supply, the ice to be cut from the pond created by a dam across the river near the entrance to the tunnel, and has caused a general examination of this source to be made by one of its engineers and samples of the water to be analyzed. The results of these analyses indicate that the water is of good quality for the purposes of an ice supply.

The river above Hoosac Tunnel has a water-shed of about 254 square miles, as measured from the available maps of the region; and the population upon this water-shed is very small, the only notable sources of pollution being three mills, one located at Monroe Bridge, 7 miles above Hoosac Tunnel, and the others at Readsboro, 4 miles further up stream, and possibly the farm-house and stable a short distance above the dam.

If such precautions as may be found necessary are taken to prevent injury to the ice from the sources referred to, the Board is of the opinion that the Deerfield River at Hoosac Tunnel will be an excellent source from which to take ice for domestic purposes.

Worcester. An application was received, on Dec. 10, 1898, from the Curtis Manufacturing Company of Worcester, for advice as to the use of Curtis Pond in that city as a source of ice supply for domestic purposes. The Board replied to this application as follows: —

JAN. 10, 1899.

In accordance with your request for advice as to the suitability of Curtis Pond, in the city of Worcester, as a source of ice supply, the Board has caused an examination of the pond to be made by one of its engineers and a sample of the water to be analyzed.

The results of the examination show that there are several factories and dwelling-houses located near the stream, for the most part at considerable distances above the pond, from some of which polluting matters enter the stream. These would render this pond an unsatisfactory source from which to obtain ice for use in drinking waters, and the Board knows of but one way to obtain ice from such a pond that can be so used with safety. This is, to remove from the ice, after cutting, the first inch of ice that formed upon the pond and all of the ice which formed above this first inch, from snow or rain or flooding, and retain for use only the clear ice which formed under the first inch.

If such a course be followed with the ice of Curtis Pond, the ice thus retained can be safely used for domestic purposes.

PUBLIC INSTITUTIONS (CHAPTER 101, ACTS OF 1886, SECTION 4).

THE MASSACHUSETTS SCHOOL FOR THE FEEBLE-MINDED. An application was received, in November, 1898, from the trustees of the Massachusetts School for the Feeble-minded, for the advice of the Board, under the provisions of chapter 101 of the Acts of 1886, relative to the propriety of taking certain land in the town of Templeton, comprising about 2,000 acres, for the location of a colony of the School for the Feeble-minded. The Board caused the proposed locality to be examined, and replied as follows: —

DEC. 2, 1898.

In compliance with your request for the approval of this Board, under the provisions of chapter 101 of the Acts of 1886, section 4, of a certain tract of land in Templeton as a location for a colony of the Massachusetts School for the Feeble-minded, the Board has caused an examination of the land to be made.

The proposed tract comprises about 2,000 acres, more or less, lying in the north-west part of the town of Templeton, between Beaver Brook and Crow Hill Brook, so called, and the road running from Baldwinville to South Royalston.

The Board has voted to approve the aforesaid tract as suitable for the purpose named in your application.

Examination of Water Supplies.

EXAMINATION OF WATER SUPPLIES.

EXPLANATORY NOTE.

The systematic examination of the water supplies of Massachusetts was begun by the State Board of Health June 1, 1887, and has been continued up to the present time. The results of the investigations which were made during the first two years were published in the special report of the Board upon the Examination of Water Supplies (1890), and the results of examinations made in succeeding years have been published in the annual reports of the Board beginning with the Twenty-second Annual Report (1890).

The special report upon the Examination of Water Supplies contains descriptions of each of the water supplies in the State existing at the date of that report, and the results of chemical and microscopical examinations of samples of water collected from the principal sources of supply. The annual reports, beginning with the report for the year 1890, contain descriptions of all new works and the important changes in existing works, together with the results of the chemical and microscopical examinations which have been made of the various sources of supply. In the more recent reports, yearly averages of the chemical analyses of those sources which have been examined regularly for a number of years have also been given.

In the present report it has been thought advisable, in certain cases, where a number of samples from one source have been analyzed during the year, and the results of the various analyses show no marked changes from time to time, to omit the results of the analysis of each individual sample, and to give only the average of the results of all the analyses of the water of this source made during the year.

The average analyses of former years are generally omitted, except those of sources in which there has been some marked change in the character of the water during the period covered by the examinations.

Microscopical examinations have been made of nearly all of the samples of water which have been examined chemically, and the methods employed have remained unchanged. The results of these examinations have been generally omitted in this report, except in cases where certain organisms which are known to have given trouble in water supplies by causing disagreeable tastes and odors have been found in considerable numbers.

In cases where a knowledge of the condition and the surroundings of the source would assist materially in understanding and interpreting the analyses, a brief description of the source is presented, and in some cases a statement as to the character of the water, as indicated by previous analyses, is given. The descriptions of sources have in many cases been obtained from reports of engineers, and in others from personal investigation by members of the engineering force of the Board. The information as to sizes of ponds and of their drainage areas has generally been obtained from the most recent maps, and the areas of water-sheds include in all cases the areas of water surfaces. The population on water-sheds has been estimated from the census of 1895.

In this report, as in former reports, an alphabetical arrangement by towns has been followed, the source of supply being tabulated under the name of the town supplied, except that the description and analyses of the sources used for the supply of the Metropolitan Water District are placed at the beginning. Waters not used as sources of supply are tabulated under the name of the towns in which they are situated. The analyses of samples collected from rivers not used directly as sources of water supply are given in a subsequent chapter on the "Examination of Rivers," and the results are tabulated alphabetically by the name of the river.

The method of making the chemical examinations has not been changed during the past year. All surface waters and such samples of ground water as contain suspended matter are filtered through filter-paper before determining the color, the residue on evaporation, the albuminoid ammonia in solution and the oxygen consumed. Some ground waters which are perfectly clear and colorless when drawn from the ground become turbid and colored on standing, in consequence of the oxidation of the iron which they contain. In these waters the residue on evaporation is determined without filtration, since this iron is an essential and not an accidental ingredient in the water. In the changes which accompany the oxidation of the iron in waters of this character, they become first cloudy (well described by the word *milky*), and finally deposit a precipitate of oxide of iron. In the cloudy condition they have a distinct color, which, while it does not have the same significance as in the case of surface waters, and is only a passing phenomenon, is, nevertheless, of interest, as showing a color which the water may assume while the oxidation of the iron is in progress. When the iron is all oxidized and precipitated the water may become colorless again. In some cases, however, the iron occurs in combination with organic matter, forming a much more stable body. In such cases the water is of a brown color when first drawn from the ground, and, while the iron begins to oxidize soon after the water is exposed to the air, the process goes on slowly, and the water may remain colored and iron continue to precipitate for a long time.

The color of the water is expressed by numbers, which increase with the amount of color. The standards used are natural waters, the color of which has been accurately determined by comparing them with the nesslerized ammonia standards which were described on page 531 of the Special Report upon the Examination of Water Supplies (1890), and on page 329 of the Annual Report for 1892. By using natural waters as standards for comparison, the apparent rather than the actual color is obtained, as a natural water nearly always has a greater or less turbidity, which gives the water the appearance of having a greater color than the water would have if there were no turbidity.

The rainfall during the year 1898 was exceptionally heavy, especially during some of the summer months, in consequence of which the flow of the streams was very large during that portion of the year when the flow is usually smallest, and the water in the storage reservoirs and ponds was consequently kept at a high level in the summer. The ground-water level was also much higher than is usual during an ordinary year. The effect of these conditions upon the sources of water supply has been to prevent troubles which often occur from the lowering of water in ponds and storage reservoirs, and the troubles which frequently occur in ground waters from imperfect filtration at times when the level of the water in the ground has been lowered considerably. Tables showing the daily rainfall at various places in the State, the average rainfall for a large number of years and the flow of some of the streams in the State, are given in a subsequent chapter, entitled "Water Supply Statistics and Flow of Streams."

EXAMINATION OF WATER SUPPLIES.

Water Supply of the Metropolitan Water District.

By the provisions of chapter 488 of the Acts of 1895, entitled "An Act to provide for a Metropolitan Water Supply," a Metropolitan Water District was created, to include the cities of Boston, Chelsea, Everett, Malden, Medford, Newton and Somerville, and the towns of Belmont, Hyde Park, Melrose, Revere, Watertown and Winthrop. In accordance with a provision made in the act for the admission of other cities and towns, the city of Quincy and town of Nahant have been admitted to the district, and, by an agreement entered into Dec. 2, 1898, a supply of water is to be furnished by the district to the town of Swampscott for a term of years.

The Metropolitan Water Board, instituted under the Metropolitan Water Act, began in 1895 the construction of works to supply the Metropolitan Water District with water from the South Branch of the Nashua River, in connection with some of the former sources of supply of the city of Boston. On Jan. 1, 1898, the Board, in accordance with the provisions of the act, took possession of Mystic Lake, the aqueduct, pumping station and distributing reservoir, the Chestnut Hill Reservoir and pumping station, and all the lands, reservoirs, pumps, dams, aqueducts, pipes and other property west of Chestnut Hill Reservoir held by the city of Boston, for the purpose of storing and supplying water and protecting its purity, including all of the Sudbury and Cochituate works.

The Sudbury and Cochituate sources formerly owned by the city of Boston are retained by the Metropolitan Water Board for use in supplying the district; but Mystic Lake, from which the water supply of the cities of Somerville, Chelsea and Everett and a portion of Boston was formerly derived, has been abandoned as a source of water supply. Spot Pond, which was formerly the chief source of supply of Malden, Medford and Melrose, is to be used in the future as a distributing reservoir for the Metropolitan District, and material changes are being made in the pond and its surroundings.

The water of the South Branch of the Nashua River, the new source of supply of the Metropolitan Water District, is taken at a point above Clinton where the river has a water-shed of 118.2 square miles. This water-shed contains no large towns and is very sparsely settled, the entire area having a population of about 69 persons per square mile, and the population is decreasing. Much of the water-shed is hilly and even mountainous, Mt. Wachusett at the northerly side of the water-shed being the highest elevation. The valleys are generally quite steep, and the areas of swampy land are small as compared with the Sudbury River water-shed. The nature of the land is, moreover, such that it is not highly cultivated.

Water from Nashua River is conveyed to the Sudbury Reservoir (formerly known as Reservoir No. 5 of the city of Boston), through the Wachusett Aqueduct, and an open channel in the bed of Stony Brook, a total distance of 12 miles. The Sudbury Reservoir was taken by the Metropolitan Water Board in January, 1896, when partially constructed, and was completed and first used in the early part of 1898. This reservoir is the largest of the various reservoirs available for the supply of the Metropolitan District. From the Sudbury Reservoir water flows through the open channel of Stony Brook to Framingham Reservoir No. 3 (formerly known as Reservoir No. 3 of the city of Boston), and from this reservoir two 48-inch pipes convey the water to the head of the Sudbury Aqueduct, which extends from Framingham Reservoir No. 1 to Chestnut Hill Reservoir, a distance of 17.4 miles.

Framingham Reservoir No. 1 (formerly Reservoir No. 1 of the Boston Water Works) is located at the confluence of Stony Brook with the Sudbury River, and Framingham Reservoir No. 2 (formerly Reservoir No. 2 of the Boston Water Works) is located on the Sudbury River just above Reservoir No. 1. There are three other large reservoirs, located on tributaries of the Sudbury River, now under the control of the Metropolitan Water Board; viz., Ashland Reservoir (formerly known as Reservoir No. 4), located on Cold Spring Brook; Hopkinton Reservoir (formerly known as Reservoir No. 6), located on Indian Brook; and Whitehall Reservoir (formerly known as Whitehall Pond, or Reservoir No. 8), located near the headwaters of the Sudbury River. Water from the last three reservoirs is drawn through the channels of the brooks upon which the reservoirs are built to the Sudbury River, through which it flows to Framingham Reservoir No. 2, and may thence be drawn into the aqueduct leading to Chestnut Hill Reservoir. Farm Pond in Framingham, formerly used as a source of supply for the city of Boston, is now controlled by the Metropolitan Water Board, and is connected with the Sudbury Aqueduct. Lake Cochituate, which has also been acquired as one of the sources of supply of the district, is connected by a separate aqueduct with Chestnut Hill Reservoir. Dudley Pond is a tributary of Lake Cochituate, and its waters can be drawn into the lake. The following table gives statistics relating to the various reservoirs and lakes above referred to: —

NAME.	Areas of Water-sheds, including Water Surfaces.		Area of Water Surface (Acres).	Available Storage Capacity of Reservoir (U. S. Gallons).	Maximum Depth of Reservoir (Feet).
	Exclusive of Reservoirs above (Square Miles).	Total Contributing Water-shed (Square Miles).			
Sudbury Reservoir, . . .	22.28	22.28*	1,292	7,253,500,000	67
Framingham Reservoir No. 3, .	5.40	27.68*	253	1,183,500,000	25
Framingham Reservoir No. 1, .	1.84	74.66*	143	287,500,000	15
Framingham Reservoir No. 2, .	28.50	45.14	134	529,900,000	18
Ashland Reservoir, . . .	6.43	6.43	167	1,416,400,000	49
Hopkinton Reservoir, . .	5.86	5.86	185	1,520,900,000	55
Whitehall Reservoir, . .	4.35	4.35	601	1,256,900,000	18
Farm Pond, ...	0.54	0.54	159	167,500,000	12
Lake Cochituate, . . .	18.87	19.75	776	2,011,200,000	72
Dudley Pond, ...	0.88	0.88	93	231,200,000	29
Spot Pond, ...	2.06	2.06	301	758,300,000	38

* The water-shed of the Nashua River, above Clinton, water from which is diverted into Sudbury Reservoir, has an area of 118.2 square miles.

Whitehall Reservoir, Farm Pond, Lake Cochituate, Dudley Pond and Spot Pond are natural ponds, in which the level of the water has been raised somewhat by damming the outlets. Framingham reservoirs Nos. 1, 2 and 3 are artificial reservoirs, containing on

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the bottom much of the soil and organic matter which was on the surface of the ground before the reservoirs were constructed. Sudbury Reservoir, Ashland Reservoir and Hopkinton Reservoir are artificial reservoirs, from the bottoms of which all of the soil and organic matter have been removed.

The Metropolitan Water Board began to supply water to the Metropolitan Water District Jan. 1, 1898, and during the year the following cities and towns were supplied, either wholly or in part, with water from these works: —

CITY OR TOWN.	Population in 1895.
Boston,	496,920
Somerville,	52,200
Chelsea,	31,264
Malden,	29,708
Quincy,	20,712
Everett,	18,573
Medford,	14,474
Melrose,	11,965
Watertown,	7,788
Revere,	7,423
Winthrop,	4,192
Belmont,	2,843
Total population of cities and towns supplied,	698,062

During the year 1898, the water for Boston and the greater part of the cities and towns in the above table was taken mainly from Framingham reservoirs Nos. 1 and 2, up to April 20, and for the remainder of the year from Framingham Reservoir No. 3. The water of the Nashua River has been discharged through the Wachusett Aqueduct into the Sudbury Reservoir, from which it has been drawn into Framingham Reservoir No. 3. A small part of the supply was furnished from Lake Cochituate early in the year, and again in September and October. The water of Spot Pond has been supplied to Melrose and occasionally to other cities and towns in the northerly part of the district. The cities of Malden, Medford and Quincy, and the towns of Revere, Winthrop, Watertown and Belmont, supplied themselves, either wholly or in part, during a portion of the year with water from local sources.

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Chemical Examination of Water from the Quinepoxet River in Holden.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21745	Jan. 3	Slight.	Slight.	0.63	3.70	1.60	.0032	.0258	.0236	.0022	.29	.0100	.0000	.62	1.4
22075	Feb. 4	Slight.	Cons.	0.48	3.50	1.30	.0024	.0268	.0228	.0040	.25	.0050	.0000	.45	1.0
22404	Mar. 1	Slight.	Slight.	0.50	3.00	1.25	.0014	.0210	.0182	.0028	.20	.0150	.0000	.41	1.0
22758	Apr. 7	Slight.	V. slight.	0.50	2.40	1.10	.0006	.0192	.0172	.0020	.21	.0000	.0001	.49	0.8
23040	May 2	Slight.	Slight.	0.68	3.20	1.30	.0002	.0162	.0140	.0022	.20	.0040	.0001	.50	0.8
23376	June 1	Slight.	Cons.	1.00	3.25	1.65	.0012	.0272	.0230	.0042	.19	.0000	.0000	.79	0.8
23801	July 5	Slight.	Cons.	0.52	3.45	1.50	.0094	.0288	.0254	.0034	.19	.0040	.0002	.53	0.6
24126	Aug. 1	Slight.	Slight.	0.55	4.00	1.80	.0108	.0292	.0246	.0046	.18	.0020	.0002	.54	0.6
24510	Aug. 31	V. slight.	Slight.	0.82	4.10	1.95	.0024	.0296	.0276	.0020	.18	.0020	.0002	.66	0.6
24906	Oct. 4	Slight.	Slight.	0.52	4.05	1.75	.0020	.0252	.0222	.0030	.21	.0000	.0001	.69	0.6
25243	Nov. 1	V. slight.	V. slight.	0.72	3.90	2.00	.0010	.0268	.0238	.0030	.22	.0020	.0000	.91	0.8
25533	Dec. 5	Slight.	Slight.	0.48	3.15	1.40	.0010	.0214	.0152	.0062	.20	.0010	.0000	.57	0.5
Av..	....	....	....	0.62	3.47	1.55	.0030	.0248	.0215	.0033	.21	.0037	.0001	.60	0.8

Odor, generally faintly vegetable, occasionally musty, sometimes becoming stronger on heating.—— The samples were collected from the river, at Smith's Woolen Mill in Holden, and 1,000 feet above the boundary line between Holden and West Boylston. This river is one of the principal tributaries of the South Branch of the Nashua River above Clinton.

Chemical Examination of Water from Stillwater River in Sterling.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21746	Jan. 3	V. slight.	V. slight.	.46	3.30	1.40	.0006	.0108	.0104	.0004	.20	.0090	.0000	.42	1.1
22076	Feb. 4	V. slight.	Slight.	.46	3.00	1.10	.0010	.0094	.0078	.0016	.20	.0020	.0000	.41	1.7
22405	Mar. 1	V. slight	V. slight.	.45	2.50	0.75	.0004	.0086	.0084	.0002	.14	.0050	.0000	.36	0.8
22759	Apr. 7	V. slight.	Slight.	.37	2.35	1.00	.0012	.0138	.0128	.0010	.17	.0030	.0000	.38	0.8
23041	May 2	Slight.	Slight.	.55	2.40	1.05	.0002	.0136	.0116	.0020	.13	.0020	.0001	.46	0.8
23377	June 1	Slight.	V. slight.	.90	2.85	1.50	.0012	.0202	.0180	.0022	.14	.0000	.0000	.70	1.0
23802	July 5	V. slight.	Slight.	.50	3.20	1.50	.0010	.0258	.0232	.0026	.14	.0010	.0000	.54	0.8
24127	Aug. 1	V. slight.	Slight.	.44	3.55	1.50	.0016	.0238	.0210	.0028	.14	.0020	.0000	.47	0.8
24511	Aug 31	V. slight	V. slight.	.70	3.95	1.80	.0010	.0218	.0204	.0014	.13	.0010	.0005	.50	0.6
24907	Oct. 4	V. slight.	V. slight.	.41	3.45	1.40	.0008	.0170	.0146	.0024	.17	.0000	.0001	.54	0.5
25244	Nov. 1	None.	V. slight.	.50	3.25	1.50	.0006	.0132	.0116	.0016	.17	.0040	.0000	.70	0.8
25534	Dec. 5	V. slight.	V. slight.	.35	2.40	1.25	.0006	.0116	.0102	.0014	.14	.0020	.0000	.46	0.3
Av..	....	....	....	.51	3.02	1.31	.0008	.0158	.0142	.0016	.16	.0026	.0001	.50	0.8

Odor, generally faintly vegetable, occasionally musty, sometimes becoming stronger on heating.—— The samples were collected from the river, at a highway bridge about 1 mile above the boundary line between Sterling and West Boylston. This river is one of the principal tributaries of the South Branch of the Nashua River above Clinton.

METROPOLITAN WATER DISTRICT.

Chemical Examination of Water from the South Branch of the Nashua River above Clinton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21743	Jan. 3	Distinct.	Cons.	.40	3.65	1.25	.0002	.0144	.0138	.0006	.25	.0130	.0001	.41	1.4
22041	Jan. 31	Slight.	Slight.	.41	3.25	1.25	.0016	.0152	.0126	.0026	.24	.0130	.0000	.42	1.3
22381	Feb. 28	Slight.	V. slight.	.45	3.35	1.10	.0010	.0176	.0154	.0022	.21	.0080	.0000	.36	0.8
22710	Apr. 4	V. slight.	V. slight.	.35	2.75	1.45	.0002	.0116	.0104	.0012	.16	.0020	.0000	.40	0.6
23038	May 2	Slight.	V. slight.	.51	2.70	1.05	.0002	.0164	.0152	.0012	.19	.0000	.0001	.42	1.0
23334	May 31	V. slight.	V. slight.	.76	3.55	2.00	.0022	.0188	.0162	.0026	.16	.0040	.0001	.61	0.8
23785	July 1	Slight.	Cons.	.48	3.95	1.80	.0040	.0234	.0200	.0034	.20	.0050	.0001	.44	1.0
24125	Aug. 1	Slight.	V. slight.	.30	3.95	1.50	.0014	.0242	.0188	.0054	.21	.0020	.0000	.33	1.0
24508	Aug. 31	V. slight.	V. slight.	.70	4.45	2.15	.0030	.0236	.0208	.0028	.18	.0060	.0001	.89	1.1
24896	Oct. 3	V. slight.	V. slight.	.45	4.00	1.75	.0018	.0202	.0190	.0012	.20	.0010	.0000	.58	1.1
25215	Oct. 31	V. slight.	V. slight.	.65	3.75	1.75	.0000	.0154	.0148	.0006	.20	.0020	.0000	.78	1.0
25526	Dec. 1	V. slight.	V. slight.	.40	3.00	1.40	.0006	.0128	.0108	.0020	.18	.0070	.0001	.52	1.0
Av..	....	....	....	.49	3.53	1.54	.0013	.0178	.0156	.0022	.20	.0052	.0000	.51	1.0

Odor, generally faintly vegetable; in August, a distinctly fishy odor was developed on heating. —— The samples were collected from the river, at the dam of the Lancaster Manufacturing Company, at the place where water is diverted for use in supplying the Metropolitan Water District.

Chemical Examination of Water from Walker's Brook, Marlborough.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21724	Jan. 3	Decided.	Cous.	0.41	14.05	4.50	.0700	.0194	.0144	.0050	1.78	.2720	.0018	.40	5.4
22022	Jan. 31	Slight.	Slight.	0.33	13.55	4.50	.0848	.0172	.0144	.0028	1.79	.3750	.0017	.34	5.3
22360	Feb. 28	Decided.	Cons.	0.59	11.35	3.45	.0528	.0176	.0156	.0020	1.14	.2300	.0018	.50	3.8
22704	Apr. 4	V. slight.	V. slight.	0.67	12.50	4.10	.0760	.0208	.0196	.0012	1.56	.2320	.0012	.61	4.3
23020	May 2	Slight.	Slight.	0.62	12.40	3.80	.0552	.0216	.0198	.0018	1.49	.1860	.0012	.48	4.3
23320	May 31	Slight.	Slight.	1.12	14.60	4.15	.0746	.0300	.0276	.0024	1.69	.2250	.0030	.72	5.0
23758	June 30	Decided.	Slight.	0.40	17.80	5.10	.0568	.0220	.0210	.0010	2.22	.2400	.0190	.44	6.6
24102	Aug. 1	Decided, milky.	V. slight.	0.61	18.75	5.35	.0256	.0302	.0296	.0006	2.10	.1060	.0112	.62	6.6
24491	Aug. 31	Slight.	Slight.	0.60	15.30	4.55	.0468	.0254	.0244	.0010	1.77	.1300	.0044	.69	5.1
24878	Oct. 3	Decided.	Slight.	0.42	16.80	4.80	.0584	.0216	.0208	.0008	2.01	.1780	.0060	.54	6.0
25203	Oct. 31	Decided.	Cons.	0.81	14.00	4.25	.0332	.0300	.0240	.0060	1.50	.1720	.0024	.91	4.4
25507	Dec. 1	Decided.	Cons.	0.40	13.25	4.60	.0488	.0202	.0158	.0044	1.45	.1360	.0018	.45	4.2
Av..	....	....	....	0.58	14.53	4.43	.0569	.0230	.0206	.0024	1.71	.2068	.0046	.56	5.1

Odor, generally faintly vegetable and musty, occasionally unpleasant, becoming stronger on heating. —— The samples were collected from the brook, at the first road bridge below Maple Street, about 1 mile south of the centre of the city of Marlborough. This brook is one of the tributaries of Stony Brook above the Sudbury Reservoir.

METROPOLITAN WATER DISTRICT.

Chemical Examination of Water from Sudbury Reservoir, collected near the Surface.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21731	Jan 3	Decided.	Slight.	.58	7.30	2.25	.0054	.0232	.0212	.0020	.53	.0220	.0002	.59	3.4
22028	Jan. 31	V. slight.	V. slight.	.30	4.20	1.45	.0044	.0130	.0116	.0014	.30	.0180	.0002	.32	1.8
22363	Feb. 28	Decided.	Cons.	.56	4.60	1.70	.0116	.0206	.0154	.0052	.23	.0280	.0001	.42	–
22483	Mar. 8	Decided.	Cons.	.50	4.25	1.25	.0056	.0306	.0170	.0136	.18	.0220	.0003	.48	2.0
22713	Apr. 4	Slight.	Slight.	.40	3.95	1.50	.0006	.0150	.0098	.0052	.26	.0280	.0002	.38	1.6
22789	Apr. 11	V. slight.	Slight.	.40	4.05	1.65	.0014	.0152	.0098	.0054	.25	.0170	.0002	.37	1.4
22874	Apr. 18	Slight.	Slight.	.40	3.60	1.15	.0006	.0106	.0086	.0020	.28	.0120	.0001	.37	1.1
22963	Apr. 25	V. slight.	Slight.	.40	3.70	1.35	.0014	.0130	.0092	.0038	.25	.0140	.0001	.37	1.3
23028	May 2	Slight.	Cons.	.39	3.45	1.10	.0008	.0124	.0090	.0034	.24	.0120	.0002	.34	1.1
23137	May 12	Slight.	Cons.	.36	3.75	1.10	.0016	.0142	.0106	.0036	.28	.0130	.0002	.32	1.1
23164	May 16	Slight.	Slight.	.36	3.65	1.45	.0010	.0146	.0128	.0018	.31	.0120	.0002	.33	1.1
23267	May 23	V. slight.	V. slight.	.40	3.40	1.15	.0006	.0168	.0136	.0032	.30	.0130	.0002	.38	1.3
23329	May 31	V. slight.	V. slight.	.44	3.60	1.35	.0032	.0144	.0112	.0032	.25	.0050	.0002	.34	1.4
23399	June 6	V. slight.	Slight.	.46	4.15	1.45	.0020	.0152	.0130	.0022	.26	.0090	.0002	.38	1.3
23517	June 13	V. slight.	Slight.	.44	3.60	1.60	.0010	.0166	.0142	.0024	.24	.0100	.0002	.38	1.3
23610	June 20	V. slight.	Slight.	.38	3.95	1.20	.0014	.0170	.0128	.0042	.26	.0090	.0002	.39	1.3
23709	June 27	Slight.	Slight.	.36	3.70	1.45	.0014	.0166	.0144	.0022	.26	.0080	.0002	.37	1.3
23774	June 30	Slight.	Slight.	.36	4.90	1.90	.0026	.0192	.0158	.0034	.19	.0070	.0001	.38	1.0
23844	July 11	V. slight.	Slight.	.32	3.15	1.25	.0016	.0176	.0162	.0014	.27	.0040	.0002	.36	1.4
23907	July 18	V. slight.	Cons.	.30	3.80	1.30	.0028	.0186	.0156	.0030	.24	.0060	.0002	.36	1.3
24028	July 25	V. slight.	Slight.	.30	3.60	1.30	.0014	.0210	.0154	.0056	.21	.0020	.0002	.37	1.4
24122	Aug. 1	Slight.	Cons.	.22	3.65	1.20	.0010	.0206	.0162	.0044	.22	.0030	.0001	.34	1.3
24183	Aug. 8	Slight.	Cons.	.20	3.50	1.30	.0010	.0204	.0156	.0048	.18	.0010	.0002	.31	1.3
24289	Aug. 15	Slight.	Cons.	.24	3.45	1.45	.0006	.0188	.0166	.0022	.23	.0030	.0002	.30	1.3
24381	Aug. 22	Slight.	V. slight.	.20	3.65	1.40	.0008	.0176	.0148	.0028	.23	.0010	.0001	.30	1.3
24504	Aug. 31	Slight.	Slight.	.21	3.70	1.25	.0010	.0180	.0150	.0030	.24	.0020	.0001	.42	1.3
24537	Sept. 6	V. slight.	V. slight.	.21	3.85	1.35	.0008	.0182	.0160	.0022	.26	.0010	.0002	.38	1.6
24589	Sept. 12	Slight.	Cons.	.27	4.20	1.80	.0018	.0192	.0160	.0032	.24	.0020	.0001	.43	1.7
24675	Sept. 19	V slight.	Cons.	.38	4.45	1.75	.0028	.0210	.0188	.0022	.26	.0000	.0000	.55	1.8
24755	Sept. 26	Slight.	Cons.	.41	4.95	1.90	.0036	.0216	.0198	.0018	.25	.0040	.0000	.55	1.7
24898	Oct. 3	V. slight.	Slight.	.40	4.80	1.65	.0008	.0210	.0192	.0018	.24	.0030	.0001	.56	1.7
24939	Oct. 10	V. slight.	Cons.	.37	4.50	1.70	.0018	.0216	.0198	.0018	.26	.0000	.0001	.53	1.7
25037	Oct. 17	V. slight	V. slight.	.36	4.45	1.65	.0014	.0192	.0166	.0026	.27	.0030	.0001	.54	1.7
25129	Oct. 24	V. slight.	V. slight.	.36	4.25	1.75	.0014	.0166	.0140	.0026	.25	.0020	.0000	.62	1.7
25206	Oct. 31	Slight.	Slight.	.30	4.55	2.00	.0014	.0190	.0158	.0032	.28	.0030	.0000	.50	1.7
25262	Nov. 7	V. slight.	Slight.	.31	4.95	1.75	.0016	.0184	.0158	.0026	.28	.0060	.0001	.47	1.7
25359	Nov. 14	V. slight.	Slight.	.38	5.00	1.90	.0030	.0194	.0182	.0012	.28	.0050	.0001	.53	1.7
25432	Nov. 21	Slight.	V. slight.	.45	5.35	1.90	.0038	.0194	.0168	.0026	.33	.0120	.0001	.54	1.8
25510	Dec. 1	Decided.	Cons.	.46	5.65	2.25	.0062	.0198	.0172	.0026	.30	.0110	.0000	.55	1.8
25589	Dec. 12	Decided.	Slight.	.50	5.45	1.60	.0048	.0172	.0156	.0016	.33	.0220	.0000	.55	1.8
25669	Dec. 19	Slight.	Slight.	.56	5.75	2.50	.0054	.0180	.0166	.0014	.32	.0230	.0003	.58	2.1
25766	Dec. 27	Slight.	V. slight.	.48	4.55	2.15	.0016	.0134	.0118	.0016	.25	.0130	.0002	.53	1.4

Odor, generally none, occasionally faintly vegetable. A vegetable odor was developed in most of the samples on heating. —— The samples were collected from the reservoir, near the gate-house, at a depth of 1 foot beneath the surface. For monthly record of height of water in this reservoir, see table on page 150.

METROPOLITAN WATER DISTRICT.

Microscopical Examination of Water from Sudbury Reservoir, collected near the Surface.

[Number of organisms per cubic centimeter.]

Month, 1898,	Jan.	Feb.	March.		April.				May.				June.	
Day of examination,	4	2	1	9	5	12	18	26	3	13	17	23	1	7
Number of sample,	21731	22028	22363	22483	22713	22789	22874	22963	23028	23137	23164	23267	23329	23399
PLANTS.														
Diatomaceæ,	218	0	0	1	49	96	190	160	124	266	276	140	47	59
Asterionella,	208	0	0	0	28	76	80	74	7	108	110	43	12	18
Cyclotella,	3	0	0	0	0	0	0	0	1	2	0	1	3	19
Synedra,	0	0	0	1	3	12	82	77	112	126	152	72	30	16
Tabellaria,	6	0	0	0	16	8	28	9	4	26	12	24	2	5
Cyanophyceæ,	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Anabæna,	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Algæ,	60	0	0	0	0	5	12	0	0	8	0	2	8	18
Botrycoccus,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protococcus,	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Raphidium,	60	0	0	0	0	0	6	0	0	0	0	2	0	17
ANIMALS.														
Rhizopoda,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Infusoria,	0	0	13	229	61	104	37	82	25	62	29	19	3	0
Ciliated infusorian,	0	0	0	0	4	10	10	0	10	3	0	0	0	0
Cryptomonas,	0	0	0	60	22	8	3	5	10	3	3	3	0	0
Dinobryon,	0	0	5	51	27	83	24	71	0	52	12	15	3	0
Peridinium,	0	0	2	6	4	1	0	3	2	0	14	0	0	0
Synura,	0	0	4	100	3	1	0	1	1	0	0	0	0	0
Uroglena,	0	0	2	11	0	1	0	1	1	0	0	0	0	0
Vorticella,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vermes,	1	0	0	0	1	2	0	2	0	6	4	4	2	1
Crustacea,	0	0	0	0	0	0	0	0	0	0	pr.	pr.	pr.	pr.
Bosmina,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyclops,	0	0	0	0	0	0	0	0	0	0	pr.	0	pr.	pr.
Daphnia,	0	0	0	0	0	0	0	0	0	0	pr.	pr.	0	0
Miscellaneous, Zoöglœa,	5	3	7	10	8	5	7	5	5	5	5	3	0	3
Total,	284	3	20	240	119	212	246	249	154	347	314	168	60	91

METROPOLITAN WATER DISTRICT.

Microscopical Examination of Water from Sudbury Reservoir, collected near the Surface — Continued.

[Number of organisms per cubic centimeter.]

Month, 1898,	June.			July.				August.				September.		
Day of examination,	14	21	29	1	12	19	26	2	9	16	23	1	7	13
Number of sample,	23517	23610	23709	23774	23844	23907	24028	24122	24183	24289	24381	24504	24537	24589
PLANTS.														
Diatomaceæ,	**221**	**508**	**740**	**495**	**500**	**269**	**197**	**1,154**	**2,406**	**2,572**	**974**	**185**	**117**	**206**
Asterionella,	17	16	292	180	416	156	10	16	20	8	36	4	40	128
Cyclotella,	196	472	422	314	50	103	160	1,072	2,256	2,456	800	100	14	4
Synedra,	5	16	4	0	0	0	13	8	22	8	2	7	5	34
Tabellaria,	3	4	2	1	34	10	14	58	108	100	136	74	58	36
Cyanophyceæ,	**20**	**22**	**4**	**1**	**48**	**2**	**1**	**20**	**10**	**4**	**4**	**1**	**1**	**8**
Anabæna,	20	22	4	1	48	1	0	18	10	4	2	0	0	0
Algæ,	**31**	**10**	**8**	**1**	**8**	**10**	**6**	**4**	**22**	**88**	**88**	**71**	**14**	**58**
Botrycoccus,	0	0	0	0	0	0	0	0	0	72	0	0	0	0
Protococcus,	28	0	0	0	0	0	0	0	0	0	0	63	13	40
Raphidium,	2	2	4	0	0	0	6	4	4	10	74	7	1	16
ANIMALS.														
Rhizopoda,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**
Infusoria,	**15**	**3**	**2**	**1**	**40**	**7**	**2**	**8**	**4**	**0**	**0**	**1**	**6**	**34**
Ciliated infusorian,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptomonas,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dinobryon,	0	0	0	0	30	6	0	4	0	0	0	0	5	28
Peridinium,	0	0	2	0	0	0	1	0	0	0	0	0	0	2
Synura,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uroglena,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vorticella,	15	0	0	0	10	0	0	4	0	0	0	0	0	0
Vermes,	**1**	**1**	**2**	**0**	**0**	**2**	**3**	**2**	**2**	**1**	**1**	**0**	**1**	**0**
Crustacea,	**pr.**	**pr.**	**0**	**0**	**0**	**pr.**	**pr.**	**pr.**	**pr.**	**0**	**pr.**	**pr.**	**pr.**	**pr.**
Bosmina,	0	0	0	0	0	0	0	pr.	0	0	0	0	0	0
Cyclops,	pr.	pr.	0	0	0	pr.	pr.	pr.	pr.	0	pr.	pr.	pr.	pr.
Daphnia,	0	0	0	0	0	pr.	0	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	**0**	**0**	**3**	**0**	**5**	**3**	**3**	**3**	**3**	**3**	**5**	**3**	**3**	**8**
Total,	288	544	759	498	601	293	212	1,191	2,447	2,668	1,072	261	142	316

METROPOLITAN WATER DISTRICT.

Microscopical Examination of Water from Sudbury Reservoir, collected near the Surface — Concluded.

[Number of organisms per cubic centimeter.]

Month, 1898, . . .	September.		October.				November.				December.			
Day of examination, .	20	27	5	11	18	25	1	8	15	21	2	13	19	28
Number of sample, .	24675	24755	24898	24939	25037	25129	25206	25262	25359	25432	25510	25589	25669	25766
PLANTS.														
Diatomaceæ, .	572	411	1,312	1,172	382	166	156	213	302	141	110	97	33	30
Asterionella, . .	478	337	1,246	1,072	302	94	45	49	136	95	59	41	2	12
Cyclotella, . .	0	16	10	6	6	0	30	47	57	29	21	26	26	1
Synedra, . .	17	12	4	2	6	6	15	29	16	7	6	11	1	3
Tabellaria, . .	77	21	52	80	56	64	56	71	93	9	6	15	4	6
Cyanophyceæ, .	2	4	8	0	8	0	2	0	1	0	0	0	0	0
Anabæna, . .	0	0	6	0	8	0	0	0	0	0	0	0	0	0
Algæ, ...	27	6	20	22	7	24	12	15	15	4	5	4	3	7
Botrycoccus, . .	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protococcus, . .	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Raphidium, . .	15	4	14	16	2	24	12	9	9	4	5	3	3	3
ANIMALS.														
Rhizopoda, . .	0	0	2	0	0	0	0	0	1	0	0	0	0	0
Infusoria, . .	2	4	4	2	0	4	0	4	1	0	0	0	2	4
Ciliated Infusorian,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptomonas, .	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dinobryon, . .	1	0	2	0	0	0	0	0	1	0	0	0	0	3
Peridinium, . .	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Synura, . . .	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Uroglena, . .	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vorticella, . .	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Vermes, . . .	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Crustacea, . .	pr.	pr.	pr.	pr.	pr.	pr.	0	0	pr.	0	pr.	pr.	pr.	0
Bosmina, . .	0	0	0	0	0	pr.	0	0	0	0	0	0	0	0
Cyclops, . . .	pr.	pr.	pr.	pr.	pr.	pr.	0	0	pr.	0	pr.	pr.	pr.	0
Daphnia, . .	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	5	8	5	5	8	8	5	5	8	7	8	12	5	5
Total, . . .	608	433	1,351	1,201	405	202	175	237	328	152	123	115	43	46

METROPOLITAN WATER DISTRICT.

Chemical Examination of Water from Sudbury Reservoir, collected about Midway between the Surface and Bottom.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21732	Jan. 3	Decided.	Cons.	.70	7.45	2.40	.0080	.0244	.0222	.0022	.46	.0320	.0002	.61	3.3
22029	Jan. 31	Decided.	Cons.	.70	7.65	2.80	.0080	.0228	.0216	.0012	.52	.0390	.0002	.62	3.1
22364	Feb. 28	Decided.	Cons.	.69	6.10	1.60	.0112	.0180	.0170	.0010	.33	.0370	.0002	.57	2.2
22484	Mar. 8	Decided.	Cons.	.60	5.55	1.80	.0126	.0142	.0126	.0016	.39	–	.0004	.46	–
22714	Apr. 4	Slight.	Slight.	.40	3.90	1.50	.0008	.0146	.0114	.0032	.25	.0270	.0002	.38	1.7
22790	Apr. 11	V. slight.	Slight.	.40	3.90	1.50	.0014	.0136	.0098	.0038	.25	.0170	.0002	.36	1.3
22875	Apr. 18	Slight.	Slight.	.40	3.50	1.25	.0006	.0106	.0084	.0022	.28	.0130	.0001	.37	1.1
22964	Apr. 25	V. slight.	Slight.	.40	3.85	1.65	.0006	.0122	.0100	.0022	.26	.0140	.0001	.37	1.4
23029	May 2	Slight.	Cons.	.36	3.65	1.15	.0014	.0124	.0102	.0022	.23	.0120	.0002	.34	1.3
23138	May 12	V. slight.	Slight.	.37	3.80	1.30	.0020	.0124	.0102	.0022	.29	.0120	.0002	.32	1.3
23165	May 16	Slight.	Slight.	.37	3.65	1.45	.0012	.0132	.0110	.0022	.29	.0130	.0001	.34	1.3
23268	May 23	V. slight.	V. slight.	.40	3.40	1.10	.0014	.0148	.0114	.0034	.28	.0130	.0002	.37	1.1
23330	May 31	V. slight.	Slight.	.39	3.60	1.25	.0032	.0122	.0102	.0020	.25	.0100	.0002	.35	1.4
23400	June 6	V. slight.	Slight.	.41	3.85	1.60	.0032	.0122	.0112	.0010	.26	.0140	.0002	.38	1.4
23518	June 13	V. slight.	V. slight.	.45	3.60	1.55	.0044	.0112	.0110	.0002	.25	.0090	.0002	.34	1.4
23611	June 20	V. slight.	V. slight.	.38	4.20	1.35	.0046	.0114	.0106	.0008	.26	.0080	.0001	.38	1.4
23710	June 27	Slight.	Slight.	.36	3.60	1.25	.0040	.0156	.0124	.0032	.26	.0080	.0001	.36	1.3
23775	June 30	Slight.	Slight.	.36	4.15	1.40	.0060	.0148	.0138	.0010	.19	.0080	.0002	.39	1.1
23845	July 11	V. slight.	V. slight.	.32	3.95	1.75	.0068	.0138	.0138	.0000	.25	.0070	.0001	.36	1.3
23908	July 18	V. slight.	Cons.	.31	4.15	1.50	.0040	.0162	.0140	.0022	.24	.0080	.0001	.36	1.3
24029	July 25	V. slight.	V. slight.	.28	3.65	1.30	.0062	.0158	.0138	.0020	.21	.0060	.0002	.37	1.4
24123	Aug. 1	Slight.	Slight.	.23	4.00	1.40	.0068	.0164	.0152	.0012	.21	.0030	.0001	.32	1.3
24184	Aug. 8	Slight.	Cons.	.23	3.70	1.50	.0056	.0152	.0122	.0030	.19	.0060	.0001	.30	1.3
24290	Aug. 15	V. slight.	Slight.	.25	3.65	1.75	.0044	.0176	.0154	.0022	.24	.0030	.0001	.29	1.4
24382	Aug. 22	V. slight.	V. slight.	.20	3.70	1.40	.0032	.0164	.0134	.0030	.24	.0000	.0001	.31	1.4
24505	Aug. 31	Slight.	Slight.	.21	3.75	1.30	.0028	.0154	.0134	.0020	.24	.0020	.0002	.35	1.4
24538	Sept. 6	V. slight.	V. slight.	.22	3.85	1.50	.0048	.0158	.0138	.0020	.24	.0000	.0003	.37	1.4
24590	Sept. 12	V. slight.	Cons.	.25	4.10	1.40	.0020	.0190	.0158	.0032	.25	.0000	.0001	.41	1.6
24676	Sept. 19	V. slight.	Cons.	.40	4.45	1.75	.0036	.0222	.0196	.0026	.26	.0020	.0001	.56	1.7
24756	Sept. 26	Slight.	Slight.	.39	4.75	1.80	.0038	.0216	.0192	.0024	.25	.0050	.0000	.54	1.7
24899	Oct. 3	V. slight.	Slight.	.40	4.65	1.95	.0030	.0184	.0170	.0014	.24	.0040	.0001	.54	1.6
24940	Oct. 10	Slight.	Cons.	.37	4.50	1.70	.0014	.0202	.0172	.0030	.25	.0020	.0002	.52	1.7
25038	Oct. 17	V. slight.	Slight.	.35	4.55	1.80	.0016	.0200	.0172	.0028	.26	.0060	.0001	.52	1.7
25130	Oct. 24	V. slight.	V. slight.	.34	4.55	1.85	.0012	.0174	.0152	.0022	.25	.0030	.0001	.61	1.7
25207	Oct. 31	Slight.	Slight.	.32	4.65	2.00	.0014	.0186	.0156	.0030	.27	.0030	.0000	.50	1.7
25263	Nov. 7	V. slight.	Slight.	.31	7.25	4.15	.0018	.0184	.0154	.0030	.26	.0040	.0000	.47	1.7
25360	Nov. 14	V. slight.	Slight.	.38	5.15	2.10	.0032	.0192	.0180	.0012	.28	.0070	.0002	.53	1.8
25433	Nov. 21	Slight.	Slight.	.46	5.35	2.00	.0048	.0196	.0172	.0024	.31	.0150	.0001	.54	1.8
25511	Dec. 1	Decided.	Cons.	.47	5.60	2.35	.0060	.0194	.0172	.0022	.30	.0110	.0000	.58	1.8
25590	Dec. 12	Decided.	Slight.	.53	5.55	1.80	.0050	.0166	.0130	.0036	.33	.0240	.0001	.57	2.0
25670	Dec. 19	Slight.	Slight.	.57	5.60	2.30	.0054	.0186	.0168	.0018	.29	.0300	.0003	.64	2.2
25767	Dec. 27	Slight.	Slight.	.59	5.50	2.00	.0046	.0166	.0138	.0028	.31	.0140	.0003	.56	2.0

Odor, generally none, occasionally faintly vegetable. A vegetable odor was developed in most of the samples on heating. —— The samples were collected from the reservoir, near the gate-house, at depths ranging from 21 to 28 feet beneath the surface. For monthly record of height of water in this reservoir, see table on page 150.

METROPOLITAN WATER DISTRICT.

Microscopical Examination of Water from Sudbury Reservoir, collected about Midway between the Surface and Bottom.

[Number of organisms per cubic centimeter.]

Month, 1898, . . .	Jan.	Feb.	March.		April.				May.				June.	
Day of examination, .	4	2	1	9	5	12	18	26	3	13	17	23	1	7
Number of sample, .	21732	22029	22364	22484	22714	22790	22875	22964	23029	23138	23165	23268	23330	23400
PLANTS.														
Diatomaceæ, .	286	44	3	pr.	33	49	176	166	176	424	264	132	84	27
Asterionella, . .	286	43	2	0	13	36	88	74	92	178	76	21	3	18
Cyclotella, . .	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Melosira, . .	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synedra, . .	0	1	0	0	4	13	82	78	68	180	144	88	59	4
Tabellaria, . .	0	0	0	0	14	0	4	13	16	56	44	21	18	0
Cyanophyceæ, .	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Algæ, ...	90	38	2	0	0	11	18	16	0	8	4	3	6	4
Raphidium, . .	90	38	2	0	0	2	8	0	0	0	0	0	0	3
ANIMALS.														
Rhizopoda, . .	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Infusoria, . .	1	0	0	0	27	36	50	60	59	63	56	46	12	1
Cryptomonas, .	0	0	0	0	14	7	0	6	5	4	0	1	1	0
Dinobryon, . .	0	0	0	0	8	19	44	47	44	50	52	44	10	0
Vermes, . . .	1	1	0	0	0	1	1	1	0	0	2	2	3	0
Crustacea, . .	pr.	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyclops, . . .	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	10	15	5	10	5	8	3	5	5	5	5	5	3	3
TOTAL, . . .	388	98	10	10	65	105	248	248	240	500	331	188	108	35

METROPOLITAN WATER DISTRICT.

Microscopical Examination of Water from Sudbury Reservoir, collected about Midway between the Surface and Bottom — Continued.

[Number of organisms per cubic centimeter.]

Month, 1898,	June.			July.				August.				September.		
Day of examination,	14	21	29	1	12	19	26	2	9	16	23	1	7	13
Number of sample,	23518	23611	23710	23775	23845	23908	24029	24123	24184	24290	24382	24505	24538	24590
PLANTS.														
Diatomaceæ,	14	88	224	285	202	406	78	204	254	1,110	436	250	102	143
Asterionella,	1	12	96	113	126	314	27	0	16	6	22	50	30	90
Cyclotella,	12	70	122	170	63	70	40	94	158	1,016	300	70	6	0
Melosira,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synedra,	1	2	1	0	0	1	0	24	14	2	0	6	0	13
Tabellaria,	0	4	4	2	13	21	11	84	64	86	112	124	66	40
Cyanophyceæ,	0	0	0	0	5	1	2	0	0	0	2	2	2	0
Algæ,	1	2	2	1	8	5	1	4	0	12	2	35	14	47
Raphidium,	0	0	2	0	0	0	0	4	0	12	2	8	0	19
ANIMALS.														
Rhizopoda,	0	0	0	0	0	0	0	0	0	2	0	0	0	1
Infusoria,	1	2	1	2	10	9	13	0	0	2	2	2	0	5
Cryptomonas,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dinobryon,	0	0	0	0	10	9	13	0	0	2	2	0	0	2
Vermes,	2	0	0	1	0	1	0	0	0	1	1	0	0	1
Crustacea,	0	0	0	0	0	pr.	pr.	0	0	0	pr.	pr.	pr.	pr.
Cyclops,	0	0	0	0	0	0	0	0	0	0	pr.	pr.	pr.	pr.
Miscellaneous, Zoöglœa,	0	0	3	3	5	5	3	5	5	8	8	3	3	8
TOTAL,	18	92	230	292	230	427	97	213	259	1,135	451	292	121	205

METROPOLITAN WATER DISTRICT.

Microscopical Examination of Water from Sudbury Reservoir, collected about Midway between the Surface and Bottom — Concluded.

[Number of organisms per cubic centimeter.]

Month, 1898,	September.		October.				November.				December.			
Day of examination,	20	27	5	11	18	25	1	8	15	21	2	13	19	28
Number of sample,	24676	24756	24899	24940	25038	25130	25207	25263	25360	25433	25511	25590	25670	25767
PLANTS.														
Diatomaceæ,	373	318	360	1,340	348	100	149	126	183	98	76	64	24	18
Asterionella,	310	294	342	1,252	246	46	65	36	104	35	33	31	10	2
Cyclotella,	0	2	0	4	4	2	11	30	45	28	22	17	8	6
Melosira,	20	0	6	16	6	6	0	0	0	5	6	0	0	0
Synedra,	26	5	2	0	12	8	15	15	12	13	10	8	2	2
Tabellaria,	16	16	10	54	80	38	58	44	20	15	5	4	0	8
Cyanophyceæ,	0	2	0	0	4	0	2	0	0	0	0	0	0	0
Algæ,	9	20	6	40	18	18	13	13	26	6	11	0	2	0
Raphidium,	7	18	4	14	6	16	6	6	5	0	6	0	2	0
ANIMALS.														
Rhizopoda,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Infusoria,	6	2	2	0	2	8	7	1	2	2	1	1	0	0
Cryptomonas,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dinobryon,	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Vermes,	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Crustacea,	pr.	0	0	pr.	pr.	pr.	0	0	pr.	0	0	0	0	0
Cyclops,	0	0	0	pr.	pr.	pr.	0	0	pr.	0	0	0	0	0
Miscellaneous, Zoöglœa,	10	8	8	8	10	10	8	5	10	8	8	10	7	5
TOTAL,	398	350	376	1,388	382	136	180	145	221	115	99	72	33	23

METROPOLITAN WATER DISTRICT.

Chemical Examination of Water from Sudbury Reservoir, collected near the Bottom.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21733	Jan. 3	Decided.	Cons.	.71	7.35	2.25	.0072	.0240	.0216	.0024	.46	.0320	.0001	.63	3.1
22030	Jan. 31	Decided.	Cons.	.70	7.80	2.50	.0100	.0222	.0198	.0024	.55	.0470	.0000	.64	3.1
22365	Feb. 28	Decided.	Cons.	.60	6.80	1.80	.0118	.0170	.0154	.0016	.41	.0480	.0002	.50	2.5
22485	Mar. 8	Decided.	Cons.	.61	6.40	2.20	.0122	.0172	.0140	.0032	.42	.0420	.0003	.44	3.6
22715	Apr. 4	Slight.	Slight.	.40	3.95	1.50	.0006	.0142	.0104	.0038	.26	.0200	.0002	.39	1.6
22791	Apr. 11	V. slight	Slight.	.41	4.00	1.50	.0016	.0122	.0114	.0008	.26	.0180	.0002	.37	1.4
22876	Apr. 18	V. slight.	Slight.	.41	3.35	1.10	.0010	.0108	.0098	.0010	.26	.0120	.0001	.37	1.1
22965	Apr. 25	Slight.	Slight.	.40	3.80	1.65	.0010	.0128	.0100	.0028	.26	.0130	.0001	.37	1.4
23030	May 2	Slight.	Cons.	.40	3.55	1.20	.0014	.0130	.0104	.0026	.23	.0120	.0002	.34	1.1
23139	May 12	V. slight.	Cons.	.37	3.55	1.15	.0024	.0124	.0112	.0012	.28	.0140	.0002	.33	1.1
23166	May 16	Slight.	Slight.	.37	3.50	1.50	.0022	.0128	.0114	.0014	.28	.0120	.0001	.33	1.3
23269	May 23	V. slight.	V. slight.	.40	3.40	1.10	.0022	.0130	.0114	.0016	.27	.0140	.0001	.37	1.3
23331	May 31	V. slight.	Slight.	.38	3.60	1.25	.0052	.0120	.0104	.0016	.25	.0150	.0001	.34	1.4
23401	June 6	V. slight.	Slight.	.38	3.80	1.40	.0040	.0102	.0086	.0016	.25	.0170	.0002	.35	1.4
23519	June 13	V. slight.	V. slight.	.43	3.80	1.50	.0062	.0118	.0094	.0024	.24	.0180	.0002	.34	1.3
23612	June 20	V. slight.	V. slight.	.37	3.75	1.15	.0050	.0098	.0096	.0002	.26	.0170	.0001	.34	1.4
23711	June 27	Slight.	V. slight.	.32	3.60	1.20	.0046	.0122	.0112	.0010	.26	.0120	.0002	.23	1.3
23776	June 30	V. slight.	Slight.	.32	4.00	1.70	.0072	.0130	.0112	.0018	.20	.0120	.0001	.35	1.1
23846	July 11	V. slight.	V. slight.	.30	3.60	1.50	.0076	.0146	.0132	.0014	.24	.0070	.0001	.36	1.4
23909	July 18	Slight.	Slight.	.30	3.95	1.35	.0062	.0128	.0122	.0006	.24	.0130	.0004	.37	1.3
24030	July 25	V. slight.	V. slight.	.28	3.80	1.35	.0074	.0148	.0128	.0020	.22	.0070	.0006	.36	1.3
24124	Aug. 1	Slight.	Slight.	.25	3.80	1.50	.0068	.0154	.0142	.0012	.22	.0030	.0002	.34	1.3
24185	Aug. 8	Slight.	Slight.	.24	3.60	1.35	.0070	.0128	.0114	.0014	.20	.0050	.0002	.31	1.3
24291	Aug. 15	V. slight.	Slight.	.31	3.95	1.90	.0068	.0166	.0142	.0024	.24	.0080	.0004	.32	1.3
24383	Aug. 22	V. slight.	V. slight.	.21	3.60	1.20	.0050	.0146	.0130	.0016	.24	.0020	.0008	.30	1.4
24506	Aug. 31	Slight.	Slight.	.21	3.85	1.50	.0070	.0136	.0128	.0008	.23	.0060	.0005	.35	1.4
24539	Sept. 6.	V. slight.	Slight.	.22	4.05	1.50	.0066	.0150	.0132	.0018	.24	.0050	.0003	.43	1.6
24591	Sept. 12	V. slight.	Cons.	.25	4.10	1.45	.0030	.0188	.0158	.0030	.23	.0010	.0001	.43	1.6
24677	Sept. 19	Slight.	Cons.	.65	5.00	2.05	.0060	.0276	.0224	.0052	.24	.0020	.0000	.76	2.0
24757	Sept. 26	Slight.	Slight.	.40	4.75	1.85	.0030	.0206	.0188	.0018	.24	.0020	.0000	.56	1.6
24900	Oct. 3	Slight.	Slight.	.39	4.50	1.90	.0026	.0196	.0166	.0030	.23	.0030	.0001	.54	1.4
24941	Oct. 10	Slight.	Cons.	.38	4.55	1.80	.0024	.0188	.0172	.0016	.25	.0030	.0001	.52	1.7
25039	Oct. 17	Slight.	Slight.	.34	4.60	1.75	.0016	.0192	.0158	.0034	.25	.0050	.0002	.54	1.7
25131	Oct. 24	V. slight.	V. slight.	.33	4.50	1.70	.0010	.0180	.0148	.0032	.24	.0060	.0001	.61	1.7
25208	Oct. 31	Slight.	Slight.	.31	4.60	2.00	.0012	.0186	.0152	.0034	.27	.0020	.0000	.50	1.7
25264	Nov. 7	V. slight.	Slight.	.31	7.60	4.35	.0016	.0184	.0168	.0016	.25	.0050	.0000	.47	1.7
25361	Nov. 14	Slight.	Cons.	.46	5.35	1.95	.0036	.0210	.0202	.0008	.31	.0060	.0001	.58	1.8
25434	Nov. 21	Slight.	V. slight.	.46	5.25	1.90	.0048	.0194	.0164	.0030	.31	.0130	.0001	.56	1.8
25512	Dec. 1	Decided.	Cons.	.47	5.65	2.15	.0066	.0206	.0186	.0020	.30	.0140	.0001	.58	2.0
25591	Dec. 12	Decided.	Slight.	.52	5.60	1.85	.0046	.0156	.0140	.0016	.33	.0240	.0001	.56	2.0
25671	Dec. 19	Slight.	Slight.	.56	5.80	1.85	.0064	.0184	.0170	.0014	.33	.0300	.0002	.61	2.1
25768	Dec. 27	Slight.	Slight.	.59	6.15	1.85	.0058	.0164	.0154	.0010	.32	.0200	.0003	.57	2.1

Odor, generally none, occasionally faintly vegetable. —— The samples were collected from the reservoir, near the gate-house. For monthly record of height of water in this reservoir, see table on page 150.

METROPOLITAN WATER DISTRICT.

Microscopical Examination of Water from Sudbury Reservoir, collected near the Bottom.

[Number of organisms per cubic centimeter.]

Month. 1898,	Jan.	Feb.	March.		April.				May.				June.	
Day of examination,	4	2	1	9	5	12	18	26	3	13	17	23	1	7
Number of sample,	21733	22030	22365	22485	22715	22791	22876	22965	23030	23139	23166	23269	23331	23401
PLANTS.														
Diatomaceæ,	358	25	2	0	65	33	244	128	156	342	218	122	85	13
Asterionella,	356	25	0	0	23	26	98	60	58	52	48	29	20	7
Cyclotella,	0	0	0	0	0	0	4	2	0	0	0	0	2	0
Synedra,	2	0	0	0	5	3	142	54	38	248	132	64	38	3
Tabellaria,	0	0	0	0	37	4	0	12	60	40	38	29	22	3
Cyanophyceæ,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Algæ,	24	34	0	0	7	0	32	0	0	0	12	1	1	2
ANIMALS.														
Infusoria,	0	1	0	0	23	17	52	14	39	26	33	18	4	2
Cryptomonas,	0	0	0	0	16	5	0	0	4	2	0	1	0	0
Dinobryon,	0	0	0	0	2	6	46	11	26	8	26	16	4	1
Vermes,	4	1	0	0	0	2	4	1	0	0	2	1	1	1
Crustacea, Cyclops,	pr.	0	0	0	0	0	0	pr.	0	0	0	0	pr.	pr.
Miscellaneous, Zoöglœa,	15	15	5	12	8	8	5	7	3	5	3	5	3	3
TOTAL,	401	76	7	12	103	60	337	150	198	373	268	147	94	21

METROPOLITAN WATER DISTRICT.

Microscopical Examination of Water from Sudbury Reservoir, collected near the Bottom — Continued.

[Number of organisms per cubic centimeter.]

Month, 1898,	June.			July.				August.				September.		
Day of examination,	14	21	29	1	12	19	26	2	9	16	23	1	7	13
Number of sample,	23519	23612	23711	23776	23846	23909	24030	24124	24185	24291	24383	24506	24539	24591
PLANTS.														
Diatomaceæ,	6	14	87	152	271	85	63	41	49	142	100	64	39	143
Asterionella,	1	0	12	34	121	39	42	0	0	0	0	8	7	86
Cyclotella,	1	10	68	118	148	34	6	3	23	110	80	10	3	0
Synedra,	4	2	2	0	0	1	0	8	1	8	2	12	2	9
Tabellaria,	0	1	5	0	2	10	15	26	24	24	18	32	27	47
Cyanophyceæ,	0	0	0	0	0	0	0	1	0	0	1	0	0	0
Algæ,	0	0	0	1	4	0	0	0	1	0	6	6	4	18
ANIMALS.														
Infusoria,	0	1	1	1	1	4	1	1	0	0	0	4	5	24
Cryptomonas,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dinobryon,	0	0	0	0	0	3	0	0	0	0	0	0	0	22
Vermes,	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Crustacea, Cyclops,	0	0	pr.	0	0	0	0	0	0	0	0	pr.	0	pr.
Miscellaneous, Zoöglœa,	3	5	5	3	8	5	8	0	5	10	12	5	5	8
TOTAL,	9	20	93	158	284	94	72	43	55	152	119	79	53	196

METROPOLITAN WATER DISTRICT.

Microscopical Examination of Water from Sudbury Reservoir, collected near the Bottom — Concluded.

[Number of organisms per cubic centimeter.]

Month, 1898,	September.		October.				November.				December.			
Day of examination,	20	27	5	11	18	25	1	8	15	21	2	13	19	28
Number of sample,	24677	24757	24900	24941	25039	25131	25208	25264	25361	25434	25512	25591	25671	25768
PLANTS.														
Diatomaceæ,	362	420	490	444	312	174	185	246	163	132	78	98	34	29
Asterionella,	310	382	456	392	250	78	68	98	46	56	40	64	14	14
Cyclotella,	2	4	0	6	2	2	12	38	38	32	20	14	10	9
Synedra,	24	8	16	8	16	14	22	20	27	6	2	1	4	2
Tabellaria,	26	23	18	16	32	78	48	90	46	24	16	12	6	4
Cyanophyceæ,	0	0	2	0	4	0	0	1	0	0	0	0	0	0
Algæ,	14	7	4	4	6	26	9	14	12	4	4	1	1	0
ANIMALS.														
Infusoria,	9	0	0	4	6	0	1	1	3	0	1	0	0	0
Cryptomonas,	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dinobryon,	8	0	0	2	6	0	1	0	0	0	0	0	0	0
Vermes,	4	0	0	0	0	0	1	1	3	0	1	0	0	0
Crustacea, Cyclops,	pr.	0	0	pr.	0	0	0	0	pr.	0	0	0	0	0
Miscellaneous, Zoöglœa,	20	12	15	10	15	5	8	8	10	8	7	10	7	5
TOTAL,	409	439	511	462	343	207	203	270	188	148	90	109	42	34

Table showing Height of Water in Sudbury Reservoir on the First Day of Each Month in 1898.

[Heights are in feet above Boston city base.]

DATE.	Sudbury Reservoir. Crest of Dam = 259.00.	DATE.	Sudbury Reservoir. Crest of Dam = 259.00.
January 1,	244.41	July 1,	257.74
February 1,	248.22	August 1,	253.90
March 1,	244.80	September 1,	249.32
April 1,	256.54	October 1,	248.65
May 1,	258.70	November 1,	247.38
June 1,	259.05	December 1,	247.57

METROPOLITAN WATER DISTRICT.

Chemical Examination of Water from Stony Brook, at Head of Framingham Reservoir No. 3, Southborough.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended		Nitrates.	Nitrites.		
	1898.														
21735	Jan. 3	Slight.	V. slight.	.05	11.85	1.85	.0070	.0090	.0086	.0004	.67	.1360	.0012	.18	5.0
22036	Jan. 31	Decided.	Cons.	.68	7.50	2.45	.0086	.0210	.0204	.0006	.51	.0380	.0002	.58	3.0
22374	Feb. 28	Decided.	Slight.	.62	6.00	1.50	.0116	.0166	.0160	.0006	.31	.0350	.0003	.47	2.1
22718	Apr. 4	V. slight.	V. slight.	.40	5.75	2.10	.0002	.0118	.0104	.0014	.42	.0380	.0003	.37	2.1
23032	May 2	Slight.	Slight.	.37	3.75	1.15	.0002	.0122	.0100	.0022	.24	.0130	.0002	.32	1.0
23337	May 31	V. slight.	V. slight.	.45	4.35	1.85	.0028	.0136	.0118	.0018	.25	.0050	.0002	.42	1.3
23770	June 30	Slight.	Slight.	.28	3.70	1.25	.0048	.0130	.0118	.0012	.22	.0110	.0002	.38	1.0
24109	Aug. 1	Slight.	Slight.	.27	4.05	1.35	.0056	.0166	.0144	.0022	.23	.0130	.0002	.36	1.3
24502	Aug 31	Slight.	Slight.	.20	3.50	1.30	.0032	.0154	.0130	.0024	.23	.0050	.0002	.39	1.4
24884	Oct. 3	Slight.	Cons.	.40	4.70	1.75	.0016	.0202	.0178	.0024	.24	.0030	.0001	.54	1.6
25211	Oct. 31	V. slight.	V. slight.	.30	4.85	1.65	.0014	.0174	.0150	.0024	.27	.0050	.0000	.51	1.8
25521	Dec. 1	Slight.	Slight.	.51	5.50	2.00	.0068	.0198	.0188	.0010	.29	.0160	.0002	.56	1.8
Av..	....	....	....	.38	5.46	1.68	.0045	.0155	.0140	.0015	.32	.0265	.0003	.42	1.9

Odor, generally faintly vegetable, becoming stronger on heating.——The samples were collected from the brook, about 50 feet below the first road above Framingham Reservoir No. 3.

Chemical Examination of Water from Framingham Reservoir No. 3, Framingham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended		Nitrates.	Nitrites.		
	1898.														
21736	Jan. 3	Decided.	Cons.	.50	5.75	1.85	.0024	.0222	.0220	.0002	.43	.0130	.0001	.53	2.5
22037	Jan. 31	V. slight.	Slight.	.50	4.90	1.90	.0022	.0252	.0212	.0040	.44	.0150	.0000	.56	2.2
22375	Feb. 28	Decided.	Slight.	.60	5.90	1.35	.0086	.0166	.0154	.0012	.35	.0320	.0003	.49	2.2
22719	Apr. 4	Slight.	Slight.	.38	4.70	1.50	.0010	.0154	.0120	.0034	.34	.0350	.0002	.39	1.7
23033	May 2	Slight.	Slight.	.40	3.65	1.15	.0002	.0144	.0114	.0030	.23	.0130	.0002	.34	1.0
23338	May 31	V. slight.	Slight.	.45	4.10	1.65	.0006	.0148	.0118	.0030	.24	.0090	.0002	.37	1.1
23771	June 30	Decided.	Slight.	.25	3.60	1.20	.0006	.0158	.0126	.0032	.21	.0030	.0004	.34	1.1
24110	Aug. 1	V. slight.	V. slight.	.24	3.70	1.35	.0002	.0176	.0152	.0024	.19	.0030	.0002	.39	1.3
24503	Aug. 31	Slight.	Cons.	.22	3.85	1.45	.0010	.0176	.0142	.0034	.23	.0020	.0001	.42	1.4
24885	Oct. 3	Slight.	Slight.	.32	4.75	1.80	.0002	.0206	.0182	.0024	.25	.0010	.0001	.48	1.7
25212	Oct. 31	V. slight.	V. slight.	.33	4.75	1.75	.0020	.0186	.0160	.0026	.25	.0030	.0000	.54	1.8
25522	Dec. 1	Slight.	Slight.	.42	4.80	1.80	.0032	.0196	.0182	.0014	.29	.0090	.0002	.54	1.8
Av..	....	....	....	.38	4.54	1.56	.0018	.0182	.0157	.0025	.29	.0115	.0002	.45	1.6

Odor, generally faintly vegetable, becoming stronger on heating.——The samples were collected from the reservoir, near the gate-house, at a depth of 8 feet beneath the surface.

METROPOLITAN WATER DISTRICT.

Microscopical Examination of Water from Framingham Reservoir No. 3, Framingham.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	4	2	1	5	3	1	1	1	1	4	1	2
Number of sample,	21736	22037	22375	22719	23033	23338	23771	24110	24503	24885	25212	25522
PLANTS.												
Diatomaceæ,	**1,280**	**512**	**8**	**438**	**262**	**398**	**1,589**	**248**	**137**	**355**	**166**	**197**
Asterionella,	496	104	4	156	68	2	200	0	30	287	34	106
Cyclotella,	52	72	0	2	0	4	1,384	238	2	10	18	41
Melosira,	350	0	0	208	0	68	0	0	0	0	0	0
Synedra,	0	36	3	60	128	308	1	4	10	17	15	3
Tabellaria,	356	300	0	10	64	12	4	6	94	40	96	47
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**16**	**0**	**0**
Anabæna,	0	0	0	0	0	0	0	0	0	15	0	0
Algæ,	**52**	**16**	**2**	**10**	**12**	**12**	**8**	**118**	**43**	**58**	**23**	**0**
Protococcus,	56	0	0	0	10	0	5	116	38	0	0	0
ANIMALS.												
Infusoria,	**34**	**146**	**2**	**62**	**60**	**8**	**1**	**16**	**20**	**5**	**2**	**2**
Dinobryon,	26	144	0	46	48	8	0	14	19	4	1	1
Peridinium,	4	1	0	2	10	0	0	0	1	0	0	0
Vermes,	**0**	**2**	**0**	**0**	**0**	**2**	**2**	**0**	**0**	**0**	**0**	**0**
Crustacea, Cyclops,	**0**	pr.	**0**	**0**	**0**	pr.	**0**	**0**	pr.	**0**	**0**	**0**
Miscellaneous, Zoöglœa,	0	5	7	10	7	8	0	3	5	5	8	8
TOTAL,	1,366	681	19	520	341	428	1,600	385	207	439	199	207

Chemical Examination of Water from Indian Brook, at Head of Hopkinton Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21727	Jan. 3	V. slight.	V. slight.	1.30	6.50	3.25	.0006	.0248	.0226	.0022	.62	.0080	.0001	1.27	2.6
22025	Jan. 31	V. slight.	V. slight.	1.45	5.15	2.40	.0006	.0200	.0200	.0000	.48	.0060	.0000	1.22	1.6
22368	Feb. 28	V. slight.	V. slight.	1.44	3.70	1.60	.0010	.0158	.0152	.0006	.28	.0070	.0001	0.82	1.1
22768	Apr. 7	V. slight.	V. slight.	1.10	4.10	2.20	.0010	.0152	.0138	.0014	.46	.0000	.0000	0.90	1.0
23021	May 2	V. slight.	Slight.	1.30	3.95	1.80	.0004	.0236	.0210	.0026	.39	.0000	.0000	1.02	1.0
23321	May 31	V. slight.	V. slight.	2.50	5.60	3.40	.0018	.0370	.0356	.0014	.30	.0030	.0001	1.81	1.3
23762	June 30	None.	V. slight.	2.00	7.80	4.70	.0020	.0602	.0554	.0048	.27	.0010	.0002	2.30	1.6
24114	Aug. 1	V. slight.	V. slight.	2.00	8.05	4.65	.0026	.0564	.0548	.0016	.50	.0020	.0000	2.00	1.4
24492	Aug. 31	V. slight.	V. slight.	1.70	7.00	4.10	.0034	.0478	.0460	.0018	.43	.0030	.0000	1.94	1.2
24891	Oct. 3	V. slight.	V. slight.	1.05	6.65	3.35	.0002	.0348	.0318	.0030	.56	.0000	.0000	1.31	1.4
25393	Nov. 15	None.	V. slight.	1.10	5.60	2.85	.0002	.0238	.0232	.0006	.48	.0020	.0000	1.44	1.0
25513	Nov. 30	V. slight.	V. slight.	1.20	5.65	3.15	.0004	.0222	.0210	.0012	.51	.0070	.0000	1.22	1.3
Av.	....	....	....	1.51	5.81	3.12	.0012	.0318	.0300	.0018	.44	.0032	.0000	1.44	1.4

Odor, generally faintly vegetable, becoming stronger on heating. —— The samples were collected from the brook, at its entrance to Hopkinton Reservoir.

METROPOLITAN WATER DISTRICT.

Chemical Examination of Water from Hopkinton Reservoir, collected near the Surface.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21728	Jan. 3	Slight.	Slight.	.70	4.25	1.75	.0030	.0232	.0190	.0042	.41	.0070	.0000	.72	1.6
22026	Jan. 31	Slight.	Slight.	.76	4.00	2.05	.0024	.0204	.0200	.0004	.43	.0040	.0000	.75	1.7
22366	Feb. 28	V. slight.	V. slight.	.72	3.80	1.50	.0024	.0170	.0164	.0006	.33	.0070	.0001	.68	1.0
22711	Apr. 4	V. slight.	V. slight.	.70	3.40	1.70	.0014	.0168	.0152	.0016	.36	.0050	.0000	.62	1.0
23022	May 2	V. slight.	Slight.	.68	3.50	1.60	.0010	.0168	.0162	.0006	.39	.0030	.0000	.57	1.0
23322	May 31	V. slight.	Slight.	.70	3.55	1.80	.0026	.0208	.0172	.0036	.37	.0020	.0001	.63	1.1
23763	June 30	V. slight.	Slight.	.59	3.70	1.70	.0006	.0222	.0194	.0028	.28	.0000	.0001	.71	1.0
24115	Aug. 1	Slight.	Cons.	.54	3.55	1.75	.0016	.0244	.0206	.0038	.30	.0010	.0000	.66	0.8
24493	Aug. 31	V. slight.	Slight.	.55	3.35	1.85	.0018	.0244	.0214	.0030	.30	.0010	.0001	.78	0.8
24892	Oct. 3	V. slight.	V. slight.	.49	3.70	1.80	.0004	.0204	.0186	.0018	.32	.0000	.0000	.72	1.0
25394	Nov. 15	None.	V. slight.	.50	3.95	1.95	.0008	.0194	.0182	.0012	.35	.0020	.0000	.71	0.8
25514	Nov. 30	V. slight.	V. slight.	.53	3.75	2.15	.0016	.0190	.0178	.0012	.32	.0040	.0000	.74	1.0
Av.	....	....	....	.62	3.71	1.80	.0016	.0204	.0183	.0021	.35	.0030	.0000	.69	1.1

Odor, of Nos. 24493 and 24892, none; of No. 23322, distinctly oily; of the others, faintly vegetable and sometimes musty.—— The samples were collected from the reservoir, near the dam.

Microscopical Examination of Water from Hopkinton Reservoir, collected near the Surface.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	May.	June.	Aug.	Aug.	Oct.	Nov.	Dec.
Day of examination,	4	2	1	5	3	31	30	2	31	4	16	2
Number of sample,	21728	22026	22366	22711	23022	23322	23763	24115	24493	24892	25394	25514
PLANTS.												
Diatomaceæ,	426	208	40	284	415	266	722	854	1,088	22	78	48
Asterionella,	400	187	36	268	344	34	0	406	1,008	21	26	26
Cyclotella,	9	9	3	1	10	18	672	352	76	1	16	8
Tabellaria,	17	11	1	13	51	180	49	96	3	0	30	13
Cyanophyceæ,	1	0	0	0	0	0	4	14	0	18	3	0
Clathrocystis,	1	0	0	0	0	0	4	14	0	10	1	0
Algæ,	6	9	2	0	1	48	3	2	0	0	4	0
ANIMALS.												
Infusoria,	2	2	1	1	17	110	13	6	5	1	0	1
Dinobryon,	0	0	0	0	16	96	8	0	0	0	0	0
Uroglena,	0	0	0	0	0	10	0	0	0	0	0	0
Vermes,	1	0	0	0	1	2	0	0	0	0	0	0
Crustacea,	pr.	0	0	pr.	0	0	pr.	0	0	0	0	0
Cyclops,	0	0	0	pr.	0	0	pr.	0	0	0	0	0
Daphnia,	pr.	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	3	5	0	5	3	3	0	3	3	3	5	3
TOTAL,	439	224	43	290	437	429	742	879	1,096	44	90	52

METROPOLITAN WATER DISTRICT.

Chemical Examination of Water from Hopkinton Reservoir, collected near the Bottom.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21729	Jan. 3	V. slight.	Slight.	.70	4.20	1.80	.0032	.0206	.0194	.0012	.42	.0070	.0000	.74	1.6
22027	Jan. 31	V. slight.	Cons.	.90	4.25	2.05	.0034	.0190	.0186	.0004	.43	.0070	.0000	.81	1.4
22367	Feb. 28	V. slight.	V. slight.	.89	4.15	1.55	.0040	.0180	.0174	.0006	.35	.0050	.0001	.74	1.1
22712	Apr. 4	V. slight	V. slight.	.70	3.40	1.65	.0018	.0150	.0144	.0006	.34	.0050	.0000	.62	0.8
23023	May 2	V. slight.	Slight.	.70	3.45	1.50	.0010	.0160	.0152	.0008	.37	.0050	.0000	.60	0.8
23323	May 31	V. slight.	V. slight.	.68	3.35	1.10	.0020	.0168	.0154	.0014	.37	.0070	.0001	.59	1.0
23764	June 30	V. slight.	V. slight.	.50	3.65	1.55	.0020	.0150	.0142	.0008	.29	.0070	.0002	.54	0.8
24116	Aug. 1	Slight.	Slight.	.51	3.50	1.85	.0028	.0152	.0140	.0012	.31	.0080	.0000	.54	0.6
24494	Aug. 31	V. slight.	V. slight.	.49	3.55	1.80	.0030	.0154	.0128	.0026	.30	.0070	.0001	.56	0.8
24893	Oct. 3	V. slight.	V. slight.	.42	3.45	1.60	.0018	.0144	.0126	.0018	.31	.0030	.0001	.55	1.0
25395	Nov. 15	None.	V. slight.	.50	4.00	1.95	.0006	.0184	.0166	.0018	.34	.0010	.0000	.72	0.8
25515	Nov. 30	V. slight.	V. slight.	.51	4.00	2.05	.0014	.0184	.0172	.0012	.35	.0060	.0000	.74	1.0
Av.	....	....	....	.62	3.74	1.70	.0022	.0168	.0156	.0012	.35	.0057	.0000	.65	1.0

Odor of Nos. 21729, 24893 and 25395, none; of the others, faintly vegetable, sometimes becoming stronger on heating. —— The samples were collected from the reservoir, near the dam.

Chemical Examination of Water from Cold Spring Brook, at Head of Ashland Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21734	Jan. 3	Slight.	Slight.	1.27	5.30	2.55	.0006	.0256	.0234	.0022	.56	.0140	.0000	1.08	1.7
22031	Jan. 31	V. slight.	Slight.	1.20	4.55	2.15	.0004	.0220	.0216	.0004	.40	.0100	.0000	0.96	1.6
22369	Feb. 28	V. slight.	Slight.	0.88	3.50	1.35	.0002	.0174	.0162	.0012	.24	.0020	.0002	0.69	1.1
22721	Apr. 4	V. slight.	V. slight.	1.25	3.90	2.10	.0006	.0286	.0284	.0002	.32	.0020	.0001	1.10	1.0
23025	May 2	V. slight.	V. slight.	1.30	3.85	2.00	.0006	.0276	.0268	.0008	.31	.0030	.0000	1.00	1.0
23324	May 31	V. slight.	V. slight.	1.82	4.75	2.90	.0014	.0370	.0332	.0038	.27	.0020	.0000	1.30	1.1
23765	June 30	V. slight.	Slight.	0.90	3.60	1.70	.0006	.0260	.0234	.0026	.23	.0010	.0000	0.83	1.0
24111	Aug. 1	V. slight.	V. slight.	0.64	3.70	1.75	.0006	.0260	.0220	.0040	.23	.0010	.0000	0.79	0.8
24495	Aug. 31	V. slight.	V. slight.	2.30	7.30	4.20	.0038	.0560	.0534	.0026	.31	.0040	.0001	1.62	1.4
24888	Oct. 3	V. slight.	V. slight.	0.52	4.50	1.85	.0002	.0204	.0190	.0014	.28	.0000	.0000	0.67	1.3
25226	Oct. 31	V. slight.	V. slight.	1.80	6.60	4.00	.0014	.0400	.0372	.0028	.30	.0010	.0000	1.94	1.3
25516	Dec. 1	V. slight.	V. slight.	1.06	4.85	2.60	.0006	.0260	.0246	.0014	.28	.0020	.0000	1.22	1.0
Av.	....	....	....	1.24	4.70	2.43	.0009	.0294	.0274	.0020	.31	.0035	.0000	1.10	1.2

Odor, distinctly vegetable and sometimes musty. —— The samples were collected from the brook, at its entrance into Ashland Reservoir.

METROPOLITAN WATER DISTRICT.

Chemical Examination of Water from Ashland Reservoir, collected near the Surface.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21753	Jan. 4	Slight.	Slight.	0.85	4.15	2.00	.0010	.0248	.0236	.0012	.40	.0050	.0000	.82	1.3
22032	Jan. 31	V. slight.	Slight.	1.00	4.20	2.20	.0006	.0222	.0212	.0010	.33	.0090	.0000	.78	1.0
22370	Feb. 28	V. slight.	V. slight.	0.72	3.80	1.55	.0004	.0198	.0188	.0010	.33	.0060	.0000	.66	1.3
22722	Apr. 4	V. slight.	V. slight.	0.72	3.40	1.75	.0008	.0188	.0176	.0012	.30	.0050	.0000	.68	1.0
23026	May 2	V. slight.	V. slight.	0.77	3.65	1.70	.0004	.0210	.0196	.0014	.31	.0030	.0000	.74	1.0
23325	May 31	V. slight.	V. slight.	0.95	3.40	1.45	.0016	.0232	.0196	.0036	.32	.0030	.0001	.74	1.0
23766	June 30	V. slight.	Slight.	0.66	4.10	2.20	.0004	.0248	.0230	.0018	.25	.0010	.0000	.77	1.0
24112	Aug. 1	V. slight.	V. slight.	0.61	3.70	1.85	.0004	.0238	.0210	.0028	.27	.0020	.0000	.66	1.0
24496	Aug. 31	V. slight.	V. slight.	0.60	3.75	2.15	.0008	.0264	.0246	.0018	.26	.0000	.0000	.85	0.8
24889	Oct. 3	V. slight.	V. slight.	0.52	3.70	1.75	.0004	.0216	.0204	.0012	.25	.0010	.0000	.74	1.3
25227	Oct. 31	V slight.	V. slight.	0.65	3.45	1.60	.0010	.0184	.0168	.0016	.25	.0020	.0000	.78	1.0
25517	Dec. 1	V. slight.	V. slight.	0.58	3.90	2.05	.0014	.0210	.0200	.0010	.27	.0020	.0002	.77	0.8
Av.	....	....	....	0.72	3.76	1.85	.0008	.0221	.0205	.0016	.29	.0032	.0000	.75	1.0

Odor, generally faintly vegetable.—The samples were collected from the reservoir, near the gate-house.

Microscopical Examination of Water from Ashland Reservoir, collected near the Surface.

[Number of organisms per cubic centimeter.]

	1898. Jan.	Feb.	Mar.	Apr.	May.	May.	June.	Aug.	Aug.	Oct.	Nov.	Dec.
Day of examination,	5	2	1	6	3	31	30	1	31	4	2	2
Number of sample,	21753	22032	22370	22722	23026	23325	23766	24112	24496	24889	25227	25517
PLANTS.												
Diatomaceæ,	124	3	4	34	73	18	305	108	33	6	24	49
Cyclotella,	8	1	2	1	1	11	300	86	33	3	1	0
Cyanophyceæ,	0	0	0	0	0	0	4	0	8	0	0	0
Algæ,	2	48	0	0	1	2	24	8	43	10	2	0
ANIMALS.												
Rhizopoda,	0	1	0	0	0	0	0	0	0	0	0	0
Infusoria,	2	22	8	18	74	2	0	0	7	2	2	0
Dinobryon,	0	22	8	17	74	2	0	0	0	0	0	0
Vermes,	2	1	0	0	0	0	0	0	0	1	0	0
Crustacea, Cyclops,	0	0	0	0	pr.	pr.	0	0	pr.	0	0	0
Miscellaneous, Zoöglœa,	0	3	0	0	3	0	3	3	3	3	3	3
Total,	130	78	12	52	151	22	336	119	94	22	31	52

METROPOLITAN WATER DISTRICT.

Chemical Examination of Water from Ashland Reservoir, collected near the Bottom.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
21754	Jan. 4	V. slight.	Slight.	.84	4.20	2.10	.0012	.0232	.0228	.0004	.34	.0070	.0000	.82	1.3
22033	Jan. 31	V. slight.	V. slight.	.90	4.25	1.85	.0020	.0228	.0228	.0000	.36	.0040	.0000	.80	1.3
22371	Feb. 28	Slight.	V. slight.	.85	4.30	1.80	.0026	.0240	.0234	.0006	.30	.0030	.0000	.76	1.3
22723	Apr. 4	V. slight.	V. slight.	.72	3.50	1.80	.0008	.0182	.0168	.0014	.31	.0070	.0003	.73	1.0
23027	May 2	V. slight.	V. slight.	.77	3.90	1.80	.0006	.0194	.0182	.0012	.32	.0030	.0000	.70	1.0
23326	May 31	V. slight.	V. slight.	.73	3.60	1.95	.0014	.0186	.0182	.0004	.33	.0040	.0000	.67	1.0
23767	June 30	V. slight.	V. slight.	.58	3.75	1.80	.0028	.0194	.0164	.0030	.26	.0030	.0002	.68	1.0
24113	Aug. 1	V. slight.	V. slight.	.60	3.55	1.70	.0040	.0204	.0182	.0022	.25	.0040	.0002	.58	0.8
24497	Aug. 31	V. slight.	V. slight.	.56	3.55	1.75	.0002	.0170	.0158	.0012	.23	.0070	.0000	.70	0.6
24890	Oct. 3.	V. slight.	V. slight.	.51	3.70	2.05	.0004	.0216	.0202	.0014	.24	.0000	.0000	.76	1.0
25228	Oct. 31	V. slight.	V. slight.	.64	3.95	1.85	.0012	.0194	.0176	.0018	.27	.0010	.0000	.76	1.0
25518	Dec. 1	V. slight.	V. slight.	.58	3.80	1.95	.0014	.0202	.0192	.0010	.26	.0020	.0001	.78	0.8
Av..	....	....	....	.69	3.84	1.87	.0015	.0203	.0191	.0012	.29	.0037	.0001	.73	1.0

Odor, generally faintly vegetable. —— The samples were collected from the reservoir, near the gate-house.

Chemical Examination of Water from Sudbury River, at Head of Framingham Reservoir No. 2.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
21737	Jan. 3	V. slight.	V. slight.	0.72	4.25	1.80	.0012	.0180	.0174	.0006	.38	.0100	.0000	0.70	2.1
22034	Jan. 31	V. slight.	V. slight.	0.85	4.50	1.75	.0006	.0168	.0156	.0012	.40	.0130	.0000	0.72	1.7
22372	Feb. 28	V. slight.	V. slight.	0.66	3.30	1.15	.0008	.0150	.0142	.0008	.24	.0060	.0001	0.56	0.8
22716	Apr. 4	None.	V. slight.	0.78	3.75	1.60	.0002	.0184	.0166	.0018	.34	.0080	.0000	0.70	1.1
23034	May 2	V. slight.	V. slight.	0.98	3.65	1.55	.0002	.0214	.0176	.0038	.24	.0030	.0001	0.74	1.0
23335	May 31	V. slight.	V. slight.	1.29	4.55	2.35	.0016	.0284	.0250	.0034	.27	.0030	.0001	0.98	1.0
23768	June30	Decided.	Slight.	1.00	4.90	2.55	.0042	.0324	.0298	.0026	.26	.0040	.0002	0.98	1.1
24107	Aug. 1	Slight.	Slight.	0.65	4.75	2.20	.0014	.0416	.0296	.0120	.29	.0030	.0000	0.74	1.1
24500	Aug. 30	Slight.	Slight.	2.00	6.70	3.95	.0108	.0476	.0420	.0056	.28	.0060	.0001	2.06	1.3
24882	Oct. 3	V. slight.	V. slight.	0.90	5.40	2.40	.0040	.0298	.0288	.0010	.36	.0030	.0000	1.00	1.4
25209	Oct. 31	V. slight.	V. slight.	1.05	4.85	2.35	.0010	.0264	.0256	.0008	.35	.0020	.0000	1.40	1.0
25519	Dec. 1	V. slight.	V. slight.	0.60	4.00	1.90	.0008	.0180	.0170	.0010	.27	.0070	.0000	0.77	0.8
Av..	....	....	....	0.96	4.55	2.13	.0022	.0262	.0233	.0029	.31	.0057	.0000	0.95	1.2

Odor, vegetable. —— The samples were collected from the river, near the old dam at the upper end of Framingham Reservoir No. 2, at a depth of 1 foot beneath the surface.

METROPOLITAN WATER DISTRICT.

Chemical Examination of Water from Framingham Reservoir No. 2.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21738	Jan. 3	V. slight.	V. slight.	0.73	5.40	2.90	.0008	.0192	.0176	.0016	.38	.0130	.0001	0.79	1.6
22035	Jan. 31	V. slight.	Slight.	0.70	4.00	1.75	.0002	.0152	.0140	.0012	.35	.0130	.0000	0.71	1.3
22373	Feb. 28	V. slight.	V. slight.	0.67	3.25	1.05	.0002	.0142	.0134	.0008	.23	.0050	.0001	0.57	0.8
22717	Apr. 4	V. slight.	V. slight.	0.70	3.35	1.75	.0002	.0162	.0142	.0020	.30	.0070	.0000	0.66	0.8
23035	May 2	V. slight.	V. slight.	0.90	3.80	1.55	.0002	.0184	.0170	.0014	.24	.0050	.0001	0.71	0.8
23336	May 31	V. slight.	V. slight.	1.04	4.00	2.15	.0020	.0234	.0208	.0026	.30	.0040	.0001	0.81	1.1
23769	June 30	Slight.	Slight.	0.82	4.20	2.20	.0030	.0266	.0242	.0024	.27	.0020	.0002	0.82	1.1
24108	Aug. 1	V. slight.	None.	0.61	4.35	2.00	.0002	.0290	.0252	.0038	.24	.0020	.0000	0.72	1.7
24501	Aug. 31	Slight.	Slight.	1.70	6.20	3.90	.0100	.0424	.0388	.0036	.26	.0030	.0001	1.85	1.3
24883	Oct. 3	V. slight.	V. slight.	1.30	6.25	3.05	.0078	.0414	.0388	.0026	.33	.0040	.0000	1.50	1.4
25210	Oct. 31	V. slight.	V. slight.	0.95	5.00	2.15	.0016	.0240	.0226	.0014	.34	.0020	.0000	1.18	1.0
25520	Dec. 1	V. slight.	V. slight.	0.61	3.85	1.85	.0006	.0190	.0166	.0024	.28	.0050	.0001	0.82	0.8
Av.	....	....	....	0.89	4.47	2.19	.0022	.0241	.0220	.0021	.29	.0054	.0001	0.93	1.1

Odor, vegetable. —— The samples were collected from the reservoir, near the gate-house, at a depth of 8 feet beneath the surface.

Microscopical Examination of Water from Framingham Reservoir No. 2.

[Number of organisms per cubic centimeter.]

	1898. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	4	2	1	5	3	1	1	1	1	4	1	2
Number of sample,	21738	22035	22373	22717	23035	23336	23769	24108	24501	24883	25210	25520
PLANTS.												
Diatomaceæ,	4	64	5	26	58	70	46	134	62	17	18	13
Asterionella,	0	50	1	18	19	25	3	0	18	0	8	3
Cyclotella,	0	2	1	1	0	4	20	82	9	0	1	0
Cyanophyceæ,	0	0	0	0	0	0	1	8	0	1	0	0
Algæ,	0	0	0	0	3	1	34	194	32	9	0	0
Protococcus,	0	0	0	0	0	0	20	192	32	0	0	0
ANIMALS.												
Infusoria,	0	1	0	2	2	0	3	2	2	2	1	0
Vermes,	0	0	0	0	2	1	0	0	0	0	0	0
Crustacea,	0	0	0	0	0	pr.	pr.	0	0	pr.	0	0
Miscellaneous, Zoöglœa,	0	5	3	3	3	5	3	3	3	3	5	3
TOTAL,	4	70	8	31	68	77	87	341	99	32	24	16

METROPOLITAN WATER DISTRICT.

Chemical Examination of Water from Lake Cochituate in Wayland.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21739	Jan. 3	Slight.	Cons.	.28	5.30	1.90	.0016	.0198	.0176	.0022	.54	.0060	.0002	.40	2.7
22038	Jan. 31	V. slight.	Cons.	.38	5.10	1.75	.0028	.0196	.0178	.0018	.53	.0070	.0001	.47	2.3
22376	Feb. 28	Slight.	Cons.	.48	4.85	1.50	.0026	.0192	.0174	.0018	.39	.0100	.0002	.51	2.1
22720	Apr. 4	Slight.	Slight.	.32	5.05	1.70	.0010	.0202	.0162	.0040	.47	.0120	.0000	.51	2.1
23031	May 2	V. slight.	Slight.	.38	5.05	1.65	.0006	.0190	.0176	.0014	.51	.0110	.0003	.44	2.0
23340	May 31	V. slight.	V. slight.	.42	4.90	1.85	.0014	.0216	.0156	.0060	.50	.0090	.0002	.47	1.8
23773	June 30	Slight.	Slight.	.29	4.70	1.85	.0016	.0208	.0182	.0026	.41	.0060	.0003	.50	2.1
24118	Aug. 1	V. slight.	Slight.	.22	4.75	1.70	.0010	.0192	.0174	.0018	.40	.0020	.0002	.39	1.8
24512	Sept. 1	V. slight.	Slight.	.19	4.95	2.15	.0026	.0290	.0232	.0058	.45	.0020	.0000	.40	1.7
24886	Oct. 3	V. slight.	Slight.	.19	4.85	1.95	.0006	.0202	.0164	.0038	.45	.0000	.0000	.44	2.2
25213	Oct. 31	V. slight.	Slight.	.20	4.70	1.65	.0000	.0168	.0136	.0032	.42	.0060	.0000	.43	2.0
25523	Dec. 1	V. slight.	Slight.	.30	4.90	1.85	.0032	.0184	.0162	.0022	.54	.0080	.0002	.50	2.1
Av.	....	....	....	.30	4.92	1.79	.0016	.0203	.0173	.0030	.47	.0066	.0001	.45	2.1

Odor, vegetable, becoming stronger on heating.—The samples were collected from the gate-house.

Microscopical Examination of Water from Lake Cochituate in Wayland.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Date of examination,	4	2	1	5	3	1	1	2	2	4	1	2
Number of sample,	21739	22038	22376	22720	23031	23340	23773	24118	24512	24886	25213	25523
PLANTS.												
Diatomaceæ,	4	1,728	63	550	152	850	38	43	16	74	429	766
Asterionella,	0	536	8	238	58	8	0	8	0	16	303	662
Cyclotella,	0	36	8	34	0	604	24	4	5	0	0	4
Melosira,	0	700	43	272	0	16	0	0	0	3	51	64
Synedra,	4	0	2	0	86	12	0	10	9	3	14	0
Tabellaria,	0	156	2	4	8	174	14	0	0	5	61	36
Cyanophyceæ,	100	20	0	0	0	0	29	19	67	21	26	30
Anabæna,	0	0	0	0	0	0	22	14	55	20	0	0
Aphanizomenon,	100	20	0	0	0	0	0	0	0	0	25	30
Clathrocystis,	0	0	0	0	0	0	5	3	12	1	1	0
Algæ,	4	2	0	8	2	4	55	8	13	2	3	0

METROPOLITAN WATER DISTRICT.

Miscroscopical Examination of Water from Lake Cochituate in Wayland— Concluded.

[Number of organisms per cubic centimeter.]

	1898. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Rhizopoda,	0	2	0	0	0	0	0	0	0	0	0	0
Infusoria,	0	52	12	66	6	62	1	2	1	3	8	6
Dinobryon,	0	6	5	26	2	62	0	0	0	0	6	2
Synura,	0	40	30	0	0	0	0	0	0	0	0	2
Vermes,	0	0	0	0	0	0	0	0	0	0	1	0
Crustacea, Cyclops,	0	pr.	0	pr.	0	0	pr.	0	0	pr.	0	0
Miscellaneous, Zoöglœa,	5	5	3	10	10	0	3	3	3	3	5	5
TOTAL,	113	1,809	78	634	170	916	126	75	100	103	472	807

Chemical Examination of Water from the Terminal Chamber of the Sudbury Aqueduct at Chestnut Hill Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
22706	Apr. 4	V. slight.	V. slight.	.70	3.65	1.65	.0014	.0182	.0160	.0022	.29	.0090	.0000	.59	1.1
23036	May 2	V. slight.	Slight.	.40	4.25	1.25	.0002	.0122	.0092	.0030	.24	.0120	.0002	.35	1.1
23346	May 31	Slight.	Slight.	.40	4.10	1.75	.0014	.0140	.0114	.0026	.25	.0100	.0002	.48	1.3
23783	July 1	Slight.	Slight.	.30	3.90	1.65	.0020	.0156	.0122	.0034	.26	.0110	.0001	.36	1.3
24104	Aug. 1	Slight.	Slight.	.28	4.20	1.65	.0030	.0170	.0126	.0044	.22	.0040	.0002	.34	1.3
24517	Aug. 31	V. slight.	V. slight.	.20	4.00	1.40	.0032	.0182	.0150	.0032	.26	.0040	.0001	.33	1.3
24933	Oct. 6	Slight.	Slight.	.33	4.60	1.75	.0022	.0204	.0174	.0030	.29	.0020	.0002	.50	1.8
25254	Nov. 2	V. slight.	V. slight.	.41	4.25	2.25	.0014	.0172	.0150	.0022	.26	.0070	.0000	.51	1.6
25557	Dec. 6	V. slight.	V. slight.	.41	5.25	1.75	.0020	.0128	.0104	.0024	.28	.0140	.0000	.51	1.8
Av.	....	....	....	.38	4.24	1.68	.0019	.0162	.0133	.0029	.26	.0081	.0001	.44	1.4

Odor, generally faintly vegetable.

METROPOLITAN WATER DISTRICT.

Chemical Examination of Water from Spot Pond, Stoneham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21760	Jan. 4	Slight.	Slight.	.40	6.00	2.10	.0050	.0284	.0262	.0022	.68	.0060	.0001	.52	2.9
22087	Feb. 7	Slight.	V. slight.	.48	5.45	1.60	.0040	.0198	.0188	.0010	.61	.0070	.0001	.49	2.1
22344	Feb. 24	Slight.	Slight.	.60	5.05	1.75	.0058	.0168	.0164	.0004	.54	.0100	.0000	.53	2.0
22707	Apr. 4	V. slight.	V. slight.	.45	4.65	1.80	.0022	.0214	.0184	.0030	.46	.0050	.0001	.50	1.8
23019	May 2	Slight.	Slight.	.50	4.50	1.50	.0010	.0226	.0194	.0032	.46	.0060	.0001	.50	1.7
23347	June 1	Slight.	Slight.	.57	4.55	1.75	.0058	.0224	.0162	.0062	.46	.0040	.0002	.53	1.8
23761	June 30	Slight.	Slight.	.45	4.90	1.60	.0102	.0216	.0194	.0022	.50	.0010	.0002	.54	1.7
24117	Aug. 1	Decided.	Cons.	.58	5.10	1.95	.0142	.0240	.0210	.0030	.40	.0020	.0002	.47	1.7
24499	Aug. 31	Decided.	Cons.	.40	4.65	1.95	.0006	.0280	.0230	.0050	.37	.0000	.0000	.58	1.6
24881	Oct. 3	Decided.	Cons.	.39	5.10	1.90	.0030	.0266	.0246	.0020	.36	.0000	.0000	.51	1.8
25205	Oct. 31	Decided.	Slight.	.31	4.60	2.00	.0014	.0288	.0206	.0082	.37	.0010	.0000	.54	1.8
25508	Dec. 1	Slight.	Slight.	.40	4.85	2.25	.0014	.0264	.0226	.0038	.37	.0020	.0000	.57	1.8
Av.	....	....	....	.46	4.95	1.85	.0045	.0239	.0205	.0034	.46	.0028	.0001	.52	1.9

Odor, generally faintly vegetable, and occasionally musty and disagreeable, becoming stronger on heating. —— The first two samples were collected from the pond; the others, from a tap in the Melrose pumping station.

Chemical Examination of Water from a Faucet at the State House, Boston.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21744	Jan. 4	V. slight.	Slight.	.61	4.75	2.10	.0010	.0204	.0172	.0032	.44	.0110	.0001	.58	2.1
22039	Feb. 1	Slight.	Slight.	.60	4.50	1.70	.0014	.0164	.0152	.0012	.43	.0150	.0000	.61	1.8
22377	Mar. 1	Slight.	Slight.	.60	3.80	1.35	.0024	.0134	.0128	.0006	.25	.0130	.0000	.47	1.1
22708	Apr. 4	V. slight.	V. slight.	.68	3.30	1.75	.0016	.0178	.0152	.0026	.30	.0070	.0000	.57	0.8
23051	May 4	V. slight.	Slight.	.40	3.70	1.55	.0010	.0102	.0090	.0012	.24	.0130	.0000	.32	1.1
23328	June 1	V. slight.	V. slight.	.40	3.85	1.40	.0006	.0122	.0094	.0028	.28	.0190	.0000	.36	1.4
23760	June 30	V. slight	Slight.	.30	4.15	1.05	.0004	.0134	.0130	.0004	.26	.0130	.0002	.34	1.3
24103	Aug. 1	Slight.	Slight.	.25	4.30	1.30	.0002	.0134	.0124	.0010	.22	.0080	.0001	.31	1.3
24490	Aug. 31	V. slight.	V. slight.	.22	3.75	1.45	.0002	.0166	.0136	.0030	.23	.0040	.0001	.38	1.4
24879	Oct. 3	Slight.	Slight.	.24	4.45	1.50	.0002	.0188	.0174	.0014	.31	.0040	.0001	.41	1.6
25204	Oct. 31	Slight.	Slight.	.30	4.90	1.90	.0000	.0152	.0150	.0002	.29	.0030	.0000	.43	1.7
25509	Dec. 1	Slight.	Slight.	.35	4.85	2.20	.0010	.0146	.0126	.0020	.29	.0070	.0001	.45	1.8
Av.	....	....	....	.41	4.19	1.60	.0008	.0152	.0136	.0016	.29	.0097	.0001	.44	1.4

Odor of the first six samples, generally vegetable; of the last six samples, none, becoming faintly vegetable on heating.

Water Supply of Abington and Rockland.

The source of supply is Big Sandy Pond in Pembroke, a natural pond having an area of 111 acres. The general depth of the pond is about 15 feet, its maximum depth 20 feet, and the bottom is said to contain very little organic matter. Its drainage area, including the area of the pond and of Little Sandy Pond, which is within this water-shed, is 1.15 square miles, and this area, which is largely covered with wood, is estimated to contain a permanent population of about 50 per square mile. There are a large number of cottages on the shores of the ponds which are occupied during the summer months.

Chemical Examination of Water from Big Sandy Pond, Pembroke.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dissolved.	Sus-pended.					
	1898.														
21813	Jan. 10	Slight.	Slight.	.10	3.30	1.40	.0014	.0240	.0184	.0056	.72	.0000	.0000	.23	0.6
22098	Feb. 7	Slight.	Slight.	.11	3.35	1.50	.0034	.0210	.0170	.0040	.73	.0020	.0000	.24	0.8
23096	May 9	V. slight.	V. slight.	.16	3.00	1.20	.0008	.0150	.0140	.0010	.70	.0030	.0000	.26	0.5
24179	Aug. 7	V. slight.	V. slight.	.17	3.20	1.35	.0006	.0170	.0156	.0014	.64	.0010	.0000	.22	0.3
25312	Nov. 8	V. slight.	V. slight	.21	3.25	1.35	.0000	.0162	.0154	.0008	.64	.0010	.0000	.30	0.6
25576	Dec. 7	Slight.	V. slight.	.20	3.05	1.20	.0004	.0126	.0100	.0026	.61	.0000	.0000	.34	0.8
Av...	....	....	....	.16	3.19	1.33	.0011	.0176	.0151	.0025	.67	.0012	.0000	.26	0.6

Odor, faintly vegetable or none. —— The samples were collected from a faucet in the pumping station.

Acton.

The advice of the State Board of Health to Freeman W. Robbins of Acton, relative to the use of the water of an artificial pond in Concord as a source of ice supply, may be found on pages 123 and 124 of this volume. The results of the analysis of a sample of water collected from the pond are given under Concord, on page 188 of this report.

ADAMS.

Water Supply of Adams Fire District, Adams.

The principal sources of supply are two mountain streams known as Bassett and Dry brooks, but water is also sometimes supplied from a well owned by a private corporation in the village, and other wells located in the valley of the Hoosac River below the village have been used at times in previous years. The Bassett Brook water-shed, which has an area of 2.6 square miles, is an uninhabited mountain side. The water-shed of Dry Brook has an area of 7.8 square miles, and contains a small population. The water-shed is mountainous, but there is a small area of nearly level swampy land near the head waters of the brook.

Chemical Examination of Water from Bassett Brook Reservoir, Adams.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21928	Jan 21	Slight.	Cons.	.07	2.40	0.85	.0002	.0064	.0040	.0024	.08	.0150	.0000	.17	1.7
23316	May 26	None.	V. slight.	.14	2.75	1.10	.0008	.0056	.0048	.0008	.08	.0090	.0000	.22	1.0
24069	July 27	V. slight.	Slight.	.05	5.10	1.30	.0014	.0056	.0044	.0012	.04	.0140	.0000	.14	3.1
24387	Aug. 22	None.	V. slight.	.10	3.75	1.05	.0004	.0050	.0046	.0004	.07	.0070	.0002	.18	2.3
24751	Sept. 23	None.	V. slight.	.08	4.75	1.05	.0004	.0026	.0022	.0004	.06	.0110	.0000	.06	3.1
25356	Nov. 12	V. slight.	None.	.12	2.55	1.00	.0004	.0046	.0040	.0006	.07	.0280	.0000	.20	1.0
Av...	....	....	....	.09	3.55	1.06	.0006	.0050	.0040	.0010	.07	.0140	.0000	.16	2.0

Odor, none.—— No. 24387 was collected from the reservoir; the others, from a faucet supplied with water from the reservoir.

Chemical Examination of Water from Dry Brook Reservoir in Adams and Cheshire.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21927	Jan. 21	Slight.	Cons.	.23	4.05	1.20	.0002	.0142	.0066	.0076	.08	.0120	.0000	.27	2.7
22474	Mar. 7	None.	None.	.03	3.50	0.75	.0002	.0024	.0022	.0002	.06	.0130	.0000	.14	2.5
23317	May 26	Slight.	V. slight.	.53	5.80	1.75	.0010	.0114	.0108	.0006	.06	.0170	.0000	.54	3.0
24068	July 27	Slight.	V. slight.	.30	8.70	2.65	.0002	.0136	.0124	.0012	.07	.0060	.0000	.42	4.6
24386	Aug. 22	V. slight.	V. slight.	.40	8.15	2.40	.0004	.0132	.0128	.0004	.06	.0020	.0000	.54	5.0
24750	Sept. 23	V. slight.	Slight.	.17	10.75	2.35	.0004	.0102	.0092	.0010	.14	.0010	.0001	.24	7.9
25357	Nov. 12	V. slight.	V. slight.	.51	4.75	2.00	.0010	.0130	.0110	.0020	.08	.0070	.0000	.74	2.2
Av...	....	....	....	.31	6.53	1.87	.0005	.0111	.0093	.0018	.08	.0083	.0000	.41	4.0

Odor, none, becoming faintly vegetable or musty on heating.—— Nos. 24386 and 24750 were collected from the reservoir; the others, from a faucet supplied with water from the reservoir.

ADAMS.

Chemical Examination of Water from the Well of the Renfrew Manufacturing Company, Adams.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
24071	1898. July 27	None.	V. slight.	.02	15.80	.0000	.0020	.09	.0330	.0001	.03	12.0	.0010

Odor, none. —— The Renfrew well is used as a supplementary source of supply at times, when the yield of the other sources is insufficient for the supply of the fire district, or when the other sources are shut off for any cause. During 1898 this well was used for only a day and a half.

Agawam.

The advice of the State Board of Health to George D. Cooley, with reference to the use of a certain spring as a source of water supply for a portion of the village of Mittineague in Agawam, may be found on pages 4 and 5 of this volume. The results of the chemical analysis of a sample of water collected from the spring are as follows: —

Chemical Examination of Water from a Spring in the Village of Mittineague, Agawam.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
25043	1898. Oct. 17	None.	V. slight.	.01	5.10	.0004	.0026	.19	.0200	.0000	.00	2.6	.0030

Odor, none. —— The sample was collected from a spring, on land owned by George D. Cooley. The spring is situated about 300 feet south of Moore Street.

AMESBURY.

WATER SUPPLY OF AMESBURY.—POWOW HILL WATER COMPANY.

Chemical Examination of Water from the Wells of the Powow Hill Water Company in Amesbury.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
24668	Sept. 17	V. slight.	V. slight.	.01	20.70	.0032	.0022	1.14	.0000	.0000	.06	10.8	.0090
24669	Sept. 19	Distinct, milky.	None.	.14	8.50	.0004	.0010	0.60	.0580	.0001	.04	3.5	.0460

Odor, none. —— The first sample was collected from the tubular wells near Market Street; the last, from the tubular wells supplying the open basins near Main Street.

WATER SUPPLY OF AMHERST.—AMHERST WATER COMPANY.

Chemical Examination of Water from the Amethyst Brook Reservoir of the Amherst Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
23724	June 27	V. slight.	V. slight.	.48	3.50	1.40	.0006	.0158	.0132	.0026	.13	.0070	.0000	.44	0.5
24048	July 25	Decided.	Cons.	.21	3.85	1.85	.0060	.0232	.0134	.0098	.10	.0020	.0001	.27	0.6
24487	Aug. 30	V. slight.	V. slight.	.53	4.00	2.10	.0006	.0200	.0194	.0006	.10	.0020	.0001	.85	0.8
24775	Sept. 26	Slight.	Slight.	.57	4.30	1.80	.0010	.0174	.0168	.0006	.12	.0050	.0002	.80	0.8
Av...	....	....	....	.45	3.91	1.79	.0020	.0191	.0157	.0034	.11	.0040	.0000	.59	0.7

Odor, faintly vegetable or none. A distinctly fishy odor was developed in the July sample on heating.

WATER SUPPLY OF ANDOVER.

The source of supply is Haggett's Pond in Andover, which has an area of about 200 acres, and a drainage area, including the area of the pond, of about 2.7 square miles. The drainage area contains a population of about 40 per square mile, and the shores of the pond are used to some extent as a pleasure resort in the summer season.

Chemical Examination of Water from Haggett's Pond, Andover.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21801	Jan. 10	V. slight.	Slight.	.16	3.30	1.40	.0018	.0174	.0170	.0004	.40	.0030	.0000	.34	1.7
22800	Apr. 11	Slight.	V. slight.	.20	3.60	1.65	.0002	.0166	.0138	.0028	.30	.0020	.0001	.38	1.3
23870	July 12	Decided.	V. slight.	.18	3.15	1.25	.0008	.0210	.0176	.0034	.33	.0000	.0000	.33	1.1
24952	Oct. 10	V. slight.	None.	.16	3.20	1.20	.0006	.0180	.0168	.0012	.35	.0000	.0000	.38	1.1
Av...	....	....	....	.17	3.31	1.37	.0008	.0182	.0163	.0019	.34	.0012	.0000	.36	1.3

Odor of the first three samples, vegetable; of the last, none. —— The samples were collected from a faucet at the pumping station.

Water Supply of Arlington.

The original source of supply was a storage reservoir on North Brook, Lexington, having an area of 31 acres, a capacity of 77,000,000 gallons and an average depth of about 8 feet. The area of the water-shed, including the area of the reservoir, is 2.25 square miles, and this area contains about 200 persons per square mile. The yield of the reservoir can be increased by diverting into it water from the Great Meadows, so called, which have a drainage area of 0.5 of a square mile.

Along one side of the reservoir is a filter-gallery, and the water from the brook which feeds the reservoir is also turned directly into this gallery. The supply of the town has been drawn chiefly from the filter-gallery and brook, the reservoir being used only when the yield from the other sources is insufficient.

The higher portions of the town are supplied with water which is drawn from a group of tubular wells located at the edge of the Great Meadows in East Lexington. The wells have an average depth of

ARLINGTON.

about 35 feet, and water from them was first used in 1895. When water was first drawn from the wells it had considerable color, and contained an excessive amount of iron and a larger amount of organic matter than is found in good water. Since that time the color has increased considerably, and there has also been a decided increase in the quantity of organic matter and iron present in the water.

A communication from the State Board of Health to the Arlington Water Board, relative to the pollution of the water supply of that town by refuse from a slaughter house upon the water-shed of one of the sources of supply, may be found on pages 111 and 112 of this volume.

Chemical Examination of Water from the Storage Reservoir of the Arlington Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
22202	Feb. 14	V. slight.	V. slight.	0.70	5.85	2.35	.0098	.0298	.0252	.0046	.52	.0650	.0003	0.73	2.1
22869	Apr. 18	Slight.	Cons.	0.98	6.35	2.50	.0012	.0356	.0236	.0120	.58	.0290	.0003	0.73	2.3
23607	June 20	Decided.	Cons.	1.00	6.80	2.95	.0030	.0752	.0368	.0384	.63	.0100	.0003	0.87	2.2
24385	Aug. 22	Decided.	Cons.	1.20	8.55	4.40	.0036	.0784	.0470	.0314	.44	.0030	.0001	1.45	2.3
25126	Oct. 24	Slight.	Slight.	0.97	8.15	3.60	.0084	.0622	.0400	.0222	.56	.0160	.0003	0.67	2.5
25786	Dec. 28	V. slight.	V. slight.	0.68	7.30	2.80	.0016	.0260	.0236	.0024	.64	.0260	.0004	0.81	2.6
Av..	....	....	....	0.92	7.17	3.10	.0046	.0512	.0327	.0185	.56	.0248	.0003	0.88	2.3

Odor, vegetable and occasionally grassy or disagreeable.

Microscopical Examination.

In the sample examined in April, 252 *Synedra* per cubic centimeter were found; in June, 368 *Fragilaria*, 436 *Anabæna* and 560 *Scenedesmus;* in August, 1,660 *Fragilaria*, 234 *Clathrocystis*, 3,000 *Protococcus* and 400 *Scenedesmus;* in October, 268 *Melosira* and 1,500 *Protococcus*. An insignificant number of organisms was found in the remaining samples.

ARLINGTON.

Chemical Examination of Water from Tubular Wells at East Lexington.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22197	Feb. 14	Slight, milky.	V. slight.	.55	9.20	.0202	.0116	.59	.0030	.0000	.22	4.6	.0950
23676	June 24	Decided.	Slight.	.36	8.40	.0150	.0086	.52	.0020	.0000	.22	3.6	.0730
24397	Aug. 22	Decided.	Cons.	.51	9.00	.0200	.0142	.49	.0000	.0000	.24	4.3	.3030
25127	Oct. 24	Decided.	Slight.	.45	9.00	.0210	.0130	.49	.0010	.0000	.28	3.8	.0850
25790	Dec. 27	Decided.	Cons.	.50	8.00	.0188	.0116	.50	.0010	.0001	.24	3.8	.1150

Averages by Years.

–	1895	–	–	.17	9.90	.0097	.0075	.52	.0045	.0001	.18	5.5	.0958
–	1896	–	–	.24	9.88	.0090	.0102	.54	.0052	.0001	.21	5.3	.0742
–	1897	–	–	.45	9.05	.0167	.0102	.55	.0042	.0000	.22	4.7	.0993
–	1898	–	–	.47	8.72	.0190	.0118	.52	.0014	.0000	.24	4.0	.1342

NOTE to analyses of 1898: Odor of the second sample, faintly vegetable, becoming distinctly vegetable on heating; of the other samples, none. A faintly unpleasant odor was developed in the last sample on heating. —— The samples were collected from a faucet at the pumping station.

The advice of the State Board of Health to the Robbins Spring Water Company, with reference to the quality of the water of certain springs in Arlington, the water from which is used for the supply of several families in that town, and is also sold for drinking purposes in Boston and its vicinity, may be found on pages 5 and 6 of this volume. The results of analyses of samples of water collected from the springs are given in the following table: —

Chemical Examination of Water from Robbins Springs in Arlington.

[Parts per 100,000.]

Number.	Date of Collection	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid		Nitrates.	Nitrites.			
	1898.												
25009	Oct. 13	None.	None.	.01	6.40	.0000	.0014	.63	.1400	.0000	.04	2.3	.0010
25010	Oct. 13	None.	None.	.00	6.30	.0000	.0032	.53	.0730	.0000	.03	2.1	.0000
25011	Oct. 13	None.	None.	.00	5.70	.0000	.0014	.48	.0220	.0000	.06	1.8	.0010
25114	Oct. 21	None.	V. slight.	.02	7.30	.0026	.0030	.67	.1680	.0000	.06	3.0	.0010
25012	Oct. 13	None.	None.	.00	6.40	.0000	.0022	.58	.0600	.0000	.04	2.5	.0010

Odor, none. —— The samples were collected from the Robbins Springs, which are located on the northerly slope of Arlington Heights. The first three samples were collected from springs Nos. 1, 2 and 3, respectively, which are located in the vicinity of the spring house, about 1,600 feet south-west of Massachusetts Avenue; the last two samples were collected from springs Nos. 4 and 5, which are located about 1,000 feet south-west of Massachusetts Avenue.

ATHOL.

Water Supply of Athol. — Athol Water Company.

Chemical Examination of Water from the Large Storage Reservoir in Phillipston.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
22677	Mar. 29	V. slight.	Slight.	.79	3.05	1.25	.0008	.0160	.0128	.0032	.11	.0120	.0000	.62	0.5
23714	June 27	Decided.	Cons.	.51	3.40	1.65	.0056	.0796	.0294	.0502	.19	.0010	.0011	.79	0.5
24760	Sept. 26	Decided.	Cons., green.	.67	3.45	2.10	.0044	.0624	.0302	.0322	.13	.0000	.0001	.86	0.8
25687	Dec. 19	V. slight.	None.	.65	3.70	1.65	.0010	.0194	.0158	.0036	.13	.0060	.0002	.73	0.6
Av...	....	....	....	.65	3.40	1.66	.0029	.0443	.0220	.0223	.14	.0047	.0003	.75	0.6

Odor, generally distinctly vegetable.

Microscopical Examination.

In the sample collected in June, 2,480 *Anabæna* per cubic centimeter were found; in the September sample 2,600 *Anabæna* and 9,184 *Melosira* per cubic centimeter were observed. An insignificant number of organisms was found in the remaining samples.

Chemical Examination of Water from Buckman Brook Reservoir, Athol.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
22678	Mar. 29	V. slight.	Slight.	.20	1.75	0.65	.0000	.0098	.0082	.0016	.08	.0070	.0000	0.25	0.5
23713	June 27	Slight.	Slight.	.70	4.35	2.00	.0030	.0362	.0322	.0040	.20	.0210	.0001	0.98	0.5
24761	Sept. 26	V. slight.	V. slight.	.90	5.05	2.65	.0052	.0324	.0288	.0036	.14	.0050	.0000	1.16	1.0
25688	Dec. 19	V. slight.	None	.29	3.20	1.10	.0000	.0068	.0064	.0004	.10	.0010	.0001	0.39	0.5
Av..	....	....	....	.52	3.59	1.60	.0020	.0213	.0189	.0024	.13	.0085	.0000	0.69	0.6

Odor of the first two samples, faintly vegetable; of the third, faintly musty, becoming also fishy on heating; of the last, none.

Microscopical Examination.

In the sample collected in September, 678 *Dinobryon* per cubic centimeter were found. An insignificant number of organisms was found in the remaining samples.

ATTLEBOROUGH.

WATER SUPPLY OF ATTLEBOROUGH.

The source of supply is a well about 150 feet from Seven Mile River, just above Orr's Pond, a mill pond at the confluence of Seven Mile River and Four Mile Brook, not far from the village of South Attleborough. The well is 30 feet in diameter and 25 feet in depth. The water as drawn from the well has always been clear and practically free from color or odor, and the quantity of organic matter in the water has been very small.

Chemical Examination of Water from the Well of the Attleborough Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21794	Jan. 10	None.	None.	.01	4.00	.0008	.0042	.48	.0170	.0000	.02	2.3	.0010
22250	Feb. 15	None.	None.	.02	3.80	.0006	.0022	.44	.0140	.0000	.05	1.7	.0010
22498	Mar. 8	None.	None.	.01	3.20	.0000	.0014	.40	.0180	.0000	.06	2.0	.0010
22810	Apr. 12	None.	None.	.03	3.50	.0000	.0014	.39	.0150	.0000	.04	2.0	.0060
23133	May 11	V. slight.	None.	.05	3.60	.0006	.0022	.38	.0130	.0000	.03	2.0	.0030
23465	June 8	None.	None.	.00	4.00	.0002	.0016	.36	.0070	.0000	.06	1.7	.0020
23893	July 12	None.	None.	.02	4.50	.0000	.0016	.34	.0100	.0000	.03	2.0	.0020
24225	Aug. 9	None.	None.	.06	4.10	.0000	.0010	.35	.0110	.0000	.06	1.7	.0060
24627	Sept. 14	None.	V. slight.	.04	4.40	.0000	.0032	.34	.0100	.0000	.10	1.7	.0130
24959	Oct. 10	V. slight.	None.	.02	4.60	.0000	.0042	.36	.0080	.0000	.04	2.0	.0080
25313	Nov. 8	None.	None.	.06	4.60	.0000	.0022	.37	.0060	.0001	.05	2.0	.0060
25649	Dec. 15	V slight.	None.	.02	4.40	.0000	.0016	.34	.0130	.0000	.04	2.1	.0030
Av...	....	....	....	.03	4.06	.0002	.0022	.38	.0118	.0000	.05	1.9	.0043

Odor, none.—— The samples were collected from a faucet at the pumping station, while pumping.

AVON.

Water Supply of Avon.

Chemical Examination of Water from the Well of the Avon Water Works.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of six samples collected in February, April, June, August, October and December, 1898.	.01	3.52	.0003	.0009	.40	.0170	.0000	.02	1.1	.0047

Odor, none.

Water Supply of Ayer.

The source of supply is a well 25.5 feet in diameter and 25.7 feet in depth, situated near a small stream flowing from Sandy Pond, close to the south-easterly side of the main village of Ayer.

Chemical Examination of Water from the Well of the Ayer Water Works.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of six samples collected in February, April, June, August, October and December, 1898.	.02	5.72	.0005	.0016	.52	.0465	.0000	.41	2.7	.0077

Odor, none.

Water Supply of Barre. — Barre Water Company.

The source of supply is a small storage reservoir having an area of 4.25 acres and a capacity of 10,000,000 gallons, in which water from several springs in the vicinity is collected. The reservoir was made by excavating in a depression and building a dyke around the edges, material for the dyke being taken from the excavation. The reservoir is about 10 feet deep, and its bottom is of hard-pan.

BARRE.

Chemical Examination of Water from the Reservoir of the Barre Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved	Suspended.		Nitrates.	Nitrites.		
	1898.														
21818	Jan. 11	Decided.	Slight.	.15	2.50	1.00	.0002	.0096	.0096	.0000	.14	.0090	.0000	.20	1.0
22808	Apr. 12	Decided.	Cons.	.11	1.90	0.65	.0018	.0272	.0240	.0032	.15	.0010	.0002	.22	0.8
23796	July 5	Slight.	V. slight	.11	2.50	1.00	.0042	.0330	.0278	.0052	.13	.0010	.0001	.24	0.5
24905	Oct. 4	Slight.	Cons.	.10	2.50	1.25	.0156	.0536	.0190	.0346	.14	.0020	.0000	.29	0.8
Av...	....	....	....	.12	2.35	0.97	.0054	.0308	.0201	.0107	.14	.0032	.0001	.24	0.8

Odor of the first three samples, none; of the last, distinctly musty, becoming also fishy on heating. —— The first sample was collected from a faucet at the dead end of a pipe line; the remaining samples were collected from the reservoir.

Microscopical Examination.

In the sample collected in April, 824 *Dinobryon* per cubic centimeter were found. An insignificant number of organisms was found in the remaining samples.

Water Supply of Belmont.

The town of Belmont, until Nov. 30, 1898, was supplied with water from the works of the town of Watertown, and analyses of the water may be found under "Watertown." Since Nov. 30, 1898, water has been supplied from the Metropolitan Works, and analyses of the water and descriptions of the sources of supply may be found under "Metropolitan Water District," pages 133 to 160 of this volume.

Water Supply of Beverly.

(See *Salem.*)

Water Supply of Billerica.

Population in 1895, 2,577. The works are owned by the town, and water was introduced in January, 1899. The source of supply is a system of tubular wells on the west bank of the Concord River, about a mile above the village of North Billerica. The system con-

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sists of 35 four-inch wells, driven to depths ranging from 15 to 31 feet, the average depth being 26 feet. The wells are arranged in five groups of seven wells each, and provision has been made for shutting off any of the groups if it should be found desirable to do so. Water is pumped from the wells to the town and to a covered iron tank. Service pipes used are of wrought iron, lined with cement.

The advice of the State Board of Health to the town of Billerica, relative to a proposed water supply for that town to be taken from the ground on the west side of the Concord River, may be found on pages 6 to 8 of this volume. The results of chemical analyses of numerous samples of water collected in the course of two pumping tests, which were made to obtain information as to the quantity and quality of the water that might be obtained from the ground in this region, may be found on pages 108 to 111 of the annual report for the year 1897.

The advice of the Board to the water commissioners of Billerica, relative to the use of lead service pipes in connection with the public water supply of that town, may be found on page 8 of this volume.

Boxford.

Chemical Examination of Water from Bald Pate Pond, Boxford.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21967	Jan. 24	Slight.	V.slight.	.11	2.65	0.65	.0014	.0208	.0196	.0012	.34	.0090	.0000	.24	1.1
22307	Feb. 22	Slight.	V slight.	.11	2.85	0.90	.0010	.0156	.0148	.0008	.48	.0070	.0000	.24	1.0
22613	Mar. 21	V.slight.	V.slight.	.30	3.60	1.70	.0034	.0276	.0254	.0022	.42	.0000	.0000	.36	1.7
Av...	....	....	....	.17	3.03	1.08	.0019	.0213	.0199	.0014	.41	.0053	.0000	.28	1.3

Odor of the second sample, none; of the others, faintly vegetable.——The examinations of this pond were made with reference to its possible use as a source of water supply for the town of Georgetown.

Water Supply of Boston.

(See *Metropolitan Water District.*)

Water Supply of Braintree.

The source of supply is a filter-gallery on the shore of Little Pond in South Braintree. Little Pond has an area of 62 acres when full, and a water-shed of 0.46 of a square mile, excluding the area of the pond. The water-shed of the pond contains a population of about 1,100 per square mile, the larger portion of which is situated on that side of the pond on which the filter-gallery is located. The filter-gallery is 112 feet long and 15 feet wide, and is located very close to the high-water mark of the pond. At times it has been necessary to supplement the supply from the filter-gallery by drawing water directly from the pond.

Chemical Examination of Water from the Filter-gallery of the Braintree Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21768	Jan. 5	None.	None.	.04	6.10	.0020	.0048	0.97	.0530	.0000	.10	2.5	.0020
22057	Feb. 3	None.	None.	.05	5.30	.0006	.0054	0.94	.0380	.0000	.11	2.2	.0000
22402	Mar. 2	V. slight.	V. slight.	.09	4.90	.0022	.0104	0.89	.0380	.0000	.20	1.8	.0020
22745	Apr. 6	None.	None.	.05	4.80	.0014	.0050	0.87	.0520	.0000	.11	1.8	.0030
23065	May 4	None.	None.	.06	5.30	.0012	.0040	0.89	.0670	.0000	.11	2.0	.0020
23372	June 1	None.	None.	.09	5.00	.0004	.0052	0.81	.0390	.0000	.17	1.8	.0030
23817	July 6	V. slight.	None.	.08	4.30	.0018	.0058	0.83	.0160	.0000	.11	2.5	.0040
24152	Aug. 3	V. slight.	None.	.05	5.10	.0022	.0042	0.81	.0080	.0000	.10	1.8	.0060
24534	Sept. 6	V. slight.	None.	.19	5.30	.0010	.0044	0.81	.0230	.0001	.14	1.8	.0350
24911	Oct. 5	None.	V. slight.	.08	4.50	.0020	.0048	0.83	.0050	.0000	.10	1.8	.0070
25249	Nov. 2	None.	None.	.03	5.30	.0014	.0040	0.85	.0240	.0000	.13	2.0	.0030
25555	Dec. 6	None.	None.	.03	6.80	.0000	.0014	1.08	.2160	.0000	.06	2.1	.0040
Av...	1898	....	....	.07	5.22	.0013	.0049	0.88	.0482	.0000	.12	2.0	.0059
Av...	1897	....	....	.04	5.20	.0010	.0058	0.90	.0287	.0001	.10	2.0	.0059

Note to analyses of 1898: Odor of No. 22402, faintly vegetable; of the others, none. —— Nos. 22402, 22745, 23065, 24911 and 25555 were collected from the filter-gallery, and the others from a faucet at the pumping station.

BRAINTREE.

Chemical Examination of Water from Little Pond, Braintree.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21767	Jan. 5	Distinct.	Slight.	.34	4.30	1.25	.0026	.0376	.0334	.0042	1.05	.0080	.0000	.51	1.6
22401	Mar. 2	Slight	Slight.	.38	4.15	1.50	.0026	.0296	.0254	.0042	0.69	.0070	.0000	.40	1.0
23064	May 4	V. slight.	V. slight.	.31	3.75	1.40	.0010	.0188	.0174	.0014	0.75	.0030	.0000	.44	1.0
23816	July 6	V. slight.	Slight.	.29	4.10	1.70	.0026	.0260	.0236	.0024	0.72	.0010	.0000	.47	0.8
24533	Sept. 6	Slight.	Cons.	.25	3.80	1.65	.0006	.0250	.0206	.0044	0.75	.0020	.0001	.51	1.1
25248	Nov. 2	V. slight.	Slight.	.23	4.00	1.50	.0022	.0278	.0264	.0014	0.81	.0010	.0000	.48	1.0
Av...	....	....	....	.30	4.02	1.50	.0019	.0275	.0245	.0030	0.79	.0037	.0000	.47	1.1

Odor of No. 24533, faintly musty; of the others, vegetable, becoming stronger on heating. A fishy odor was developed in No. 22401 on heating.

Water Supply of Bridgewater and East Bridgewater. — The Bridgewaters Water Company.

Chemical Examination of Water from the Wells of the Bridgewaters Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22063	Feb. 3	Slight.	Slight.	.16	8.20	.0008	.0010	.39	.0000	.0000	.04	3.3	.0400
22742	April 6	V. slight.	Slight, floc.	.18	7.00	.0018	.0010	.50	.0030	.0000	.04	2.6	.0550
23350	June 1	Decided, milky.	Cons., floc.	.02	7.50	.0008	.0004	.40	.0050	.0000	.02	2.5	.0380
24141	Aug. 3	Slight, milky.	Slight.	.20	7.50	.0016	.0008	.32	.0020	.0000	.02	2.5	.0980
24923	Oct. 5	Decided, milky.	Slight.	.12	7.10	.0002	.0008	.44	.0060	.0000	.02	2.2	.0820
25543	Dec. 6	Slight, milky.	Cons., white floc.	.27	7.80	.0002	.0002	.43	.0040	.0000	.03	2.7	.0550
Av...	....	....	....	.16	7.52	.0009	.0007	.41	.0033	.0000	.03	2.6	.0613

Odor, none. —— The samples were collected from a faucet at the pumping station.

Water Supply of Brockton.

The source of supply is a storage reservoir on Salisbury Brook in the town of Avon. The reservoir has an area of 100 acres, a maximum depth of 19 feet and a capacity of about 325,000,000 gallons. Very little of the soil and organic matter was removed from the area flowed when the reservoir was constructed, and there is said to be but little shallow flowage except at the upper end of the reservoir, where a swampy area is flooded to a slight depth at high water. The reservoir has a water-shed of 3.24 square miles, which contains about 54 persons per square mile. There are considerable areas of swamp or meadow land on the water-shed.

Much trouble was experienced by the occurrence of bad tastes and odors in the water soon after the reservoir was built, in 1880. The analyses indicate that the water has been of somewhat less objectionable quality since 1891 than in the four years during which examinations were made previous to that time.

Analyses of samples of water from Silver Lake in Pembroke, which has been considered a possible source of supply for Brockton, may be found under "Pembroke" in this volume.

Chemical Examination of Water from Salisbury Brook at its Entrance to the Storage Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21769	Jan. 5	V slight.	V. slight.	1.00	5.35	2.30	.0012	.0232	.0216	.0016	.68	.0020	.0000	0.86	2.3
22132	Feb. 10	V. slight.	Slight.	1.00	4.60	2.00	.0010	.0246	.0230	.0016	.47	.0000	.0000	0.86	1.4
22431	Mar. 2	V. slight.	V. slight.	0.70	3.10	1.50	.0004	.0154	.0142	.0012	.41	.0000	.0000	0.59	0.5
22753	Apr. 6	V. slight.	V. slight.	0.91	3.15	1.70	.0004	.0174	.0162	.0012	.40	.0000	.0000	0.74	1.3
23066	May 4	V. slight	V. slight.	1.25	3.35	2.00	.0004	.0216	.0198	.0018	.34	.0020	.0000	0.94	0.5
23370	June 1	V. slight.	V slight.	2.30	5.20	3.25	.0008	.0422	.0388	.0034	.33	.0010	.0000	1.46	0.8
23812	July 6	Decided.	Cons.	1.70	6.35	4.10	.0052	.0656	.0566	.0090	.46	.0090	.0000	1.66	1.3
24148	Aug. 2	V. slight.	V. slight.	2.35	7.75	4.85	.0026	.0602	.0566	.0036	.34	.0020	.0000	3.24	1.3
24542	Sept. 6	V. slight.	V. slight.	2.00	8.50	4.80	.0052	.0572	.0544	.0028	.46	.0020	.0000	2.08	1.6
24924	Oct. 5	V. slight.	V. slight.	1.12	6.40	3.40	.0004	.0338	.0326	.0012	.44	.0000	.0001	1.50	1.1
25250	Nov. 2	None.	None.	1.00	5.25	2.85	.0006	.0228	.0220	.0008	.44	.0010	.0000	1.37	1.3
25547	Dec. 6	V. slight	V. slight.	0.66	4.05	1.70	.0002	.0094	.0088	.0006	.44	.0000	.0000	0.75	0.6
Av..	....	....	....	1.33	5.25	2.87	.0015	.0328	.0304	.0024	.43	.0016	.0000	1.34	1.2

Odor, generally distinctly vegetable; in February and July, musty.

BROCKTON.

Chemical Examination of Water from Salisbury Brook Storage Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
21770	Jan. 5	V. slight.	Slight.	.98	4.45	2.15	.0024	.0264	.0238	.0026	.53	.0060	.0001	0.80	1.1
22058	Feb. 3	Slight.	Slight.	.90	4.45	2.20	.0008	.0220	.0202	.0018	.50	.0000	.0000	0.77	1.6
22432	Mar. 2	V. slight.	V. slight.	.50	2.80	1.30	.0004	.0126	.0112	.0014	.35	.0010	.0000	0.47	0.5
22754	Apr. 6	Slight.	Slight.	.61	3.05	1.45	.0002	.0190	.0172	.0018	.39	.0000	.0000	0.52	1.4
23067	May 4	V. slight.	V. slight.	.70	3.40	1.30	.0006	.0206	.0172	.0034	.31	.0000	.0000	0.57	0.5
23371	June 1	Slight.	Cons.	.88	3.40	1.65	.0006	.0262	.0216	.0046	.35	.0000	.0000	0.76	0.5
23813	July 6	Decided.	Cons.	.80	3.70	2.20	.0006	.0256	.0240	.0016	.33	.0020	.0000	1.12	0.5
24149	Aug. 2	Slight.	Cons.	.62	3.30	1.90	.0006	.0266	.0232	.0034	.32	.0010	.0000	0.74	0.8
24543	Sept. 6	V. slight.	Slight.	.80	4.25	2.35	.0028	.0330	.0274	.0056	.35	.0010	.0000	1.04	0.8
24925	Oct. 5	V. slight.	Slight.	.55	3.65	2.10	.0002	.0284	.0236	.0048	.32	.0010	.0000	0.78	0.8
25251	Nov. 2	Slight.	Cons.	.70	4.05	2.15	.0010	.0266	.0236	.0030	.36	.0010	.0000	1.02	1.1
25548	Dec. 6	V. slight.	Slight.	.74	4.15	2.35	.0002	.0170	.0150	.0020	.38	.0010	.0000	0.84	0.5

Averages by Years.

-	1888	-	-	.76	3.76	1.61	.0031	.0369	-	-	.31	.0066	.0001	-	-
-	1889	-	-	.78	2.79	1.01	.0028	.0306	.0218	.0088	.30	.0048	.0002	-	-
-	1890	-	-	.75	4.07	1.98	.0016	.0274	.0219	.0055	.32	.0063	.0001	-	0.9
-	1891	-	-	.62	3.15	1.45	.0010	.0213	.0169	.0044	.28	.0061	.0001	-	0.6
-	1892	-	-	.55	3.41	1.37	.0004	.0213	.0168	.0045	.36	.0030	.0000	-	0.7
-	1893	-	-	.67	3.59	1.70	.0007	.0237	.0196	.0041	.40	.0019	.0001	0.65	0.7
-	1894	-	-	.81	3.71	1.63	.0012	.0228	.0188	.0040	.44	.0021	.0000	0.66	0.7
-	1895	-	-	.80	3.75	1.86	.0009	.0263	.0224	.0039	.43	.0018	.0000	0.74	0.9
-	1896	-	-	.64	3.59	1.55	.0007	.0224	.0186	.0038	.38	.0022	.0000	0.66	0.6
-	1897	-	-	.85	3.80	1.72	.0011	.0236	.0195	.0041	.44	.0020	.0000	0.75	0.8
-	1898	-	-	.73	3.72	1.92	.0009	.0237	.0207	.0030	.37	.0012	.0000	0.79	0.8

NOTE to analyses of 1898: Odor, generally vegetable; in February and July, musty. A fishy odor was developed in the last sample on heating. —— The samples were collected from the reservoir, near the gate-house, 1 foot beneath the surface.

BROCKTON.

Microscopical Examination of Water from Salisbury Brook Storage Reservoir.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	6	4	3	7	5	2	7	4	7	6	3	7
Number of sample,	21770	22058	22432	22754	23067	23371	23813	24149	24543	24925	25251	25547
PLANTS.												
Diatomaceæ,	228	164	1	54	129	261	3,556	4,084	1,420	4,818	1,022	12
Asterionella,	212	160	0	20	47	37	1,184	3,712	1,328	4,288	294	0
Melosira,	0	0	0	7	16	9	0	0	0	0	118	0
Synedra,	11	2	0	5	54	18	0	4	11	332	142	3
Tabellaria,	4	2	1	16	11	196	2,340	368	79	198	468	8
Cyanophyceæ, Merismopœdia,	0	0	0	0	0	0	0	12	0	4	0	0
Algæ,	3	0	0	1	3	4	16	14	4	2	46	0
ANIMALS.												
Rhizopoda,	0	0	0	0	0	0	0	2	0	0	0	0
Infusoria,	23	70	11	66	25	6	10	42	9	14	12	0
Dinobryon,	0	64	6	52	19	2	0	0	1	0	0	0
Peridinium,	23	6	5	8	2	0	10	30	5	6	8	0
Vermes,	2	3	0	4	0	1	1	2	0	4	0	0
Crustacea,	pr.	0	0	0	0	0	0	pr.	pr.	pr.	0	0
Cyclops,	0	0	0	0	0	0	0	pr.	pr.	pr.	0	0
Daphnia,	pr.	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	3	3	3	3	7	5	10	5	5	5	7	3
TOTAL,	259	240	15	128	164	277	3,593	4,161	1,438	4,847	1,087	15

Water Supply of Brookline.

The original source of supply is a filter-gallery located on the right bank of the Charles River at West Roxbury, the bottom of the gallery being about 6 feet below the level of low water in the river. The total length of the gallery is 1,142 feet, its width being from 4 to 6 feet.

Water is also taken from a system of tubular wells driven on both sides of the river in the vicinity of the pumping station. One hundred and seventy-eight wells, $2\frac{1}{2}$ inches in diameter, have been

BROOKLINE.

driven to depths of from 35 to 95 feet. The wells are driven in lines radiating from a main line which crosses the river, the total length of the lines being 6,620 feet.

Until 1893 water was pumped from the wells and the filter-gallery to an open distributing reservoir. The water as it came from the wells was colorless and odorless, but after being stored in the open reservoir large numbers of organisms appeared in the water, giving it a disagreeable taste and odor. In 1893 a new masonry reservoir was constructed, covered in such a manner as to exclude the light, and since that time the water has been entirely free from tastes and odors.

The analyses of samples of water collected from the river opposite the wells and filter-gallery may be found in the chapter on the "Examination of Rivers," in a subsequent portion of this report.

Chemical Examination of Water from a Faucet at the Low-service Pumping Station of the Brookline Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1898.												
21877	Jan. 17	None.	None.	.05	9.20	.0020	.0036	.60	.0350	.0000	.10	4.6	.0010
22211	Feb. 14	None.	None.	.04	9.60	.0010	.0036	.60	.0280	.0000	.08	5.1	.0010
22544	Mar. 14	V. slight.	None.	.07	8.00	.0012	.0044	.62	.0280	.0000	.14	3.6	.0040
22902	Apr. 18	None.	None.	.05	8.70	.0010	.0030	.55	.0330	.0000	.12	4.2	.0020
23173	May 16	V. slight.	None.	.08	8.60	.0010	.0046	.56	.0360	.0000	.12	4.0	.0030
23524	June 13	None.	None.	.09	8.20	.0014	.0052	.52	.0260	.0000	.16	4.2	.0030
23948	July 19	None.	None.	.10	8.80	.0014	.0052	.52	.0320	.0002	.17	4.4	.0070
24303	Aug. 15	V. slight.	None.	.10	8.90	.0016	.0058	.54	.0260	.0002	.15	4.4	.0050
24692	Sept. 19	None.	None.	.08	9.40	.0008	.0028	.55	.0370	.0001	.12	4.2	.0040
25050	Oct. 17	None.	None.	.06	9.30	.0012	.0036	.61	.0380	.0001	.12	4.9	.0030
25376	Nov. 14	None.	None.	.04	9.10	.0016	.0034	.57	.0360	.0001	.11	4.4	.0040
25604	Dec. 12	V. slight.	None.	.10	8.40	.0006	.0036	.54	.0300	.0001	.13	3.9	.0020
Av...	....	....	....	.07	8.85	.0012	.0041	.56	.0321	.0001	.13	4.3	.0032

Odor, none.

Water Supply of Cambridge.

The sources of supply are Fresh Pond in Cambridge and Stony Brook in Waltham and Weston. Fresh Pond, the original source of supply, is a natural pond, having an area of 165 acres and a maximum depth of 46 feet. The pond is now used principally as a receiving and storage reservoir for the water from Stony Brook, which flows to the pond by gravity.

The water of Stony Brook is taken from a storage reservoir on the stream at the boundary line between Waltham and Weston. The storage reservoir has a capacity of 354,000,000 gallons, an area of 72 acres and an average depth of 15 feet. The area of its water-shed is 22.9 square miles, exclusive of the water-shed of Sandy Pond in Lincoln, the water of which is practically all taken for the supply of the towns of Concord and Lincoln. The water-shed contains a population of about 107 persons per square mile. In 1897 two large storage reservoirs were constructed on Hobbs Brook in Waltham, one of the tributaries of Stony Brook. The upper of these reservoirs has an area of 92 acres, a maximum depth of 15 feet and a storage capacity of 240,000,000 gallons. The lower reservoir has an area of 467 acres, a maximum depth of 26 feet and a storage capacity of 1,450,000,000 gallons. Water from these reservoirs flows through the natural bed of the brook to the Stony Brook Reservoir, a distance of about 3 miles.

Chemical Examination of Water from Fresh Pond, Cambridge.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21748	Jan. 4	Slight.	Slight.	.39	7.40	2.15	.0112	.0246	.0232	.0014	.68	.0280	.0009	.45	3.6
22042	Feb. 1	Slight.	Slight.	.45	7.15	2.50	.0072	.0238	.0212	.0026	.69	.0320	.0004	.62	3.6
22389	Mar. 1	Decided.	Cons.	.44	8.15	2.05	.0006	.0212	.0190	.0022	.65	.0450	.0001	.46	3.1
22726	Apr. 5	V. slight.	V. slight.	.36	6.90	2.10	.0012	.0262	.0172	.0090	.61	.0480	.0003	.40	3.4
23042	May 3	Decided.	Cons.	.31	7.00	1.95	.0020	.0246	.0174	.0072	.66	.0450	.0002	.41	3.3
23375	June 1	Slight.	Slight.	.41	6.70	1.95	.0052	.0230	.0172	.0058	.63	.0390	.0004	.47	2.9
23787	July 1	V. slight.	Slight.	.29	6.95	2.70	.0072	.0212	.0178	.0034	.60	.0290	.0006	.40	3.3
24140	Aug. 2	Slight.	Cons.	.23	6.60	2.00	.0016	.0252	.0178	.0074	.50	.0300	.0005	.39	2.9
24547	Sept. 6	V. slight.	V. slight.	.30	6.55	2.50	.0032	.0208	.0182	.0026	.57	.0270	.0015	.50	3.0
24908	Oct. 4	Slight.	Slight.	.30	6.80	2.65	.0022	.0240	.0194	.0046	.54	.0180	.0006	.50	2.9
25234	Nov. 1	V slight.	Slight.	.36	7.10	2.05	.0236	.0222	.0188	.0034	.52	.0190	.0007	.48	3.3
25539	Dec. 5	Slight.	Cons.	.38	7.55	2.60	.0182	.0212	.0168	.0044	.61	.0240	.0014	.48	3.0
Av...	....	....	....	.35	7.07	2.27	.0069	.0232	.0187	.0045	.60	.0320	.0006	.46	3.2

Odor, generally faintly vegetable, sometimes musty, becoming stronger on heating. —— The samples were collected from the pump well at the pumping station.

CAMBRIDGE.

Microscopical Examination of Water from Fresh Pond, Cambridge.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	4	2	2	6	4	2	5	4	7	4	2	6
Number of sample,	21748	22042	22389	22726	23042	23375	23787	24140	24547	24908	25234	25539
PLANTS.												
Diatomaceæ,	692	474	30	1,070	1,418	412	408	234	34	177	391	2,840
Asterionella,	164	152	4	184	110	88	96	0	0	16	124	1,320
Cyclotella,	204	176	23	124	94	96	78	8	0	2	4	80
Fragilaria,	16	0	0	0	0	0	62	96	5	30	14	72
Melosira,	62	14	3	744	1,200	24	58	6	23	22	148	1,044
Synedra,	8	18	0	8	6	64	2	92	1	5	5	18
Tabellaria,	224	112	0	2	8	140	112	32	4	99	96	304
Cyanophyceæ,	42	8	0	0	0	0	24	76	11	71	8	0
Anabæna,	0	0	0	0	0	0	8	0	7	64	5	0
Aphanizomenon,	40	8	0	0	0	0	0	0	0	0	0	0
Cœlosphærium,	0	0	0	0	0	0	16	62	3	5	3	0
Microcystis,	0	0	0	0	0	0	0	14	0	0	0	0
Algæ,	132	154	39	24	60	182	28	38	9	7	8	16
Staurastrum,	76	108	11	12	30	144	12	4	0	1	1	2
ANIMALS.												
Infusoria,	10	8	14	14	43	38	8	14	6	5	1	3
Cryptomonas,	0	0	0	8	15	0	0	0	0	0	0	0
Mallomonas,	2	0	0	0	0	16	0	0	0	0	1	0
Trachelomonas,	4	6	14	2	26	20	8	12	1	1	0	2
Vermes,	0	0	0	2	4	0	2	0	0	0	1	0
Crustacea,	pr.	pr.	pr.	pr.	pr.	pr.	0	pr.	0	0	0	pr.
Cyclops,	pr.	pr.	pr.	pr.	pr.	pr.	0	0	0	0	0	pr.
Daphnia,	pr.	0	0	0	pr.	pr.	0	pr.	0	0	0	0
Miscellaneous, Zoöglœa,	10	10	7	10	8	3	8	5	8	5	5	5
TOTAL,	886	654	90	1,120	1,533	635	478	367	68	265	414	2,864

CAMBRIDGE.

Chemical Examination of Water from Stony Brook Storage Reservoir, Waltham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21752	Jan. 4	Slight.	V. slight.	0.56	6.45	2.30	.0022	.0172	.0156	.0016	.60	.0430	.0001	0.60	2.6
22043	Feb. 2	Slight.	V. slight.	0.60	5.50	2.45	.0026	.0190	.0176	.0014	.52	.0320	.0001	0.58	2.3
22395	Mar. 1	Slight.	V. slight.	0.59	4.50	1.65	.0022	.0212	.0202	.0010	.34	.0230	.0000	0.50	1.7
22724	Apr. 5	V. slight.	V. slight.	0.68	4.65	1.95	.0008	.0188	.0172	.0016	.46	.0280	.0002	0.36	2.2
23039	May 3	Slight.	V. slight.	0.84	4.85	1.85	.0004	.0226	.0208	.0018	.42	.0130	.0002	0.66	1.8
23339	June 1	V. slight.	Slight.	1.03	5.65	2.65	.0010	.0292	.0254	.0038	.44	.0120	.0002	0.86	2.1
23786	July 5	V. slight.	V. slight.	0.60	5.75	2.75	.0010	.0258	.0234	.0024	.50	.0120	.0003	0.66	2.0
24145	Aug. 3	Slight.	Slight.	0.50	5.45	2.20	.0018	.0254	.0196	.0058	.36	.0080	.0003	0.60	2.2
24525	Sept. 6	V. slight.	Slight.	0.97	7.15	3.55	.0016	.0396	.0356	.0040	.45	.0070	.0003	1.20	2.1
24904	Oct. 4	Slight.	Slight.	0.70	6.00	2.60	.0010	.0310	.0278	.0032	.44	.0120	.0004	0.43	2.2
25222	Nov. 1	Slight.	Slight.	0.70	6.40	2.60	.0014	.0274	.0246	.0028	.50	.0050	.0001	0.94	2.2
25531	Dec. 5	V. slight.	V. slight.	0.48	5.65	2.25	.0004	.0178	.0156	.0022	.44	.0230	.0000	0.59	2.2
Av.	....	....	....	0.69	5.67	2.40	.0014	.0246	.0220	.0026	.46	.0182	.0002	0.66	2.1

Odor, vegetable, and sometimes musty, becoming somewhat stronger on heating.——The samples were collected from the reservoir, near the surface, at the dam.

Chemical Examination of Water from Hobbs Brook, at Winter Street, Waltham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21780	Jan. 6	Decided.	Slight.	.51	9.15	2.80	.0034	.0270	.0230	.0040	.60	.0280	.0000	.58	4.0

Odor, faintly vegetable, becoming stronger on heating.

CANTON.

Water Supply of Canton.

The sources of supply are wells situated in the valley of Beaver Brook. The first well, which is located near a brook at Springdale not far from the boundary line between Canton and Stoughton, is about 40 feet in diameter. Near this well are several tubular wells which are also connected with the pumps.

The second well is located in the valley of the brook about 9,000 feet above the well at Springdale, and is connected with it by a cast-iron pipe, through which the water flows by gravity. This well is 40 feet in diameter and 23 feet deep, sunk through quicksand into a gravel stratum. Provision has been made for collecting water from the ground in the vicinity of the brook between the two wells whenever it is found necessary.

Chemical Examination of Water from the Wells of the Canton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
24579	Sept. 8	None.	None.	.00	4.50	.0000	.0002	.34	.0120	.0000	.03	1.0	.0070
25447	Nov. 21	V. slight.	V. slight.	.10	5.00	.0000	.0036	.42	.0170	.0000	.10	1.7	.0150

Odor, none. —— The first sample was collected from the well at Springdale, and the last from the well at Henry Spring.

Water Supply of Chelsea.

(See *Metropolitan Water District*, pages 133–160.)

Water Supply of Cheshire. — Cheshire Water Company.

The advice of the State Board of Health to the Cheshire Water Company, relative to a proposed additional water supply to be taken from Kitchen Brook in that town, may be found on page 9 of this volume. The results of the analyses of samples of water from Kitchen Brook, the proposed source of supply, and from the present source of supply, which is a small reservoir on Thunder Brook, a tributary of Kitchen Brook, are given in the following tables. Both sources are mountain streams, and there are very few inhabitants on their water-sheds.

CHESHIRE.

Chemical Examination of Water from the Reservoir of the Cheshire Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22007	Jan. 26	V. slight.	Slight.	.04	3.00	.0004	.0036	.08	.0130	.0000	.06	2.3	.0030
22623	Mar. 22	V. slight.	Slight.	.07	2.60	.0000	.0026	.06	.0070	.0000	.14	2.3	.0050
22689	Mar. 29	V. slight.	Slight.	.05	2.40	.0000	.0032	.04	.0180	.0000	.10	1.8	-
23285	May 24	V. slight.	Slight.	.09	2.85	.0006	.0086	.05	.0030	.0000	.14	2.1	-
24057	July 26	V. slight.	V. slight.	.08	5.35	.0006	.0056	.07	.0040	.0000	.20	3.0	-
24802	Sept. 27	None.	V. slight.	.08	5.15	.0000	.0038	.07	.0060	.0000	.07	3.3	-
25443	Nov. 21	None.	V. slight.	.05	3.15	.0000	.0032	.06	.0050	.0001	.04	2.1	-
Av.*	....	....	....	.07	3.67	.0003	.0046	.06	.0072	.0000	.10	2.5	.0040

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor, none. A faintly musty odor was developed in the July sample on heating. —— Nos. 22007 and 22623 were collected from a faucet supplied from the reservoir, and the others from the reservoir.

Chemical Examination of Water from Kitchen Brook in Cheshire.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
22688	1898. Mar. 29	V. slight.	Slight.	.05	2.90	0.55	.0000	.0024	.0022	.0002	.05	.0130	.0000	.10	2.1

Odor, none. —— The sample was collected from Kitchen Brook, just above the old dam and a little below the probable place of diversion.

Water Supply of Chester.

The source of supply is Austin Brook, a mountain stream on which a small reservoir is built. The water-shed, of about 1.25 square miles, is said to contain but one dwelling-house.

CHESTER.

Chemical Examination of Water from the Austin Brook Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
24583	1898. Sept. 8	None.	None.	.14	3.45	1.20	.0002	.0062	.0060	.0002	.11	.0020	.0001	.26	1.4

Odor, none.

Water Supply of Chicopee.

The principal sources of supply are Cooley Brook and Morton Brook, the waters of which are taken from small reservoirs near their confluence. Cooley Brook is a tributary of the Chicopee River from the north, and a large part of its course is through a ravine in a great sandy plain. It is fed largely by springs. Morton Brook is a small tributary of Cooley Brook, with a similar watershed.

Chemical Examination of Water from Cooley Brook Reservoir, Chicopee.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
21980	1898. Jan. 24	Slight.	Cons.	1.10	4.20	1.70	.0004	.0176	.0132	.0044	.13	.0070	.0000	0.82	1.0
22983	Apr. 26	Slight.	Cons.	1.30	4.20	1.95	.0008	.0156	.0134	.0022	.13	.0030	.0000	0.90	0.6
24040	July 25	Slight.	Cons.	0.35	4.05	1.45	.0038	.0172	.0078	.0094	.12	.0030	.0000	0.30	1.3
25133	Oct. 24	V. slight.	V. slight.	1.05	4.60	2.30	.0002	.0152	.0136	.0016	.12	.0020	.0000	1.08	0.8
Av.	....	....	....	0.95	4.26	1.85	.0013	.0164	.0120	.0044	.12	.0037	.0000	0.77	0.9

Odor in January and April, vegetable; in July and October, none, becoming faintly musty or earthy on heating.

CHICOPEE.

Chemical Examination of Water from Morton Brook Reservoir, Chicopee.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21981	Jan. 24	V. slight.	Cons., earthy.	0.07	3.35	0.85	.0006	.0062	.0030	.0032	.15	.0080	.0000	.14	0.8
22982	Apr. 26	Slight.	V. slight.	0.06	3.55	0.90	.0006	.0042	.0040	.0002	.16	.0180	.0000	.10	0.8
24041	July 25	V. slight.	V. slight, sandy.	0.07	3.80	1.10	.0002	.0024	.0018	.0006	.12	.0040	.0002	.07	0.6
25134	Oct. 24	None.	V. slight.	0.07	3.40	0.90	.0000	.0026	.0022	.0004	.14	.0020	.0002	.08	0.8
Av..	....	....	....	0.07	3.52	0.94	.0003	.0038	.0027	.0011	.14	.0080	.0001	.10	0.7

Odor, none.

Water Supply of Clinton and Lancaster.

Chemical Examination of Water from Faucets supplied from the Clinton Water Works.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
Average of three samples collected in January, May and September, 1898.	.14	3.50	0.98	.0007	.0089	.0081	.0008	.18	.0073	.0000	.21	1.5

Odor, none.

COHASSET.

WATER SUPPLY OF COHASSET. — COHASSET WATER COMPANY.

The advice of the State Board of Health to the Cohasset Water Company, relative to a proposed additional supply of water for that town, to be taken from tubular wells in the Ellms Meadow, situated a short distance south of the main village, may be found on pages 9 and 10 of this volume.

The original source of supply is a system of tubular wells in low ground west of the main village, which has been in use since 1886. Works for obtaining water from wells in the Ellms Meadow were constructed in the spring of 1898, and water from this source was used, in part, during the drier portion of the year, for the supply of the town. The results of analyses of samples of water collected from this source and from the system of tubular wells which is the original source of supply are given in the following tables: —

Chemical Examination of Water from the Tubular Wells of the Cohasset Water Company, situated West of the Main Village.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22045	Feb. 3	Decided.	V. slight.	.05	15.60	.0008	.0026	1.90	.0350	.0000	.02	7.6	.0080
23848	July 12	Distinct, milky.	None.	.08	13.70	.0008	.0030	1.75	.0180	.0000	.03	6.0	.0170
24197	Aug. 8	Slight, milky.	None.	.10	14.40	.0004	.0018	1.70	.0170	.0000	.02	6.1	.0380
24609	Sept. 13	Slight.	V. slight.	.07	13.20	.0006	.0026	1.81	.0280	.0000	.06	5.7	.0300
24809	Sept. 27	Slight, milky.	None.	.07	13.70	.0000	.0008	1.72	.0110	.0000	.06	5.9	.0320
25283	Nov. 7	Slight, clayey.	V. slight, clayey.	.08	15.20	.0000	.0014	1.71	.0270	.0000	.01	6.0	.0130
25556	Dec. 6	V. slight.	V. slight.	.06	13.50	.0000	.0010	1.66	.0240	.0000	.04	6.6	.0100
Av.*.	....	....	....	.07	14.31	.0004	.0019	1.75	.0234	.0000	.03	6.3	.0195

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor, none. —— The samples were collected from a faucet at the pumping station, and represent water from the original source of supply.

COHASSET.

Chemical Examination of Water from the Tubular Wells of the Cohasset Water Company in Ellms Meadow.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22746	Apr. 6	V. slight.	Slight.	.02	9.00	.0002	.0008	1.04	.0150	.0000	.02	3.6	.0040
23434	June 7	Slight.	V. slight.	.00	10.20	.0002	.0006	1.09	.0130	.0000	.05	3.6	.0050
23729	June 28	None.	None.	.02	10.80	.0002	.0006	1.34	.0460	.0000	.02	3.8	.0010
23818	July 6	None.	None.	.00	10.20	.0000	.0010	1.34	.0490	.0000	.02	3.6	.0010
23849	July 12	None.	None.	.03	9.90	.0000	.0016	1.13	.0190	.0000	.02	3.5	.0030
24049	July 26	None.	None.	.04	10.10	.0000	.0004	1.33	.0430	.0000	.02	3.8	.0010
24380	Aug. 22	None.	None.	.01	9.30	.0000	.0004	1.10	.0200	.0000	.01	3.4	.0030
24554	Sept. 7	None.	None.	.02	9.00	.0000	.0002	1.08	.0220	.0000	.02	3.1	.0110
24810	Sept. 27	None.	None.	.01	9.10	.0000	.0000	1.07	.0110	.0000	.02	3.3	.0030
24980	Oct. 11	None.	None.	.01	11.10	.0000	.0012	1.51	.0700	.0000	.02	4.2	.0040
Av.*.	....	....	....	.01	9.84	.0001	.0007	1.20	.0313	.0000	.02	3.6	.0038

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor of No. 24810, faintly musty, becoming faintly unpleasant on heating; of the others, none. —— The samples were collected from a faucet in the pumping station at Ellms Meadow, and represent the new source of supply.

Water Supply of Concord and Lincoln.

The source of supply is Sandy Pond, in Lincoln, which has an area of 150 acres and a water-shed of 0.58 of a square mile, including the area of the pond. The storage capacity of the pond is very large in comparison to the size of the water-shed, and the quantity of water drawn from it is so great that there is seldom any water flowing away from the pond through its outlet.

CONCORD AND LINCOLN.

Chemical Examination of Water from Sandy Pond, Lincoln.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21786	Jan. 10	V. slight.	Slight.	.05	2.60	1.00	.0004	.0124	.0120	.0004	.35	.0030	.0000	.14	1.1
22081	Feb. 7	V. slight.	Slight.	.08	2.65	0.90	.0004	.0104	.0086	.0018	.32	.0030	.0000	.19	1.1
22466	Mar. 7	V. slight.	Slight.	.13	2.60	1.00	.0004	.0108	.0098	.0010	.30	.0010	.0000	.22	0.8
22788	Apr. 10	V. slight.	Slight.	.09	2.25	1.00	.0000	.0064	.0052	.0012	.27	.0020	.0000	.18	1.0
23080	May 9	V. slight.	V. slight.	.08	2.75	1.05	.0004	.0104	.0100	.0004	.30	.0020	.0000	.18	0.8
23826	July 10	V. slight.	Slight.	.10	3.00	0.45	.0004	.0156	.0130	.0026	.30	.0020	.0000	.16	0.8
24588	Sept. 12	V. slight.	Slight.	.09	2.60	1.05	.0006	.0114	.0104	.0010	.26	.0010	.0000	.29	1.1
24958	Oct. 11	V. slight.	V. slight.	.10	2.55	1.15	.0000	.0108	.0096	.0012	.28	.0010	.0000	.18	0.6
25271	Nov. 7	V. slight.	V. slight.	.11	2.75	1.25	.0000	.0112	.0104	.0008	.26	.0010	.0000	.18	0.8
25532	Dec. 5	V. slight.	V. slight.	.15	2.40	1.10	.0002	.0096	.0090	.0006	.27	.0010	.0000	.19	1.0
Av...	....	....	....	.10	2.61	0.99	.0003	.0109	.0098	.0011	.29	.0017	.0000	.19	0.9

Odor, faintly vegetable or none. A faintly vegetable odor was developed in most of the samples on heating. —— The samples were collected from a faucet in the town of Concord.

Chemical Examination of Water from an Artificial Ice Pond in Concord.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
25651	Dec. 16	V. slight.	V. slight.	.60	4.40	1.65	.0008	.0162	.0148	.0014	.25	.0000	.0000	.75	1.1

Odor, none, becoming faintly unpleasant on heating. —— The sample was collected from an artificial pond formed by the construction of a small dam on a brook which crosses the road from Concord Junction to East Acton, just east of the line between the towns of Concord and Acton. The advice of the State Board of Health to Freeman W. Robbins of Acton, relative to the use of the water of this pond as a source of ice supply, may be found on pages 123 and 124 of this volume.

Water Supply of Cottage City. — Cottage City Water Company.

Water is obtained by a system of collecting pipes, which collect the water flowing from springs near the head of Lagoon Pond and convey it to a pump well from which the water is pumped for the supply of the town.

Chemical Examination of Water from the Springs of the Cottage City Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22324	Feb. 22	V. slight.	Slight.	.07	3.90	.0004	.0010	1.02	.0170	.0000	.02	0.5	.0110
22877	Apr. 18	V. slight.	V. slight.	.01	4.20	.0002	.0008	0.98	.0120	.0001	.01	0.6	.0030
23708	June 27	None.	V. slight.	.00	4.70	.0000	.0012	1.00	.0150	.0000	.02	0.5	.0030
24436	Aug. 24	None.	None.	.04	3.80	.0004	.0020	0.96	.0090	.0000	.02	0.7	.0110
25232	Nov. 1	None.	None.	.02	4.00	.0004	.0010	0.93	.0110	.0000	.04	0.5	.0030
25807	Dec. 29	V. slight.	V. slight.	.01	4.40	.0000	.0004	0.99	.0110	.0000	.02	0.6	.0080
Av...	....	....	....	.02	4.17	.0002	.0011	0.98	.0125	.0000	.02	0.6	.0065

Odor, none. —— Nos. 22877 and 25232 were collected from the spring, and the others from a faucet at the pumping station.

Water Supply of Dalton Fire District, Dalton.

The source of supply is Egypt Brook, a mountain stream, on which two small reservoirs have been built.

Chemical Examination of Water from the Reservoirs on Egypt Brook.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
24580	Sept. 7	V. slight.	V. slight.	.40	3.00	1.50	.0036	.0170	.0110	.0060	.05	0050	.0001	.56	0.5
24581	Sept. 7	V. slight.	Slight.	.41	3.25	1.75	.0010	.0162	.0124	.0038	.05	0050	.0001	.61	0.8

Odor of the first sample, distinctly musty and unpleasant, becoming also fishy on heating; of the last, none. —— The first sample was collected from the upper reservoir, and the last from the lower reservoir.

DANVERS AND MIDDLETON.

Water Supply of Danvers and Middleton.

The sources of supply are Middleton Pond, or Forest Lake, and Swan's Pond in Middleton. Middleton Pond has an area of 90 acres, a maximum depth of 33 feet and a general depth of about 25 feet. The water-shed of 1.7 square miles is generally hilly and well wooded, and contains a population of about 15 per square mile. There are about 30 acres of swamp bordering the pond. Swan's Pond, which is connected with Middleton Pond by a pipe about half a mile in length, has an area of 45 acres and a water-shed of 0.17 of a square mile. The water-shed contains no population.

Chemical Examination of Water from Middleton Pond, Middleton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21763	Jan. 5	V. slight.	V. slight.	.65	4.00	1.80	.0010	.0202	.0184	.0018	.56	.0010	.0000	.72	1.6
22046	Feb. 3	V. slight.	None.	.70	4.35	1.90	.0016	.0176	.0156	.0020	.46	.0000	.0000	.75	1.6
22403	Mar. 2	V. slight.	V. slight.	.90	4.45	1.85	.0008	.0212	.0200	.0012	.36	.0020	.0000	.41	1.7
22752	Apr. 6	V. slight.	V. slight.	.71	3.95	1.70	.0010	.0216	.0194	.0022	.45	.0000	.0000	.77	1.1
23074	May 5	V. slight.	V. slight.	.90	3.95	2.00	.0010	.0218	.0208	.0010	.41	.0000	.0000	.80	1.1
23416	June 7	None.	V. slight.	.90	4.25	2.35	.0006	.0210	.0206	.0004	.38	.0020	.0000	.83	1.0
23810	July 6	Slight.	Slight.	.70	3.75	2.20	.0004	.0250	.0224	.0026	.32	.0060	.0000	.82	0.8
24535	Sept. 6	V. slight.	Slight.	.69	4.20	2.40	.0014	.0334	.0268	.0066	.35	.0010	.0000	.98	1.1
24919	Oct. 5	Slight.	Slight.	.68	3.90	2.40	.0008	.0308	.0234	.0074	.32	.0020	.0000	.88	1.1
25245	Nov. 2	None.	None.	.71	4.60	2.20	.0006	.0206	.0190	.0016	.33	.0010	.0000	.94	1.3
25545	Dec. 6	V. slight.	V. slight.	.75	4.00	2.20	.0020	.0186	.0170	.0016	.34	.0010	.0000	.99	1.0
Av...	....	....	....	.75	4.13	2.09	.0010	.0229	.0203	.0026	.39	.0015	.0000	.81	1.2

Odor of Nos. 21763 and 25245, none; of the others, faintly vegetable or musty, becoming generally stronger on heating.—— Nos. 22752, 23074, 23810 and 24535 were collected from the pond; the others, from a faucet at the pumping station.

Water Supply of Dedham. — Dedham Water Company.

The source of supply is a covered well about 26 feet in diameter and 18 feet deep, located about 40 feet from the southerly bank of Charles River, near the thickly settled portion of the town.

DEDHAM.

Chemical Examination of Water from the Well of the Dedham Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21762	Jan. 5	None.	None.	.00	9.40	.0008	.0024	.88	.2400	.0000	.03	4.4	.0010
22192	Feb. 14	V. slight.	None.	.04	9.50	.0000	.0022	.87	.2200	.0000	.06	4.2	.0020
22400	Mar. 2	None.	None.	.01	8.50	.0010	.0022	.80	.1640	.0000	.06	3.6	.0010
22743	Apr. 6	None.	None.	.04	9.30	.0010	.0022	.86	.2100	.0000	.05	3.9	.0020
23072	May 5	None.	V. slight.	.05	9.60	.0010	.0068	.91	.2120	.0000	.06	4.2	.0020
23396	June 6	None.	None.	.03	10.50	.0004	.0016	.80	.1940	.0000	.06	3.8	.0020
23797	July 6	None.	None.	.03	9.70	.0010	.0076	.85	.1540	.0000	.05	3.8	.0010
24156	Aug. 4	V. slight.	None.	.04	8.90	.0006	.0058	.67	.1200	.0000	.07	3.3	.0000
24532	Sept. 6	None.	V. slight.	.01	10.60	.0008	.0010	.80	.1640	.0000	.06	3.6	.0060
24921	Oct. 5	None.	None.	.00	10.10	.0000	.0010	.90	.2400	.0000	.03	4.0	.0050
25235	Nov. 2	None.	None.	.00	8.70	.0000	.0038	.77	.1880	.0000	.09	3.8	.0010
25541	Dec. 6	None.	None.	.03	9.00	.0000	.0036	.75	.1680	.0000	.04	3.8	.0010
Av...	....	....	....	.02	9.48	.0005	.0033	.82	.1895	.0000	.05	3.9	.0020

Odor, none.—— Nos. 21762, 22192, 22400, 22743 and 23396 were collected from a faucet at the pumping station; the others, from the well.

Water Supply of East Bridgewater.

(See *Bridgewater.*)

Water Supply of Easthampton.

Chemical Examination of Water from Bassett Brook, Easthampton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
24566	Sept. 7	Slight.	Slight.	.23	4.30	1.45	.0028	.0098	.0084	.0014	.11	.0030	.0000	.29	1.6

Odor, none, becoming faintly unpleasant on heating. —— Bassett Brook drains an area of 6.9 square miles, which contains a small population.

EASTON.

Water Supply of North Easton Village District, Easton.

Chemical Examination of Water from the Well of the North Easton Village District.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22207	Feb. 14	None.	None.	.00	4.70	.0000	.0014	.61	.0600	.0000	.01	1.7	.0010
22809	Apr. 11	None.	None.	.03	3.90	.0000	.0012	.48	.0430	.0000	.02	1.3	.0030
23667	June 22	None.	None.	.01	3.90	.0004	.0012	.48	.0250	.0000	.02	1.7	.0010
24424	Aug. 24	None.	None.	.00	4.40	.0000	.0014	.45	.0260	.0000	.05	1.8	.0030
25171	Oct. 25	None.	V. slight.	.00	5.50	.0000	.0016	.48	.0220	.0000	.06	2.2	.0020
25602	Dec. 12	None.	None.	.01	4.00	.0000	.0010	.42	.0360	.0000	.01	1.4	.0010
Av...	....	....	....	.01	4.40	.0001	.0013	.49	.0353	.0000	.03	1.7	.0018

Odor, none. —— No. 22809 was collected from the well; the others, from a faucet at the pumping station.

Enfield.

The advice of the State Board of Health to the town of Enfield, relative to taking certain springs in that town as sources of water supply, may be found on pages 10 and 11 of this volume. During the investigations which were made by the Board analyses were made of samples of water from various sources in the town, the results of which are given in the following table: —

Chemical Examination of Water from Various Sources in the Town of Enfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
22640	Mar. 25	None.	V. slight.	.05	1.75	0.25	.0000	.0036	.0024	.0012	.06	.0050	.0000	.09	0.8
22641	Mar. 25	V. slight.	Cons., earthy.	.06	2.35	0.35	.0002	.0040	.0026	.0014	.12	.0040	.0000	.09	0.5
22642	Mar. 25	None.	Slight, sandy.	.05	3.00	–	.0002	.0036	–	–	.16	.0070	.0000	.07	0.8
22643	Mar. 25	None.	Slight, sandy.	.05	2.70	–	.0002	.0044	–	–	.14	.0040	.0000	.08	0.8
22644	Mar. 25	None.	V. slight, sandy.	.01	2.50	–	.0000	.0010	–	–	.09	.0090	.0000	.02	0.5
22682	Mar. 29	V. slight.	Slight, sandy.	.02	3.20	–	.0000	.0014	–	–	.09	.0060	.0000	.02	0.8

Odor, none. —— The first sample was collected from a brook on the northerly slope of Quabin Hill; the second, from Thurston Brook, about thirty feet above Greenwich Road; the third, from Wood's Spring, about three-quarters of a mile north of the village of Enfield; the fourth, from a spring flowing from Hunt's pasture, just west of Wood's Spring; the fifth, from a spring in the south-west corner of Shearer's pasture, about half a mile north of the village; the last, from a small reservoir fed by springs, situated about half a mile north of the village and just below Shearer Spring. Water from this reservoir is used for the supply of several houses and a drinking fountain in the village.

Water Supply of Everett.

(See *Metropolitan Water District*, pages 133-160.)

Water Supply of Fairhaven. — Fairhaven Water Company.

A communication from the State Board of Health to the board of health of Fairhaven, with regard to the action of the water supplied by the Fairhaven Water Company on lead pipes used as service pipes in connection with the public water supply, may be found on pages 11 and 12 of this volume.

The public water supply is drawn from a system of tubular wells, having an average depth of about 35 feet, located in the valley of the Nasketucket River. The wells are located on both sides and in the bed of the river, which is a small and shallow stream, and cover an area of approximately 300 feet in length in a northerly and southerly direction by about 130 feet in width.

Chemical Examination of Water from the Tubular Wells of the Fairhaven Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22226	Feb. 15	V. slight.	None.	.08	5.20	.0000	.0030	.96	.0380	.0000	.08	1.6	.0080
22908	Apr. 20	None.	None.	.16	4.60	.0000	.0026	.87	.0370	.0001	.15	2.0	.0150
23677	June 24	None.	None.	.11	5.90	.0004	.0040	.81	.0370	.0000	.18	1.7	.0010
24337	Aug. 16	V. slight.	None.	.17	5.20	.0000	.0054	.84	.0270	.0001	.22	1.6	.0100
25030	Oct. 15	None.	None.	.37	5.80	.0008	.0088	.83	.0240	.0003	.49	2.0	.0140
25783	Dec. 27	None.	None.	.07	5.30	.0000	.0014	.70	.0540	.0001	.08	1.6	.0050
Av...	....	....	....	.16	5.33	.0002	.0042	.83	.0362	.0001	.20	1.7	.0088

Odor in October, faintly earthy; at other times, none. —— The samples were collected from a faucet at the pumping station.

FALL RIVER.

Water Supply of Fall River.

The source of supply is North Watuppa Lake in Fall River. This lake has an area, when full, of about 2.8 square miles, and a water-shed of 11.17 square miles, which contains a considerable population. The water flowing out of North Watuppa Lake passes into the South Watuppa Lake, which is not used as a source of public water supply.

Chemical Examination of Water from North Watuppa Lake.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21900	Jan. 18	V. slight.	V. slight.	.30	3.85	1.40	.0006	.0182	.0176	.0006	.73	.0030	.0001	.44	0.8
22199	Feb. 14	None.	None.	.34	3.65	1.20	.0002	.0196	.0160	.0036	.76	.0050	.0000	.42	1.1
22537	Mar. 14	Slight.	Cons.	.40	3.65	1.65	.0004	.0200	.0174	.0026	.56	.0030	.0000	.40	1.3
22872	Apr. 18	V. slight.	Cons.	.31	3.20	1.25	.0024	.0186	.0152	.0034	.60	.0000	.0000	.43	0.6
23162	May 16	Slight.	Cons.	.39	3.05	1.65	.0030	.0186	.0162	.0024	.61	.0030	.0001	.44	0.8
23509	June 13	Slight.	Slight.	.48	3.70	1.50	.0012	.0210	.0192	.0018	.60	.0040	.0001	.48	0.8
23976	July 20	Slight.	Cons.	.26	3.25	1.20	.0016	.0184	.0160	.0024	.49	.0020	.0001	.42	0.5
24292	Aug. 15	Slight.	Cons.	.26	3.35	1.45	.0004	.0208	.0192	.0016	.52	.0010	.0000	.40	0.5
24673	Sept. 19	Slight.	Slight.	.22	3.30	1.35	.0008	.0242	.0196	.0046	.53	.0010	.0000	.43	0.8
25044	Oct. 17	V. slight.	V. slight.	.20	3.65	1.90	.0028	.0196	.0176	.0020	.53	.0010	.0000	.43	0.8
25364	Nov. 14	V. slight.	V. slight.	.28	3.30	1.30	.0002	.0186	.0172	.0014	.53	.0020	.0000	.46	0.6
25592	Dec. 12	Decided.	Cons.	.39	3.70	1.35	.0002	.0152	.0118	.0034	.52	.0050	.0000	.50	1.0
25806	Dec. 30	V. slight.	V. slight.	.29	3.10	1.45	.0002	.0162	.0156	.0006	.54	.0020	.0000	.46	0.6
Av.*	....	....	....	.31	3.45	1.44	.0011	.0194	.0171	.0023	.58	.0024	.0000	.44	0.8

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor, faintly vegetable or none. A vegetable odor was developed in most of the samples on heating. —— The samples were collected from the lake.

FALL RIVER.

Microscopical Examination of Water from North Watuppa Lake.

[Number of organisms per cubic centimeter.]

	1898.												1899.
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Day of examination, . .	20	15	15	20	17	14	21	16	20	18	15	13	2
Number of sample, . .	21900	22199	22537	22872	23162	23509	23976	24292	24673	25044	25364	25592	25806
PLANTS.													
Diatomaceæ, . .	142	25	230	222	132	35	0	7	5	1	17	23	104
Asterionella, . .	0	2	2	56	0	0	0	2	0	0	0	0	2
Cyclotella, . . .	92	8	164	96	124	34	0	0	0	0	10	11	87
Tabellaria, . . .	22	3	57	22	1	0	0	0	0	0	1	3	6
Cyanophyceæ, . .	0	0	0	0	0	0	11	11	8	4	0	0	0
Anabæna, . . .	0	0	0	0	0	0	10	0	5	3	0	0	0
Merismopœdia, . .	0	0	0	0	0	0	0	11	0	0	0	0	0
Algæ, ...	12	11	27	20	39	6	19	61	13	0	0	1	0
Botrycoccus, . .	0	0	0	0	0	0	0	50	0	0	0	0	0
ANIMALS.													
Infusoria, . . .	2	0	754	40	1	1	4	0	1	1	0	0	0
Dinobryon, . . .	0	0	752	36	1	0	0	0	1	0	0	0	0
Vermes, ...	0	0	1	0	0	0	0	0	0	0	0	0	0
Crustacea, Cyclops, .	0	0	0	pr.	0	0	0	0	0	0	0	pr.	0
Miscellaneous, Zoöglœa, .	3	3	5	5	3	5	0	5	5	5	8	5	3
TOTAL, ...	159	39	1,016	287	175	47	34	84	32	11	25	29	107

Chemical Examination of Water from South Watuppa Lake.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21901	Jan. 18	V. slight	V. slight.	.42	6.15	1.85	.0004	.0236	.0212	.0024	.92	.0020	.0003	.51	1.8
22200	Feb. 14	None.	None.	.41	5.50	1.75	.0006	.0244	.0222	.0022	.87	.0070	.0002	.50	2.0
22538	Mar. 14	Slight.	Cons.	.40	3.75	1.65	.0002	.0208	.0178	.0030	.65	.0030	.0000	.43	1.0
22873	Apr. 18	Slight.	Cons.	.38	3.35	1.20	.0016	.0180	.0158	.0022	.66	.0030	.0001	.43	1.0
23163	May 16	Slight.	Slight.	.43	3.75	1.50	.0020	.0184	.0170	.0014	.67	.0020	.0001	.45	1.0
23510	June 13	Slight.	Slight.	.48	3.60	1.70	.0010	.0222	.0206	.0016	.61	.0040	.0002	.45	0.6
23920	July 18	Slight.	Slight.	.31	4.50	1.45	.0008	.0244	.0206	.0038	.71	.0020	.0001	.45	1.1
24293	Aug. 15	Distinct.	Cons.	.28	4.40	1.70	.0032	.0294	.0222	.0072	.73	.0010	.0001	.40	0.8
24674	Sept. 19	Slight.	Slight.	.22	3.30	1.20	.0010	.0220	.0192	.0028	.59	.0000	.0000	.42	0.8
25045	Oct. 17	V. slight.	V. slight.	.22	3.65	1.55	.0006	.0188	.0174	.0014	.64	.0010	.0001	.43	0.8
25365	Nov. 14	Slight.	Slight.	.31	3.70	1.20	.0006	.0190	.0184	.0006	.58	.0020	.0000	.46	0.6
25593	Dec. 12	Decided.	Cons.	.33	3.90	1.75	.0002	.0148	.0118	.0030	.53	.0070	.0000	.48	0.6
Av...	....	....	....	.35	4.13	1.54	.0010	.0213	.0187	.0026	.68	.0028	.0001	.45	1.0

Odor, faintly vegetable or none. A vegetable odor was developed in most of the samples on heating. —— The samples were collected from the lake.

FALL RIVER.

Microscopical Examination of Water from South Watuppa Lake.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	20	15	15	20	17	14	19	16	20	18	15	13
Number of sample,	21901	22200	22538	22873	23163	23510	23920	24293	24674	25045	25365	25593
PLANTS.												
Diatomaceæ,	174	158	185	222	132	24	12	0	8	3	14	29
Asterionella,	98	117	7	70	1	0	6	0	0	0	0	0
Cyclotella,	50	28	108	110	120	17	1	0	0	0	4	16
Tabellaria,	12	8	57	4	0	1	0	0	0	0	0	1
Cyanophyceæ,	0	0	0	0	0	12	16	28	7	0	0	1
Anabæna,	0	0	0	0	0	0	14	0	0	0	0	1
Merismopœdia,	0	0	0	0	0	12	0	26	0	0	0	0
Algæ,	2	0	31	10	1	8	28	30	3	0	6	0
ANIMALS.												
Rhizopoda,	0	0	1	0	0	0	0	0	0	0	0	0
Infusoria,	6	37	228	10	0	1	0	0	1	0	0	0
Dinobryon,	6	36	228	10	0	0	0	0	1	0	0	0
Vermes,	0	0	2	0	0	0	0	0	0	0	0	0
Crustacea, Cyclops,	0	0	pr.	pr.	0	0	0	0	0	0	0	pr.
Miscellaneous, Zoöglœa,	3	5	15	3	5	3	3	15	5	5	8	5
TOTAL,	185	200	462	245	138	48	59	73	24	8	28	35

WATER SUPPLY OF FITCHBURG.

The sources of supply are storage reservoirs upon Scott and Falulah brooks in Fitchburg, and Meetinghouse Pond in Westminster. The reservoir on Scott Brook has an area of 35 acres, a maximum depth of 40 feet and a capacity of 210,000,000 gallons. Its drainage area of 0.77 of a square mile contains a population of about 55 per square mile.

Falulah Reservoir, which is of small capacity, is situated a short distance below Scott Reservoir, at the junction of Scott and Falulah brooks. It has a water-shed of 3.05 square miles, exclusive of the drainage area of Scott Reservoir, which is tributary to it, and this area contains 30 persons per square mile.

FITCHBURG.

Meetinghouse Pond is situated in the town of Westminster, about 6.5 miles south-west of the city. The area of the pond is 152 acres, and its water-shed of 1.47 square miles contains about 95 persons per square mile.

Chemical Examination of Water from Scott Reservoir, Fitchburg.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21922	Jan. 19	Slight.	Cons.	.21	2.75	1.00	.0018	.0194	.0140	.0054	.22	.0030	.0001	.33	0.8
22932	Apr. 20	V. slight.	Slight.	.12	2.00	0.90	.0024	.0146	.0128	.0018	.15	.0000	.0000	.23	0.2
23964	July 19	Slight	Slight.	.20	2.15	1.00	.0006	.0192	.0168	.0024	.10	.0010	.0000	.36	0.0
25059	Oct. 18	V. slight.	V. slight.	.21	2.15	0.95	.0000	.0194	.0148	.0046	.15	.0010	.0000	.36	0.8
Av...	....	....	....	.18	2.26	0.96	.0012	.0181	.0146	.0035	.15	.0012	.0000	.32	0.4

Odor of No. 23964, distinctly musty and unpleasant; of the others, none, becoming vegetable on heating.

Microscopical Examination of Water from Scott Reservoir, Fitchburg.

[Number of organisms per cubic centimeter.]

	1898. January.	1898. April.	1898. July.	1898. October.
Day of examination,	20	22	21	19
Number of sample,	21922	22932	23964	25059
PLANTS.				
Diatomaceæ,	276	156	347	1,466
Asterionella,	20	23	153	380
Melosira,	0	41	0	228
Synedra,	192	92	177	788
Tabellaria,	64	0	15	70
Cyanophyceæ,	0	0	1	0
Algæ,	16	3	10	26
ANIMALS.				
Infusoria,	4	69	418	58
Dinobryon,	0	56	412	0
Euglena,	2	11	0	0
Peridinium,	2	0	6	56
Vermes,	4	1	5	3
Crustacea, Cyclops,	0	0	0	pr.
Miscellaneous, Zoöglœa,	10	5	3	12
TOTAL,	310	234	784	1,565

FITCHBURG.

Chemical Examination of Water from Meetinghouse Pond, Westminster.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21921	Jan. 19	V. slight.	Slight.	.11	2.70	1.50	.0014	.0144	.0122	.0022	.24	.0030	.0001	.26	0.8
22933	Apr. 20	V slight.	Slight.	.10	2.35	1.00	.0008	.0108	.0092	.0016	.20	.0030	.0000	.26	0.5
23965	July 19	Slight.	Slight.	.11	2.20	1.30	.0004	.0164	.0152	.0012	.15	.0020	.0000	.28	0.3
25058	Oct. 18	Slight.	V. slight.	.12	2.50	1.25	.0000	.0192	.0138	.0054	.15	.0010	.0000	.37	0.8
Av. . .	. . . .	. . . .	. . . .	.11	2.44	1.26	.0006	.0152	.0126	.0026	.18	.0025	.0000	.29	0.6

Odor of the first two samples, none; of the last two, none, becoming vegetable on heating.

Microscopical Examination.

In the sample examined in January, 264 *Dinobryon* per cubic centimeter were found. An insignificant number of organisms was found in the remaining samples.

WATER SUPPLY OF FOXBOROUGH WATER SUPPLY DISTRICT, FOXBOROUGH.

The source of supply is a system of 24 two-inch tubular wells, in the vicinity of the Neponset Reservoir. The wells are sunk in porous gravel to a depth of from 23 to 50 feet. There is no population in the immediate vicinity of the wells.

Chemical Examination of Water from the Tubular Wells of the Foxborough Water Supply District.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22047	Feb. 2	None.	V. slight.	.00	3.90	.0002	.0010	.41	.0380	.0000	.02	1.0	.0000
22761	Apr. 5	None.	None.	.00	3.20	.0000	.0010	.39	.0460	.0000	.01	1.0	.0040
23354	June 1	None.	None.	.00	3.50	.0000	.0006	.40	.0450	.0000	.01	1.0	.0010
24182	Aug. 8	None.	None.	.00	3.60	.0000	.0006	.40	.0460	.0000	.01	1.0	.0000
24887	Oct. 3	V slight.	None.	.02	4.20	.0000	.0004	.40	.0460	.0000	.04	1.0	.0060
25551	Dec. 6	None.	None.	.00	4.70	.0000	.0000	.40	.0540	.0000	.01	0.8	.0060
Av. . .	. . . .	. . . .	. . . .	.00	3.85	.0000	.0006	.40	.0458	.0000	.02	1.0	.0028

Odor, none. —— The samples were collected from a faucet at the pumping station.

FRAMINGHAM.

Water Supply of Framingham. — Framingham Water Company.

The source of supply is a filter-gallery on the shore of Farm Pond in South Framingham. The filter-gallery is 450 feet long, 4 feet high and from 42 to 48 inches wide, the bottom being about 6 feet below the surface of the water in the pond. A part of the gallery extends beneath the edge of the pond, and at some places there are but 2 feet of sand between the top of the arch of the filter-gallery and the bottom of the pond above it. The arch, however, is water-tight, and water from the pond cannot enter the filter-gallery without passing through at least 5 feet of sand.

Chemical Examination of Water from the Filter-gallery of the Framingham Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21756	Jan. 4	Slight.	Slight.	.03	7.80	.0042	.0052	0.97	.0410	.0001	.06	3.9	.0060
22480	Mar. 7	V. slight.	V. slight.	.02	6.90	.0068	.0086	0.81	.0280	.0000	.18	3.1	.0070
23098	May 9	None.	None.	.04	7.00	.0020	.0024	0.88	.0420	.0002	.05	3.3	.0040
23847	July 11	None.	V. slight.	.09	7.15	.0008	.0096	0.93	.0160	.0001	.07	3.0	.0040
24608	Sept. 12	V. slight.	V. slight.	.05	6.70	.0018	.0092	0.92	.0140	.0000	.14	3.1	.0190
25284	Nov. 7	None.	V. slight.	.05	9.20	.0026	.0040	0.90	.0410	.0001	.05	3.1	.0140

Averages by Years.

-	1888	-	-	.10	5.81	.0027	.0081	0.44	.0308	.0004	-	-	-
-	1889	-	-	.00	6.18	.0031	.0050	0.56	.0366	.0002	-	-	-
-	1890	-	-	.00	7.09	.0020	.0039	0.65	.0631	.0001	-	3.0	-
-	1891	-	-	.00	6.25	.0023	.0035	0.63	.0707	.0001	-	2.8	-
-	1893	-	-	.04	6.07	.0026	.0033	0.62	.0460	.0001	.11	2.6	.0099
-	1894	-	-	.03	6.75	.0025	.0043	0.79	.0515	.0001	.08	2.8	.0272
-	1895	-	-	.04	7.32	.0020	.0049	0.92	.0230	.0000	.07	3.0	.0130
-	1896	-	-	.04	7.37	.0022	.0040	0.91	.0317	.0002	.04	3.2	.0145
-	1897	-	-	.04	7.00	.0021	.0076	1.00	.0245	.0001	.06	3.3	.0072
-	1898	-	-	.05	7.46	.0030	.0065	0.90	.0303	.0001	.09	3.2	.0090

Note to analyses of 1898: Odor, none.

FRANKLIN.

WATER SUPPLY OF FRANKLIN. — FRANKLIN WATER COMPANY.

The sources of supply are two large wells and Beaver Pond. The wells are about 15 feet apart, and are located about 150 feet from Mine Brook, on the northerly side of the village of Franklin. When the wells do not furnish a sufficient supply, water is drawn from Beaver Pond, which has an area of about 33 acres and a water-shed of about 0.44 of a square mile, including the area of the pond. The population on the water-shed is very small. There is much swampy land about the pond, and the water is highly colored by vegetable matter.

Chemical Examination of Water from the Wells of the Franklin Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22073	Feb. 5	V. slight.	V. slight.	.46	6.50	.0016	.0094	.86	.1100	.0000	.42	3.1	-
22731	Apr. 5	V. slight.	V. slight.	.05	8.80	.0010	.0024	.90	.2800	.0000	.09	3.6	.0060
23389	June 3	None.	V. slight.	.10	9.50	.0002	.0036	.85	.2960	.0000	.14	3.5	.0060
24130	Aug. 2	Slight.	Slight.	.20	9.00	.0014	.0088	.69	.0350	.0001	.28	2.9	.0200
24977	Oct. 11	V. slight.	V. slight.	.07	8.70	.0000	.0030	.86	.1400	.0000	.11	3.4	.0180
25544	Dec. 6	V. slight.	V. slight.	.12	8.70	.0000	.0010	.86	.3200	.0000	.07	3.8	.0090
Av...	....	....	....	.17	8.53	.0007	.0047	.84	.1968	.0000	.18	3.4	.0098

Odor, none. A faintly unpleasant odor was developed in No. 24130 when heated. —— The first sample was collected from a faucet at the pumping station; the other samples, from the well.

Water Supply of Gardner. — Gardner Water Company.

The source of supply is Crystal Lake in the town of Gardner. The area of the lake is 154 acres, and its maximum depth is about 40 feet. Its drainage area of 0.94 of a square mile contains a population of about 490 persons per square mile.

Chemical Examination of Water from Crystal Lake, Gardner.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
22467	Mar. 7	V. slight.	V. slight.	.07	3.75	1.20	.0030	.0138	.0124	.0014	.40	.0110	.0000	.25	1.1
23413	June 6	V. slight.	V. slight.	.08	3.70	1.65	.0020	.0192	.0166	.0026	.37	.0150	.0001	.24	1.0
24695	Sept. 20	V. slight.	V. slight.	.09	3.10	1.25	.0004	.0190	.0160	.0030	.37	.0010	.0000	.22	1.3
25554	Dec. 6	V. slight.	V. slight.	.10	3.30	1.15	.0004	.0090	.0084	.0006	.35	.0060	.0000	.22	1.4
Av.	....	....	....	.08	3.46	1.31	.0014	.0152	.0133	.0019	.37	.0082	.0000	.23	1.2

Odor, none. On heating, an odor was developed in three of the samples, the odor in December being distinctly fishy. —— The first sample was collected from a faucet in the town; the others, from the lake.

Water Supply of Gloucester.

The sources of supply are Dike's Brook Reservoir and Wallace Pond in West Gloucester. Dike's Brook Reservoir was formed by flooding meadows, from which the soil was not removed. The area of this reservoir is 57.6 acres, its average depth 12.5 feet and its storage capacity 235,000,000 gallons. The reservoir has a water-shed of 0.68 of a square mile, which is uninhabited.

Wallace Pond is an artificial storage reservoir, covering an area of 24 acres, from which the soil was not removed. The pond has an average depth of 8 feet and a capacity of 63,000,000 gallons. Its water-shed of 0.29 of a square mile contains a small area of swamp, but is uninhabited.

GLOUCESTER.

Chemical Examination of Water from Dike's Brook Storage Reservoir, Gloucester.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
22680	Mar. 29	V.slight.	V.slight.	.40	3.05	1.50	.0002	.0168	.0148	.0020	.87	.0080	.0000	.35	0.3
23721	June 28	Slight.	Slight.	.21	4.05	1.60	.0006	.0176	.0128	.0048	.84	.0010	.0000	.33	0.3
24843	Sept. 28	Slight.	Cons.	.40	3.95	1.55	.0002	.0236	.0160	.0076	.73	.0020	.0001	.48	0.6
25681	Dec. 19	V.slight.	V.slight.	.42	4.00	1.35	.0060	.0150	.0138	.0012	.91	.0040	.0001	.50	0.5
Av...	....	....	....	.36	3.76	1.50	.0018	.0182	.0143	.0039	.84	.0037	.0000	.41	0.4

Odor of the first two samples, faintly musty; of the last two, faintly vegetable.

Microscopical Examination.

The number of organisms per cubic centimeter found in the sample collected in September was 1,322, consisting chiefly of the organism *Synedra*. An insignificant number of organisms was found in the remaining samples.

Chemical Examination of Water from Wallace Pond, Gloucester.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
22679	Mar. 29	Slight.	Slight.	.40	3.90	1.50	.0006	.0224	.0138	.0086	1.01	.0070	.0000	.42	0.5
23722	June 28	Decided.	Cons.	.39	4.30	1.60	.0004	.0254	.0206	.0048	1.02	.0010	.0000	.54	0.6
24844	Sept. 28	Slight.	Cons.	.55	4.55	1.80	.0006	.0276	.0228	.0048	0.93	.0010	.0000	.58	0.5
25682	Dec. 19	V.slight.	V.slight.	.45	4.75	2.00	.0000	.0244	.0180	.0064	1.18	.0010	.0000	.52	0.8
Av...	....	....	....	.45	4.37	1.72	.0004	.0249	.0188	.0061	1.03	.0025	.0000	.51	0.6

Odor of the first two samples, distinctly musty, becoming also fishy on heating; of the third, faintly vegetable, becoming distinctly vegetable on heating; of the last, none, becoming faintly vegetable and disagreeable on heating.

Microscopical Examination.

The number of organisms per cubic centimeter found in the June sample was 784, and in the September sample, 1022, consisting chiefly of the organism *Synedra*. An insignificant number of organisms was found in the remaining samples.

GRAFTON.

Water Supply of Grafton. — Grafton Water Company.

Chemical Examination of Water from the Filter-gallery of the Grafton Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
24471	1898. Aug. 29	V. slight.	V. slight.	.04	11.30	.0004	.0030	1.40	.1860	.0002	.05	3.6	.0140

Odor, none. —— The sample was collected from a faucet at the office of the water company.

Water Supply of Greenfield.

The source of supply is Glen Brook in Leyden, on which a storage reservoir has been built. The reservoir has an area of 5.26 acres, a maximum depth of 32 feet and a capacity of 18,000,000 gallons. The drainage area of the reservoir is 5.36 square miles, consisting principally of mountainous country and contains a population of 54 persons per square mile. The supply from Glen Brook Reservoir is supplemented at times by pumping directly from Green River, the water-shed of which contains a small population.

During the year 1898 four samples of water were collected from faucets in the town which were supplied with water from the Glen Brook Reservoir, the average of these analyses being as follows: —

Chemical Examination of Water from Glen Brook Storage Reservoir in Leyden.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
Average of four samples collected in March, June, September and December, 1898.	.07	4.91	0.97	.0008	.0054	.0047	.0007	.10	.0102	.0000	.10	2.8

Odor, none.

GROTON.

Water Supply of Groton. — Groton Water Company.

The Groton Water Company applied to the State Board of Health Dec. 30, 1897, for the approval by the Board, under the provisions of chapter 388 of the Acts of 1895, of the taking of certain sources of water supply and lands in that town. The reply of the Board to this application may be found on pages 12 and 13 of this volume.

The source of supply is a covered masonry well, located about 50 feet from the south-westerly shore of Baddacook Pond in Groton. The bottom of the well is 10 feet below the ordinary water level in Baddacook Pond. The works were constructed in 1897, and beginning with January, 1898, analyses have been made of samples collected from the pond and well each month.

Chemical Examination of Water from the Well of the Groton Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21783	Jan. 6	None.	V. slight.	.02	3.80	.0010	.0018	.20	.0070	.0001	.01	2.9	.0050
22160	Feb. 10	V. slight.	None.	.02	2.00	.0004	.0028	.18	.0080	.0000	.02	2.0	.0030
22379	Feb. 28	Slight, milky.	V. slight	.07	4.40	.0006	.0018	.20	.0070	.0001	.02	2.3	.0120
22783	Apr. 8	None.	None.	.00	3.80	.0000	.0006	.17	.0050	.0000	.02	2.2	.0030
23195	May 17	None.	None.	.04	4.00	.0004	.0012	.23	.0070	.0001	.02	2.0	.0020
23681	June 23	None.	None.	.04	4.00	.0000	.0012	.21	.0070	.0000	.01	2.0	.0010
23821	July 6	V. slight.	None.	.02	3.70	.0004	.0010	.22	.0070	.0000	.02	2.0	.0050
24576	Sept. 7	None.	None.	.01	4.10	.0000	.0002	.18	.0090	.0000	.02	2.0	.0110
24938	Oct. 7	V. slight.	None.	.07	4.00	.0000	.0020	.19	.0090	.0001	.01	2.0	.0140
25291	Nov. 7	V. slight.	None.	.08	5.50	.0000	.0008	.18	.0040	.0000	.05	2.1	.0180
25587	Dec. 9	None.	None.	.01	4.50	.0006	.0006	.17	.0140	.0000	.01	2.2	.0010
Av...	....	....	....	.03	3.98	.0003	.0013	.19	.0076	.0000	.02	2.2	.0068

Odor, none. —— The samples were collected from a faucet at the pumping station.

GROTON.

Chemical Examination of Water from Baddacook Pond, Groton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21782	Jan. 6	Slight.	Slight.	.56	6.45	2.50	.0022	.0312	.0278	.0034	.26	.0070	.0001	.69	2.7
22159	Feb. 10	Decided.	Cons.	.60	5.45	1.85	.0044	.0334	.0312	.0022	.26	.0080	.0003	.66	2.5
22378	Feb. 28	V. slight.	V. slight.	.50	4.80	1.60	.0006	.0180	.0148	.0032	.17	.0070	.0002	.52	2.5
22782	Apr. 8	Slight.	Slight.	.76	5.45	2.15	.0002	.0160	.0132	.0028	.19	.0120	.0000	.66	2.3
23194	May 17	V. slight.	V. slight.	.76	5.75	2.10	.0010	.0228	.0208	.0020	.22	.0120	.0001	.73	2.2
23680	June 23	V. slight.	Slight.	.49	5.50	2.05	.0022	.0242	.0204	.0038	.20	.0020	.0001	.62	2.3
23820	July 6	Slight.	Slight.	.45	5.40	2.20	.0012	.0274	.0246	.0028	.22	.0010	.0000	.63	2.2
24575	Sept. 7	V. slight.	Slight.	.41	5.90	2.55	.0006	.0248	.0212	.0036	.22	.0020	.0000	.67	2.3
24937	Oct. 7	V. slight.	Slight.	.38	5.60	2.25	.0008	.0228	.0208	.0020	.19	.0000	.0000	.59	2.3
25290	Nov. 7	Slight.	Slight.	.45	6.00	2.60	.0010	.0208	.0180	.0028	.18	.0030	.0001	.66	2.3
25586	Dec. 9	V. slight.	V. slight.	.53	5.05	1.90	.0006	.0132	.0116	.0016	.24	.0060	.0001	.68	2.3
Av...	....	....	....	.54	5.58	2.16	.0013	.0231	.0204	.0027	.21	.0055	.0001	.65	2.4

Odor, faintly vegetable or none.

Microscopical Examination of Water from Baddacook Pond, Groton.

[Number of organisms per cubic centimeter.]

	1898.										
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Sept.	Oct.	Nov.	Dec.
Day of examination,	10	14	1	12	18	27	7	8	10	9	12
Number of sample,	21782	22159	22378	22782	23194	23680	23820	24575	24937	25290	25586
PLANTS.											
Diatomaceæ,	0	1	0	110	133	157	142	19	96	589	231
Asterionella,	0	0	0	15	26	19	0	0	30	186	202
Cyclotella,	0	0	0	3	61	132	104	2	6	6	0
Melosira,	0	0	0	44	19	0	28	0	28	135	12
Synedra,	0	1	0	24	17	6	2	3	8	16	5
Tabellaria,	0	0	0	6	4	0	8	14	24	231	12
Cyanophyceæ,	0	0	1	0	0	1	16	11	2	0	0
Microcystis,	0	0	0	0	0	1	14	0	0	0	0
Algæ,	0	0	0	6	18	7	2	0	0	7	0

GROTON.

Microscopical Examination of Water from Baddacook Pond, Groton — Concluded.

[Number of organisms per cubic centimeter.]

	1898.										
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Sept.	Oct.	Nov.	Dec.
ANIMALS.											
Rhizopoda,	0	0	0	0	0	0	0	0	0	1	0
Infusoria,	126	2	479	9	29	4	8	17	18	12	15
Dinobryon,	124	0	476	0	21	3	0	0	10	1	12
Peridinium,	0	0	3	4	2	0	2	8	0	0	2
Trachelomonas,	1	1	0	4	2	1	2	1	6	8	0
Vorticella,	0	0	0	0	0	0	4	8	0	0	0
Vermes,	7	1	1	1	0	0	0	6	0	0	0
Crustacea,	pr.	0	0	0	0	0	0	pr.	0	0	0
Miscellaneous, Zoöglœa,	0	3	3	5	0	3	5	5	5	5	3
TOTAL,	133	7	484	131	180	172	173	58	121	614	249

HANSON.

Chemical Examination of Water from Maquam Pond in Hanson.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
25573	Dec. 7	V. slight.	V. slight.	.09	2.25	1.00	.0002	.0162	.0146	.0016	0.61	.0000	.0000	.16	0.3
25675	Dec. 19	V. slight.	V. slight.	.10	2.75	1.00	.0000	.0116	.0104	.0012	0.74	.0000	.0001	.13	0.0
25676	Dec. 19	V. slight.	V. slight.	.10	2.95	1.00	.0002	.0122	.0114	.0008	0.77	.0010	.0000	.14	0.2
25805	Dec. 29	V. slight.	Slight.	.08	2.40	1.15	.0000	.0118	.0106	.0012	0.66	.0010	.0000	.28	0.0
25574	Dec. 7	None.	V. slight.	.30	4.35	2.20	.0004	.0076	.0062	.0014	1.05	.0000	.0000	.42	0.6
25677	Dec. 19	V. slight.	V. slight.	.20	3.50	1.25	.0006	.0122	.0090	.0032	0.96	.0010	.0001	.33	0.6

Odor of the second sample, none, becoming distinctly fishy and unpleasant on heating; of the others, none, becoming very faintly vegetable on heating. —— The first two samples were collected from the northerly end of the pond, near the shore; the third, from the southerly end, about 200 feet from the shore; the fourth, from the southerly end, about 30 feet from the outlet of the pond; the last two, from the brook flowing from the pond, about 100 feet from the pond.

These examinations were made in connection with an investigation of possible sources of water supply for the town of Whitman.

Harvard.

The advice of the State Board of Health to the board of health of Harvard, relative to the quality of the water of a well in that town which is used by the public for drinking purposes and largely used by the pupils in one of the public schools, may be found on page 13 of this volume. The results of analyses of two samples of water collected from the well are given in the following table: —

Chemical Examination of Water from a Well in Harvard.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
25073	Oct. 18	Slight.	Cons.	.23	3.60	.0116	.0056	.43	.0010	.0000	.10	1.6	.0760
25270	Nov. 7	Slight.	Cons.	.04	4.60	.0356	.0072	.46	.0000	.0000	.10	0.8	.0730

Odor, distinctly disagreeable. —— The samples were collected from a public well, located in the common in the village of Harvard.

Water Supply of Hatfield.

The source of supply is a small reservoir on Running Gutter Brook in Hatfield.

Chemical Examination of Water from the Reservoir of the Hatfield Water Works.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Suspended.					
Average of four samples collected in January, April, August and October, 1898.	.24	4.21	1.44	.0009	.0085	.0075	.0010	.13	.0052	.0001	.36	1.7

Odor in January and August, none; in April, none, becoming faintly vegetable on heating; in October, faintly vegetable, becoming distinctly vegetable on heating.

HAVERHILL.

Water Supply of Haverhill.

The sources of supply are Crystal, Kenoza, Saltonstall and Pentucket lakes in Haverhill, Johnson's Pond in Boxford and Groveland, and Millvale Reservoir on East Meadow River in Haverhill. Statistics as to the various sources are given in the following table: —

Source.	Area of Water Surface (Acres).	Average Depth (Feet).	Maximum Depth (Feet).	Storage Capacity (Mil. Gals.).	Drainage Area (Sq. Miles).	Population per Sq. Mile of Drainage Area.
Crystal Lake,	145	15	25	500	3.18	42
Kenoza Lake,	225	-	-	490	1.72	76
Saltonstall Lake,	45	-	-	107	0.30	930
Pentucket Lake,	38	-	-	82	0.32	47
Johnson's Pond,	222	14	33	1,014	4.96	60
Millvale Reservoir,	47	8	-	125	7.75	59

The water of Crystal Lake is somewhat colored, and contains at times considerable numbers of microscopical organisms. The waters of Kenoza Lake, Lake Pentucket and Lake Saltonstall are much less colored and contain less organic matter. The latter source receives the drainage from a very large population and is not used at the present time. Johnson's Pond is the principal source of supply for that portion of the city which was formerly comprised in the town of Bradford. There is said to be considerable mud in the deeper portions of this pond, and the shores are used quite largely as picnic grounds and are occupied by summer cottages. There is another large pond within the water-shed a short distance above Johnson's Pond. Millvale Reservoir was constructed by building a dam across the East Meadow River. All of the soil was removed from the area flowed. There is considerable swamp upon the water-shed of the reservoir, and the reservoir itself is shallow. Water from this source is supplied to the city by pumping it into Kenoza Lake, but, up to the present time, only a small amount has been used.

A communication from the State Board of Health to the board of health of Haverhill, in regard to an epidemic of typhoid fever in that city, may be found on pages 13 to 17 of this volume.

HAVERHILL.

Chemical Examination of Water from Inlet of Crystal Lake.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21965	Jan. 24	V. slight.	Slight.	.40	3.45	1.60	.0004	.0128	.0116	.0012	.28	.0140	.0000	.42	1.1
22346	Feb. 24	None.	V. slight.	.35	3.05	1.00	.0010	.0116	.0100	.0016	.39	.0130	.0000	.36	0.8
22621	Mar. 21	Slight.	Cons.	.44	3.15	1.10	.0024	.0166	.0148	.0018	.30	.0000	.0000	.38	1.1
22957	Apr. 25	V. slight.	Slight.	.40	2.20	1.10	.0004	.0096	.0086	.0010	.14	.0020	.0000	.43	0.5
23276	May 23	V. slight.	V. slight.	.45	4.70	1.45	.0012	.0242	.0234	.0008	.24	.0000	.0000	.50	2.8
23618	June 20	V. slight.	V. slight.	.49	4.60	1.70	.0010	.0198	.0192	.0006	.25	.0010	.0000	.59	1.6
24035	July 25	V. slight.	V. slight.	.36	5.15	1.55	.0016	.0220	.0204	.0016	.31	.0010	.0001	.52	2.5
24388	Aug. 22	None.	V. slight.	.67	5.25	2.45	.0020	.0272	.0266	.0006	.28	.0020	.0000	.55	1.7
24770	Sept. 26	V. slight	V. slight	.35	5.10	2.15	.0008	.0160	.0156	.0004	.37	.0040	.0000	.46	1.8
25145	Oct. 24	None.	V. slight.	.48	4.30	2.35	.0000	.0170	.0162	.0008	.26	.0040	.0001	.66	1.1
25439	Nov. 21	V. slight.	V slight.	.43	3.70	1.75	.0002	.0130	.0106	.0024	.25	.0050	.0001	.50	1.1
25796	Dec. 28	V. slight.	Slight.	.20	3.60	1.35	.0000	.0122	.0110	.0012	.30	.0020	.0000	.28	1.3
Av...	....	....	....	.42	4.02	1.63	.0009	.0168	.0157	.0011	.28	.0040	.0000	.47	1.4

Odor, frequently none, sometimes vegetable or musty. On heating, the odor of some of the samples became stronger, and of the last sample, distinctly fishy and oily. —— The samples were collected from the principal feeder, just above its entrance into the lake.

Chemical Examination of Water from Crystal Lake, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21966	Jan. 24	V. slight.	V. slight.	.26	3.85	1.90	.0044	.0196	.0192	.0004	.39	.0060	.0000	.41	1.3
22347	Feb. 24	None.	V. slight.	.19	2.85	1.00	.0052	.0178	.0150	.0028	.42	.0090	.0000	.34	0.6
22622	Mar. 21	V. slight.	Slight.	.27	2.65	1.15	.0024	.0264	.0254	.0010	.28	.0040	.0000	.33	0.8
22958	Apr. 25	V. slight.	V. slight.	.29	2.65	1.10	.0004	.0148	.0128	.0020	.29	.0040	.0000	.36	1.0
23275	May 23	V. slight.	V. slight.	.30	2.90	1.20	.0006	.0196	.0168	.0028	.27	.0030	.0000	.40	1.0
23617	June 20	V. slight.	Slight.	.26	3.10	1.25	.0010	.0212	.0170	.0042	.28	.0020	.0000	.38	1.0
24036	July 25	V. slight.	V. slight.	.20	3.05	1.45	.0006	.0194	.0172	.0022	.20	.0010	.0001	.44	1.1
24389	Aug. 22	V. slight.	Cons.	.19	3.05	1.40	.0006	.0230	.0174	.0056	.23	.0010	.0002	.40	0.8
24771	Sept. 26	Slight.	Slight.	.18	3.25	1.40	.0002	.0184	.0148	.0036	.25	.0020	.0000	.42	0.8
25146	Oct. 24	V. slight.	Slight.	.11	3.90	1.70	.0000	.0212	.0182	.0030	.37	.0030	.0001	.31	1.6
25440	Nov. 21	V. slight.	None.	.08	3.70	1.40	.0000	.0146	.0142	.0004	.41	.0040	.0000	.22	1.3
25797	Dec. 28	V. slight.	Slight.	.21	3.25	1.50	.0020	.0256	.0238	.0018	.29	.0010	.0000	.46	1.0
Av...	....	....	....	.21	3.18	1.37	.0014	.0201	.0176	.0025	.31	.0033	.0000	.37	1.0

Odor, faintly vegetable or none. A vegetable odor was developed in most of the samples on heating. —— The samples were collected from the lake, near its outlet.

HAVERHILL.

Chemical Examination of Water from Kenoza Lake, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21959	Jan. 24	Slight.	Slight.	.09	3.65	1.10	.0014	.0154	.0150	.0004	.45	.0030	.0000	.23	1.8
22962	Apr. 25	Slight.	Slight.	.12	4.00	1.25	.0002	.0130	.0122	.0008	.42	.0030	.0000	.24	1.8
24032	July 25	V. slight.	None.	.10	3.75	1.30	.0004	.0174	.0152	.0022	.33	.0010	.0000	.34	1.7
25142	Oct. 24	V. slight.	V. slight.	.09	3.50	1.25	.0004	.0160	.0154	.0006	.41	.0020	.0000	.27	1.8
Av...	....	....	....	.10	3.72	1.22	.0006	.0154	.0144	.0010	.40	.0022	.0000	.27	1.8

Odor, faintly vegetable or none. The odor of the first sample became faintly fishy on heating.

Chemical Examination of Water from Lake Saltonstall, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21961	Jan. 24	Slight.	V. slight.	.18	5.00	1.35	.0018	.0156	.0142	.0014	.64	.0080	.0000	.30	3.0
22955	Apr. 25	Slight.	V. slight.	.05	5.55	1.30	.0010	.0154	.0140	.0014	.75	.0080	.0002	.23	2.6
24038	July 25	V. slight.	None.	.09	6.55	2.00	.0014	.0198	.0176	.0022	.74	.0010	.0000	.23	2.7
25147	Oct. 24	V. slight.	V. slight.	.10	6.25	2.10	.0002	.0158	.0152	.0006	.73	.0020	.0000	.21	2.7
Av...	....	....	....	.10	5.84	1.69	.0011	.0166	.0152	.0014	.71	.0047	.0000	.24	2.7

Odor of the first two samples, vegetable, becoming also musty on heating; of the last two, none, becoming faintly vegetable on heating.

HAVERHILL.

Chemical Examination of Water from Lake Pentucket, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21960	Jan. 24	V. slight.	None.	.07	3.75	1.00	.0002	.0174	.0146	.0028	.52	.0020	.0000	.22	1.7
22959	Apr. 25	V. slight.	V. slight.	.08	3.65	1.10	.0014	.0152	.0144	.0008	.46	.0020	.0000	.26	1.3
24037	July 25	Slight.	Slight.	.10	3.80	1.65	.0004	.0218	.0194	.0024	.38	.0010	.0000	.27	2.0
25143	Oct. 24	V. slight.	V. slight.	.21	4.00	1.45	.0000	.0232	.0202	.0030	.46	.0030	.0000	.38	1.7
Av...	....	....	....	.11	3.80	1.30	.0005	.0194	.0172	.0022	.45	.0020	.0000	.28	1.7

Odor, faintly vegetable.

Chemical Examination of Water from Johnson's Pond in Boxford and Groveland

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21964	Jan. 24	Decided.	Slight.	.17	3.80	1.25	.0018	.0210	.0194	.0016	.39	.0030	.0000	.38	2.0
22956	Apr. 25	Slight.	V. slight.	.20	3.85	1.35	.0016	.0218	.0194	.0024	.42	.0040	.0001	.38	1.7
24031	July 25	V. slight.	None.	.15	4.25	1.40	.0008	.0194	.0180	.0014	.27	.0020	.0000	.34	1.8
25140	Oct. 24	None.	V. slight.	.20	4.20	1.55	.0000	.0162	.0158	.0004	.38	.0040	.0000	.35	2.0
Av..	....	....	....	.18	4.02	1.39	.0010	.0196	.0182	.0014	.36	.0032	.0000	.36	1.9

Odor of the first two samples, faintly musty; of the third, none; of the last, faintly vegetable.— The first two samples were collected from the pond; the last two, from faucets in the city.

HAVERHILL.

Chemical Examination of Water from East Meadow River at its Entrance into Millvale Reservoir, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21963	Jan. 24	V. slight.	V. slight.	0.91	3.85	1.55	.0006	.0142	.0128	.0014	.28	.0080	.0000	0.79	1.3
22318	Feb. 23	V. slight.	Cons.	0.73	4.00	1.75	.0006	.0136	.0128	.0008	.39	.0090	.0000	0.62	1.1
22611	Mar. 21	V. slight.	V. slight.	0.90	3.40	1.45	.0006	.0152	.0142	.0010	.30	.0000	.0000	0.68	1.4
22960	Apr. 25	V. slight.	Cons.	1.05	3.85	2.00	.0002	.0208	.0186	.0022	.23	.0020	.0000	0.91	1.0
23277	May 23	V. slight.	Slight.	1.05	4.90	1.85	.0010	.0212	.0196	.0016	.31	.0080	.0000	0.78	2.1
23619	June 20	V. slight	Slight.	1.10	6.25	3.25	.0016	.0364	.0324	.0040	.29	.0020	.0000	1.30	2.5
24033	July 25	V. slight.	V. slight.	0.50	5.50	1.90	.0006	.0152	.0136	.0016	.25	.0010	.0001	0.52	2.0
24391	Aug. 22	None.	V. slight.	1.44	7.30	4.00	.0020	.0428	.0380	.0048	.26	.0040	.0001	1.67	2.1
24772	Sept. 26	Slight.	V. slight.	0.65	6.05	2.40	.0006	.0234	.0202	.0032	.29	.0040	.0000	0.78	1.8
25141	Oct. 24	None.	V. slight	1.64	6.60	3.75	.0012	.0350	.0316	.0034	.27	.0040	.0000	1.37	2.0
25437	Nov. 21	V. slight.	V. slight.	0.95	5.00	2.35	.0004	.0214	.0198	.0016	.29	.0040	.0000	1.13	1.4
25794	Dec. 28	V. slight.	V. slight.	0.60	5.10	2.15	.0012	.0186	.0176	.0010	.32	.0020	.0001	0.64	1.7
Av.	....	....	....	0.96	5.15	2.37	.0009	.0231	.0209	.0022	.29	.0040	.0000	0.93	1.7

Odor, generally none, occasionally musty and vegetable, sometimes faintly unpleasant. All of the samples had a vegetable or musty odor when heated. —— The samples were collected from the river, at Thompson's bridge, just above its entrance into Millvale storage reservoir.

Chemical Examination of Water from Millvale Reservoir on East Meadow River, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21962	Jan. 24	V. slight.	V. slight.	.70	4.15	1.70	.0008	.0160	.0160	.0000	.31	.0070	.0000	0.69	1.6
22319	Feb. 23	Slight.	V. slight	.65	4.25	1.65	.0006	.0108	.0102	.0006	.42	.0100	.0000	0.57	1.1
22612	Mar. 21	V. slight.	V. slight.	.65	3.15	1.60	.0004	.0146	.0132	.0014	.26	.0000	.0000	0.54	1.0
22961	Apr. 25	Slight.	Slight.	.98	4.40	1.80	.0004	.0184	.0158	.0026	.30	.0030	.0001	0.77	1.3
23278	May 23	V. slight.	V. slight.	.98	4.25	2.10	.0010	.0224	.0208	.0016	.30	.0030	.0000	0.72	1.8
23620	June 20	Slight.	Slight.	.88	5.35	2.85	.0014	.0326	.0298	.0028	.28	.0000	.0000	0.93	1.8
24034	July 25	V. slight.	Slight.	.55	5.25	2.35	.0004	.0234	.0206	.0028	.23	.0000	.0002	0.72	2.1
24390	Aug. 22	Slight.	Slight.	.57	5.20	2.45	.0006	.0230	.0216	.0014	.29	.0020	.0001	0.78	1.7
24773	Sept. 26	Slight.	Cons.	.53	5.65	2.75	.0010	.0264	.0228	.0036	.27	.0010	.0001	0.78	1.8
25144	Oct. 24	V. slight.	V. slight.	.82	5.55	3.15	.0004	.0292	.0282	.0010	.29	.0020	.0000	1.10	1.8
25438	Nov. 21	V. slight.	Slight.	.95	5.20	2.35	.0008	.0204	.0202	.0002	.32	.0050	.0001	1.03	1.6
25795	Dec. 28	V. slight.	None.	.60	5.00	1.90	.0014	.0284	.0222	.0062	.33	.0030	.0001	0.67	1.7
Av.	....	....	....	.74	4.78	2.22	.0008	.0221	.0201	.0020	.30	.0030	.0001	0.77	1.6

Odor, faintly vegetable or none. On heating, the odor of most of the samples became distinctly vegetable. —— The samples were collected from the reservoir, near its outlet.

HAVERHILL.

The advice of the State Board of Health to the board of health of Haverhill, relative to the use by the public for drinking purposes of water from two wells at the birthplace of Whittier in Haverhill, may be found on pages 17 and 18 of this volume. The results of analyses of samples of water from each of the wells are given in the following table: —

Chemical Examination of Water from Wells on Whittier place in Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
23146	May 13	None.	None.	.02	11.20	.0004	.0026	1.02	.3720	.0000	.01	4.3	.0010
23387	June 3	None.	None.	.02	12.00	.0012	.0022	0.95	.3450	.0000	.02	4.9	.0010
23855	July 12	None.	V. slight.	.03	11.80	.0000	.0016	0.97	.3480	.0000	.03	5.0	.0010
23147	May 13	V. slight.	Slight.	.08	6.30	.0040	.0080	0.29	.0240	.0000	.07	3.1	.0060
23388	June 3	V. slight.	Slight.	.09	6.00	.0104	.0096	0.29	.0140	.0006	.06	2.6	.0180
23856	July 12	Decided.	Heavy.	.32	11.70	.1210	.0890	0.39	.0010	.0001	.60	4.9	.3800

Odor of the first four samples, none; of the fifth, none, becoming faintly musty on heating; of the last, decidedly unpleasant, becoming offensive on heating. —— The first three samples were collected from a well on the easterly side of the road, nearly opposite the Whittier homestead; the last three samples were collected from a well in the rear of the Whittier homestead, about 80 feet southwest of the road.

The reply of the State Board of Health to the Gale Shoe Manufacturing Company, relative to the quality of the water of a well on the premises of the company and its fitness for drinking, may be found on page 17 of this volume. The results of an analysis of a sample of water collected from the well are given in the following table: —

HAVERHILL.

Chemical Examination of Water from the Well of the Gale Shoe Manufacturing Company, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
22163	1898. Feb. 11	V. slight.	Cons., floc.	.04	40.00	.0068	.0044	4.01	.2300	.0360	.11	24.5	.0050

Odor, tarry and disagreeable. —— The sample was collected from a tubular well, beneath the boiler room of the factory.

Water Supply of Hingham and Hull. — Hingham Water Company.

The sources of supply are Accord and Fulling Mill ponds in Hingham. Accord Pond has an area of 98 acres, an average depth of about 15 feet and a maximum depth of 43 feet. The bottom is said to be gravelly, with deposits of mud in the deeper portions, and there is a small area of the pond which is flooded to only a slight depth. The drainage area of 0.72 of a square mile contains 15 acres of swamp land and a population of about 50 per square mile of water-shed.

The water of Accord Pond has been subject to the frequent occurrence of bad tastes and odors from the growth of certain microscopical organisms, and especially of the organisms *Anabœna* and *Uroglena*. During the winter of 1897–98 the presence of *Uroglena* gave the water a very offensive taste and odor for a period of several months.

Fulling Mill Pond has an area of 14 acres, a maximum depth of 6 feet and an average depth of 3 feet. The bottom is covered with mud. The water-shed of the pond is 0.36 of a square mile, containing a population of 14 per square mile. Water is not usually drawn directly from Fulling Mill Pond, but is drawn from basins on the shore of the pond, into which water from the pond enters by passing through a gravel dike. These basins are not covered, and have frequently contained the organisms *Peridinium* and *Anabœna*, which have been known to impart to water a disagreeable taste and odor.

HINGHAM AND HULL.

The advice of the State Board of Health to the Hingham Water Company, relative to improving the water of Accord Pond, the principal source of supply of that town, and in regard to securing a supply of water from a system of wells in the vicinity of the pond, may be found on pages 19 to 22 of this volume. The results of analyses of samples of water collected from test wells during the investigations are contained in one of the following tables : —

Chemical Examination of Water from Accord Pond, Hingham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21815	Jan. 11	Slight.	Cons.	.20	3.40	1.50	.0012	.0262	.0158	.0104	.79	.0000	.0000	.32	0.6
21816	Jan. 11	V. slight.	Slight.	.18	3.25	1.30	.0018	.0178	.0142	.0036	.76	.0020	.0000	.34	0.6
21817	Jan. 11	V. slight.	Slight.	.19	3.40	1.35	.0024	.0158	.0140	.0018	.76	.0020	.0000	.31	1.1
22049	Feb. 3	V slight.	Slight.	.22	3.30	1.05	.0020	.0174	.0128	.0046	.78	.0000	.0000	.36	1.0
22050	Feb. 3	V. slight.	Slight.	.22	3.20	1.15	.0010	.0156	.0116	.0040	.72	.0000	.0000	.38	1.1
22382	Feb. 28	V. slight.	Slight.	.35	2.60	1.00	.0006	.0198	.0118	.0080	.36	.0000	.0002	.40	0.2
22458	Mar. 7	Slight.	Cons.	.26	2.85	1.35	.0006	.0192	.0138	.0054	.46	.0000	.0000	.38	0.2
22542	Mar. 14	V. slight.	V. slight.	.29	3.00	1.20	.0002	.0148	.0102	.0046	.62	.0000	.0000	.38	0.5
22614	Mar. 21	V. slight.	Slight.	.30	2.95	1.20	.0004	.0148	.0116	.0032	.65	.0000	.0000	.37	0.5
22799	Apr. 11	Slight.	Cons.	.30	3.60	1.40	.0004	.0170	.0118	.0052	.51	.0000	.0000	.39	0.5
23514	June 13	V. slight.	V. slight.	.52	3.25	1.50	.0006	.0182	.0160	.0022	.62	.0010	.0001	.52	0.3
24483	Aug. 30	V. slight.	V. slight.	.34	2.75	1.60	.0006	.0208	.0198	.0010	.65	.0020	.0000	.52	0.3
25498	Nov. 29	V. slight	Slight.	.30	3.25	1.60	.0010	.0130	.0110	.0020	.62	.0010	.0000	.46	0.5
Av*..	....	....	....	.31	3.19	1.40	.0009	.0175	.0139	.0036	.63	.0008	.0000	.42	0.5

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor of the last two samples, none; of the others, fishy and oily. The odor of most of the samples became stronger on heating.

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Microscopical Examination of Water from Accord Pond, Hingham.

[Number of organisms per cubic centimeter.]

	1898.												
	Jan.	Jan.	Jan.	Feb.	Feb.	Mar.	Mar.	Mar.	Mar.	Apr.	June.	Aug.	Nov.
Day of examination,	11	11	11	4	4	1	8	15	22	12	14	31	30
Number of sample,	21815	21816	21817	22049	22050	22382	22458	22542	22614	22799	23514	24483	25498
PLANTS.													
Diatomaceæ,	0	6	22	5	0	1	0	5	8	0	0	15	73
Cyanophyceæ, Anabæna,	0	0	0	0	0	0	0	0	0	0	20	0	0
Algæ, Protococcus,	0	0	0	0	0	0	0	0	0	0	0	10	0
ANIMALS.													
Infusoria,	16	36	24	177	89	36	46	77	31	50	9	27	0
Dinobryon,	0	32	23	164	84	0	14	56	17	36	0	22	0
Peridinium,	0	0	0	1	0	0	0	0	0	0	5	5	0
Uroglena,	16	4	1	12	4	36	32	21	14	14	0	0	0
Vermes,	1	0	1	1	0	0	0	0	0	0	2	0	0
Crustacea, Cyclops,	0	0	pr.	0	pr.	0	pr.	0	0	0	0	0	pr.
Miscellaneous, Zoöglœa,	10	5	2	0	0	0	0	3	0	0	3	0	5
TOTAL,	27	47	49	183	89	37	46	85	39	50	34	52	78

Chemical Examination of Water from Accord Pond, collected at Different Points.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
22051	Feb. 3	V. slight.	Cons.	.20	3.25	1.10	.0006	.0208	.0116	.0092	.75	.0000	.0000	.36	0.8
22052	Feb. 3	V. slight.	Cons.	.21	3.25	1.35	.0014	.0202	.0136	.0066	.72	.0000	.0000	.39	0.8
22053	Feb. 3	V. slight.	Cons.	.21	3.50	1.45	.0014	.0212	.0142	.0070	.77	.0000	.0000	.37	0.8
22054	Feb. 3	V. slight.	Cons.	.21	3.25	1.25	.0006	.0144	.0122	.0022	.75	.0000	.0000	.35	0.8
22055	Feb. 3	V. slight.	Cons.	.49	3.50	1.70	.0004	.0200	.0140	.0060	.74	.0000	.0000	.52	0.8

Odor of the first sample, faintly vegetable, becoming distinctly vegetable and fishy on heating; of the others, faintly fishy, becoming distinctly fishy on heating. —— The first sample was collected from the east side of the pond, at the surface; the second, from the south end of the pond, at the surface; the third, from the centre of the pond, at the surface; the fourth, from the centre of the pond, 10 feet beneath the surface; the last, from the west side of the pond, at the surface.

HINGHAM AND HULL.

Chemical Examination of Water from Fulling Mill Pond, Hingham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
22056	Feb. 3	None.	V. slight.	.07	5.15	1.15	.0006	.0030	.0030	.0000	.84	.0230	.0000	.11	1.4
23515	June 13	V. slight.	Slight.	.30	5.00	1.25	.0012	.0072	.0060	.0012	.68	.0140	.0001	.23	1.1
24482	Aug. 30	V. slight.	V. slight.	.20	5.15	1.45	.0040	.0114	.0104	.0010	.75	.0110	.0001	.17	1.3
25499	Nov. 29	V. slight.	Slight.	.27	5.40	1.75	.0006	.0074	.0046	.0028	.80	.0120	.0000	.27	1.6
Av...	....	....	....	.21	5.17	1.40	.0016	.0072	.0060	.0012	.77	.0150	.0000	.19	1.3

Odor of the first sample, faintly vegetable; of the second, none; of the third, none, becoming faintly unpleasant on heating; of the last, none, becoming faintly vegetable on heating. —— The first and third samples were collected from the filter basin located on the south-east side of Fulling Mill Pond; the second and last samples, from the gate-house, and represent water from the filter basin.

Chemical Examination of Water from Accord Brook in Hingham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
23516	June 13	V. slight.	Slight.	4.44	7.70	3.75	.0032	.0524	.0456	.0068	.71	.0050	.0002	2.91	1.1

Odor, none, becoming distinctly vegetable on heating. —— The sample was collected from the brook, at road crossing about 1 mile from Fulling Mill Pond, near point from which water can be diverted into Fulling Mill Pond.

HINGHAM AND HULL.

Chemical Examination of Water from Tubular Test Wells near Accord Pond in Hingham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22534	Mar. 11	V. slight.	None.	0.70	6.30	.0396	.0018	.54	.0000	.0000	.10	2.6	.1940
22547	Mar. 14	Slight.	V. slight.	1.00	7.00	.0422	.0018	.54	.0000	.0000	.08	2.6	.2500
22548	Mar. 14	Decided, milky.	Cons.	0.40	6.90	.0236	.0020	.56	.0000	.0000	.12	2.6	.1850
23058	May 3	Decided.	Heavy.	0.20	6.30	.0000	.0010	.75	.0030	.0000	.05	1.0	.0630
23145	May 13	Decided, milky.	Cons.	0.05	5.40	.0004	.0018	.73	.0020	.0000	.01	0.8	.0120
23149	May 13	Decided, milky.	Cons.	0.12	6.40	.0008	.0024	.73	.0020	.0000	.01	0.8	.0250
22770	Apr. 7	Slight.	Slight.	0.03	3.50	.0006	.0012	.68	.0020	.0000	.01	0.5	.0110
22771	Apr. 7	None.	None.	0.00	4.10	.0002	.0008	.67	.0000	.0000	.02	0.5	.0010
23057	May 3	V. slight.	Slight.	0.05	3.50	.0000	.0014	.72	.0020	.0001	.01	0.5	.0700
23144	May 13	Decided, milky.	Heavy.	0.06	5.50	.0004	.0022	.72	.0040	.0000	.01	0.6	.0230
23148	May 13	Decided, milky.	Cons.	0.06	5.00	.0002	.0022	.72	.0020	.0000	.01	0.8	.0180
23056	May 3	Decided.	Cons.	0.03	3.70	.0000	.0010	.65	.0040	.0000	.02	0.6	.0080
23055	May 3	Slight.	Cons.	0.03	6.00	.0000	.0012	.67	.0000	.0000	.02	0.8	.0010
23054	May 3	Slight.	Cons.	0.03	6.40	.0000	.0016	.72	.0020	.0000	.03	0.8	.0080
23053	May 3	V. slight.	None.	0.02	4.50	.0000	.0008	.90	.0070	.0000	.02	1.1	.0060

Odor of Nos. 22548 and 23058, faintly earthy; of the others, none. —— Samples Nos. 22534 and 22547 were collected from a well located a short distance north of the dam at the outlet of Accord Pond, on the easterly side of the brook flowing from the pond; No. 22548, from a well about 75 feet east of the well just described; the remaining samples were collected from a line of eight test wells on the northerly side of the pond, extending from a point about 100 feet south-east of the easterly end of the dam at the outlet of the pond to a point about 450 feet from the dam; Nos. 23058, 23145 and 23149 were collected from the well nearest the dam; Nos. 22770, 22771, 23057, 23144 and 23148 were collected from the third well from the dam; Nos. 23056, 26055, 23054 and 23053 were collected from the fourth, fifth, sixth and eighth wells respectively.

Water Supply of Hinsdale Fire District, Hinsdale.

The source of supply is a storage reservoir on a mountain stream. The reservoir has an area of 9 acres, a maximum depth of 21 feet and a capacity of 35,000,000 gallons. During the years 1894–96 the reservoir contained enormous numbers of the organism *Palmella.* Trouble has also been occasioned by the presence in the reservoir of large numbers of the organism *Peridinium.*

HINSDALE.

Chemical Examination of Water from the Storage Reservoir of the Hinsdale Fire District.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21986	Jan. 25	None.	Slight.	.30	2.65	1.25	.0014	.0122	.0106	.0016	.07	.0030	.0000	.34	1.0
22316	Feb. 22	V. slight.	V. slight.	.32	1.95	0.75	.0050	.0080	.0066	.0014	.10	.0080	.0000	.28	1.0
22681	Mar. 29	V. slight.	None.	.20	1.20	0.50	.0014	.0100	.0088	.0012	.06	.0010	.0000	.26	0.5
22981	Apr. 26	Slight.	Slight.	.24	1.90	0.75	.0002	.0110	.0080	.0030	.08	.0020	.0000	.30	0.8
23286	May 24	V. slight.	V. slight.	.22	1.75	0.95	.0004	.0136	.0098	.0038	.07	.0030	.0000	.26	0.5
23643	June 21	Decided, milky.	Cons.	.19	2.50	1.25	.0008	.0186	.0094	.0092	.06	.0020	.0000	.34	1.0
24058	July 26	Decided.	V. slight.	.32	2.85	1.35	.0004	.0228	.0156	.0072	.04	.0000	.0000	.44	1.3
24419	Aug. 24	Slight.	V. slight.	.41	2.65	1.05	.0006	.0184	.0158	.0026	.06	.0020	.0001	.40	1.0
24842	Sept. 28	Slight.	V. slight.	.32	2.55	1.35	.0004	.0202	.0160	.0042	.04	.0020	.0000	.42	0.8
25152	Oct. 25	V. slight.	V. slight.	.30	2.20	1.20	.0000	.0152	.0122	.0030	.05	.0010	.0000	.38	0.5
25442	Nov. 21	V. slight.	V. slight.	.27	2.25	0.75	.0004	.0158	.0132	.0026	.07	.0000	.0000	.31	0.8
25788	Dec. 28	V. slight.	V. slight.	.20	2.30	0.85	.0000	.0104	.0096	.0008	.06	.0000	.0001	.30	0.8
Av...	....	....	....	.27	2.23	1.00	.0009	.0147	.0113	.0034	.06	.0020	.0000	.34	0.8

Odor, faintly vegetable or none; in August, faintly musty. On heating, the odor of most of the samples became distinctly vegetable; in January, November and December, faintly fishy, and in October and November, also disagreeable. —— The sample in May was collected from the reservoir; the others, from a faucet in the village.

Microscopical Examination.

The number of organisms per cubic centimeter found in the sample collected in May was 703, consisting chiefly of *Dinobryon*; in the sample collected in August, 845, consisting chiefly of the organism *Protococcus*. An insignificant number of organisms was found in each of the other samples.

Water Supply of Holbrook.

(See *Randolph.*)

Water Supply of Holliston. — Holliston Water Company.

The source of supply is a well in the valley of Jar Brook in East Holliston. The well, which is situated about 400 feet below a mill pond, is 26 feet in diameter and 30 feet deep, the lower 10 feet being in ledge. A small storage reservoir has been constructed below the mill pond, and the shore of the reservoir is within 15 feet of the well; a connection has been made between the reservoir

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and the well, so that water can be drawn directly from the reservoir. The reservoir has a maximum depth of 8 feet, and all of the soil was removed from the area flooded when the dam was constructed. The water drawn from the well contains a large amount of iron and organic matter, and is highly colored.

Chemical Examination of Water from the Well of the Holliston Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1898.												
21868	Jan. 17	V. slight.	V. slight.	.30	3.80	.0002	.0090	.38	.0130	.0000	.27	1.6	.0300
22549	Mar. 14	Slight.	V. slight.	.34	3.00	.0002	.0090	.26	.0070	.0000	.28	0.8	.0070
23227	May 19	V. slight	V. slight.	.31	2.90	.0022	.0102	.23	.0030	.0000	.20	1.1	.0200
23918	July 18	Slight.	Slight.	.35	4.30	.0026	.0158	.26	.0030	.0001	.32	1.3	.0130
24732	Sept. 21	Slight.	V. slight.	.47	4.50	.0006	.0146	.27	.0000	.0000	.34	1.4	.0560
25370	Nov. 14	V. slight.	V. slight.	.51	4.40	.0010	.0154	.29	.0010	.0001	.61	1.0	.0200
Av...	....	....	....	.38	3.82	.0011	.0123	.28	.0045	.0000	.34	1.2	.0243

Odor of No. 21868, distinctly vegetable; of No. 24732, faintly musty; of the others, none. —— Nos. 23918 and 25370 were collected from the well; the others, from a tap in the pumping station.

Water Supply of Holyoke.

The sources of supply are Ashley and Wright ponds and Whiting Street storage reservoir in Holyoke, and the Manhan River in Southampton. Ashley and Wright ponds, the original sources of supply, are connected by a culvert, and water for the supply of the city is drawn from Wright Pond. Wright Pond has an area of 45 acres and Ashley Pond an area of 185 acres. The bottoms are muddy, but the swamps which originally bordered the ponds in places have been cleared and filled in with gravel and the shallow places deepened. The ponds have a drainage area of 2.06 square miles, nearly all of which is owned by the city, and is now uninhabited.

Whiting Street storage reservoir has an area of 112 acres, an average depth of 15 feet and a maximum depth of 20 feet. The bottom was originally swampy, and none of the soil or organic matter was removed when the reservoir was constructed. The drainage area of Whiting Street Reservoir is 1.34 square miles, and this area, like that of Wright and Ashley ponds, is practically uninhabited.

During the years 1897–98 works were constructed for obtaining an additional water supply from the Manhan River in Southampton. A small reservoir having an area of 10.33 acres, was built on the river at the junction of the two principal tributaries, Manhan and Tucker brooks. Water from this reservoir is conveyed through a pipe to the upper end of Ashley Pond, from the lower end of which water flows into Wright Pond, and is thence distributed to the city. Manhan River, at the point where the storage reservoir is constructed, has a drainage area of 13.2 square miles, which contains a population of 18 per square mile.

The water of Whiting Street Reservoir contains at times very large amounts of organic matter, much of which is in the form of microscopical organisms. The water of Wright and Ashley ponds is of somewhat better quality than that of Whiting Street Reservoir, and the quality has been improved by the introduction of water from the Manhan River and by improvements made in the pond and its water-shed.

The advice of the State Board of Health to the water commissioners of Holyoke, relative to the advisability of allowing ice to be cut from Ashley Pond, may be found on page 124 of this volume.

Chemical Examination of Water from Whiting Street Storage Reservoir, Holyoke.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
22005	Jan. 25	Slight.	Slight.	.13	4.30	1.50	.0012	.0222	.0172	.0050	.15	.0030	.0000	.30	2.3
22326	Feb. 22	V. slight.	Slight.	.13	4.40	1.30	.0034	.0164	.0142	.0022	.14	.0030	.0000	.26	2.5
22625	Mar. 22	V. slight.	V. slight.	.06	1.15	0.40	.0010	.0046	.0038	.0008	.06	.0000	.0000	.10	0.6
23009	Apr. 27	Slight.	Cons.	.07	3.65	1.10	.0004	.0178	.0120	.0058	.13	.0020	.0001	.19	2.1
23283	May 24	Slight.	Slight.	.09	3.65	1.20	.0006	.0196	.0142	.0054	.11	.0030	.0001	.22	2.2
23668	June 21	V. slight.	Cons.	.16	5.00	1.35	.0102	.0220	.0132	.0088	.10	.0000	.0000	.24	2.3
24055	July 26	V. slight.	Slight.	.14	4.55	1.20	.0028	.0258	.0174	.0084	.06	.0000	.0000	.30	2.5
24407	Aug. 23	Slight.	Slight.	.11	4.55	1.20	.0022	.0354	.0210	.0144	.06	.0000	.0000	.30	2.7
24803	Sept. 27	Decided.	Cons.	.20	5.90	2.25	.0128	.0654	.0286	.0368	.08	.0050	.0000	.34	2.7
25167	Oct. 25	V. slight	V. slight.	.18	5.50	2.25	.0162	.0334	.0288	.0046	.13	.0030	.0005	.35	2.9
25445	Nov. 21	V. slight.	V. slight.	.18	4.75	1.50	.0032	.0174	.0156	.0018	.11	.0020	.0002	.25	2.6
25792	Dec. 28	V. slight.	Slight.	.10	4.20	1.25	.0000	.0234	.0204	.0030	.11	.0040	.0002	.30	2.1
Av.	....	....	....	.13	4.30	1.37	.0045	.0253	.0172	.0081	.10	.0021	.0001	.26	2.3

Odor, generally vegetable or none; sometimes musty. On heating, the odor was generally stronger.

HOLYOKE.

Microscopical Examination of Water from Whiting Street Storage Reservoir, Holyoke.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	27	24	23	29	25	24	27	24	28	26	22	29
Number of sample,	22005	22326	22625	23009	23283	23668	24055	24407	24803	25167	25445	25792
PLANTS.												
Diatomaceæ,	984	74	4	1,258	1,001	170	136	182	64	108	880	3
Asterionella,	128	2	0	42	0	32	11	0	0	0	16	0
Cyclotella,	0	0	1	2	0	112	0	28	14	46	2	1
Fragilaria,	132	0	0	82	84	24	52	124	50	52	14	0
Melosira,	0	0	0	0	0	0	0	0	0	0	842	0
Synedra,	724	68	3	1,100	896	0	0	12	0	6	6	2
Tabellaria,	0	4	0	26	7	0	72	18	0	2	0	0
Cyanophyceæ,	0	0	0	0	4	0	61	62	136	44	12	3
Anabæna,	0	0	0	0	4	0	60	62	120	44	10	0
Cœlosphærium,	0	0	0	0	0	0	0	0	6	0	2	3
Merismopœdia,	0	0	0	0	0	0	0	0	8	0	0	0
Algæ,	10	8	0	7	43	28	81	10	662	66	12	0
Raphidium,	0	0	0	6	19	6	33	2	8	8	10	0
Scenedesmus,	0	0	0	1	7	0	23	0	10	42	2	0
Staurastrum,	0	0	0	0	2	20	14	6	644	10	0	0
ANIMALS.												
Rhizopoda,	0	0	0	0	0	0	0	2	0	0	0	0
Infusoria,	58	213	20	38	77	6	17	92	262	48	40	24
Ceratium,	0	0	0	0	1	0	5	0	10	0	0	0
Dinobryon,	52	204	19	28	66	0	0	4	0	0	28	19
Mallomonas,	0	2	0	2	0	0	0	0	10	12	4	0
Peridinium,	0	0	0	2	0	0	2	24	16	0	0	0
Trachelomonas,	6	7	1	2	2	0	10	62	220	36	4	1
Vermes,	0	0	0	2	1	0	1	2	12	0	0	2
Crustacea,	pr.	pr.	0	0	pr.	pr.	pr.	pr.	pr.	0	0	0
Bosmina,	0	0	0	0	0	0	pr.	0	pr.	0	0	0
Cyclops,	pr.	pr.	0	0	pr.	pr.	pr.	pr.	pr.	0	0	pr.
Daphnia,	0	0	0	0	pr	pr.	pr.	pr.	pr.	0	0	pr.
Miscellaneous, Zoöglœa,	0	3	5	8	10	5	10	8	10	12	3	3
TOTAL,	1,052	298	29	1,313	1,136	209	306	358	1,146	278	947	35

HOLYOKE.

Chemical Examination of Water from Wright and Ashley Ponds, Holyoke.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
22327	Feb. 22	Slight.	V. slight.	.17	3.95	1.25	.0064	.0274	.0180	.0094	.16	.0120	.0001	.27	2.3
23284	May 24	V. slight.	V. slight.	.08	4.50	1.00	.0010	.0184	.0158	.0026	.14	.0000	.0000	.20	2.9
24408	Aug. 23	V. slight	V. slight.	.10	4.50	1.20	.0006	.0178	.0142	.0036	.12	.0020	.0002	.23	2.6
25444	Nov. 21	V. slight.	V. slight.	.20	4.05	1.55	.0036	.0288	.0226	.0062	.10	.0030	.0001	.30	2.2
Av...	....	....	....	.14	4.25	1.25	.0029	.0231	.0177	.0054	.13	.0042	.0001	.25	2.5

Odor of the first sample, faintly vegetable, becoming distinctly vegetable and grassy on heating; of the second, faintly oily, becoming strongly oily on heating; of the third, none, becoming faintly grassy on heating; of the last, none, becoming faintly vegetable on heating. —— Water from Manhan River has been diverted into these ponds since the beginning of 1898.

Microscopical Examination of Water from Wright and Ashley Ponds, Holyoke.

[Number of organisms per cubic centimeter.]

	1898.			
	February.	May.	August.	November.
Day of examination,	24	25	24	22
Number of sample,	22327	23284	24408	25444
PLANTS.				
Diatomaceæ,	2	1,045	10	196
Asterionella,	0	736	0	3
Fragilaria,	0	29	7	173
Melosira,	0	94	0	0
Synedra,	2	172	3	5
Cyanophyceæ,	0	0	11	0
Algæ,	0	3	8	10
ANIMALS.				
Infusoria,	404	40	1	23
Cryptomonas,	400	3	0	0
Dinobryon,	0	29	1	2
Mallomonas,	0	0	0	12
Vermes,	0	0	3	2.
Crustacea,	0	0	0	pr.
Cyclops,	0	0	0	pr.
Daphnia,	0	0	0	pr.
Miscellaneous, Zoöglœa,	5	5	5	5
TOTAL,	411	1,093	38	236

HOLYOKE.

Chemical Examination of Water from Fomar Reservoir on the Manhan River, Southampton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
22006	Jan. 25	V. slight.	V. slight.	.31	2.75	1.15	.0006	.0104	.0096	.0008	.12	.0020	.0000	.30	1.0
22325	Feb. 22	V. slight.	V. slight.	.28	3.10	1.10	.0002	.0056	.0048	.0008	.13	.0070	.0000	.26	1.1
22624	Mar. 22	V. slight.	V. slight.	.33	2.25	0.90	.0006	.0084	.0068	.0016	.08	.0020	.0000	.31	1.1
23008	Apr. 27	V. slight.	Slight.	.39	3.90	1.00	.0004	.0090	.0086	.0004	.11	.0050	.0001	.37	1.3
23282	May 24	V. slight.	V. slight.	.37	3.00	1.05	.0004	.0106	.0098	.0008	.10	.0020	.0001	.33	1.4
23669	June 21	V. slight.	Cons.	.47	4.00	1.75	.0010	.0114	.0102	.0012	.09	.0000	.0001	.58	1.0
24056	July 26	V. slight.	V. slight.	.23	4.30	1.40	.0006	.0078	.0066	.0012	.06	.0010	.0001	.26	1.3
24409	Aug. 23	None.	V. slight.	.40	4.25	1.50	.0004	.0132	.0116	.0016	.08	.0020	.0000	.55	1.3
24804	Sept. 27	V. slight.	Slight.	.49	4.60	2.10	.0006	.0134	.0122	.0012	.11	.0050	.0000	.65	1.6
25166	Oct. 25	V. slight.	V. slight.	.73	4.25	1.95	.0004	.0154	.0140	.0014	.13	.0030	.0000	.84	1.4
25446	Nov. 21	V. slight.	None.	.55	3.40	1.80	.0006	.0136	.0120	.0016	.08	.0040	.0001	.74	1.1
25793	Dec. 28	V. slight.	V. slight.	.20	3.45	1.15	.0006	.0126	.0092	.0034	.12	.0010	.0001	.30	1.1
Av...	....	....	....	.40	3.60	1.40	.0005	.0109	.0096	.0013	.10	.0028	.0000	.46	1.2

Odor, generally faintly vegetable or none, sometimes musty. —— No. 23282 was collected from the outlet of the pipe which conveys water from Fomar Reservoir to Ashley Pond; the other samples were collected from the reservoir.

Water Supply of Hopedale.

(See *Milford.*)

Water Supply of Hudson.

The source of supply is Gates Pond in Berlin. The pond has an area of about 90 acres, a maximum depth of 80 feet and an average depth of 30 feet. During the year 1897 a new dam was constructed on the brook below the outlet of the pond, by which the water of the pond will be raised about 2 feet, and the drainage area considerably increased. In 1898 works were constructed for the diversion into the pond of the water of Fosgate Brook, which flows near the pond and at a higher level but in another water-shed. The water-shed of Fosgate Brook contained about 15 acres of swamp land through which the brook passed, and the water from this portion of the stream was very highly colored. A ditch was built around the edges of this swamp, to intercept the water from the higher land as it flows toward the brook and prevent it from passing over the swamp. The water which falls upon the swamp is diverted from the brook by means of a line of pipe laid to a point outside the water-shed. These works were completed about Oct. 1, 1898, and the effect upon the quality of the water can be seen by referring to the table of chemical analyses of water from Fosgate Brook which is given on a succeeding page. It will be seen that, whereas in September, just before the work was completed, the color was 2.00, in October it had been reduced to 0.32 and in December to 0.12. A corresponding reduction will be noticed in the organic matter.

Gates Pond now has a water-shed of 0.58 of a square mile, which contains a small permanent population. There are several houses on the shores of the pond which are occupied during the summer.

The advice of the State Board of Health to the water commissioners of Hudson, relative to a proposed additional water supply to be taken from Fosgate Brook in that town, may be found on pages 22 to 24 of this volume.

Chemical Examination of Water from Gates Pond, Berlin.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21867	Jan. 17	V. slight.	V. slight.	.05	2.35	1.00	.0066	.0176	.0170	.0006	.31	.0020	.0000	.14	1.0
22579	Mar. 16	None.	V. slight.	.05	2.20	1.00	.0038	.0128	.0110	.0018	.24	.0070	.0000	.14	0.8
22912	Apr. 20	V. slight.	Slight.	.05	2.30	0.95	.0016	.0134	.0108	.0026	.24	.0040	.0000	.12	0.8
23182	May 17	V. slight.	Slight.	.07	2.10	1.00	.0012	.0148	.0134	.0014	.25	.0020	.0000	.17	0.8
23505	June 13	V. slight.	V. slight.	.08	2.90	1.30	.0010	.0184	.0152	.0032	.25	.0020	.0000	.21	0.3
23925	July 19	V. slight.	Slight.	.07	2.50	0.75	.0000	.0174	.0142	.0032	.19	.0020	.0000	.18	0.5
24672	Sept. 19	V. slight.	Slight.	.07	2.10	0.75	.0004	.0166	.0134	.0032	.21	.0000	.0000	.23	0.6
25416	Nov. 17	V. slight.	V. slight.	.12	2.50	1.15	.0008	.0132	.0116	.0016	.20	.0020	.0001	.23	0.8
Av...	....	....	....	.07	2.37	0.99	.0019	.0155	.0133	.0022	.24	.0026	.0000	.18	0.7

Odor, generally none. On heating, the odor of No. 23505 became distinctly vegetable and grassy; of No. 23925, faintly musty; of No. 25416, faintly fishy.

HUDSON.

Microscopical Examination of Water from Gates Pond, Berlin.

[Number of organisms per cubic centimeter.]

	1898.							
	Jan.	March.	April.	May.	June.	July.	Sept.	Nov.
Day of examination,	18	17	21	18	14	20	20	18
Number of sample,	21867	22579	22912	23182	23505	23925	24672	25416
PLANTS.								
Diatomaceæ,	2	14	25	161	12	13	23	315
Asterionella,	0	0	1	109	0	8	23	75
Melosira,	0	0	23	11	0	0	0	226
Tabellaria,	1	13	0	30	1	0	0	11
Cyanophyceæ,	0	0	0	0	40	0	8	1
Anabæna,	0	0	0	0	40	0	0	0
Algæ,	0	0	2	31	26	19	17	13
Raphidium,	0	0	2	15	8	8	10	9
ANIMALS.								
Infusoria,	4	216	20	32	16	22	30	173
Dinobryon,	0	214	19	30	0	11	28	173
Vorticella,	0	0	0	0	15	0	0	0
Vermes,	0	0	0	0	0	1	0	0
Crustacea,	0	0	0	0	0	pr.	pr.	0
Miscellaneous, Zoöglœa,	0	3	3	3	5	3	3	5
TOTAL,	6	233	50	227	99	58	81	507

HUDSON.

Chemical Examination of Water from Fosgate Brook, in Berlin.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21866	Jan. 17	V. slight.	V. slight.	1.50	5.20	2.85	.0008	.0268	.0248	.0020	.22	.0030	.0000	1.26	1.3
22019	Jan. 28	V. slight.	Cons.	1.80	4.25	2.40	.0004	.0250	.0236	.0014	.18	.0020	.0000	1.24	1.4
22194	Feb. 14	V. slight.	Cons.	1.30	4.30	2.10	.0006	.0232	.0220	.0012	.21	.0120	.0000	1.03	1.3
22578	Mar. 16	V. slight.	Slight.	0.80	2.90	1.25	.0004	.0172	.0148	.0024	.16	.0000	.0000	0.63	0.6
22911	Apr. 20	V. slight.	Cons.	1.40	4.00	2.45	.0010	.0240	.0222	.0018	.14	.0030	.0000	1.24	0.8
23183	May 17	V. slight.	Cons.	2.00	4.50	2.75	.0006	.0306	.0302	.0004	.16	.0020	.0000	1.44	1.0
23504	June 13	None.	Slight.	2.20	5.00	2.75	.0006	.0322	.0314	.0008	.16	.0010	.0001	1.41	1.0
23927	July 19	Slight.	Slight.	1.80	5.65	3.05	.0034	.0418	.0386	.0032	.14	.0010	.0001	1.66	0.8
24287	Aug. 15	None.	V. slight.	2.84	8.95	5.90	.0052	.0638	.0612	.0026	.10	.0000	.0000	3.14	1.8
24671	Sept. 19	Slight.	Cons.	2.00	6.50	3.55	.0040	.0448	.0404	.0044	.11	.0000	.0000	1.97	1.8
25042	Oct. 17	V. slight.	Slight.	0.32	3.95	1.35	.0018	.0176	.0102	.0074	.19	.0020	.0000	0.43	1.3
25417	Nov. 17	V. slight.	V. slight.	0.22	3.10	1.10	.0000	.0042	.0042	.0000	.17	.0010	.0003	0.24	0.8
25610	Dec. 13	None.	V. slight.	0.12	3.05	1.00	.0002	.0046	.0042	.0004	.20	.0080	.0000	0.15	1.0
Av.*.	....	....	....	1.39	4.72	2.49	.0015	.0275	.0253	.0022	.16	.0027	.0000	1.22	1.1

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor, generally faintly vegetable, sometimes none. The odor of some of the samples became stronger and also musty on heating.

Chemical Examination of Water from Tributaries of Fosgate Brook.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
22017	Jan. 28	V. slight.	Cons.	0.20	2.15	0.75	.0002	.0062	.0060	.0002	.22	.0020	.0000	.22	0.8
22018	Jan. 28	V. slight.	Cons.	1.25	3.75	1.65	.0004	.0202	.0178	.0024	.21	.0020	.0000	.95	1.0

Odor, none, becoming vegetable on heating. —— The first sample was collected from the north branch of Fosgate Brook, just above its junction with the south branch; the second, from the south branch, just above its junction with the north branch. There is a considerable area of swamp upon the water-shed of the south branch.

HULL.

Water Supply of Hull.

(See *Hingham.*)

Huntington.

The advice of the State Board of Health to the water commissioners of the Huntington fire district, relative to a proposed system of water supply for the district, may be found on pages 24 to 26 of this volume. The results of analyses of samples of water collected from various sources in the town during the investigations in connection with the selection of a source of water supply are given in the following table: —

Chemical Examination of Water from Various Surface Water Sources in Huntington and Vicinity.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
23791	July 3	V. slight.	Slight.	0.95	4.15	2.75	.0054	.0292	.0274	.0018	.04	.0040	.0001	0.98	1.1
24529	Sept. 5	V. slight.	Slight.	0.85	5.35	2.40	.0014	.0238	.0232	.0006	.09	.0040	.0000	1.08	1.4
24530	Sept. 5	None.	V. slight.	0.27	3.00	1.15	.0004	.0072	.0062	.0010	.08	.0070	.0000	0.43	1.0
23792	July 4	None.	Slight.	0.14	3.75	1.75	.0002	.0048	.0038	.0010	.04	.0120	.0000	0.16	1.1
24528	Sept. 5	None.	V. slight.	0.17	3.50	1.00	.0002	.0038	.0034	.0004	.12	.0030	.0000	0.25	1.4
24531	Sept. 5	Slight.	Heavy.	1.30	7.40	3.65	.0084	.0392	.0296	.0096	.09	.0020	.0000	0.79	2.3
24067	July 26	V. slight.	V. slight.	0.19	3.95	1.55	.0002	.0090	.0074	.0016	.07	.0120	.0000	0.29	1.0
24527	Sept. 5	None.	None.	0.19	3.65	1.20	.0000	.0046	.0038	.0008	.14	.0050	.0000	0.28	1.0
23793	July 4	None.	Slight.	0.07	3.80	1.15	.0014	.0042	.0034	.0008	.09	.0070	.0002	0.09	1.6
23794	July 4	Decided.	Slight.	0.53	6.40	2.00	.0044	.0160	.0146	.0014	.09	.0060	.0000	0.54	2.9

Odor of No. 23791, faintly vegetable, becoming also musty on heating; No. 24529, none, becoming faintly unpleasant on heating; Nos. 24530, 23792, 24528, 24527 and 23793, none; No. 24531, faintly musty; No. 24067, none, becoming faintly vegetable on heating; No. 23794, distinctly vegetable.—— The first three samples were collected from Gold Mine Brook; the first and third being collected from a point near the mouth of the brook, the second from the upper end of the brook in Blandford at a point where water can be diverted into the water-shed of Cold Brook. Nos. 23792, 24528 and 24531 were collected from Cold Brook, at a point from which water can be distributed to the village of Huntington by gravity. Nos. 24067 and 24527 were collected from Black Brook in Blandford, near its upper end in the vicinity of a point where water can be diverted into the water-shed of Cold Brook. No. 23793 was collected from Cook Brook, near its mouth. The last sample was collected from Woodruff Brook, near its mouth.

HYDE PARK AND MILTON.

Water Supply of Hyde Park and Milton. — Hyde Park Water Company.

The source of supply is a system of tubular wells on the shore of the Neponset River in Hyde Park. Some of the wells are located close to the river, while others are situated at a considerable distance from it, and the character of the water drawn from the wells, as indicated by analyses of samples collected from different groups, varies greatly. The water contains a large amount of organic matter in the form of free ammonia, and also, at times, of iron.

Chemical Examination of Water from the Wells of the Hyde Park Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1898.												
21884	Jan. 18	V. slight.	Slight.	.05	10.50	.0106	.0038	1.46	.1520	.0008	.08	5.6	.0100
22215	Feb. 15	None.	None.	.05	11.40	.0104	.0048	1.40	.1900	.0006	.05	4.6	.0080
22553	Mar. 15	None.	V. slight.	.05	8.50	.0070	.0032	1.04	.1400	.0003	.10	3.8	.0070
22910	Apr. 20	None.	V. slight.	.05	9.90	.0098	.0030	1.18	.1640	.0002	.07	4.9	.0040
23186	May 17	None.	None.	.06	9.60	.0094	.0046	1.07	.1320	.0002	.11	4.0	.0030
23542	June 14	None.	None.	.05	9.50	.0100	.0046	1.02	.1420	.0002	.13	3.8	.0040
23946	July 20	None.	V. slight.	.07	10.80	.0136	.0046	1.12	.1140	.0002	.13	4.0	.0040
24301	Aug. 16	V. slight.	None.	.10	10.50	.0140	.0058	1.12	.0840	.0001	.18	4.7	.0120
24694	Sept. 20	V. slight.	V. slight.	.10	11.00	.0174	.0058	1.15	.0990	.0002	.15	4.7	.0150
25055	Oct. 18	V. slight.	V. slight.	.11	11.00	.0170	.0074	1.25	.0920	.0001	.17	4.4	.0260
25374	Nov. 15	V. slight, milky.	V. slight.	.14	10.50	.0146	.0044	1.19	.1180	.0001	.13	4.4	.0250
25706	Dec. 20	V. slight.	V. slight.	.09	10.20	.0100	.0034	1.05	.0980	.0008	.10	3.9	.0180
Av...	....	....	....	.08	10.28	.0120	.0046	1.17	.1271	.0003	.12	4.4	.0113

Odor, none. On heating, the odor of Nos. 25055 and 25374 became faintly unpleasant or disagreeable. —— The samples were collected from a faucet at the pumping station.

IPSWICH.

WATER SUPPLY OF IPSWICH.

The source of supply is a storage reservoir on Dow's Brook in Ipswich. The reservoir has an area of 17.5 acres, a maximum depth of 20 feet, an average depth of 9.6 feet and a storage capacity of 55,000,000 gallons. All of the soil and organic matter was removed from the area flooded. The water-shed of the reservoir has an area of 0.94 of a square mile, which contains a population of 48 per square mile. A large part of this population is located quite close to the shores of the reservoir, or near small brooks which enter the reservoir directly.

Chemical Examination of Water from Dow's Brook above the Storage Reservoir of the Ipswich Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21953	Jan. 24	Slight.	Cons.	0.60	2.65	1.50	.0010	.0434	.0144	.0290	.35	.0030	.0000	.58	1.0
22294	Feb. 21	V. slight.	V. slight.	0.56	4.20	1.70	.0004	.0100	.0088	.0012	.58	.0070	.0000	.43	1.3
22606	Mar. 21	V. slight.	V. slight.	0.60	3.35	1.25	.0000	.0110	.0096	.0014	.51	.0030	.0000	.47	1.1
22951	Apr. 25	Slight.	Cons.	1.10	3.35	1.70	.0012	.0246	.0176	.0070	.33	.0030	.0002	.95	0.6
23265	May 23	V. slight.	V. slight.	0.66	4.50	1.55	.0006	.0132	.0112	.0020	.53	.0040	.0000	.50	1.6
23609	June 20	Slight.	Slight.	0.37	4.60	1.75	.0012	.0250	.0202	.0048	.59	.0010	.0000	.46	1.6
24021	July 25	V. slight.	Slight.	0.50	5.30	2.00	.0010	.0148	.0116	.0032	.39	.0010	.0001	.56	1.6
24392	Aug. 22	V. slight.	V. slight.	0.72	5.05	2.00	.0010	.0184	.0170	.0014	.47	.0020	.0000	.46	1.4
24758	Sept. 26	Slight.	V. slight.	0.35	5.05	2.00	.0020	.0232	.0190	.0042	.58	.0030	.0000	.44	1.7
25135	Oct. 24	None.	V. slight.	0.85	4.95	2.60	.0000	.0136	.0126	.0010	.45	.0010	.0000	.96	1.3
25435	Nov. 21	V. slight.	V. slight.	0.90	4.15	1.90	.0002	.0166	.0132	.0034	.41	.0010	.0000	.91	1.0
25776	Dec. 27	V. slight.	V. slight.	0.30	3.85	1.45	.0002	.0060	.0058	.0002	.45	.0060	.0001	.33	1.4
Av...	....	....	....	0.63	4.25	1.78	.0007	.0183	.0134	.0049	.47	.0029	.0000	.59	1.3

Odor, generally none, occasionally faintly vegetable. On heating, the odor of some of the samples became distinctly vegetable and sometimes musty. —— The samples were collected from the brook, at its entrance to the storage reservoir.

IPSWICH.

Chemical Examination of Water from the Storage Reservoir of the Ipswich Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21954	Jan. 24	Slight.	V. slight.	.41	4.15	1.50	.0006	.0170	.0158	.0012	.61	.0080	.0000	.41	1.7
22295	Feb. 21	V. slight.	V. slight.	.40	4.05	1.65	.0020	.0114	.0090	.0024	.66	.0070	.0000	.32	1.0
22607	Mar. 21	Slight.	Slight.	.49	4.15	1.50	.0016	.0144	.0126	.0018	.62	.0060	.0000	.38	1.6
22952	Apr. 25	Slight.	Slight.	.50	4.60	1.45	.0014	.0168	.0134	.0034	.60	.0050	.0001	.42	1.3
23266	May 23	V. slight.	V. slight.	.44	4.00	1.25	.0014	.0184	.0142	.0042	.61	.0060	.0001	.43	1.4
23608	June 20	V. slight.	Slight.	.38	4.70	1.75	.0014	.0190	.0174	.0016	.58	.0020	.0000	.46	1.6
24022	July 25	Slight.	Slight.	.30	4.95	1.85	.0012	.0222	.0186	.0036	.49	.0000	.0000	.44	1.6
24393	Aug. 22	Slight.	Slight.	.41	5.20	2.15	.0014	.0264	.0248	.0016	.46	.0040	.0002	.54	1.6
24759	Sept. 26	Slight.	Slight.	.32	5.05	2.10	.0018	.0218	.0184	.0034	.51	.0020	.0000	.47	1.8
25136	Oct. 24	Decided.	Slight.	.89	6.20	2.65	.0076	.0316	.0212	.0104	.46	.0050	.0001	.99	1.6
25436	Nov. 21	Slight.	V. slight.	.63	5.05	1.80	.0026	.0172	.0144	.0028	.48	.0070	.0000	.62	1.6
25777	Dec. 27	Slight.	V. slight.	.41	4.80	1.80	.0010	.0126	.0122	.0004	.50	.0060	.0003	.43	1.6
Av...	....	....	....	.46	4.74	1.79	.0020	.0191	.0160	.0031	.55	.0048	.0001	.49	1.5

Odor, generally none, occasionally faintly vegetable or musty. On heating, the odor became vegetable or musty.

Miscroscopical Examination of Water from the Storage Reservoir of the Ipswich Water Works.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, ...	25	23	22	26	23	21	25	23	27	25	22	28
Number of sample, ...	21954	22295	22607	22952	23266	23608	24022	24393	24759	25136	25436	25777
PLANTS.												
Diatomaceæ, ...	0	2	6	12	25	14	2	94	4	20	9	14
Synedra, ...	0	0	5	8	21	12	2	92	1	10	8	14
Algæ, ...	0	0	0	4	45	68	10	0	0	1	0	0

IPSWICH.

Microscopical Examination of Water from the Storage Reservoir of the Ipswich Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Infusoria,	13	0	7	8	15	972	504	2	70	8	1	0
Dinobryon,	0	0	0	6	15	964	480	0	0	6	0	0
Mallomonas,	0	0	0	0	0	0	14	0	70	2	1	0
Peridinium,	13	0	7	1	0	6	8	2	0	0	0	0
Vermes,	1	0	0	0	1	0	4	0	1	0	0	0
Crustacea, Bosmina,	0	0	0	0	0	0	0	0	0	pr.	0	0
Miscellaneous, Zoöglœa,	3	3	3	5	5	3	15	10	3	60	5	0
TOTAL,	17	5	16	29	91	1,057	535	106	78	89	15	14

WATER SUPPLY OF KINGSTON.

Chemical Examination of Water from Faucets supplied from the Kingston Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
23315	Feb. 21	None.	None.	.01	4.70	.0002	.0010	.73	.0130	.0000	.03	1.0	.0020
22463	Mar. 7	None.	None.	.00	5.10	.0000	.0010	.72	.0070	.0000	.01	1.1	.0040
24628	Sept. 12	None.	None.	.01	6.50	.0000	.0000	.75	.0100	.0000	.06	1.3	.0000
25255	Nov. 1	None.	None.	.02	4.30	.0000	.0002	.78	.0080	.0000	.02	1.1	.0010
Av.	....	....	....	.01	5.15	.0000	.0005	.74	.0095	.0000	.03	1.1	.0017

Odor, none.

WATER SUPPLY OF LANCASTER.

(See *Clinton*.)

Water Supply of Lawrence.

The source of supply is the Merrimack River, above the thickly populated portion of the city. The river water is filtered through a sand filter having an area of 2.5 acres, which has been fully described on page 543 of the annual report for 1893. The filtered water is pumped to a large open distributing reservoir. The results obtained by the use of the filter are shown in a subsequent portion of this report upon the purification of water.

The advice of the State Board of Health to the city of Lawrence, relative to increasing the capacity of the Lawrence city filter, may be found on pages 26 to 28 of this volume.

Chemical Examination of Water from the Merrimack River above Lawrence, opposite the Intake of the Lawrence Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21908	Jan. 19	Slight.	Slight.	.41	3.65	1.45	.0016	.0170	.0150	.0020	.24	.0090	.0002	.45	1.6
22237	Feb. 16	Decided.	Slight.	.43	3.75	1.50	.0040	.0156	.0138	.0018	.25	.0090	.0002	.42	1.1
22580	Mar. 16	Decided.	Cons.	.44	2.65	1.00	.0018	.0176	.0108	.0068	.11	.0050	.0000	.46	0.6
22882	Apr. 19	Slight.	Cons.	.50	3.05	1.40	.0010	.0150	.0112	.0038	.13	.0020	.0000	.49	0.5
23206	May 18	Slight.	Cons.	.57	3.05	1.45	.0028	.0160	.0128	.0032	.17	.0080	.0001	.52	1.1
23570	June 15	Slight.	Cons.	.45	3.90	1.40	.0034	.0250	.0192	.0058	.20	.0070	.0004	.46	1.0
23971	July 20	Decided.	Cons.	.31	4.40	1.95	.0128	.0232	.0182	.0050	.25	.0060	.0003	.39	1.3
24339	Aug. 17	Slight.	Cons.	.50	4.80	2.05	.0120	.0304	.0242	.0062	.27	.0010	.0004	.62	1.4
24713	Sept. 21	Slight.	Cons.	.34	4.55	1.70	.0096	.0274	.0192	.0082	.28	.0050	.0004	.44	1.4
25105	Oct. 18	V. slight.	V. slight.	.52	4.95	2.20	.0058	.0234	.0186	.0048	.28	.0050	.0018	.79	1.6
25396	Nov. 16	Slight.	Slight.	.51	4.15	1.90	.0022	.0276	.0254	.0022	.22	.0060	.0000	.82	1.0
25725	Dec. 21	Slight.	V. slight.	.41	3.95	1.55	.0032	.0166	.0140	.0026	.20	.0070	.0002	.47	1.0
Av...	....	....	....	.45	3.90	1.63	.0050	.0212	.0169	.0043	.22	.0058	.0003	.53	1.1

Odor, faintly vegetable or musty. —— The samples were collected from the river, opposite the intake of the Lawrence water works, about 1 foot beneath the surface. For a comparison of the analyses of the river water at Lowell and Lawrence for a series of years, see "Merrimack River," in the chapter on "Examination of Rivers."

LAWRENCE.

Chemical Examination of Water from the Merrimack River after passing through the Sand Filter of the Lawrence Water Works.

[Parts per 100,000.]

		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as			
								Albuminoid.							
Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21909	Jan. 19	V. slight.	V. slight.	.50	4.50	1.90	.0098	.0082	.0070	.0012	.29	.0220	.0001	.38	1.8
22239	Feb. 16	Decided.	Cons., floc.	.60	5.40	1.50	.0208	.0094	.0088	.0006	.30	.0360	.0001	.31	2.3
22581	Mar. 16	V. slight.	Slight.	.60	3.85	1.45	.0138	.0066	.0064	.0002	.18	.0320	.0000	.32	2.0
22883	Apr. 19	V. slight.	None.	.40	3.35	1.30	.0054	.0062	.0062	.0000	.17	.0180	.0000	.34	1.1
23207	May 18	Slight.	Slight.	.40	5.45	1.70	.0130	.0072	.0068	.0004	.28	.0870	.0001	.26	2.5
23571	June 15	Slight.	Slight.	.30	3.75	1.25	.0044	.0080	.0074	.0006	.23	.0240	.0000	.31	1.6
23972	July 20	Slight.	None.	.17	4.05	1.50	.0036	.0058	.0054	.0004	.26	.0220	.0000	.23	1.7
24340	Aug. 17	Slight.	V. slight.	.42	5.10	2.25	.0048	.0150	.0140	.0010	.36	.0130	.0000	.46	2.0
24714	Sept. 21	Slight.	V. slight.	.30	5.15	1.70	.0076	.0098	.0096	.0002	.34	.0320	.0001	.29	2.0
25106	Oct. 18	Slight.	Cons., floc.	.40	7.05	2.15	.0272	.0088	.0078	.0010	.38	.0620	.0001	.33	2.9
25468	Nov. 23	Slight.	V. slight.	.70	3.90	1.90	.0094	.0134	.0130	.0004	.16	.0130	.0000	.62	1.6
25726	Dec. 21	V. slight.	None.	.41	4.40	1.70	.0088	.0092	.0086	.0006	.22	.0280	.0002	.40	1.7
Av...	....	....	....	.43	4.66	1.69	.0107	.0090	.0084	.0006	.26	.0324	.0001	.35	1.9

Odor of No. 25106, faintly musty and unpleasant, becoming stronger on heating; of the others, none. —— The samples were collected from a faucet in the check valve, just beyond the pump.

Chemical Examination of Water from the Distributing Reservoir of the Lawrence Water Works.

[Parts per 100,000.]

		Appearance.			Residue on Evaporation.		Ammonia.					Nitrogen as			
								Albuminoid.							
Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21910	Jan. 19.	V. slight.	V. slight.	.42	4.50	1.70	.0078	.0098	.0098	.0000	.26	.0240	.0001	.31	2.1
22238	Feb. 16.	Slight.	V. slight.	.50	4.45	1.45	.0080	.0100	.0090	.0010	.27	.0280	.0000	.30	2.0
22582	Mar. 16.	Decided.	None.	.45	4.05	1.55	.0076	.0084	.0084	.0000	.23	.0300	.0000	.30	2.0
22884	Apr. 19.	V. slight.	V. slight.	.31	3.20	1.00	.0034	.0070	.0062	.0008	.20	.0160	.0001	.29	1.1
23208	May 18.	V. slight.	V. slight.	.38	3.55	1.65	.0012	.0086	.0074	.0012	.19	.0240	.0000	.29	1.6
23572	June 15.	None.	V. slight	.29	3.40	1.15	.0018	.0086	.0078	.0008	.19	.0270	.0000	.29	1.4
23973	July 20.	V. slight.	V. slight.	.20	4.35	1.70	.0024	.0084	.0076	.0008	.23	.0210	.0002	.25	1.7
24341	Aug. 17.	Slight.	Slight.	.20	4.40	1.80	.0106	.0308	.0122	.0186	.30	.0240	.0004	.26	1.7
24715	Sept. 21.	V. slight.	V. slight.	.25	4.80	1.50	.0034	.0138	.0128	.0010	.29	.0230	.0002	.32	1.7
25107	Oct. 18.	V. slight.	V. slight.	.31	4.65	1.85	.0012	.0128	.0108	.0020	.30	.0200	.0001	.54	1.6
25398	Nov. 16.	V. slight.	V. slight.	.42	4.40	1.75	.0032	.0128	.0120	.0008	.22	.0140	.0000	.50	1.7
25727	Dec. 21.	V. slight.	V. slight.	.43	4.70	1.60	.0068	.0124	.0108	.0016	.21	.0190	.0001	.44	1.6
Av...	....	....	....	.35	4.20	1.56	.0048	.0120	.0096	.0024	.24	.0225	.0001	.34	1.7

Odor of No. 25398, faintly musty; of the others, none, becoming faintly vegetable on heating. —— The samples were collected from a faucet at the gate-house, and represent water flowing out of the reservoir. The reservoir is supplied with filtered water.

Water Supply of Lee. — Berkshire Water Company.

Chemical Examination of Water from the Upper Reservoir of the Berkshire Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
22998	Apr. 27	Slight.	Slight.	.20	2.15	1.00	.0004	.0154	.0112	.0042	.06	.0020	.0000	.38	0.6
23420	June 7	Slight.	Slight.	.38	2.25	1.10	.0004	.0202	.0138	.0064	.06	.0000	.0001	.44	0.5
24569	Sept. 6	V. slight.	Slight.	.48	2.45	1.60	.0038	.0288	.0216	.0072	.10	.0000	.0000	.69	0.3
25161	Oct. 25	V. slight.	V. slight.	.41	2.75	1.95	.0000	.0356	.0258	.0098	.08	.0010	.0000	.75	0.5
25578	Dec. 6	V. slight.	V. slight.	.23	2.45	1.05	.0018	.0076	.0060	.0016	.06	.0010	.0000	.40	0.5
Av...	....	....	....	.34	2.41	1.34	.0013	.0215	.0157	.0058	.07	.0008	.0000	.53	0.5

Odor, faintly vegetable, becoming stronger on heating; in September, faintly unpleasant; and in October, faintly disagreeable.

Chemical Examination of Water from the Lower Reservoir of the Berkshire Water Company.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
Average of five samples collected in April, June, September, October and December, 1898.	.28	3.34	1.43	.0004	.0114	.0096	.0018	.06	.0026	.0000	.40	1.4

Odor in April, faintly vegetable, becoming distinctly vegetable and faintly fishy on heating; in June, none, becoming faintly musty on heating; in September, none; in October, faintly vegetable; in December, distinctly disagreeable.

LEICESTER.

Water Supply of Leicester Water Supply District, Leicester.

Chemical Examination of Water from the Wells of the Leicester Water Supply District.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of three samples collected in January, May and September, 1898.	.10	4.97	.0003	.0028	.28	.0747	.0000	.12	2.0	.0033

Odor, none. —— The samples were collected from a faucet in the village.

Water Supply of Lenox. — Lenox Water Company.

The source of supply is a storage reservoir on the head waters of Williams River. The reservoir has an area of 7 acres, an average depth of about 9 feet, a storage capacity of 20,000,000 gallons and a water-shed of 0.61 of a square mile. The water-shed contains a population of about 17 per square mile.

The advice of the State Board of Health to the Lenox Water Company, relative to improving the quality of the water supplied to the town, may be found on pages 28 to 30 of this volume.

Chemical Examination of Water from the Inlet to the Reservoir of the Lenox Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
22095	Feb. 7	V. slight.	Slight.	.06	6.30	0.80	.0002	.0024	.0024	.0000	.08	.0130	.0003	.07	5.3
22784	Apr. 7	V. slight.	Slight.	.05	6.35	0.85	.0004	.0034	.0028	.0006	.08	.0070	.0000	.09	4.3
23716	June 27	V. slight.	Slight.	.09	8.55	0.75	.0004	.0046	.0040	.0006	.07	.0020	.0000	.07	5.9
24411	Aug. 22	V. slight.	V. slight.	.10	7.80	1.35	.0036	.0144	.0128	.0016	.06	.0010	.0000	.20	6.3
24875	Sept. 29	V. slight.	Slight.	.09	10.75	1.45	.0002	.0072	.0050	.0022	.10	.0020	.0000	.11	7.9
25181	Oct. 25	None.	V. slight.	.09	8.10	1.00	.0004	.0028	.0020	.0008	.08	.0010	.0000	.15	5.6
25764	Dec. 23	None.	V. slight.	.06	3.00	0.85	.0004	.0026	.0024	.0002	.05	.0010	.0000	.10	2.1
Av.	....	....	....	.08	7.26	1.01	.0008	.0053	.0045	.0008	.07	.0039	.0000	.11	5.3

Odor, none.

LENOX.

Chemical Examination of Water from the Storage Reservoir of the Lenox Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21988	Jan. 24.	V. slight.	V. slight.	.06	5.90	0.85	.0002	.0030	.0030	.0000	.09	.0080	.0000	.16	4.6
22785	April 7.	Slight.	Slight.	.06	5.55	0.75	.0000	.0036	.0026	.0010	.08	.0030	.0000	.08	4.0
23717	June 27.	Slight.	Slight.	.09	8.10	0.85	.0022	.0144	.0098	.0046	.07	.0010	.0000	.16	5.4
24412	Aug. 22.	V. slight.	V. slight.	.10	9.50	1.25	.0044	.0232	.0224	.0008	.08	.0030	.0000	.24	6.7
24876	Sept. 29.	V. slight.	V. slight.	.06	10.05	1.60	.0008	.0086	.0060	.0026	.08	.0000	.0000	.15	7.9
25182	Oct. 25.	None	V. slight.	.12	8.50	1.25	.0002	.0068	.0060	.0008	.09	.0020	.0000	.20	6.0
25620	Dec. 11.	V. slight.	None.	.08	7.85	0.85	.0004	.0086	.0084	.0002	.08	.0070	.0000	.12	6.0
Av...	....	....	....	.08	7.92	1.06	.0012	.0097	.0083	.0014	.08	.0034	.0000	.16	5.8

Odor, none. —— The samples were collected from the reservoir on Williams River, near its outlet.

Water Supply of Leominster.

The sources of supply are Morse, Haynes and Fall Brook reservoirs. Haynes Reservoir has an area of 58 acres, a maximum depth of 12 feet and a capacity of 140,000,000 gallons. A large portion of the area of the reservoir is flooded to a slight depth when the reservoir is full. The bottom was originally swampy, and none of the soil was removed when the reservoir was constructed. The drainage area of the reservoir is 0.49 of a square mile, which contains a population of 30 per square mile.

Morse reservoir has a maximum depth of 23 feet and a capacity of 40,000,000 gallons. Its bottom is said to be sandy, but a large portion of the reservoir is quite shallow. The water-shed contains no population.

Fall Brook Reservoir was constructed in 1896. It has an area of 82.5 acres, an average depth of 14.3 feet, a maximum depth of 28 feet and a storage capacity of 386,000,000 gallons. The soil and organic matter were removed from all of the area flowed with the exception of about 20 acres, where the mud was so deep that it was not removed, but was covered with gravel to a depth of from

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15 to 18 inches. The reservoir has a water-shed of 1.26 square miles, which contains a population of 20 per square mile.

The water of Haynes Reservoir has always given much trouble, as it contains at times very large quantities of organic matter, much of which is in the form of microscopical organisms. The water of Morse Reservoir is of much better quality, although it is affected unfavorably by the water of Haynes Reservoir, which is diverted into it at times. The water of Fall Brook Reservoir has always been of good quality, and its quality has improved each year since the reservoir was first filled in 1896.

Chemical Examination of Water from Haynes Reservoir, Leominster.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21975	Jan. 25	Slight.	Slight.	.31	2.35	1.00	.0006	.0242	.0220	.0022	.20	.0030	.0001	.40	0.6
22629	Mar. 22	Slight.	Slight.	.20	1.75	0.95	.0074	.0130	.0108	.0022	.11	.0000	.0000	.31	0.8
23291	May 24	Slight.	Slight.	.41	2.20	1.35	.0008	.0318	.0208	.0110	.12	.0000	.0000	.36	0.5
24054	July 26	Slight.	Cons.	.33	2.75	1.35	.0002	.0338	.0252	.0086	.15	.0010	.0001	.41	0.2
24800	Sept. 27	Slight.	Cons.	.20	2.35	1.50	.0004	.0418	.0246	.0172	.14	.0050	.0000	.40	0.3
25466	Nov. 22	Slight.	Cons.	.30	2.50	1.70	.0002	.0312	.0206	.0106	.12	.0020	.0000	.42	0.3
Av...	....	....	....	.29	2.32	1.31	.0016	.0293	.0207	.0086	.14	.0018	.0000	.38	0.4

Odor, faintly vegetable or none. On heating, the odor in some of the samples became stronger; in January, also faintly fishy; and in November, disagreeable. —— The samples were collected from the reservoir.

Microscopical Examination of Water from Haynes Reservoir, Leominster.

[Number of organisms per cubic centimeter.]

	1898.					
	January.	March.	May.	July.	Sept.	Nov.
Date of examination,	26	23	25	27	28	23
Number of sample,	21975	22629	23291	24054	24800	25466
PLANTS.						
Diatomaceæ,	**0**	**19**	**1,716**	**156**	**852**	**5,866**
Asterionella,	0	0	88	16	86	5,200
Melosira,	0	0	52	22	108	16
Tabellaria,	pr.	16	1,576	118	644	644

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Microscopical Examination of Water from Haynes Reservoir, Leominster — Concluded.

[Number of organisms per cubic centimeter.]

	1898.					
	January.	March.	May.	July.	Sept.	Nov.
PLANTS — Con.						
Cyanophyceæ,	0	0	2	6	224	6
Anabæna,	0	0	0	0	62	0
Clathrocystis,	0	0	0	6	162	4
Algæ,	0	1	606	524	156	134
Cœlastrum,	0	0	0	418	108	80
Protococcus,	0	0	600	62	0	0
Staurastrum,	0	0	2	26	8	18
ANIMALS.						
Infusoria,	6	5	750	30	25	234
Dinobryon,	0	0	740	26	20	228
Vermes,	1	0	8	0	4	2
Crustacea, Cyclops,	0	0	0	0	pr.	0
Miscellaneous, Zoöglœa,	1	8	10	10	5	7
TOTAL,	8	33	3,092	726	1,266	6,249

Chemical Examination of Water from Morse Reservoir, Leominster.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21974	Jan. 25	Slight.	V slight.	.34	2.25	0.80	.0034	.0202	.0168	.0034	.19	.0030	.0001	.40	1.4
22630	Mar. 22	Slight.	Slight.	.30	1.80	0.90	.0052	.0128	.0102	.0026	.12	.0000	.0000	.30	0.8
23292	May 24	Slight.	Cons.	.29	2.00	1.00	.0012	.0204	.0160	.0044	.11	.0000	.0000	.29	0.5
24053	July 26	Slight.	Slight.	.29	1.75	0.95	.0012	.0252	.0210	.0042	.10	.0000	.0000	.39	0.0
24799	Sept. 27	V.slight.	Slight.	.35	2.40	1.45	.0038	.0252	.0210	.0042	.13	.0010	.0000	.43	0.3
25465	Nov. 22	Slight.	Cons.	.31	2.00	1.25	.0006	.0200	.0154	.0046	.12	.0020	.0000	.45	0.3
Av...	....	....	....	.31	2.03	1.06	.0026	.0206	.0167	.0039	.13	.0010	.0000	.38	0.5

Odor, faintly vegetable, sometimes none. The odor of all of the samples was faintly vegetable when heated. —— The samples were collected from the reservoir.

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Microscopical Examination of Water from Morse Reservoir, Leominster.

[Number of organisms per cubic centimeter.]

	1898.					
	January.	March.	May.	July.	Sept.	Nov.
Day of examination,	26	23	25	27	28	23
Number of sample,	21974	22630	23292	24053	24799	25465
PLANTS.						
Diatomaceæ,	4	3	518	62	104	2,839
Asterionella,	0	0	0	0	26	2,753
Tabellaria,	4	1	508	60	45	85
Cyanophyceæ,	0	0	0	0	8	4
Algæ,	0	0	10	16	18	10
ANIMALS.						
Rhizopoda,	pr.	0	0	0	0	0
Infusoria,	pr.	0	2,998	8	20	55
Dinobryon,	0	0	2,976	4	18	51
Mallomonas,	0	0	22	0	2	0
Vermes,	pr.	0	0	2	0	0
Crustacea, Cyclops,	0	0	0	pr.	pr.	0
Miscellaneous, Zoöglœa,	2	3	3	5	8	5
TOTAL,	6	6	3,529	93	158	2,913

Chemical Examination of Water from Fall Brook, above the Fall Brook Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21971	Jan 25	V. slight.	Cons., floc.	.48	2.50	1.00	.0002	.0116	.0102	.0014	.16	.0050	.0001	.45	1.1
22304	Feb. 22	V. slight.	V. slight.	.42	2.35	1.15	.0002	.0070	.0068	.0002	.18	.0070	.0000	.36	0.5
22626	Mar. 22	None.	V. slight.	.45	1.60	0.75	.0004	.0084	.0080	.0004	.12	.0020	.0000	.38	0.5
22970	Apr. 26	V. slight.	V. slight.	.60	1.95	1.15	.0000	.0106	.0094	.0012	.12	.0030	.0000	.53	0.6
23288	May 24	V. slight.	Slight.	.65	2.25	1.25	.0010	.0184	.0160	.0024	.15	.0020	.0000	.56	0.5
23623	June 21	V. slight.	Slight.	.52	3.10	1.55	.0004	.0128	.0110	.0018	.13	.0050	.0000	.61	1.0
24050	July 26	V. slight.	V. slight.	.15	2.25	1.15	.0024	.0164	.0140	.0024	.11	.0010	.0000	.29	0.5
24398	Aug. 23	V. slight.	V. slight.	.55	3.40	1.80	.0002	.0178	.0164	.0014	.10	.0020	.0001	.74	0.8
24796	Sept. 27	V. slight.	V. slight.	.32	3.05	1.55	.0002	.0150	.0136	.0014	.15	.0050	.0001	.46	0.6
25154	Oct. 25	V. slight.	V. slight.	.63	2.90	1.85	.0000	.0126	.0118	.0008	.11	.0030	.0000	.70	0.3
25462	Nov. 22	None.	V. slight.	.41	2.50	1.35	.0006	.0106	.0092	.0014	.14	.0020	.0000	.56	0.3
25672	Dec 19	V. slight.	V. slight.	.31	2.60	1.10	.0002	.0130	.0102	.0028	.15	.0050	.0001	.40	0.5
Av...	1898	....	....	.46	2.54	1.30	.0005	.0129	.0114	.0015	.13	.0035	.0000	.50	0.6
Av...	1897	....	....	.61	3.01	1.49	.0006	.0135	.0126	.0009	.16	.0041	.0000	.60	0.5

NOTE to analyses of 1898: Odor, faintly vegetable or none. —— The samples were collected from Fall Brook, as it enters the reservoir.

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Chemical Examination of Water from Fall Brook Reservoir, Leominster.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21972	Jan. 25	Slight.	Slight.	.37	2.65	1.10	.0014	.0230	.0188	.0042	.23	.0060	.0001	.43	1.1
22305	Feb. 22	V. slight.	Slight.	.40	2.80	1.10	.0028	.0144	.0114	.0030	.20	.0070	.0000	.40	0.5
22627	Mar. 22	V. slight.	V. slight.	.36	2.00	1.00	.0002	.0132	.0108	.0024	.17	.0060	.0000	.34	1.0
22971	April 26	Slight.	Slight.	.26	2.60	1.25	.0006	.0156	.0124	.0032	.19	.0060	.0001	.34	0.5
23289	May 24	V slight.	Cons.	.29	2.45	1.25	.0026	.0196	.0138	.0058	.17	.0030	.0000	.31	0.5
23624	June 21	None.	V. slight.	.17	2.05	1.00	.0010	.0122	.0104	.0018	.16	.0030	.0001	.30	0.5
24051	July 26	V. slight	V. slight.	.16	2.25	1.35	.0018	.0184	.0160	.0024	.12	.0010	.0000	.30	0.3
24399	Aug. 23	V. slight.	V. slight.	.15	2.20	0.90	.0018	.0162	.0152	.0010	.13	.0010	.0000	.33	0.3
24797	Sept. 27	V. slight.	Slight.	.19	2.15	1.20	.0002	.0174	.0154	.0020	.14	.0020	.0001	.30	0.3
25155	Oct. 25	V. slight.	Slight.	.23	2.25	1.45	.0002	.0166	.0142	.0024	.12	.0030	.0000	.38	0.3
25463	Nov. 22	V. slight	Slight.	.29	2.25	1.25	.0006	.0172	.0138	.0034	.15	.0020	.0001	.42	0.3
25673	Dec. 19	V. slight.	Slight.	.30	2.50	1.10	.0006	.0188	.0150	.0038	.13	.0040	.0002	.36	0.3
Av...	....	....	....	.26	2.35	1.16	.0011	.0169	.0139	.0030	.16	.0037	.0001	.35	0.5

Odor, frequently faintly vegetable, occasionally none, sometimes musty. —— The samples were collected from the reservoir, at the gate-house, 1 foot beneath the surface.

Microscopical Examination of Water from Fall Brook Reservoir, Leominster.

[Number of organisms per cubic centimeter.]

	1898. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec.
Day of examination,	26	23	23	27	25	22	27	24	28	26	23	20
Number of sample,	21972	22305	22627	22971	23289	23624	24051	24399	24797	25155	25463	25673
PLANTS.												
Diatomaceæ,	**82**	**0**	**12**	**146**	**504**	**2**	**0**	**11**	**3**	**2,360**	**4,020**	**649**
Asterionella,	0	0	0	0	0	0	0	0	2	2,360	4,000	642
Synedra,	82	0	7	120	480	2	0	5	1	0	1	4
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**25**	**5**	**20**	**2**
Anabæna,	0	0	0	0	0	0	0	3	0	5	20	2
Merismopœdia,	0	0	0	0	0	0	0	0	25	0	0	0
Algæ,	**0**	**0**	**0**	**1**	**322**	**53**	**400**	**1**	**6**	**16**	**0**	**0**
Protococcus,	0	0	0	0	140	53	400	0	0	0	0	0
Raphidium,	0	0	0	0	176	0	0	0	6	16	0	0
Fungi,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**0**	**0**

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Microscopical Examination of Water from Fall Brook Reservoir, Leominster — Concluded.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.
ANIMALS.												
Rhizopoda,	0	0	0	0	0	0	0	1	0	0	0	0
Infusoria,	0	0	10	38	6	0	0	3	100	56	32	13
Cryptomonas,	0	0	10	0	0	0	0	0	0	2	3	0
Dinobryon,	0	0	0	38	4	0	0	0	94	40	7	9
Vermes,	1	0	0	0	0	1	0	0	0	0	2	0
Crustacea, Cyclops,	0	pr.	0	0	pr.	0	0	pr.	0	0	0	0
Miscellaneous, Zoögloea,	2	0	5	5	5	3	3	5	5	5	5	5
TOTAL,	85	0	27	190	837	59	403	30	139	2,442	4,079	669

Chemical Examination of Water from Fall Brook Reservoir, Leominster, collected near the Bottom.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21973	Jan. 25	V. slight.	V. slight.	.31	2.75	1.25	.0022	.0188	.0166	.0022	.23	.0070	.0001	.38	0.8
22306	Feb. 22	V. slight.	Slight.	.39	2.65	1.05	.0016	.0144	.0114	.0030	.19	.0080	.0000	.39	0.5
22628	Mar. 22	V. slight.	Slight.	.34	2.35	1.05	.0008	.0150	.0120	.0030	.18	.0070	.0000	.34	0.8
22972	Apr. 26	Slight.	Slight.	.26	2.35	1.10	.0006	.0136	.0106	.0030	.18	.0070	.0001	.34	0.8
23290	May 24	V. slight.	Cons.	.21	2.00	1.00	.0028	.0178	.0134	.0044	.19	.0030	.0000	.31	0.5
23625	June 21	None.	V. slight.	.19	2.05	1.00	.0008	.0120	.0114	.0006	.16	.0060	.0000	.30	0.5
24052	July 26	V. slight.	V. slight.	.19	2.20	1.40	.0036	.0160	.0144	.0016	.13	.0000	.0000	.29	0.3
24400	Aug. 23	V. slight.	Cons.	.18	2.05	1.10	.0024	.0224	.0154	.0070	.14	.0010	.0000	.34	0.6
24798	Sept. 27	V. slight.	Slight.	.19	2.30	1.15	.0016	.0190	.0160	.0030	.14	.0050	.0000	.33	0.5
25156	Oct. 25	Slight.	Slight.	.27	2.55	1.75	.0000	.0180	.0150	.0030	.12	.0020	.0000	.34	0.3
25464	Nov. 22	V. slight.	V. slight.	.29	2.25	1.20	.0004	.0172	.0146	.0026	.16	.0010	.0001	.40	0.5
25674	Dec. 19	V. slight	Slight.	.29	2.70	1.35	.0008	.0176	.0156	.0020	.15	.0010	.0001	.36	0.5
Av...	....	....	....	.26	2.35	1.20	.0015	.0168	.0139	.0029	.16	.0040	.0000	.34	0.5

Odor, generally faintly vegetable or none, sometimes musty. —— The samples were collected from the reservoir, near the gate-house, about 1 foot from the bottom.

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Microscopical Examination of Water from Fall Brook Reservoir Leominster, collected near the Bottom.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	26	23	23	27	25	22	27	24	28	26	23	20
Number of sample,	21973	22306	22628	22972	23290	23625	24052	24400	24798	25156	25464	25674
PLANTS.												
Diatomaceæ,	34	1	6	115	74	4	1	0	7	1,526	4,820	1,116
Asterionella,	0	0	0	0	0	0	0	0	4	1,524	4,820	1,113
Synedra,	34	0	5	100	64	4	1	0	1	0	0	3
Cyanophyceæ,	0	0	0	0	0	0	0	0	15	0	10	0
Anabæna,	0	0	0	0	0	0	0	0	0	0	10	0
Merismopœdia,	0	0	0	0	0	0	0	0	15	0	0	0
Algæ,	0	12	0	1	142	47	120	0	7	0	0	0
Protococcus,	0	12	0	0	70	47	120	0	0	0	0	0
Raphidium,	0	0	0	0	68	0	0	0	7	0	0	0
Fungi, Crenothrix,	0	0	0	0	0	0	0	500	0	0	0	0
ANIMALS.												
Infusoria,	0	0	0	72	0	29	1	1	98	68	19	10
Dinobryon,	0	0	0	72	0	29	1	0	88	50	3	3
Syncrypta,	0	0	0	0	0	0	0	0	8	12	0	0
Vermes,	1	1	0	2	0	0	0	0	1	2	1	1
Crustacea, Cyclops,	0	0	pr.	pr.	0	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	2	3	5	5	8	3	5	5	5	5	5	5
TOTAL,	37	17	11	195	224	83	127	506	133	1,601	4,855	1,132

WATER SUPPLY OF LEXINGTON.

The water supply is taken from large wells and tubular wells in a meadow in the valley of Vine Brook and from a storage reservoir on Vine Brook about a mile above the wells. The storage reservoir has an area of 5½ acres, a capacity of 14,000,000 gallons and a water-shed of 0.3 of a square mile, which contains a population of about 30 per square mile. The water of the reservoir contains so much organic matter and is otherwise of such poor

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quality that it is used only when the yield from the wells is insufficient for the supply of the town. The wells, from which the supply is ordinarily obtained, furnish water which is very highly colored and contains a large amount of organic matter. In 1897 a mechanical filter was introduced, the water being passed through a bed of charcoal.

The advice of the State Board of Health to the water commissioners of Lexington, relative to the advisability of allowing ice to be cut from the reservoir of the Lexington water works, may be found on page 125 of this volume.

Chemical Examination of Water from Vine Brook, above the Storage Reservoir of the Lexington Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
22206	Feb. 14	None.	V. slight.	.39	5.85	1.95	.0024	.0154	.0124	.0030	.52	.0950	.0000	.35	2.1
22285	Feb. 18	V. slight.	V. slight.	.23	4.45	1.95	.0002	.0124	.0106	.0018	.42	.0600	.0000	.28	1.4
22986	Apr. 27	Decided.	Slight.	.41	4.50	1.80	.0002	.0260	.0180	.0080	.40	.0140	.0001	.42	1.3
23306	May 25	Decided.	Cons.	.52	4.80	2.05	.0016	.0500	.0298	.0202	.39	.0030	.0002	.61	1.6
23665	June 22	Decided.	Cons.	.37	5.75	2.10	.0114	.0186	.0126	.0060	.52	.0330	.0006	.37	1.8
24060	July 27	Decided.	Cons.	.40	7.75	3.25	.0116	.0166	.0116	.0050	.46	.0320	.0010	.45	2.1
24465	Aug. 29	Slight.	V. slight.	.18	6.95	2.10	.0038	.0106	.0078	.0028	.54	.0690	.0004	.20	2.2
24812	Sept. 28	Decided.	Cons., green.	.50	7.60	3.70	.0056	.0468	.0296	.0172	.40	.0240	.0008	.96	2.3
25172	Oct. 26	V. slight.	V. slight.	.27	6.70	1.85	.0012	.0134	.0114	.0020	.48	.0740	.0002	.36	2.1
25460	Nov. 22	V. slight.	V. slight.	.30	5.90	2.30	.0010	.0116	.0102	.0014	.49	.0410	.0001	.38	2.0
25784	Dec. 27	V. slight.	V. slight.	.33	4.15	1.80	.0000	.0112	.0106	.0006	.33	.0040	.0002	.41	1.1
Av.*	....	....	....	.36	5.92	2.29	.0038	.0219	.0153	.0066	.45	.0371	.0004	.45	1.8

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor, vegetable and occasionally none; sometimes musty or mouldy; in October, faintly unpleasant, becoming distinctly unpleasant and fishy on heating.

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Chemical Examination of Water from the Vine Brook Storage Reservoir of the Lexington Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
22205	Feb. 14	None.	V. slight.	.18	2.90	1.25	.0004	.0144	.0118	.0026	.24	.0150	.0000	0.26	0.8
22286	Feb. 18	V. slight.	None.	.21	3.40	1.55	.0002	.0168	.0130	.0038	.35	.0240	.0000	0.34	0.8
22632	Mar. 23	Decided.	Cons.	.37	4.05	1.35	.0038	.0262	.0164	.0098	.37	.0150	.0000	0.36	1.8
22987	Apr. 27	Decided.	Slight.	.42	5.50	2.55	.0004	.0262	.0186	.0076	.40	.0180	.0000	0.53	1.3
23307	May 25	Decided, green.	Cons., green.	.49	4.85	2.25	.0018	.0488	.0288	.0200	.44	.0100	.0001	0.59	1.6
23666	June 22	Decided.	Cons., green.	.36	5.50	2.40	.0004	.0506	.0326	.0180	.45	.0010	.0002	0.71	1.7
24061	July 27	Decided.	Cons., green.	.41	6.35	3.50	.0010	.0320	.0192	.0128	.36	.0010	.0000	1.03	1.3
24466	Aug. 29	Decided.	Cons., green.	.39	6.35	3.25	.0008	.0608	.0348	.0260	.40	.0020	.0000	1.01	1.4
24813	Sept. 28	Decided.	Cons., green.	.40	6.95	3.80	.0044	.0552	.0368	.0184	.38	.0010	.0000	1.30	1.4
25173	Oct. 26	Decided.	V. slight.	.36	6.70	3.15	.0000	.0680	.0336	.0344	.40	.0030	.0000	0.75	1.6
25461	Nov. 22	Decided, green.	Cons., green.	.75	7.25	4.00	.0036	.0720	.0528	.0192	.42	.0010	.0000	1.08	1.7
25785	Dec. 27	Slight.	Slight.	.28	4.25	1.95	.0102	.0280	.0242	.0038	.33	.0020	.0002	0.61	1.3
Av.*.	....	....	....	.40	5.54	2.69	.0024	.0439	.0282	.0157	.39	.0067	.0000	0.75	1.4

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor, generally none, occasionally distinctly vegetable. On heating, the odor became distinctly vegetable or disagreeable and sometimes unpleasant. —— The samples were collected from the reservoir.

Microscopical Examination of Water from the Vine Brook Storage Reservoir of the Lexington Water Works.

[Number of organisms per cubic centimeter.]

	1898. Feb.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, ...	15	23	24	27	26	23	28	29	29	27	23	29
Number of sample, ...	22205	22286	22632	22987	23307	23666	24061	24466	24813	25173	25461	25785
PLANTS.												
Diatomaceæ, ...	0	0	2	11	116	294	48	16	9	6	8	2
Synedra, ...	0	0	1	11	112	292	48	16	8	4	5	0
Algæ, ...	0	34	40	200	9,105	8,418	13,003	12,004	12,402	9,006	8,004	4,400
Protococcus, ...	0	34	40	200	9,000	8,400	13,000	12,000	12,400	9,000	8,000	4,400
Raphidium, ...	0	0	0	0	85	14	0	0	0	0	0	0

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Microscopical Examination of Water from the Vine Brook Storage Reservoir of the Lexington Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1898.											
	Feb	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Infusoria, ...	0	0	40	10	62	8	60	122	59	12	8	0
Euglena, ...	0	0	38	0	0	0	0	0	0	0	0	0
Peridinium, ...	0	0	1	2	52	0	60	122	56	11	8	0
Vermes, ...	0	0	5	12	1	2	7	2	0	0	1	0
Miscellaneous, Zoöglœa, . .	0	0	10	5	12	10	15	8	10	15	8	3
TOTAL, ...	0	34	97	238	9,296	8,732	13,133	12,152	12,480	9,039	8,029	4,405

Chemical Examination of Water from the Wells of the Lexington Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
23308	May 25	V. slight.	None.	1.05	7.75	.0022	.0172	.60	.1120	.0001	0.72	3.0	.0060
24158	Aug. 4	V. slight.	V. slight.	0.90	8.50	.0012	.0174	.47	.0280	.0001	0.87	3.1	.0060
24468	Aug. 29	None.	None.	1.14	9.80	.0016	.0270	.53	.0720	.0000	1.26	3.1	.0180
24814	Sept. 28	None.	V. slight	0.80	9.00	.0014	.0178	.56	.0640	.0001	0.91	3.3	.0260
25174	Oct. 26	V. slight.	Slight.	0.37	11.10	.0002	.0144	.74	.1080	.0001	0.56	4.4	.0100
Av.*	....	....	....	0.81	9.25	.0013	.0179	.60	.0835	.0001	0.81	3.4	.0135

* Where more than one sample has been collected in a month, the mean analysis for that month has been used in making the average.

Odor, none. On heating, the odor of No. 24158 became faintly musty, and of Nos. 24814 and 25174, faintly vegetable. —— The samples were collected from a faucet in the pumping station, and represent water from the wells before it has passed through the mechanical filter.

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Chemical Examination of Water from the Wells of the Lexington Water Works after passing through a Mechanical Filter.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1898.												
22985	Apr. 27	V. slight.	None.	.52	11.20	.0010	.0118	.67	.1440	.0002	.50	4.9	.0050
23309	May 25	None.	None.	.91	9.25	.0020	.0164	.56	.1060	.0003	.58	4.3	.0070
24157	Aug. 4	V. slight.	None.	.25	9.60	.0030	.0110	.50	.0440	.0002	.29	4.5	.0080
24467	Aug. 29	None.	None.	.64	12.90	.0088	.0290	.53	.0650	.0032	.90	4.9	.0170
24815	Sept. 28	None.	None.	.20	10.70	.0036	.0102	.54	.0400	.0013	.42	5.1	.0040
25175	Oct. 26	None.	None.	.28	11.20	.0000	.0108	.73	.1120	.0002	.43	4.7	.0020
Av.*.	....	....	....	.47	10.72	.0025	.0138	.60	.0913	.0007	.50	4.7	.0061

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor, none.—— The samples were collected from a tap at the pumping station, and represent water from the wells that has passed through the mechanical filter.

Water Supply of Lincoln.

(See *Concord*)

Water Supply of Longmeadow.

Chemical Examination of Water from Cooley Brook, Longmeadow.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
Average of two samples collected in January and August, 1898.	.08	4.32	1.17	.0018	.0053	.0041	.0012	.19	.0245	.0000	.12	2.3

Odor in January, faintly earthy; in August, none.—— The samples were collected from a faucet at the pumping station, while pumping.

Water Supply of Lowell.

The sources of supply are three systems of tubular wells. There is also a direct connection with the Merrimack River.

The first system of driven wells, known as the "Cook" wells,

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consists of 51 6-inch tubular wells and 40 wells of smaller sizes, located in the valley of River Meadow Brook, a short distance above Plain Street. The wells are driven to depths of from 47 to 67 feet. The land in which these wells are located is so low that at times of high water in the brook it is completely flooded.

The second system of tubular wells, known as the "Hydraulic" wells, is located in the valley of River Meadow Brook, near the point where the brook is crossed by the old Middlesex canal in Chelmsford, and about a mile above the "Cook" wells. This system consists of 120 2-inch tubular wells, which are driven to an average depth of about 45 feet. The wells are located in a meadow, in some parts of which there is a considerable depth of peaty soil.

The third group of wells, known as the "Boulevard" wells, is located on the north bank of the Merrimack River, about a quarter of a mile above the Lowell dam. This group consists of 169 2½-inch wells, driven to depths varying from 27 to 40 feet.

Chemical Examination of Water from the Merrimack River above Lowell.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
21886	Jan. 18	V. slight.	V. slight.	.40	3.50	1.60	.0020	.0146	.0134	.0012	.18	.0080	.0001	.40	1.3
22227	Feb. 15	Slight.	V. slight.	.40	3.55	1.35	.0034	.0132	.0104	.0028	.20	.0070	.0001	.42	0.8
22554	Mar. 15	Decided.	Cons., floc.	.41	2.50	1.20	.0012	.0160	.0122	.0038	.12	.0000	.0001	.43	1.0
22913	April 20	Slight.	Cons.	.48	3.05	1.50	.0022	.0136	.0122	.0014	.15	.0030	.0000	.50	0.8
23177	May 17	Slight.	Cons.	.65	2.95	1.40	.0014	.0184	.0168	.0016	.15	.0050	.0000	.58	1.0
23551	June 14	V. slight.	Slight.	.42	–	–	.0038	.0214	.0188	.0026	.23	.0080	.0001	.50	0.8
23988	July 21	Decided.	Slight.	.21	4.50	1.70	.0022	.0188	.0156	.0032	.13	.0050	.0002	.34	0.8
24306	Aug. 16	Slight.	Cons.	.34	4.15	1.90	.0034	.0176	.0156	.0020	.19	.0060	.0002	.41	1.0
24696	Sept. 20	Slight.	Slight.	.27	3.60	1.60	.0034	.0216	.0168	.0048	.21	.0040	.0002	.38	1.3
25075	Oct. 18	V. slight.	V. slight.	.60	4.15	1.90	.0050	.0218	.0202	.0016	.22	.0020	.0001	.76	1.4
25378	Nov. 15	Slight.	Slight.	.50	3.25	1.60	.0014	.0172	.0158	.0014	.14	.0030	.0000	.70	0.8
25701	Dec. 20	V. slight.	V. slight.	.36	3.60	1.45	.0022	.0138	.0124	.0014	.16	.0070	.0004	.42	0.8
Av.	....	....	....	.42	3.53	1.56	.0026	.0173	.0150	.0023	.17	.0048	.0001	.49	1.0

Odor, generally vegetable or musty. —— The samples were collected from the river, opposite the intake of the Lowell water works.

For a comparison of the analyses of the river at Lowell and Lawrence for a series of years, see "Merrimack River," in the chapter on "Examination of Rivers," in a subsequent portion of this report. The river has not been used directly as a source of water supply during the year.

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Chemical Examination of Water from Tubular Wells in the Valley of River Meadow Brook, a Short Distance above Plain Street.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1898.												
21887	Jan. 18	None.	None.	.03	9.80	.0000	.0036	.64	.0500	.0001	.07	4.7	.0020
22228	Feb. 15	None.	V slight.	.04	9.80	.0000	.0044	.63	.0470	.0000	.08	4.0	.0030
22555	Mar. 15	V. slight.	V. slight.	.04	9.10	.0002	.0036	.62	.0500	.0000	.10	3.8	.0060
22915	Apr. 20	None.	V slight.	.05	8.80	.0000	.0024	.59	.0120	.0000	.10	3.9	.0040
23178	May 17	None.	V. slight.	.08	8.10	.0004	.0036	.58	.0430	.0000	.09	3.8	.0060
23553	June 14	None.	None.	.04	8.20	.0004	.0042	.53	.0400	.0000	.14	3.6	.0050
23989	July 20	None.	None.	.09	9.60	.0000	.0036	.52	.0420	.0000	.12	3.5	.0070
24307	Aug. 16	None.	V. slight.	.06	9.00	.0006	.0038	.50	.0320	.0000	.13	4.2	.0130
25380	Nov. 15	None.	None.	.05	8.80	.0000	.0048	.48	.0360	.0000	.12	3.8	.0060
25702	Dec. 20	None.	V. slight.	.10	9.00	.0000	.0036	.50	.0400	.0000	.10	3.5	.0040

Averages by Years.

-	1894	-	-	.02	7.33	.0003	.0014	.55	.0549	.0002	.02	2.8	.0078
-	1895	-	-	.02	9.22	.0001	.0024	.56	.0323	.0002	.05	3.8	.0119
-	1896	-	-	.02	8.37	.0002	.0035	.53	.0507	.0000	.09	3.8	.0068
-	1897	-	-	.02	8.71	.0008	.0035	.55	.0378	.0001	.08	3.7	.0041
-	1898	-	-	.06	9.02	.0002	.0038	.56	.0392	.0000	.10	3.9	.0056

NOTE to analyses of 1898: Odor, none.—— The samples were collected from the wells which are locally known as the "Cook" wells.

Chemical Examination of Water from Tubular Wells in the Valley of River Meadow Brook, a Short Distance above the Old Middlesex Canal in Chelmsford.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1898.												
21888	Jan. 18	Decided.	Cons.	.30	10.30	.0086	.0058	.38	.0030	.0001	.20	4.7	.0330
22229	Feb. 15	Decided.	Cons., floc.	.20	9.70	.0096	.0072	.36	.0050	.0000	.21	3.8	.0300
23179	May 17	Slight.	Slight.	.38	8.10	.0086	.0068	.38	.0060	.0000	.22	3.5	.0470
23552	June 14	Slight, milky.	Slight.	.29	8.30	.0092	.0074	.37	.0040	.0000	.27	3.4	.0350
23991	July 20	Decided.	Cons.	.26	8.70	.0076	.0066	.37	.0060	.0001	.27	2.9	.0500
24698	Sept. 20	Decided, milky.	Cons.	.28	8.00	.0096	.0084	.35	.0070	.0001	.27	3.1	.0570
25076	Oct. 18	Slight, milky.	V. slight.	.28	8.40	.0092	.0086	.33	.0030	.0001	.30	3.6	.0480

Averages by Years.

-	1895	-	-	.12	9.42	.0020	.0017	.31	.0073	.0000	.05	3.9	.0673
-	1896	-	-	.10	11.50	.0064	.0047	.32	.0071	.0001	.13	5.0	.0697
-	1897	-	-	.20	10.35	.0080	.0058	.35	.0053	.0000	.16	4.8	.0488
-	1898	-	-	.28	8.79	.0089	.0073	.36	.0049	.0001	.25	3.6	.0429

NOTE to analyses of 1898: Odor, none.—— The samples were collected from the wells which are locally known as the "Hydraulic" wells.

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Chemical Examination of Water from Tubular Wells in the Valley of the Merrimack River near the Pawtucket Boulevard.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1898.												
21889	Jan. 18	V. slight.	V. slight.	.08	4.50	.0104	.0020	.27	.0180	.0001	.04	2.3	.0140
22230	Feb. 15	V. slight.	Slight.	.15	4.20	.0102	.0032	.26	.0230	.0000	.05	2.3	.0200
22556	Mar. 15	None.	V. slight.	.11	4.40	.0116	.0018	.28	.0430	.0000	.04	2.1	.0400
22914	Apr. 20	Slight.	Cons., iron.	.06	4.50	.0118	.0018	.26	.0200	.0000	.06	1.8	.0350
23554	June 14	V. slight.	None.	.10	4.70	.0148	.0014	.29	.0380	.0000	.04	2.0	.0160
23990	July 21	Slight.	Slight.	.16	4.30	.0100	.0032	.25	.0270	.0000	.10	1.8	.0400
24308	Aug. 16	Slight, milky.	Slight.	.14	4.60	.0098	.0030	.27	.0250	.0001	.10	1.4	.0280
24697	Sept. 20	Slight, milky.	Slight.	.17	4.50	.0102	.0040	.25	.0150	.0002	.09	1.4	.0460
25077	Oct. 18	V. slight, milky.	V. slight, brown.	.12	4.50	.0084	.0054	.29	.0160	.0001	.13	1.7	.0360
25381	Nov. 15	Slight.	Slight.	.17	3.80	.0070	.0046	.25	.0120	.0000	.10	1.8	.0280
25703	Dec. 20	Slight.	Cons., floc.	.20	4.70	.0112	.0028	.27	.0350	.0000	.10	2.0	.0380

Averages by Years.

-	1896	-	-	.01	4.36	.0044	.0019	.30	.0452	.0001	.04	1.8	.0098
-	1897	-	-	.09	4.55	.0096	.0032	.24	.0255	.0001	.05	1.8	.0222
-	1898	-	-	.13	4.43	.0105	.0030	.27	.0247	.0000	.08	1.9	.0310

NOTE to analyses of 1898: Odor, none. —— The samples were collected from the wells which are locally known as the "Boulevard" wells.

WATER SUPPLY OF LUDLOW.

(See *Springfield*.)

Water Supply of Lynn and Saugus.

The sources of supply are Breed's, Birch, Glen Lewis, Walden and Hawkes ponds and the Saugus River. Statistics of the different sources are given in the following table: —

SOURCE.	Area of Water Surface (Acres).	Maximum Depth (Feet).	Average Depth (Feet).	Storage Capacity (Gallons).	Area of Watershed (Sq. Miles).	Population Per Sq. Mile of Watershed.
Breed's Pond, ...	58	22	16	263,000,000	0.93	11
Birch Pond, ...	82	21	17	381,000,000	0.66	76
Glen Lewis Pond, ...	36	17	12	120,000,000	0.36	-
Walden Pond, ...	128	17	12	403,000,000	1.31	-
Hawkes Pond, ...	75	25	16	300,000,000	1.92	44
Saugus River at Montrose, . .	-	-	-	-	11.70	590
Saugus River at Howlett's Dam, .	-	-	-	-	17.00	760

Breed's Pond, which was the original source of supply, was formerly a mill pond which was enlarged by raising the dam when it was used for a storage reservoir. Birch Pond is an artificial reservoir, in which the soil was left on the bottom. Glen Lewis and Walden ponds are both situated on Penny Brook. The site of these reservoirs was originally a swamp, from which the soil was not removed when the reservoirs were constructed, but a portion has been removed from the bottom of Walden Pond during the past few years. Hawkes Pond was constructed in 1897, and was prepared for the storage of water by the removal of all the soil and organic matter, with the exception of small areas where the soil was covered with a layer of gravel.

Water from the Saugus River was originally taken at Howlett's Dam, a short distance below the mouth of the Wakefield branch. During the year 1898 a connection was made with the river in the vicinity of Montrose, above the place where the Wakefield branch enters the river, so that water from the river may now be drawn into Hawkes Pond.

A communication from the State Board of Health to the board of health of Lynn, relative to the cause of an increased number of cases of typhoid fever in that city, may be found on pages 31 to 36 of this volume.

LYNN AND SAUGUS.

Chemical Examination of Water from Breed's Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21820	Jan. 11	V. slight.	Slight.	.40	3.75	1.15	.0080	.0190	.0160	.0030	.64	.0050	.0001	.48	1.4
22105	Feb. 8	V. slight.	Slight.	.49	3.80	1.45	.0050	.0176	.0154	.0022	.64	.0000	.0000	.60	1.0
22500	Mar. 8	V. slight.	Slight.	.60	3.25	1.25	.0018	.0132	.0116	.0016	.40	.0020	.0000	.53	0.8
22811	Apr. 12	V. slight.	V. slight.	.46	3.50	1.55	.0050	.0158	.0138	.0020	.45	.0030	.0004	.45	0.5
23102	May 10	Slight.	Slight.	.50	3.20	1.25	.0016	.0162	.0138	.0024	.50	.0000	.0001	.46	0.5
23422	June 7	V. slight.	V. slight.	.59	3.50	1.65	.0010	.0168	.0132	.0036	.50	.0000	.0001	.53	0.8
23861	July 12	V. slight.	Slight.	.39	3.40	1.60	.0006	.0218	.0174	.0044	.43	.0000	.0000	.48	0.5
24212	Aug. 8	V. slight	V. slight.	.30	2.90	1.50	.0002	.0192	.0174	.0018	.42	.0000	.0000	.43	0.6
24615	Sept. 13	V. slight.	Slight.	.42	3.30	1.50	.0010	.0360	.0326	.0034	.42	.0010	.0000	.58	0.8
24966	Oct. 11	Slight.	V. slight.	.40	3.55	1.70	.0000	.0202	.0178	.0024	.45	.0010	.0000	.50	0.6
25295	Nov. 8	V. slight.	V. slight.	.45	4.00	2.20	.0010	.0236	.0204	.0032	.50	.0010	.0002	.64	0.8
25614	Dec. 12	V. slight.	V. slight.	.50	3.65	1.65	.0014	.0180	.0172	.0008	.48	.0020	.0000	.63	1.1
Av...	....	....	....	.46	3.48	1.54	.0022	.0198	.0172	.0026	.49	.0012	.0001	.53	0.8

Odor, generally faintly vegetable, sometimes none. On heating, the odor of some of the samples became stronger, and in May, faintly oily.

Microscopical Examination of Water from Breed's Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1898. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	12	9	10	13	11	8	14	10	14	12	9	14
Number of sample,	21820	22105	22500	22811	23102	23422	23861	24212	24615	24966	25295	25614
PLANTS.												
Diatomaceæ,	14	1	1	23	71	146	48	38	143	195	77	13
Asterionella,	8	0	0	8	8	0	12	0	110	114	12	0
Cyclotella,	4	1	0	2	39	116	28	5	0	2	5	0
Cyanophyceæ,	0	0	0	0	0	38	1	2	0	6	3	0
Anabæna,	0	0	0	0	0	35	1	2	0	6	3	0
Algæ,	0	0	0	7	12	21	36	10	25	29	23	0
Raphidium,	0	0	0	2	0	10	24	6	24	29	23	0

LYNN AND SAUGUS.

Microscopical Examination of Water from Breed's Pond, Lynn — Concluded.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Rhizopoda,	1	0	0	0	0	0	0	1	0	1	0	0
Infusoria,	6	3	2	5	4	4	72	5	14	16	2	3
Dinobryon,	0	0	0	0	0	3	62	2	1	10	0	1
Raphidomonas,	0	0	0	0	0	0	0	0	10	1	0	0
Vermes,	0	0	0	0	1	2	2	0	1	1	0	0
Miscellaneous, Zoöglœa,	0	0	3	3	5	3	5	5	5	5	5	3
TOTAL,	21	4	6	38	93	214	164	61	188	253	110	19

Chemical Examination of Water from Birch Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21821	Jan. 11	Slight.	V. slight.	.38	3.55	1.45	.0042	.0172	.0166	.0006	.67	.0090	.0001	.34	1.3
22106	Feb. 8	Slight.	Slight.	.50	4.25	1.50	.0064	.0210	.0190	.0020	.73	.0120	.0000	.46	1.8
22501	Mar. 8	V. slight.	V. slight.	.20	2.95	1.00	.0028	.0090	.0078	.0012	.50	.0120	.0001	.24	0.8
22812	Apr. 12	Slight.	V. slight.	.30	3.15	1.50	.0006	.0204	.0180	.0024	.57	.0070	.0000	.34	0.8
23103	May 10	Slight.	Slight.	.31	3.35	1.40	.0002	.0166	.0150	.0016	.57	.0020	.0001	.30	0.8
23423	June 7	Slight.	Slight.	.28	3.50	1.45	.0006	.0190	.0120	.0070	.56	.0010	.0002	.30	0.5
23862	July 12	Slight.	Slight.	.24	3.40	1.30	.0022	.0270	.0226	.0044	.50	.0000	.0000	.34	1.0
24213	Aug. 9	V. slight.	Slight.	.28	3.70	1.20	.0016	.0194	.0166	.0028	.56	.0010	.0000	.32	1.3
24616	Sept. 13	Slight.	Slight.	.23	3.35	1.35	.0006	.0320	.0258	.0062	.50	.0020	.0000	.40	1.1
24967	Oct. 11	Slight.	Slight.	.20	3.65	1.85	.0000	.0238	.0204	.0034	.46	.0000	.0000	.35	0.8
25296	Nov. 8	V. slight.	Slight.	.20	3.70	1.60	.0006	.0220	.0180	.0040	.48	.0020	.0000	.34	0.8
25615	Dec. 12	V. slight.	Slight.	.21	3.50	1.50	.0004	.0206	.0160	.0046	.51	.0000	.0000	.34	1.3
Av...	....	....	....	.28	3.50	1.42	.0017	.0207	.0173	.0034	.55	.0040	.0000	.34	1.0

Odor of the last sample, distinctly fishy and oily; of the others, vegetable or none, becoming sometimes stronger and occasionally fishy on heating.

LYNN AND SAUGUS.

Microscopical Examination of Water from Birch Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	12	9	10	13	11	8	14	10	14	12	9	14
Number of sample,	21821	22106	22501	22812	23103	23423	23862	24213	24616	24967	25296	25615
PLANTS.												
Diatomaceæ,	1	6	0	29	102	172	32	131	562	320	120	10
Asterionella,	0	1	0	0	46	82	5	58	324	268	16	9
Synedra,	0	0	0	20	28	20	0	1	0	6	100	0
Tabellaria,	0	0	0	4	20	50	9	67	226	18	1	0
Cyanophyceæ,	0	0	0	0	0	6	4	30	0	10	13	0
Anabæna,	0	0	0	0	0	6	0	14	0	6	12	0
Merismopœdia,	0	0	0	0	0	0	4	16	0	0	0	0
Algæ,	0	0	0	24	63	28	8	7	0	232	88	9
Raphidium,	0	0	0	4	10	26	8	7	0	230	76	1
ANIMALS.												
Rhizopoda,	0	0	0	0	0	0	2	0	0	0	0	0
Infusoria,	0	2	0	162	25	2	8	2	32	30	19	14
Ciliated infusorian,	0	0	0	12	0	0	0	0	0	0	0	0
Dinobryon,	0	0	0	140	25	0	1	2	0	0	4	0
Trachelomonas,	0	0	0	0	0	0	0	0	20	12	8	0
Uroglena,	0	0	0	0	0	0	0	0	0	0	4	10
Vermes,	0	0	0	1	0	4	0	0	0	4	0	0
Crustacea,	0	pr.	pr.	pr.	0	0	0	pr.	0	pr.	0	0
Bosmina,	0	0	0	0	0	0	0	0	0	pr.	0	0
Cyclops,	0	pr.	pr.	pr.	0	0	0	pr.	0	0	0	0
Daphnia,	0	pr.	0	0	0	0	0	0	0	pr.	0	0
Miscellaneous, Zoöglœa,	0	3	3	3	5	3	5	0	8	10	5	0
TOTAL,	1	11	3	219	195	215	57	170	602	606	245	33

LYNN AND SAUGUS.

Chemical Examination of Water from Walden Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21822	Jan. 11	Slight.	Slight.	1.05	4.60	2.40	.0016	.0334	.0288	.0046	.57	.0150	.0001	.86	1.0
22107	Feb. 8	Slight.	Slight.	1.00	4.50	2.00	.0044	.0298	.0284	.0014	.54	.0060	.0001	.86	1.1
22502	Mar. 8	Slight.	Slight.	0.61	3.25	1.50	.0004	.0206	.0152	.0054	.32	.0030	.0000	.65	0.6
22813	Apr. 12	Slight.	Cons.	0.48	2.90	1.50	.0018	.0272	.0192	.0080	.32	.0020	.0001	.49	0.5
23104	May 10	V. slight.	Slight.	0.49	3.35	1.55	.0000	.0240	.0184	.0056	.40	.0000	.0000	.49	0.5
23424	June 7	Slight.	V. slight.	0.60	3.45	1.55	.0012	.0250	.0208	.0042	.40	.0040	.0001	.53	0.3
23863	July 12	Slight.	Slight.	0.57	3.00	1.75	.0010	.0346	.0262	.0084	.40	.0010	.0000	.58	0.5
24214	Aug. 9	V. slight.	Cons.	0.42	3.35	1.80	.0002	.0242	.0204	.0038	.39	.0000	.0000	.50	0.5
24617	Sept. 13	Decided.	Cons.	0.67	3.25	1.75	.0004	.0450	.0380	.0070	.35	.0020	.0000	.74	0.5
24968	Oct. 11	Decided.	Cons.	0.46	3.95	2.50	.0000	.0374	.0314	.0060	.33	.0000	.0000	.67	0.8
25297	Nov. 8	V. slight.	Slight.	0.63	3.60	1.40	.0002	.0292	.0262	.0030	.34	.0020	.0000	.71	0.3
25618	Dec. 12	Slight.	V. slight.	0.60	3.70	2.00	.0008	.0268	.0244	.0024	.35	.0020	.0000	.81	0.6
Av...	....	....	....	0.63	3.57	1.81	.0010	.0298	.0248	.0050	.39	.0031	.0000	.66	0.6

Odor in April, distinctly fishy, becoming strongly fishy and musty on heating; in May, none, becoming distinctly fishy on heating; at other times, generally faintly vegetable, sometimes none, becoming stronger on heating.

Microscopical Examination of Water from Walden Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	12	9	10	13	11	8	14	10	14	12	9	14
Number of sample,	21822	22107	22502	22813	23104	23424	23863	24214	24617	24968	25297	25618
PLANTS.												
Diatomaceæ,	2	11		79	1,340	44	75	368	1,092	1,808	52	1
Synedra,	1	11	0	68	1,248	8	6	142	760	1,750	33	1
Tabellaria,	0	0	0	7	22	2	56	198	292	4	11	0
Cyanophyceæ,	0	0	2	0	0	12	3	10	6	8	1	0
Anabæna,	0	0	0	0	0	10	0	0	0	0	0	0
Algæ,	0	0	40	8	7	50	469	8	32	8	12	0
Arthrodesmus,	0	0	0	0	4	36	464	4	6	0	0	0

LYNN AND SAUGUS.

Microscopical Examination of Water from Walden Pond, Lynn — Concluded.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Rhizopoda,	0	0	0	2	0	0	0	0	0	2	0	0
Infusoria,	3	7	106	2,628	232	4	49	244	68	36	16	21
Dinobryon,	0	2	24	2,536	212	4	1	182	52	18	0	0
Euglena,	0	0	8	48	0	0	1	0	0	2	0	0
Peridinium,	3	4	30	20	17	0	17	0	6	10	6	21
Synura,	0	0	34	0	0	0	0	0	0	0	0	0
Trachelomonas,	0	1	2	2	1	0	26	62	2	6	7	0
Uroglena,	0	0	2	12	1	0	0	0	0	0	0	0
Vermes,	0	1	4	8	1	2	2	0	2	3	2	0
Crustacea,	0	0	0	0	0	pr.	0	pr.	0	0	0	0
Cyclops,	0	0	0	0	0	pr.	0	0	0	0	0	0
Daphnia,	0	0	0	0	0	0	0	pr.	0	0	0	0
Miscellaneous, Zoöglœa,	0	3	5	5	5	3	10	8	10	10	5	5
TOTAL,	5	22	157	2,730	1,585	115	608	638	1,210	1,875	88	27

Chemical Examination of Water from Glen Lewis Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21825	Jan. 11	V. slight.	V. slight.	.40	3.70	1.90	.0046	.0314	.0274	.0040	.57	.0130	.0001	.56	0.8
22110	Feb. 8	V. slight.	Slight.	.30	3.70	1.40	.0040	.0242	.0200	.0042	.56	.0050	.0000	.41	0.8
22505	Mar. 8	Slight.	Cons., earthy.	.22	2.75	1.00	.0006	.0198	.0086	.0112	.34	.0050	.0000	.26	0.5
22816	Apr. 12	V. slight.	Slight.	.28	2.75	1.15	.0006	.0202	.0168	.0034	.28	.0010	.0000	.30	0.5
23107	May 10	V. slight.	Cons.	.27	3.00	1.10	.0010	.0244	.0194	.0050	.41	.0000	.0000	.34	0.5
23427	June 7	V. slight.	Cons.	.49	3.15	1.50	.0060	.0244	.0166	.0078	.39	.0030	.0002	.44	0.2
23867	July 12	Slight.	Heavy.	.60	3.40	1.30	.0128	.0490	.0280	.0210	.38	.0000	.0000	.51	0.5
24217	Aug. 9	Slight.	Cons.	.50	3.95	2.30	.0404	.0558	.0324	.0324	.36	.0020	.0002	.43	0.5
24620	Sept. 13	Decided.	Cons.	.60	4.55	2.60	.0010	.0810	.0472	.0338	.36	.0010	.0000	.67	0.5
24971	Oct. 11	Slight.	Cons., green.	.41	4.70	2.95	.0080	.0692	.0452	.0240	.36	.0030	.0000	.64	0.5
25300	Nov. 8	V. slight.	Cons., green.	.41	4.05	2.25	.0002	.0462	.0352	.0110	.37	.0020	.0000	.59	0.3
25678	Dec. 19	V. slight.	V. slight.	.30	3.85	1.35	.0002	.0264	.0206	.0058	.39	.0010	.0001	.40	0.5
Av...	....	....	....	.40	3.63	1.73	.0066	.0393	.0264	.0129	.40	.0030	.0000	.46	0.5

Odor, vegetable or mouldy and occasionally fishy or oily, becoming stronger and also sometimes grassy on heating.

LYNN AND SAUGUS.

Microscopical Examination of Water from Glen Lewis Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	12	9	10	13	11	8	14	10	14	12	9	20
Number of sample,	21825	22110	22505	22816	23107	23427	23867	24217	24620	24971	25300	25678
PLANTS.												
Diatomaceæ,	0	0	28	72	44	2	6	4	0	24	164	2
Asterionella,	0	0	22	12	32	0	0	0	0	8	121	0
Cyanophyceæ,	0	0	0	0	0	5	128	1,356	324	73	15	1
Anabæna,	0	0	0	0	0	0	30	1,336	96	0	2	0
Clathrocystis,	0	0	0	0	0	3	98	14	0	64	2	1
Cœlosphærium,	0	0	0	0	0	0	0	6	228	0	3	0
Algæ,	0	0	0	0	1	4	1	0	10	15	517	4
Protococcus,	0	0	0	0	0	0	0	0	0	0	500	0
Fungi, Crenothrix,	0	0	0	0	0	0	0	1,720	0	0	0	0
ANIMALS.												
Infusoria,	49	58	188	130	14	5	15	54	10	11	64	347
Dinobryon,	7	8	0	108	5	0	0	0	0	0	0	227
Peridinium,	42	48	180	20	0	4	0	0	0	0	12	112
Trachelomonas,	0	1	0	0	1	0	9	48	10	11	52	3
Uroglena,	0	0	0	1	7	0	0	0	0	0	0	2
Vermes,	0	0	0	4	0	1	0	0	0	1	3	1
Crustacea, Cyclops,	0	0	0	0	0	pr.	0	0	pr.	pr.	0	0
Miscellaneous, Zoöglœa,	0	0	0	6	0	3	5	0	10	15	3	0
TOTAL,	49	58	216	212	59	20	155	3,134	354	139	766	355

LYNN AND SAUGUS.

Chemical Examination of Water from Hawkes Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21823	Jan. 11	Slight.	V. slight.	.90	5.80	2.30	.0024	.0266	.0228	.0038	.63	.0210	.0001	.81	1.8
22108	Feb. 8	Slight.	Slight.	.62	4.05	1.60	.0066	.0180	.0162	.0018	.44	.0060	.0001	.62	1.0
22503	Mar. 8	Slight.	Slight, earthy.	.60	3.65	1.80	.0014	.0152	.0142	.0010	.34	.0060	.0001	.52	1.1
22815	Apr. 12	V. slight.	V. slight.	.45	4.00	1.85	.0006	.0198	.0174	.0024	.44	.0090	.0001	.52	1.3
23105	May 10	V. slight.	Slight.	.62	3.50	1.40	.0004	.0198	.0156	.0042	.47	.0040	.0002	.55	1.3
23425	June 7	V. slight.	Slight.	.70	4.00	1.65	.0012	.0282	.0186	.0096	.43	.0000	.0003	.66	1.1
23864	July 12	Slight.	Slight.	.39	3.85	1.95	.0008	.0262	.0236	.0026	.44	.0010	.0000	.51	1.0
24215	Aug. 9	Slight.	Slight.	.28	3.60	1.70	.0018	.0218	.0186	.0032	.38	.0000	.0000	.45	1.0
24618	Sept. 13	Slight.	V. slight.	.29	3.50	1.60	.0006	.0272	.0240	.0032	.35	.0000	.0000	.53	1.0
24969	Oct. 11	Slight.	Cons.	.34	3.75	2.00	.0004	.0268	.0218	.0050	.40	.0000	.0001	59	1.7
25298	Nov. 8	V. slight.	Slight.	.41	4.05	1.65	.0006	.0222	.0154	.0068	.44	.0020	.0000	.50	0.8
25617	Dec. 12	V. slight.	Slight.	.47	4.55	2.10	.0022	.0212	.0192	.0020	.41	.0040	.0000	.55	1.4
Av...	....	....	....	.51	4.02	1.80	.0016	.0227	.0189	.0038	.43	.0044	.0001	.57	1.2

Odor, generally faintly vegetable, becoming stronger and sometimes also fishy on heating.

Microscopical Examination of Water from Hawkes Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	12	9	10	13	11	8	14	10	14	12	9	14
Number of sample,	21823	22108	22503	22815	23105	23425	23864	24215	24618	24969	25298	25617
PLANTS.												
Diatomaceæ,	7	0	0	31	161	72	18	76	33	186	5	5
Diatoma,	0	0	0	0	1	0	5	0	0	140	1	0
Synedra,	0	0	0	8	136	72	10	46	22	30	4	2
Cyanophyceæ,	0	0	0	0	0	0	0	14	0	2	0	0
Anabæna,	0	0	0	0	0	0	0	14	0	0	0	0
Algæ,	0	0	0	4	4	0	4	0	0	0	0	0

LYNN AND SAUGUS.

Microscopical Examination of Water from Hawkes Pond, Lynn — Concluded.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Rhizopoda,	0	0	2	0	0	0	0	0	0	0	0	0
Infusoria,	0	0	124	38	942	1,250	10	2,282	94	512	1	10
Cryptomonas,	0	0	10	1	2	0	0	0	0	0	0	0
Dinobryon,	0	0	68	33	940	744	2	2,240	79	508	0	0
Peridinium,	0	0	32	1	0	500	6	36	6	2	0	4
Uroglena,	0	0	4	2	0	0	0	0	0	0	0	5
Vermes,	0	0	0	1	0	6	0	0	0	6	1	0
Miscellaneous, Zoöglœa,	3	0	0	5	8	3	5	5	5	10	5	7
TOTAL,	10	0	126	89	1,115	1,331	37	2,377	132	716	12	22

Chemical Examination of Water from the Saugus River at Montrose.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
23108	May 10	V. slight.	V. slight.	1.12	6.15	2.35	.0006	.0280	.0260	.0020	.68	.0020	.0000	0.97	2.5
23428	June 7	None.	V. slight.	1.50	6.90	3.15	.0010	.0320	.0314	.0006	.58	.0010	.0002	1.23	2.7
23868	July 12	V. slight.	V. slight.	0.68	8.20	3.35	.0032	.0336	.0326	.0010	.76	.0010	.0000	0.89	3.6
24218	Aug. 9	V. slight.	Slight.	1.40	9.55	4.90	.0034	.0536	.0458	.0078	.52	.0020	.0001	1.70	3.5
24621	Sept. 13	V. slight.	Slight.	0.66	8.40	3.90	.0140	.0386	.0346	.0040	.70	.0030	.0001	0.62	3.1
24973	Oct. 11	V. slight.	Cons., earthy.	0.87	7.30	3.25	.0076	.0500	.0322	.0178	.63	.0000	.0000	1.06	2.7
25302	Nov. 8	V. slight.	Cons., earthy.	0.85	6.60	3.25	.0032	.0392	.0302	.0090	.55	.0020	.0000	0.99	2.9
25679	Dec. 19	V. slight.	Slight.	0.68	7.30	2.70	.0018	.0286	.0238	.0048	.75	.0100	.0003	0.86	2.7
Av.	....	....	....	0.97	7.55	3.36	.0043	.0380	.0321	.0059	.65	.0026	.0001	1.04	3.0

Odor, vegetable or musty.

LYNN AND SAUGUS.

Chemical Examination of Water from the Saugus River at the Line between Saugus and Wakefield, and just above the Point where it is joined by the Wakefield Branch.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
21826	Jan. 11	V. slight.	Cons., sand.	1.06	8.75	3.60	.0016	.0354	.0334	.0020	.95	.0080	.0001	1.04	3.6
22111	Feb. 8	V. slight.	Slight.	1.00	7.40	2.85	.0020	.0272	.0266	.0006	.80	.0030	.0000	0.96	3.5
22506	Mar. 8	V. slight.	Cons., earthy.	0.70	5.75	2.20	.0014	.0250	.0232	.0018	.70	.0020	.0001	0.72	2.5
23063	May 3	V. slight.	Slight.	1.10	5.75	2.65	.0020	.0354	.0348	.0006	.66	.0020	.0000	0.95	2.2
23429	June 7	None.	Slight.	1.70	6.85	3.30	.0016	.0360	.0330	.0030	.56	.0010	.0002	1.28	2.7
23866	July 12	V. slight.	V. slight.	0.70	9.05	3.35	.0030	.0322	.0304	.0018	.77	.0010	.0000	0.79	3.8
24219	Aug. 9	V. slight.	V. slight.	1.45	9.40	4.65	.0032	.0508	.0456	.0052	.53	.0020	.0001	1.68	3.5
24622	Sept. 13	V. slight.	V. slight.	0.70	8.55	3.70	.0104	.0344	.0322	.0022	.69	.0060	.0002	1.05	3.3
24972	Oct. 11	Slight.	Cons.	0.90	7.70	3.85	.0132	.0416	.0322	.0094	.59	.0030	.0001	1.14	2.5
25301	Nov. 8	V. slight.	Cons.	0.95	7.20	3.05	.0038	.0340	.0312	.0028	.63	.0010	.0001	1.04	2.7
25619	Dec. 12	V. slight.	Slight.	0.68	7.30	3.10	.0008	.0270	.0254	.0016	.70	.0080	.0001	0.84	2.7
Av.	....	....	....	0.99	7.61	3.30	.0039	.0344	.0316	.0028	.69	.0034	.0001	1.04	3.0

Odor, generally faintly vegetable, sometimes mouldy or musty, becoming stronger and also disagreeable on heating.

Chemical Examination of Water from the Saugus River at Howlett's Dam, Saugus.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
21824	Jan. 11	Slight.	Slight.	1.00	8.90	3.40	.0088	.0346	.0322	.0024	1.11	.0250	.0003	0.94	3.1
22109	Feb. 8	V. slight.	V. slight.	0.93	7.95	2.80	.0128	.0246	.0220	.0026	1.10	.0330	.0003	0.86	3.8
22504	Mar. 8	Slight.	V. slight	0.70	6.00	2.50	.0016	.0234	.0200	.0034	0.76	.0130	.0002	0.65	2.3
22814	Apr. 12	V. slight.	Slight.	0.88	5.50	2.65	.0040	.0302	.0276	.0026	0.74	.0130	.0004	0.72	2.2
23106	May 10	V. slight.	V. slight.	1.00	6.45	2.35	.0010	.0254	.0244	.0010	0.81	.0050	.0004	0.49	2.3
23426	June 7	V. slight.	V. slight	1.40	6.95	3.15	.0022	.0330	.0314	.0016	0.67	.0200	.0002	1.19	2.3
23865	July 12	Decided.	Cons.	0.80	8.30	3.45	.0056	.0458	.0366	.0092	1.03	.0010	.0000	0.79	3.5
24216	Aug. 9	V. slight.	Slight.	0.94	6.95	3.30	.0054	.0374	.0362	.0012	0.60	.0010	.0000	1.00	2.5
24619	Sept. 13	V. slight.	V. slight.	0.70	8.40	3.85	.0012	.0382	.0366	.0016	0.88	.0020	.0001	1.06	3.3
24970	Oct. 11	V. slight.	Slight.	0.96	8.20	4.40	.0016	.0432	.0402	.0030	0.76	.0050	.0001	1.22	2.7
25299	Nov. 8	V. slight.	V. slight.	0.95	7.70	3.05	.0046	.0290	.0276	.0014	0.70	.0020	.0002	0.98	2.7
25616	Dec. 12	V. slight.	Slight.	0.49	7.60	2.45	.0024	.0204	.0190	.0014	0.95	.0770	.0004	0.61	3.0
Av.	....	....	....	0.90	7.41	3.11	.0043	.0321	.0295	.0026	0.84	.0164	.0002	0.88	2.8

Odor, generally vegetable and occasionally musty, becoming stronger on heating.

LYNN AND SAUGUS.

Chemical Examination of Water from a Faucet in Lynn supplied from the Lynn Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21827	Jan. 11	V. slight.	Slight.	.50	4.25	1.65	.0008	.0176	.0172	.0004	.68	.0150	.0000	.42	1.6
22112	Feb. 8	Slight.	V. slight.	.69	4.90	1.80	.0036	.0198	.0186	.0012	.54	.0100	.0002	.67	1.4
22507	Mar. 8	V. slight.	V. slight.	.54	3.75	1.60	.0006	.0154	.0140	.0014	.47	.0030	.0000	.49	1.0
22817	Apr. 12	V. slight.	V. slight.	.41	3.40	1.40	.0006	.0150	.0136	.0014	.38	.0080	.0000	.44	0.8
23109	May 10	V. slight.	Cons.	.41	3.45	1.25	.0004	.0138	.0126	.0012	.50	.0030	.0000	.44	0.8
23430	June 7	V. slight.	Cons.	.52	3.40	1.60	.0006	.0182	.0132	.0050	.44	.0010	.0001	.48	1.0
23869	July 12	Slight.	Slight.	.47	3.45	1.40	.0002	.0204	.0192	.0012	.40	.0030	.0000	.47	0.8
24220	Aug. 9	V. slight.	Slight.	.32	3.60	1.65	.0008	.0164	.0152	.0012	.36	.0050	.0001	.37	1.0
24623	Sept. 13	V. slight.	V. slight.	.37	3.75	1.75	.0004	.0178	.0164	.0014	.38	.0030	.0000	.46	1.0
24974	Oct. 11	Slight, milky.	Cons.	.39	3.80	1.50	.0002	.0184	.0180	.0004	.44	.0020	.0000	.36	1.6
25303	Nov. 8	V. slight.	V. slight.	.35	3.75	1.50	.0002	.0170	.0162	.0008	.44	.0010	.0000	.45	1.1
25680	Dec. 19	V. slight.	V. slight.	.45	3.50	1.45	.0006	.0176	.0168	.0008	.44	.0020	.0001	.53	1.1
Av...	....	....	....	.45	3.75	1.55	.0007	.0173	.0159	.0014	.46	.0047	.0000	.46	1.1

Odor of the first six samples, vegetable and sometimes musty; of the next two, none; of the others, none, becoming faintly vegetable on heating.

Microscopical Examination of Water from a Faucet in Lynn supplied from the Lynn Water Works.

[Number of organisms per cubic centimeter.]

	1898. Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	12	9	10	13	11	8	14	10	14	12	9	20
Number of sample,	21827	22112	22507	22817	23109	23430	23869	24220	24623	24974	25303	25680
PLANTS.												
Diatomaceæ,	10	2	2	16	76	63	24	3	9	59	6	12
Synedra,	0	1	1	16	54	5	0	0	0	9	0	3
Cyanophyceæ,	0	0	0	0	0	1	0	0	0	1	0	0
Algæ,	0	0	0	4	15	10	25	0	0	10	1	0

LYNN AND SAUGUS.

Microscopical Examination of Water from a Faucet in Lynn supplied from the Lynn Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Infusoria,	1	3	3	161	17	5	36	2	0	15	1	2
Dinobryon,	0	0	0	153	17	2	11	0	0	1	1	0
Trachelomonas,	0	1	0	0	0	1	25	1	0	12	0	0
Vermes,	0	1	0	2	1	1	2	0	0	0	0	0
Crustacea, Branchipus,	0	0	0	0	0	0	0	pr.	0	0	0	0
Miscellaneous, Zoöglœa,	3	3	3	3	5	10	5	0	3	35	3	3
TOTAL,	4	9	8	186	114	90	92	5	12	120	11	17

WATER SUPPLY OF MALDEN.

(See also *Metropolitan Water District,* pages 133–160.)

The lower portions of Malden, together with the city of Medford and the town of Melrose, were supplied from Spot Pond in Stoneham until Jan. 21, 1898, and during the remainder of the year from the Metropolitan Works. The high-service district was supplied with water taken from the system of tubular wells at Webster Park in Malden until the latter part of 1898, since which time both the high and low service districts have been supplied with water from the Metropolitan Works.

The system at Webster Park consists of 99 tubular wells driven through gravel to rock. The average depth of the wells is about 60 feet. There is a large population in the territory about the wells, but there are no dwelling-houses in their immediate vicinity. The following table gives the results of chemical analyses of monthly samples of water from the wells and yearly averages of analyses made in former years. The hardness of the water has increased greatly since the works were first constructed.

MALDEN.

Chemical Examination of Water from the Tubular Wells at Maplewood (Webster Park), Malden.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21761	Jan. 4	None.	None.	.00	29.20	.0006	.0024	2.50	.5200	.0000	.03	17.5	.0060
22088	Feb. 7	Slight.	Cons.	.03	24.00	.0024	.0054	2.46	.3300	.0001	.10	13.3	.0020
22410	Mar. 1	Decided.	Cons.	.05	30.80	.0140	.0040	2.92	.3900	.0000	.04	15.0	.0800
22769	Apr. 7	V. slight.	V. slight.	.02	27.00	.0006	.0018	2.90	.3600	.0000	.04	11.2	.0020
23062	May 3	None.	None.	.02	29.80	.0002	.0020	3.32	.3080	.0000	.02	12.3	.0010
23501	June 8	None.	None.	.03	29.50	.0004	.0030	2.37	.2400	.0000	.06	15.0	.0010
23822	July 7	Slight.	Slight.	.01	28.00	.0016	.0028	2.34	.1560	.0000	.03	12.5	.0480
24578	Sept. 8	None.	V. slight.	.02	28.50	.0000	.0012	2.72	.3400	.0000	.06	10.6	.0070
24965	Oct. 10	None.	V. slight.	.01	27.40	.0000	.0030	2.73	.4000	.0000	.02	10.8	.0020
25233	Nov. 1	V. slight.	V. slight.	.03	29.00	.0008	.0010	2.58	.3050	.0000	.07	15.5	.0060
25588	Dec. 10	None.	V. slight.	.03	29.30	.0002	.0016	2.71	.4200	.0000	.03	15.5	.0020

Averages by Years.

-	1888	-	-	.00	17.45	.0000	.0003	2.30	.5081	-	-	-	-
-	1890	-	-	.00	18.19	.0002	.0014	2.29	.4952	.0001	-	8.0	-
-	1891	-	-	.00	20.83	.0001	.0007	2.23	.5146	.0001	-	9.6	-
-	1892	-	-	.00	23.00	.0000	.0005	2.36	.5129	.0000	-	11.4	.0335
-	1893	-	-	.00	23.72	.0001	.0011	2.48	.4823	.0000	.02	11.1	.0121
-	1894	-	-	.00	28.23	.0000	.0012	2.74	.3946	.0000	.02	13.2	.0058
-	1895	-	-	.00	32.02	.0001	.0015	2.73	.4317	.0000	.03	14.9	.0092
-	1896	-	-	.00	30.45	.0002	.0021	2.86	.4458	.0000	.04	13.7	.0090
-	1897	-	-	.00	29.73	.0004	.0032	2.87	.4633	.0000	.03	15.5	.0010
-	1898	-	-	.02	28.41	.0019	.0026	2.69	.3426	.0000	.05	13.6	.0143

NOTE to analyses of 1898: Odor, none. The odor of the last two samples became unpleasant on heating.

MANCHESTER.

WATER SUPPLY OF MANCHESTER.

The sources of supply are a well 32 feet in diameter and 29 feet deep located in the valley of Saw-mill Brook, with 11 tubular wells driven in its bottom and 5 tubular wells driven to depths ranging from 27 to 34 feet in the valley of the brook a short distance above the large well.

Chemical Examination of Water from the Large Well of the Manchester Water Works.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of six samples collected in February, May, July, August, October and December, 1898.	.01	10.87	.0002	.0007	1.91	.1298	.0000	.01	3.6	.0023

Odor, none.

WATER SUPPLY OF MANSFIELD WATER SUPPLY DISTRICT, MANSFIELD.

The source of supply is a well 25 feet in diameter and 20 feet deep in the vicinity of Cate Springs, near the Canoe River.

Chemical Examination of Water from the Well of the Mansfield Water Works.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of six samples collected in February, April, June, August, October and December, 1898.	.00	2.88	.0000	.0008	.32	.0023	.0000	.02	0.9	.0013

Odor, none. —— The samples were collected from a faucet at the pumping station.

WATER SUPPLY OF MARBLEHEAD.

The sources of supply are two large wells in the valley of Forest River in Salem. Well No. 1, which is situated near Loring Avenue, is 30 feet in diameter and 34 feet deep. Well No. 2 is 25 feet in diameter and 34 feet deep. The latter well is situated in the bed of a pond which has been drained and was sunk through about 20 feet of mud into a stratum of gravel. The water from well No. 2 contains an excessive amount of iron, and considerable trouble has been caused by its presence in the water supplied to the town.

The reply of the State Board of Health to an application from the water commissioners of Marblehead, with regard to the iron in the water supplied to the town and the best remedy therefor, may be found on pages 37 and 38 of this volume.

Chemical Examination of Water from Faucets in Marblehead supplied from the Marblehead Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1898.												
21747	Jan. 3	Decided.	Cons.	.05	15.30	.0110	.0022	1.78	.0370	.0003	.03	7.4	.0880
22090	Feb. 7	Decided.	V. slight.	.07	12.50	.0010	.0020	1.95	.0830	.0003	.06	6.0	.0140
23296	May 25	V. slight.	None.	.07	14.30	.0020	.0042	1.47	.0380	.0000	.04	7.1	.0200
24283	Aug. 11	Decided, milky.	Heavy.	.05	16.40	.0218	.0032	1.44	.0140	.0004	.04	6.6	.2000
25421	Nov. 17	Decided, milky.	Cons.	.08	16.00	.0134	.0026	1.79	.0280	.0002	.06	6.6	.2600
25810	Dec. 30	Decided, milky.	Slight.	.34	14.20	.0110	.0024	1.59	.0300	.0004	.04	6.1	.0750
Av...	....	....	....	.11	14.78	.0100	.0028	1.67	.0383	.0003	.04	6.6	.1095

Odor of the first sample, distinctly earthy; of the others, none. —— These samples represent a mixture of water of well No. 1 with water from well No. 2, which flows into well No. 1.

Water Supply of Marlborough.

The sources of supply are Lake Williams and Millham Brook. Lake Williams has an area of 72 acres, a capacity of 270,000,000 gallons and a general depth of from 10 to 26 feet. The bottom of the lake is said to be muddy. The lake has a water-shed of 0.56 of a square mile, which contains a population of about 550 per square mile.

Millham Brook Reservoir, which was constructed in 1895, has an area of 66 acres, a storage capacity of 315,000,000 gallons and a general depth of 25 feet. The area flowed contained about 30 acres of meadow, in which the mud was 3 to 6 feet deep. All of the bottom of the reservoir which was above a plane 10 feet below

MARLBOROUGH.

high water was stripped of all soil and vegetable matter, the material removed being used to fill shallow portions, so that there is no part of the reservoir where the water is less than 6 feet deep at high water. The remainder of the bottom was cleared of brush and stumps, but none of the soil was removed. The water-shed of the reservoir, exclusive of the water-shed of Lake Williams, which is in the same water-shed, has an area of 3.56 square miles and contains 60 persons per square mile.

Just above the reservoir Millham Brook is joined by a large tributary, known as the North Branch. The North Branch contains much swamp on its water-shed, and the water is consequently very highly colored and contains a large amount of organic matter. The South Branch has much less swamp upon its water-shed, and the water is of better quality.

Water from the reservoir can be pumped into Lake Williams, or it can be pumped directly into the distributing reservoir. On account of the heavy rainfall throughout 1898 no water was used from this source for the supply of the city during the year.

The advice of the State Board of Health to the city of Marlborough, relative to plans for a proposed extension of the sewerage system of the city to the district bordering upon Lake Williams, for the purpose of protecting the purity of the water of the lake, may be found on pages 94 to 96 of this volume.

Chemical Examination of Water from Lake Williams, Marlborough.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21793	Jan. 10	Decided.	Cons.	.09	4.65	1.80	.0016	.0270	.0238	.0032	.58	.0070	.0001	.24	2.3
22794	Apr. 11	Slight.	Cons.	.09	4.25	1.50	.0010	.0234	.0182	.0052	.51	.0060	.0002	.23	1.7
23831	July 11	Slight.	V. slight.	.10	4.40	1.60	.0010	.0258	.0232	.0026	.51	.0010	.0000	.26	1.7
24943	Oct. 10	V. slight.	V. slight.	.10	4.30	1.75	.0004	.0230	.0206	.0024	.46	.0000	.0000	.29	1.8
Av...	....	....	....	.09	4.40	1.66	.0010	.0248	.0214	.0034	.51	.0035	.0000	.25	1.9

Odor, faintly vegetable or none. —— The third sample was collected from a faucet at the pumping station, and the other samples from the lake.

MARLBOROUGH.

Chemical Examination of Water from the North Branch of Millham Brook, near its Entrance to the Millham Brook Storage Reservoir, Marlborough.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21789	Jan. 10	Slight.	Cons.	0.98	5.20	2.00	.0034	.0170	.0156	.0014	.48	.0270	.0002	0.66	1.4
22091	Feb. 7	V. slight.	Slight.	0.70	4.65	1.75	.0022	.0152	.0118	.0034	.37	.0190	.0001	0.58	1.8
22459	Mar. 7	Slight.	Cons.	0.90	4.35	1.60	.0006	.0160	.0142	.0018	.28	.0250	.0000	0.58	1.0
22795	Apr. 11	V. slight.	Cons.	1.22	4.50	1.95	.0032	.0194	.0174	.0020	.24	.0100	.0002	0.78	1.3
23081	May 9	V. slight.	Cons.	1.80	4.50	2.30	.0006	.0238	.0204	.0034	.38	.0060	.0001	1.03	1.0
23402	June 6	Slight.	Cons.	2.05	5.20	2.65	.0012	.0350	.0290	.0060	.32	.0070	.0001	1.19	1.1
23827	July 11	V. slight.	Slight.	1.05	5.65	2.95	.0014	.0294	.0276	.0018	.34	.0030	.0000	0.83	1.3
24187	Aug. 8	Slight.	Cons.	2.00	7.65	4.25	.0032	.0578	.0488	.0090	.34	.0030	.0001	1.94	1.4
24593	Sept. 12	None.	V. slight.	2.00	6.95	3.10	.0056	.0394	.0364	.0030	.36	.0070	.0000	1.80	1.3
24942	Oct. 10	V. slight.	V. slight.	1.90	7.30	3.60	.0006	.0350	.0342	.0008	.34	.0020	.0000	1.62	1.8
25265	Nov. 7	V. slight.	V. slight.	1.00	5.55	2.65	.0002	.0204	.0190	.0014	.35	.0070	.0001	0.94	1.1
25561	Dec. 7	V. slight.	V. slight.	0.60	3.85	1.60	.0000	.0100	.0090	.0010	.32	.0120	.0000	0.61	1.0
Av...	....	....	....	1.35	5.44	2.53	.0018	.0265	.0236	.0029	.34	.0107	.0001	1.05	1.3

Odor, generally vegetable, sometimes musty.

Chemical Examination of Water from Millham Brook, near its Entrance to the Millham Brook Storage Reservoir, Marlborough.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21790	Jan. 10	Decided.	Cons.	.40	4.70	1.95	.0022	.0152	.0128	.0024	.49	.0360	.0001	.36	2.0
22092	Feb. 7	V. slight.	V. slight.	.40	4.65	1.65	.0030	.0102	.0100	.0002	.47	.0280	.0001	.38	2.0
22460	Mar. 7	Slight.	Cons.	.40	4.30	1.50	.0014	.0118	.0094	.0024	.36	.0230	.0000	.34	1.6
22796	Apr. 11	V. slight.	Slight.	.41	4.40	1.60	.0004	.0134	.0116	.0018	.39	.0120	.0002	.40	1.6
23082	May 9	V. slight.	Slight.	.63	4.20	1.90	.0004	.0138	.0128	.0010	.42	.0130	.0001	.44	1.6
23403	June 6	Slight.	Cons.	.87	5.25	2.40	.0012	.0244	.0238	.0006	.30	.0090	.0002	.65	1.8
23830	July 11	Slight.	Slight.	.33	4.95	1.95	.0018	.0154	.0136	.0018	.43	.0090	.0002	.28	2.0
24186	Aug. 8	Decided.	Slight.	.71	6.85	3.00	.0012	.0342	.0326	.0016	.29	.0020	.0001	.95	2.2
24592	Sept. 12	V. slight.	V. slight.	.73	6.20	2.65	.0060	.0220	.0180	.0040	.38	.0270	.0000	.76	2.0
24944	Oct. 10	Slight.	V. slight.	.85	6.40	2.95	.0008	.0228	.0210	.0018	.41	.0100	.0001	.93	2.2
25266	Nov. 7	V. slight.	V. slight.	.50	5.50	2.10	.0004	.0146	.0140	.0006	.37	.0120	.0000	.55	1.7
25560	Dec. 7	V. slight.	Slight.	.30	4.00	1.60	.0004	.0086	.0072	.0014	.38	.0170	.0000	.33	1.4
Av...	....	....	....	.54	5.12	2.11	.0016	.0172	.0156	.0016	.39	.0165	.0001	.53	1.8

Odor, generally vegetable or none, occasionally faintly musty.

MARLBOROUGH.

Chemical Examination of Water from Millham Brook Storage Reservoir, Marlborough.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21791	Jan. 10	Slight.	Slight.	0.60	4.60	2.25	.0024	.0174	.0162	.0012	.44	.0250	.0001	0.50	2.1
22093	Feb. 7	Slight.	V. slight.	0.49	4.40	1.55	.0028	.0124	.0116	.0008	.38	.0170	.0000	0.40	1.6
22461	Mar. 7	Slight.	V. slight.	0.55	3.95	1.45	.0014	.0124	.0112	.0012	.28	.0210	.0001	0.46	1.1
22797	Apr. 11	Slight.	Cons.	0.43	3.75	1.35	.0022	.0182	.0124	.0058	.25	.0120	.0002	0.40	1.0
23083	May 9	Slight.	Cons.	0.51	3.45	1.50	.0004	.0200	.0134	.0066	.35	.0090	.0001	0.46	1.1
23404	June 6	Slight.	Cons., green.	0.81	3.95	1.85	.0008	.0308	.0208	.0100	.33	.0020	.0001	0.53	1.0
23828	July 11	Slight.	Cons.	0.57	4.45	2.50	.0008	.0304	.0246	.0058	.32	.0000	.0000	0.57	1.3
24188	Aug. 8	Slight.	Cons.	0.40	4.05	2.20	.0024	.0318	.0226	.0092	.32	.0020	.0000	0.47	1.1
24594	Sept. 12	Slight.	Cons.	0.97	4.75	2.30	.0104	.0396	.0320	.0076	.28	.0010	.0000	1.03	1.3
24945	Oct. 10	Slight.	Cons.	1.20	5.10	2.35	.0270	.0350	.0290	.0060	.32	.0030	.0001	0.89	1.7
25267	Nov. 7	Slight.	Cons.	0.90	5.10	2.40	.0088	.0276	.0250	.0026	.28	.0070	.0002	0.78	1.4
25562	Dec. 7	V. slight.	V. slight.	0.56	4.00	1.75	.0010	.0112	.0106	.0006	.34	.0150	.0001	0.57	1.3

Averages by Years.

-	1896	-	-	0.80	4.44	1.68	.0058	.0306	.0248	.0058	.30	.0088	.0003	0.69	1.3
-	1897	-	-	0.83	4.24	1.77	.0031	.0293	.0243	.0050	.30	.0088	.0001	0.64	1.5
-	1898	-	-	0.67	4.30	1.95	.0050	.0239	.0191	.0048	.32	.0095	.0001	0.59	1.3

NOTE to analyses of 1898: Odor, generally vegetable, becoming stronger on heating. —— The samples were collected from the reservoir, 2 feet beneath the surface.

MARLBOROUGH.

Microscopical Examination of Water from Millham Brook Storage Reservoir, Marlborough.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	11	8	8	12	10	7	12	9	13	11	8	8
Number of sample,	21791	22093	22461	22797	23083	23404	23828	24188	24594	24945	25267	25562
PLANTS.												
Diatomaceæ,	356	4	8	432	1,060	764	372	256	1,460	1,640	440	123
Asterionella,	352	4	8	426	596	112	10	0	308	1,484	336	92
Synedra,	0	0	0	4	376	92	4	2	0	12	12	4
Tabellaria,	4	0	0	2	82	524	356	234	1,148	138	66	23
Cyanophyceæ,	0	0	0	0	0	0	50	88	64	18	0	0
Anabæna,	0	0	0	0	0	0	44	80	0	0	0	0
Cœlosphærium,	0	0	0	0	0	0	2	0	0	10	0	0
Merismopœdia,	0	0	0	0	0	0	0	8	64	0	0	0
Algæ,	4	1	0	12	194	3,294	268	52	76	120	118	8
Cosmarium,	0	0	0	0	0	0	104	0	0	0	2	0
Protococcus,	0	0	0	12	156	3,200	78	24	0	0	0	0
Raphidium,	4	0	0	0	2	74	8	4	32	98	44	1
Staurastrum,	0	0	0	0	0	4	50	12	4	16	0	0
ANIMALS.												
Rhizopoda,	0	0	0	0	0	0	0	4	0	0	0	0
Infusoria,	9	12	1	70	124	4	1,768	24	200	158	62	10
Cryptomonas,	0	0	0	4	10	0	0	0	0	0	0	0
Dinobryon,	0	1	0	4	92	0	1,680	0	108	24	18	8
Euglena,	0	0	1	56	2	0	2	0	0	0	0	1
Mallomonas,	0	2	0	0	0	0	12	2	8	0	16	0
Peridinium,	8	2	0	0	14	2	4	2	16	2	0	0
Tintinnidium,	0	0	0	0	0	0	10	0	4	0	0	0
Trachelomonas,	1	6	0	0	2	0	54	20	56	132	26	0
Vermes,	0	0	0	0	2	8	2	0	4	2	0	0
Crustacea,	0	0	0	0	0	pr.	pr.	0	pr.	pr.	0	0
Cyclops,	0	0	0	0	0	pr.	pr	0	pr.	0	0	0
Daphnia,	0	0	0	0	0	pr.	pr.	0	0	pr.	0	0
Miscellaneous, Zoöglœa,	10	3	0	7	10	0	10	5	8	10	0	3
TOTAL,	379	20	9	521	1,388	4,070	2,470	429	1,812	1,948	620	144

MARLBOROUGH.

Chemical Examination of Water from Millham Brook Storage Reservoir, Marlborough, collected near the Bottom.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Sediment.	Color.	Residue on Evaporation. Total.	Loss on Ignition.	Ammonia. Free.	Albuminoid. Total.	Dissolved.	Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21792	Jan. 10	Decided.	Cons.	0.91	4.90	2.00	.0168	.0246	.0202	.0044	.39	.0130	.0002	0.62	2.0
22094	Feb. 7	V. slight.	Cons.	1.00	4.65	2.10	.0212	.0258	.0206	.0052	.38	.0130	.0003	0.68	2.0
22462	Mar. 7	Decided.	Cons.	0.67	4.20	1.50	.0096	.0166	.0156	.0010	.27	.0160	.0001	0.46	1.1
22798	Apr. 11	Decided.	Cons.	0.44	3.75	1.50	.0020	.0156	.0120	.0036	.28	.0130	.0002	0.39	1.0
23084	May 9	Slight.	Cons.	0.49	3.65	1.55	.0000	.0198	.0142	.0056	.36	.0090	.0001	0.46	1.0
23405	June 6	Decided.	Heavy.	0.80	4.25	1.95	.0280	.0334	.0216	.0118	.30	.0010	.0006	0.54	1.3
23829	July 11	Decided.	Cons	2.65	6.55	3.25	.0878	.0408	.0310	.0098	.29	.0010	.0000	0.78	1.8
24189	Aug. 8	Decided.	Cons.	2.80	6.55	2.85	.1372	.0452	.0308	.0144	.30	.0000	.0000	0.86	1.6
24595	Sept 12	Decided.	Cons.	3.10	7.20	2.85	.2270	.0440	.0320	.0120	.26	.0000	.0000	1.16	2.0
24946	Oct. 10	Slight.	Cons.	1.10	5.35	2.70	.0244	.0314	.0304	.0010	.32	.0020	.0002	0.85	1.6
25268	Nov. 7	Slight.	Slight.	0.88	7.15	4.05	.0094	.0290	.0260	.0030	.30	.0060	.0002	0.82	1.4
25563	Dec. 7	V. slight.	Slight.	0.61	4.35	1.90	.0028	.0164	.0148	.0016	.32	.0110	.0000	0.59	1.3

Averages by Years.

-	1896	-	-	1.04	5.07	1.94	.0185	.0331	.0271	.0060	.31	.0110	.0002	0.82	1.5
-	1897	-	-	1.47	5.33	2.24	.0233	.0343	.0288	.0055	.32	.0075	.0003	0.79	1.7
-	1898	-	-	1.29	5.21	2.35	.0472	.0285	.0224	.0061	.31	.0071	.0002	0.68	1.5

NOTE to analyses of 1898: Odor, generally vegetable, sometimes musty and unpleasant or disagreeable, becoming stronger on heating. —— The samples were collected from the reservoir, 2 feet above the bottom.

Microscopical Examination of Water from Millham Brook Storage Reservoir, Marlborough, collected near the Bottom.

[Number of organisms per cubic centimeter.]

	1898. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct	Nov.	Dec.
Day of examination,	11	8	8	12	10	7	12	9	13	11	8	8
Number of sample,	21792	22094	22462	22798	23084	23405	23829	24189	24595	24946	25268	25563
PLANTS.												
Diatomaceæ,	1,158	42	10	574	724	224	522	48	974	1,920	438	149
Asterionella,	1,152	41	8	568	492	56	0	0	80	1,680	330	106
Synedra,	2	1	0	0	136	60	2	2	8	22	8	3
Tabellaria,	4	0	0	2	84	100	520	46	886	200	52	38
Cyanophyceæ,	0	0	0	0	0	0	6	8	0	16	2	2
Clathrocystis,	0	0	0	0	0	0	6	0	0	10	0	0
Algæ,	5	1	0	6	168	160	50	10	12	108	56	5
Protococcus,	0	0	0	0	142	122	0	0	0	0	0	0
Raphidium,	2	1	0	0	2	26	16	0	0	86	4	0

MARLBOROUGH.

Microscopical Examination of Water from Millham Brook Storage Reservoir, Marlborough, collected near the Bottom — Concluded.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Infusoria,	**15**	**5**	**2**	**40**	**74**	**8**	**516**	**12**	**104**	**52**	**32**	**43**
Codonella,	2	1	1	12	4	0	0	0	0	0	2	2
Cryptomonas,	0	0	0	2	16	0	0	6	0	0	0	0
Dinobryon,	0	0	0	0	38	0	488	0	56	0	18	7
Euglena,	0	1	0	18	4	2	4	0	0	0	0	0
Peridinium,	1	1	0	4	10	0	2	0	20	0	0	0
Trachelomonas,	12	2	1	2	2	2	12	6	20	46	10	29
Vermes,	**1**	**0**	**0**	**4**	**6**	**2**	**2**	**0**	**0**	**2**	**0**	**0**
Crustacea,	**pr.**	**pr.**	**0**	**0**	**pr.**	**pr.**	**pr.**	**0**	**0**	**pr.**	**0**	**pr.**
Cyclops,	pr.	pr.	0	0	pr.	0	pr.	0	0	0	0	0
Daphnia,	0	0	0	0	0	pr.	0	0	0	pr.	0	pr.
Miscellaneous Zoöglœa,	**20**	**5**	**5**	**8**	**8**	**100**	**15**	**100**	**600**	**10**	**5**	**5**
TOTAL,	1,199	53	17	632	980	494	1,111	178	1,690	2,108	533	204

WATER SUPPLY OF BRANT ROCK, MARSHFIELD. — BRANT ROCK WATER COMPANY.

Chemical Examination of Water from the Well of the Brant Rock Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
24425	1898. Aug. 23	None.	None.	.00	10.70	.0000	.0012	3.10	.0580	.0000	.06	2.0	.0060

Odor, none. —— The sample was collected from a faucet at the pumping station.

WATER SUPPLY OF MAYNARD.

The source of supply is White Pond in Hudson and Stow. The pond has an area of 58 acres and a water-shed of 0.29 of a square mile, which contains a population of about 17 per square mile. Water from the pond is drawn through a long conduit constructed

MAYNARD.

of earthen pipe with open joints to an open masonry receiving reservoir. Much ground water enters the conduit between the pond and the receiving reservoir. Water also enters the reservoir from the ground about it when the water in it is drawn down, so that the water delivered to the town is a mixture of water from the pond with a varying amount of ground water. During the early spring of 1898 the water had a fishy and oily odor, which was apparently due to a growth of the organism *Uroglena* in the open reservoir.

Chemical Examination of Water from White Pond, Maynard.

[Parts per 100,000.]

Hardness.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
22212	Feb. 15	None.	None.	.07	2.70	1.00	.0014	.0128	.0108	.0020	.32	.0020	.0000	.15	0.8
22596	Mar. 17	Slight.	V. slight.	.09	2.70	0.90	.0006	.0136	.0110	.0026	.30	.0020	.0000	.25	1.0
23924	July 19	Slight.	None.	.09	2.75	0.85	.0002	.0116	.0110	.0006	.32	.0010	.0000	.18	1.0
24716	Sept. 21	V. slight.	Slight.	.02	2.25	0.90	.0004	.0198	.0168	.0030	.35	.0000	.0000	.14	0.5
Av...	....	....	....	.07	2.60	0.91	.0006	.0144	.0124	.0020	.32	.0012	.0000	.18	0.8

Odor of the first sample, none, becoming distinctly fishy on heating; of the second, decidedly fishy, becoming stronger and also oily on heating; of the others, none. —— No. 24716 was collected from the pond, and the others from a faucet in the village. The samples collected in the village represent pond water mixed with a considerable amount of ground water.

MEDFIELD.

Chemical Examination of Water from a Spring in Medfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
24553	Sept. 7	V. slight.	None.	.18	4.70	.0008	.0056	.24	.0030	.0000	.26	1.8	.0090

Odor, none. —— The sample was collected from a spring near Vine Brook, about one-third of a mile above North Street. This spring is used as a source of water supply by a large straw factory and by a portion of the village of Medfield.

MEDFIELD INSANE ASYLUM.

Water Supply of Medfield Insane Asylum.

Chemical Examination of Water from Farm Pond in Sherborn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21992	Jan. 26	V. slight.	V. slight.	.02	2.10	0.85	.0004	.0132	.0126	.0006	.29	.0010	.0000	.12	0.5
22292	Feb. 18	V. slight.	None.	.05	3.00	1.05	.0012	.0102	.0098	.0004	.29	.0030	.0000	.11	0.3
22608	Mar. 21	V. slight.	V. slight.	.04	1.50	0.70	.0010	.0118	.0104	.0014	.27	.0050	.0000	.14	0.5
22948	Apr. 23	V. slight.	V. slight.	.08	1.95	0.85	.0006	.0094	.0088	.0006	.28	.0030	.0001	.13	0.6
23313	May 25	V. slight.	None.	.11	1.75	0.85	.0026	.0130	.0114	.0016	.27	.0060	.0000	.12	0.5
23679	June 22	V. slight.	Slight.	.06	1.80	0.50	.0000	.0128	.0112	.0016	.26	.0010	.0000	.16	0.5
24076	July 28	V. slight.	V. slight.	.02	2.05	0.95	.0008	.0104	.0100	.0004	.24	.0000	.0000	.14	0.0
24435	Aug. 24	Slight.	Slight.	.02	1.40	0.55	.0004	.0132	.0120	.0012	.22	.0010	.0000	.13	0.0
24877	Sept. 30	Slight.	V. slight.	.07	1.80	0.65	.0006	.0116	.0100	.0016	.25	.0000	.0000	.12	0.5
25176	Oct. 26	None.	V. slight.	.10	2.00	1.05	.0000	.0066	.0064	.0002	.24	.0010	.0001	.11	0.5
25449	Nov. 22	V. slight.	None.	.09	1.75	0.95	.0008	.0100	.0098	.0002	.24	.0000	.0000	.10	0.0
25803	Dec. 28	None.	V. slight.	.04	2.00	0.85	.0002	.0102	.0102	.0000	.27	.0000	.0000	.12	0.2
Av...	....	....	....	.06	1.92	0.82	.0007	.0110	.0102	.0008	.26	.0017	.0000	.12	0.3

Odor, none. A faintly vegetable odor was developed in some of the samples on heating. —— The samples were collected from faucets in the asylum supplied from the pond.

Water Supply of Medford.

(See also *Metropolitan Water District*, pages 133–160.)

The city of Medford was formerly supplied, together with the city of Malden and the town of Melrose, from Spot Pond, the supply being supplemented at times by water from Wright's Pond. Since March 12, 1898, the supply of Medford has been taken partly from the Metropolitan Water Works and partly from Wright's Pond. Wright's Pond has an area of 24 acres and an average depth of 10 feet. It is an artificial reservoir, formed by a dam across a brook which has its source in the vicinity of Spot Pond. The soil was not removed from the area flowed when the reservoir was constructed. The pond has a water-shed of 191 acres, which contains a very small population, the water-shed being mostly included in the Middlesex Fells Park Reservation. Water is also

MEDFORD.

pumped at times from two branch streams which enter the brook just below Wright's Pond.

The water of Wright's Pond is highly colored, and contains at times a very large amount of organic matter.

The reply of the State Board of Health to an application from the water commissioners of Medford for advice with reference to the use of the water of Wright's Pond during cold weather may be found on page 38 of this volume.

Chemical Examination of Water from Wright's Pond, Medford.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment	Color.	Total.	Loss on Ignition	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
24612	Sept. 13	Decided.	Cons.	.40	4.40	1.85	.0012	.0354	.0258	.0096	.32	.0010	.0000	.79	2.1
25256	Nov. 4	Slight.	Cons.	.42	4.55	1.95	.0162	.0324	.0264	.0060	.33	.0030	.0001	.62	2.0

Odor of the first sample, faintly musty, becoming distinctly musty on heating; of the last, faintly vegetable, becoming also unpleasant on heating.

Water Supply of Melrose.

(See *Metropolitan Water District*, pages 133-160.)

Water Supply of Methuen.

The source of supply is a system of tubular wells in the valley of Spicket River, at the place where the river is joined by Harris Brook.

Chemical Examination of Water from the Tubular Wells of the Methuen Water Works.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of six samples collected in February, April, June, August, October and December, 1898.	.07	6.72	.0002	.0028	.32	.0158	.0001	.11	2.8	.0038

Odor, none. —— The April sample was collected from the wells, and the others, from faucets in the town.

MIDDLEBOROUGH.

Water Supply of Middleborough Fire District, Middleborough.

The source of supply is a well near the Nemasket River, above the village of Middleborough. The well is 26 feet in diameter and 22 feet deep. There has been a marked deterioration in the quality of the water drawn from the well, which is shown in the table of yearly averages of chemical analyses.

Chemical Examination of Water from the Well of the Middleborough Fire District.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21764	Jan. 5	Slight.	Cons.	.03	5.80	.0016	.0046	.78	.0650	.0000	.17	2.9	.0070
22077	Feb. 7	Decided.	Cons.	.08	7.20	.0014	.0040	.82	.0820	.0000	.08	3.6	.0500
22393	Mar. 1	V. slight.	Cons.	.07	7.10	.0010	.0038	.86	.0970	.0000	.08	3.0	.0850
22757	Apr. 6	V. slight.	Slight.	.05	6.10	.0014	.0020	.79	.0680	.0000	.05	3.1	.0130
23061	May 4	V. slight.	Slight.	.08	6.30	.0014	.0034	.83	.1040	.0000	.06	2.5	.0250
23348	June 1	Slight.	Slight.	.08	7.50	.0002	.0024	.83	.0760	.0001	.11	3.0	.0170
23806	July 6	V. slight.	V. slight.	.15	6.70	.0004	.0050	.79	.0500	.0001	.18	2.2	.0230
24143	Aug. 3	V. slight.	None.	.20	6.70	.0010	.0072	.60	.0440	.0000	.17	2.2	.0380
24548	Sept. 7	Decided, milky.	V. slight.	.20	6.70	.0004	.0062	.66	.0500	.0003	.20	2.3	.0350
24922	Oct. 5	Decided, milky.	V. slight.	.35	7.40	.0000	.0066	.66	.0370	.0003	.21	2.5	.1100
25242	Nov. 2	Decided, milky.	V. slight.	.40	6.80	.0002	.0060	.66	.0520	.0000	.20	2.5	.0600
25558	Dec. 7	Slight.	V. slight.	.18	7.10	.0006	.0012	.74	.0990	.0000	.12	2.3	.0270

Averages by Years.

-	1888	-	-	.00	8.67	.0001	.0025	.96	.1494	.0001	-	-	-
-	1895	-	-	.06	6.74	.0001	.0028	.74	.0687	.0000	.08	2.6	.0187
-	1896	-	-	.18	6.54	.0003	.0038	.72	.0565	.0000	.09	2.4	.0288
-	1897	-	-	.09	6.28	.0006	.0039	.71	.0580	.0000	.11	2.5	.0227
-	1898	-	-	.16	6.78	.0008	.0044	.75	.0687	.0001	.14	2.7	.0408

Note to analyses of 1898: Odor of the second sample, faintly vegetable; of the others, none. —— The first three samples were collected from a faucet at the pumping station; the others, from the well.

Water Supply of Middleton.

(See *Danvers*.)

MILLBURY.

WATER SUPPLY OF MILLBURY. — MILLBURY WATER COMPANY.

The source of supply is a well 20 feet in diameter and 40 feet deep, located on a tributary of Dorothy Brook, near the Millbury branch of the Boston & Albany Railroad, about half a mile north-east of the village.

Chemical Examination of Water from the Well of the Millbury Water Company.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albu-minoid.		Nitrates.	Nitrites.			
Average of six samples collected in February, April, June, August, October and December, 1898.	.03	4.50	.0002	.0022	.24	.0137	.0000	.03	1.9	.0030

Odor, none. —— The February and August samples were collected from a faucet in the pumping station, and the others from the well.

WATER SUPPLY OF MILLIS.

Chemical Examination of Water from the Aqua Rex Spring, Millis.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
24417	1898. Aug. 24	None.	None.	.00	7.70	.0012	.0016	.54	.1740	.0000	.04	2.6	.0070

Odor, none.

WATER SUPPLY OF MILTON.

(See *Hyde Park*)

WATER SUPPLY OF MONSON.

The source of supply is a well 73 feet in diameter and 23 feet deep, located in the valley of Ingalls Brook, near its junction with Conant Brook, about 2½ miles from the village of Monson.

MONSON.

Chemical Examination of Water from a Faucet in Monson, supplied from the Monson Water Works.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
Average of six samples collected in February, April, June, August, October and December, 1898.	.01	3.33	.0002	.0011	.12	.0095	.0000	.02	1.0	.0037

Odor, none.

Water Supply of Turner's Falls Fire District, Montague.

The source of supply is Lake Pleasant, which is situated in a sandy plain in the town of Montague. The lake has an area of 45 acres and a maximum depth of 40 feet. Its shores are sandy, and the bottom is said to be free from organic matter. The lake has a water-shed of 1.78 square miles, which contains a population of about 14 persons per square mile.

The water obtained from this source, as indicated by frequent analyses, has usually been of good quality, but has been subject to occasional tastes and odors caused by the presence of the organism *Uroglena*.

Chemical Examination of Water from Lake Pleasant, Montague.

[Parts per 100,000.]

	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
Average of four samples collected in February, May, August and November, 1898.	.07	2.35	0.75	.0022	.0071	.0054	.0017	.13	.0020	.0000	.14	0.4

Odor, none. A distinctly grassy odor was developed in the last sample on heating.

Water Supply of Nahant.

(See *Swampscott.*)

NANTUCKET.

WATER SUPPLY OF NANTUCKET. — WANNACOMET WATER COMPANY.

The source of supply is Wannacomet Pond, which is situated near the sea, the level of the water in the pond being about 4 feet above the level of ordinary high tide. The pond has an area of 8 acres and a general depth of 14 feet. The shores are sandy, but the bottom is said to contain considerable mud. The drainage area of the pond is small and is uninhabited. The pond has been subject in some years to enormous growths of the organism *Anabæna* in the summer and early fall, which gives the water a very disagreeable taste and odor; and, in order to remedy this, a filter was constructed containing from 12 to 16 inches of sand, through which water has been filtered at times before being pumped to the distributing stand-pipe. The filter does not remove the taste and odor caused by the organism *Anabæna*.

Chemical Examination of Water from Wannacomet Pond, Nantucket.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
23811	July 5	V. slight.	Slight.	.08	6.55	1.95	.0022	.0170	.0150	.0020	2.33	.0000	.0001	.10	1.3
24150	Aug. 2	V. slight.	Slight.	.02	7.10	1.95	.0010	.0150	.0124	.0026	2.11	.0000	.0000	.17	1.1
24540	Sept. 6	Slight.	Cons.	.20	6.60	1.60	.0040	.0588	.0220	.0368	2.19	.0030	.0000	.22	1.3
24794	Sept. 26	Slight.	Slight.	.20	7.35	2.05	.0132	.0334	.0194	.0140	2.38	.0000	.0001	.14	1.6
24932	Oct. 6	Slight.	Cons.	.26	6.85	1.80	.0184	.0290	.0192	.0098	2.42	.0000	.0000	.16	1.8
Av.*.	....	....	....	.14	6.87	1.88	.0075	.0268	.0168	.0100	2.28	.0004	.0000	.15	1.4

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor, vegetable, becoming stronger and in some samples also unpleasant, on heating.

NANTUCKET.

Microscopical Examination of Water from Wannacomet Pond, Nantucket.

[Number of organisms per cubic centimeter.]

	1898.				
	July.	August.	Sept.	Sept.	October.
Day of examination,	7	4	7	28	7
Number of sample,	23811	24150	24540	24794	24932
PLANTS.					
Diatomaceæ,	34	6	160	0	1
Cyclotella,	0	0	160	0	0
Cyanophyceæ, Anabæna,	0	68	856	200	314
Algæ,	0	4	0	0	1
ANIMALS.					
Infusoria,	212	2	80	34	82
Dinobryon,	204	0	0	0	19
Peridinium,	0	0	72	1	0
Trachelomonas,	2	2	4	33	63
Vermes,	6	0	0	2	2
Crustacea,	0	0	0	pr.	pr.
Cyclops,	0	0	0	pr.	pr.
Daphnia,	0	0	0	0	pr.
Miscellaneous, Zoöglœa,	5	5	10	10	8
TOTAL,	257	85	1,106	246	408

NANTUCKET.

Chemical Examination of Water from the Filter of the Wannacomet Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
24541	Sept. 6	V. slight.	None.	.11	7.80	.0014	.0156	2.34	.0020	.0001	.18	1.6	.0210
24795	Sept. 26	V. slight.	V. slight.	.09	7.40	.0212	.0106	2.38	.0080	.0004	.10	1.7	.0050

Odor of the first sample, faintly vegetable; of the last, decidedly disagreeable. —— The samples were collected from a faucet in the pumping station; the first, after the filter had been in operation two days; the last, after the filter had been operated 22 days.

Microscopical Examination.

An insignificant number of organisms was found in each of these samples.

Water Supply of Natick.

The source of supply is Dug Pond, which is tributary to Lake Cochituate, one of the sources of supply of the Metropolitan District. The pond has an area of 44½ acres and a water-shed of 0.89 of a square mile, which contains a considerable part of the thickly built up portion of the town of Natick, the population on the water-shed being 1,500 per square mile.

The advice of the State Board of Health to the water commissioners of Natick, relative to a proposed water supply for that town to be taken from the ground in the vicinity of Lake Cochituate, may be found on pages 39 to 41 of this volume.

In a previous communication to the water commissioners of Natick, relative to securing a supply of water from this source (pages 32 and 33 of the annual report for 1897), the water commissioners were advised to make a test by pumping from wells in this vicinity, at a rate as great as would be necessary for the supply of Natick, and for a period of two or three weeks. In accordance with this advice, numerous test wells were driven and samples of water from each of them were analyzed. On January 19 a pumping test was begun by pumping with a steam pump from five of the wells, numbered 1, 2, 3, 4 and 9. Several samples of water were collected in the course of this test, the results of which may be found in the last of the following tables. The test was continued until January 31.

NATICK.

Chemical Examination of Water from Dug Pond, Natick.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21726	Jan. 3	Slight.	Slight.	.10	5.70	1.70	.0136	.0196	.0176	.0020	.83	.0120	.0000	.22	2.5
22024	Jan. 31	Slight.	Slight.	.44	5.50	1.00	.0032	.0146	.0142	.0004	.88	.0200	.0002	.19	2.3
22361	Feb. 28	Decided.	Slight.	.15	5.15	1.55	.0112	.0136	.0118	.0018	.79	.0160	.0006	.28	2.2
22709	Apr. 4	V. slight.	V. slight.	.12	5.00	1.70	.0018	.0154	.0132	.0022	.70	.0230	.0001	.21	2.1
23024	May 2	Slight.	Slight.	.15	5.25	1.60	.0030	.0196	.0156	.0040	.74	.0220	.0005	.26	2.2
23327	May 31	V. slight.	V. slight	.13	5.10	1.80	.0012	.0150	.0122	.0028	.75	.0220	.0001	.24	2.2
23772	June 30	Slight.	V. slight.	.16	5.05	1.35	.0054	.0188	.0182	.0006	.71	.0140	.0006	.31	1.8
24138	Aug. 1	V. slight.	V. slight.	.10	5.85	2.05	.0016	.0188	.0174	.0014	.57	.0080	.0000	.22	2.5
24498	Aug. 31	Slight.	V. slight.	.11	5.00	1.55	.0000	.0186	.0174	.0012	.52	.0020	.0000	.31	1.8
24895	Oct. 3	V. slight.	V. slight.	.12	4.80	1.45	.0002	.0180	.0168	.0012	.58	.0000	.0000	.26	2.0
25216	Oct. 31	V. slight.	None.	.12	5.15	1.45	.0006	.0150	.0144	.0006	.68	.0010	.0000	.27	2.1
25524	Dec. 1	V. slight.	V. slight.	.20	5.00	1.60	.0052	.0146	.0134	.0012	.66	.0120	.0002	.26	2.1

Averages by Years.

-	1888	-	-	.13	5.24	1.09	.0070	.0228	-	-	.66	.0197	.0003	-	-
-	1889	-	-	.16	5.55	1.20	.0046	.0242	.0197	.0045	.71	.0292	.0004	-	-
-	1890	-	-	.14	5.85	1.36	.0027	.0199	.0166	.0033	.72	.0227	.0002	-	2.7
-	1891	-	-	.09	5.71	1.45	.0085	.0207	.0167	.0040	.69	.0326	.0003	-	2.4
-	1892	-	-	.06	5.38	1.24	.0068	.0173	.0135	.0038	.72	.0323	.0001	-	2.4
-	1893	-	-	.08	5.28	1.39	.0062	.0192	.0158	.0034	.71	.0193	.0003	.23	2.1
-	1894	-	-	.10	5.64	1.65	.0060	.0155	.0132	.0023	.80	.0218	.0001	.21	2.3
-	1895	-	-	.13	6.27	1.86	.0044	.0191	.0164	.0027	.87	.0312	.0001	.24	2.6
-	1896	-	-	.15	6.19	1.77	.0045	.0176	.0147	.0029	.86	.0290	.0002	.25	2.3
-	1897	-	-	.12	5.41	1.47	.0063	.0192	.0166	.0026	.84	.0130	.0002	.25	2.4
-	1898	-	-	.16	5.21	1.57	.0039	.0168	.0152	.0016	.70	.0127	.0002	.25	2.1

NOTE to analyses of 1898: Odor from August to November, none; at other times, faintly vegetable and occasionally musty, becoming stronger on heating. —— No. 23024 was collected from the pond; the others, from a faucet in the pumping station.

NATICK.

Microscopical Examination of Water from Dug Pond, Natick.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug.	Aug.	Oct.	Nov.	Dec.
Day of examination,	4	2	1	5	3	1	1	3	31	4	1	2
Number of sample,	21726	22024	22361	22709	23024	23327	23772	24138	24498	24895	25216	25524
PLANTS.												
Diatomaceæ,	1,561	81	30	756	579	114	19	28	16	48	18	106
Asterionella,	216	2	4	428	224	4	0	0	0	0	0	5
Cyclotella,	10	5	4	64	129	35	12	0	0	0	0	2
Melosira,	0	10	0	248	0	16	0	6	6	41	17	88
Meridion,	0	1	2	0	92	0	0	0	0	0	0	0
Tabellaria,	1,288	61	8	0	116	50	6	0	0	2	0	4
Cyanophyceæ,	0	0	0	0	0	0	2	0	1	0	0	0
Algæ,	0	1	0	2	38	24	2	10	1	9	18	17
ANIMALS.												
Infusoria,	41	0	3	3	6	41	38	1	5	20	0	3
Dinobryon,	30	0	0	2	0	38	31	0	5	20	0	0
Vermes,	1	1	1	0	4	0	0	0	0	0	0	0
Crustacea,	0	0	pr.	0	pr.	0	pr.	0	0	0	0	0
Cyclops,	0	0	0	0	0	0	pr.	0	0	0	0	0
Daphnia,	0	0	pr.	0	pr.	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	0	10	0	0	10	0	3	3	3	3	3	3
TOTAL,	1,603	93	34	761	637	179	64	42	26	80	39	129

NATICK.

Chemical Examination of Water from Various Tubular Test Wells in the Vicinity of Lake Cochituate in Natick.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21774	Jan. 5	Slight.	None.	.07	5.30	.0038	.0028	.28	.0010	.0000	.01	2.5	.0170
22048	Feb. 3	Slight.	Cons.	.03	6.20	.0002	.0016	.27	.0100	.0002	.04	3.3	.0020
21775	Jan. 5	Decided.	Cons.	.06	8.60	.0006	.0006	.26	.0070	.0000	.00	4.3	.0230
21787	Jan. 9	Slight.	Cons.	.02	6.50	.0002	.0008	.26	.0040	.0000	.00	3.6	.0020
21799	Jan. 10	Slight.	Cons.	.04	7.50	.0004	.0008	.28	.0100	.0000	.00	4.2	.0030
22065	Feb. 4	V. slight	Slight.	.00	8.70	.0004	.0008	.52	.0650	.0000	.01	5.3	.0020
22066	Feb. 4	V. slight.	Cons.	.01	6.40	.0002	.0010	.27	.0050	.0000	.01	4.0	.0020
21788	Jan. 9	V. slight.	Slight.	.01	5.70	.0006	.0010	.30	.0040	.0000	.00	3.0	.0020
22067	Feb. 4	None.	Slight.	.02	5.30	.0002	.0010	.25	.0030	.0000	.00	2.9	.0010
21807	Jan. 10	V. slight.	V. slight.	.02	7.70	.0002	.0010	.28	.0190	.0000	.00	4.2	.0100
21857	Jan. 13	None.	None.	.01	8.50	.0004	.0014	.43	.0350	.0000	.00	4.9	.0040
21808	Jan. 10	V. slight.	None.	.01	9.60	.0002	.0006	.58	.1100	.0000	.00	4.9	.0100
21800	Jan. 10	Decided.	V. slight.	.04	5.00	.0034	.0020	.23	.0050	.0000	.06	2.6	.0280
21856	Jan. 13	V. slight.	Slight.	.01	6.90	.0004	.0018	.70	.1680	.0000	.00	4.2	.0020
22068	Feb. 4	Decided.	Heavy.	.05	8.00	.0002	.0016	.34	.0180	.0000	.02	4.6	.0010

Odor of Nos. 22067 and 22068, faintly earthy; of the others, none. —— The samples were collected from tubular test wells located near Lake Cochituate, in the area bounded by the Worcester turnpike, the Saxonville branch of the Boston & Albany Railroad and the southern division of the lake. Nos. 21774 and 22048 were collected from test well No. 1, located 350 feet from the lake and 70 feet from the turnpike. Nos. 21775, 21787, 21799 and 22065, from test well No. 2, located 225 feet from the lake and 190 feet from the turnpike; No. 22066, from test well No. 3, located 260 feet from the lake and 175 feet from the turnpike; Nos. 21788 and 22067, from test well No. 4, located 270 feet from the lake and 70 feet from the turnpike; No. 21807, from test well No. 5, located 35 feet from the lake and 6 feet from the turnpike; No. 21857, from test well No. 6, located 20 feet from the lake and 400 feet from the turnpike; No. 21808, from test well No. 7, located 25 feet from the lake, 400 feet from the turnpike and 275 feet from the railroad; No. 21800, from test well No. 9, located 300 feet from the lake and 120 feet from the turnpike; No. 21856, from test well No. 10, located 20 feet from the lake and 80 feet from the railroad; No. 22068, from test well No. 11, located 175 feet north of the railroad and about 20 feet from an arm of the lake. This well is 400 feet from the wells from which water was drawn during the pumping test, and was driven in order that the height of the ground water in this vicinity might be observed while water was being drawn from the test wells. The samples collected in January were collected before the pumping test was begun; those collected in February were taken a few days after the close of the pumping test.

NATICK.

Chemical Examination of Water from Tubular Test Wells in the Vicinity of Lake Cochituate in Natick, collected during a Pumping Test.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21918	Jan. 19	Decided.	Cons.	.09	5.80	.0018	.0008	.32	.0040	.0001	.00	3.1	.0280
21926	Jan. 21	Slight.	Cons.	.06	5.80	.0024	.0014	.28	.0060	.0000	.01	3.3	.0250
21949	Jan. 22	V. slight.	None.	.03	6.00	.0006	.0014	.28	.0070	.0000	.02	3.3	.0080
21950	Jan. 23	V. slight.	None.	.03	6.00	.0002	.0012	.29	.0090	.0000	.02	3.5	.0070
21970	Jan. 24	V. slight.	None.	.03	6.00	.0008	.0010	.29	.0140	.0000	.01	3.1	.0050
21987	Jan. 25	V. slight.	None.	.03	6.30	.0002	.0024	.30	.0100	.0001	.01	3.3	.0080
22009	Jan. 26	None.	None.	.01	6.80	.0004	.0010	.32	.0160	.0000	.02	3.8	.0030
22015	Jan. 28	None.	None.	.02	6.20	.0006	.0028	.32	.0170	.0001	.02	3.8	.0010
22016	Jan. 29	None.	None.	.02	6.40	.0002	.0008	.33	.0170	.0000	.01	3.8	.0000
22020	Jan. 30	None.	None.	.02	6.60	.0000	.0014	.33	.0170	.0000	.02	3.6	.0010
22021	Jan. 30	None.	None.	.02	5.90	.0002	.0012	.34	.0160	.0000	.01	3.5	.0010
22023	Jan. 31	None.	None.	.00	6.60	.0006	.0012	.33	.0170	.0000	.01	3.5	.0010

Odor of No. 21918, faintly earthy; of the others, none. —— The samples were collected from the pipe discharging water from a steam pump while pumping from five tubular wells numbered 1, 2, 3, 4 and 9. The location of the wells is given in the note at the foot of the preceding table.

Water Supply of Needham.

The source of supply is a well 22 feet in diameter and 24 feet deep, located in the valley of Colburn's Brook, about 2,000 feet from Charles River.

The advice of the State Board of Health to the Needham water board, relative to obtaining an additional water supply from the ground in the vicinity of the present source of supply, may be found on pages 41 to 43 of this volume. The results of chemical analyses of samples of water collected during the investigations are given in the tables which follow : —

NEEDHAM.

Chemical Examination of Water from the Needham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Sediment.	Color.	Residue on Evaporation.	Ammonia. Free.	Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1898.												
22074	Feb. 7	V. slight.	None.	.02	6.70	.0004	.0008	.90	.1850	.0000	.02	2.6	.0030
22747	Apr. 6	None.	None.	.02	6.90	.0006	.0020	.96	.2700	.0000	.02	2.3	.0010
23349	June 1	None.	None.	.00	7.70	.0000	.0020	.96	.2500	.0000	.04	2.5	.0020
24142	Aug. 3	None.	None.	.00	7.10	.0006	.0018	.81	.1700	.0000	.01	2.1	.0000
24918	Oct. 5	None.	None.	.00	6.70	.0000	.0006	.79	.1700	.0000	.03	2.2	.0020
25559	Dec. 7	None.	None.	.00	7.40	.0000	.0002	.86	.2750	.0000	.01	2.3	.0010
Av...	....	....	....	.01	7.08	.0003	.0012	.88	.2200	.0000	.02	2.3	.0015

Odor, none. —— The first sample was collected from a faucet at a drinking fountain, and the others, from the well.

Chemical Examination of Water from Tubular Test Wells in Needham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Sediment.	Color.	Residue on Evaporation.	Ammonia. Free.	Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1898.												
24805	Sept. 27	Decided, milky.	Slight, clayey.	.06	10.00	.0002	.0014	0.88	0.1200	.0000	.01	3.1	.0060
25488	Nov. 26	V. slight.	V. slight, clayey.	.05	13.80	.0000	.0014	1.35	0.9400	.0000	.01	4.4	.0060
25652	Dec. 16	None.	None.	.01	10.20	.0000	.0006	1.20	0.5350	.0000	.02	3.3	.0040
25653	Dec. 16	None.	None.	.00	7.10	.0000	.0006	0.88	0.2650	.0000	.02	2.7	.0010
25758	Dec. 22	None.	None.	.00	7.50	.0000	.0008	0.88	0.2735	.0000	.02	2.6	.0010
25654	Dec. 16	V. slight, clayey.	Slight, clayey.	.02	16.70	.0004	.0010	1.38	1.0800	.0001	.03	4.4	.0180
25655	Dec. 16	None.	None.	.00	13.40	.0000	.0008	1.38	1.0000	.0000	.02	4.7	.0010
25759	Dec. 22	None.	None.	.00	12.00	.0000	.0006	1.35	0.8050	.0000	.02	4.2	.0010
25656	Dec. 16	None.	None.	.00	10.00	.0000	.0008	1.14	0.5150	.0000	.03	3.5	.0010
25760	Dec. 22	None.	None.	.00	12.20	.0000	.0008	1.27	0.7350	.0000	.02	3.8	.0020
25657	Dec. 16	None.	None.	.00	8.00	.0000	.0008	1.07	0.4050	.0000	.02	2.9	.0020
25761	Dec. 22	None.	None.	.00	8.10	.0000	.0010	1.10	0.3200	.0000	.02	3.0	.0010

Odor, none. —— The samples were collected from tubular test wells in the valley of Bird's Hill Brook, near the wells of the Needham water works. Sample No. 24805 was collected from test well No. 5, located about 430 feet south west of the present well, at the place at which it was proposed to construct a new well in 1898. The remaining samples were collected from test wells located easterly and south-easterly from the present well Nos. 25488 and 25652 were collected from well No. 20; Nos. 25653 and 25758, from well No. 21; Nos. 25654, 25655 and 25759, from well No. 23; Nos. 25656 and 25760, from well No. 26; Nos. 25657 and 25761, from well No. 28.

NEEDHAM.

Chemical Examination of Water from Bird's Hill Brook, Needham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
24806	1898. Sept. 27	V. slight.	Cons.	.15	6.05	2.60	.0022	.0114	.0072	.0042	.74	.0910	.0006	.18	1.8

Odor, none. A faintly vegetable odor was developed on heating. —— The sample was collected from the brook, near the well of the Needham water works.

Water Supply of New Bedford.

The sources of supply are a storage reservoir on Acushnet River in Acushnet and Little Quittacas Pond in Lakeville. The reservoir has an area of 300 acres and an available storage capacity of 400,000,000 gallons. The bottom of the reservoir is muddy, and over much of the area the water is shallow. The water-shed of 7.3 square miles contains a population of 45 per square mile.

Little Quittacas Pond was connected with the Acushnet Reservoir in 1886. This pond has an area of 318 acres and a water-shed of 1.89 square miles, which contains a population of 34 per square mile.

The water of the Acushnet Reservoir is highly colored and contains a large amount of organic matter, much of which is in the form of microscopical organisms which give the water disagreeable tastes and odors.

Works are now nearly completed for taking water for the supply of the city from Great Quittacas Pond in Lakeville. The results of analyses of samples of water from this source, as well as from the present sources of supply, are given in the following tables: —

NEW BEDFORD.

Chemical Examination of Water from the Conduit of the New Bedford Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
21955	Jan. 24	V. slight.	Slight.	1.40	5.60	2.70	.0018	.0248	.0242	.0006	.68	.0070	.0000	1.07	1.6
22323	Feb. 23	V. slight.	Slight.	1.10	4.50	2.25	.0010	.0172	.0168	.0004	.57	.0070	.0000	0.89	1.3
22667	Mar. 28	V. slight.	V. slight.	1.00	3.75	2.10	.0026	.0190	.0174	.0016	.54	.0070	.0000	0.83	0.5
22953	Apr. 25	V. slight.	Slight.	0.89	3.50	1.70	.0018	.0168	.0154	.0014	.55	.0060	.0001	0.75	0.6
23270	May 23	Slight.	Cons.	1.30	4.30	2.00	.0028	.0234	.0208	.0026	.47	.0040	.0001	1.00	1.0
23613	June 20	V. slight.	Cons.	1.20	4.55	2.50	.0018	.0290	.0258	.0032	.53	.0070	.0000	1.22	1.0
24025	July 25	Slight.	Slight.	0.98	4.60	2.40	.0020	.0244	.0230	.0014	.43	.0010	.0002	0.89	0.6
24384	Aug. 22	V. slight.	V. slight.	1.46	5.75	3.35	.0024	.0300	.0276	.0024	.45	.0040	.0000	1.42	1.0
24765	Sept. 26	V. slight.	V. slight.	1.00	4.90	2.50	.0014	.0274	.0254	.0020	.49	.0060	.0000	1.03	0.6
25132	Oct. 24	None.	V. slight.	0.68	4.10	2.10	.0004	.0176	.0160	.0016	.50	.0050	.0000	0.95	0.8
25441	Nov. 21	V. slight.	V. slight.	1.80	6.75	3.40	.0052	.0304	.0252	.0052	.54	.0140	.0000	1.65	1.1
25800	Dec. 28	V. slight.	V. slight.	1.03	5.10	2.45	.0014	.0182	.0172	.0010	.62	.0040	.0000	1.15	1.1
Av...	....	....	....	1.15	4.78	2.45	.0020	.0232	.0212	.0020	.54	.0060	.0000	1.07	0.9

Odor, generally vegetable, sometimes none, becoming stronger and sometimes musty on heating. —— The samples were collected from the conduit, at its entrance to the receiving reservoir, and represent water from the storage reservoir.

Chemical Examination of Water from Little Quittacas Pond, Lakeville.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
22637	Mar. 24	Slight.	Slight.	.20	3.05	1.25	.0000	.0170	.0146	.0024	.52	.0000	.0000	.34	0.8
23614	June 20	V. slight.	Slight.	.21	3.00	1.25	.0004	.0180	.0142	.0038	.54	.0010	.0000	.36	1.0
24767	Sept. 26	V. slight.	V. slight	.17	3.45	1.55	.0004	.0168	.0150	.0018	.56	.0010	.0000	.34	0.8
25799	Dec. 28	Slight.	Slight.	.26	3.75	1.25	.0000	.0182	.0164	.0018	.60	.0010	.0001	.36	1.7
Av...	....	....	....	.21	3.31	1.32	.0002	.0175	.0150	.0025	.55	.0007	.0000	.35	1.1

Odor of the second sample, distinctly vegetable, becoming also musty on heating; of the others, none.

NEW BEDFORD.

Chemical Examination of Water from Great Quittacas Pond, Lakeville.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
22636	Mar. 24	V. slight.	Slight.	.70	3.50	1.60	.0002	.0200	.0176	.0024	.57	.0000	.0000	.71	0.8
23615	June 20	None.	V. slight.	.68	3.65	2.00	.0010	.0194	.0180	.0014	.54	.0010	.0000	.76	1.0
24766	Sept. 26	V. slight.	V. slight.	.50	4.00	2.05	.0008	.0200	.0188	.0012	.58	.0010	.0000	.70	0.8
25798	Dec. 28	V. slight.	V. slight.	.71	4.10	2.35	.0000	.0194	.0176	.0018	.60	.0000	.0000	.91	1.1
Av...	....	....	....	.65	3.81	2.00	.0005	.0197	.0180	.0017	.57	.0005	.0000	.77	0.9

Odor of the first two samples, distinctly vegetable; of the last two, none.

Chemical Examination of Water from Long Pond, Lakeville.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
22635	Mar. 24	V. slight.	V. slight.	1.20	3.55	2.05	.0002	.0180	.0172	.0008	.48	.0000	.0000	0.97	0.5
23616	June 20	V. slight.	V. slight.	0.98	3.80	2.35	.0006	.0214	.0200	.0014	.49	.0020	.0000	1.06	0.3
24764	Sept. 26	V. slight.	V. slight.	0.90	4.65	2.70	.0010	.0226	.0222	.0004	.45	.0020	.0000	1.06	0.8
25801	Dec. 28	Slight.	V. slight.	1.18	4.85	2.75	.0000	.0250	.0224	.0026	.54	.0010	.0000	1.44	0.8
Av...	... .	....	....	1.06	4.21	2.46	.0004	.0217	.0204	.0013	.49	.0012	.0000	1.13	0.6

Odor of the first two samples, distinctly vegetable; of the third, none, becoming faintly musty on heating; of the last, none.

Water Supply of Newburyport.

The sources of supply are wells and springs near the south bank of the Merrimack River, about 2.5 miles above the central portion of the city.

NEWBURYPORT.

Chemical Examination of Water from the Newburyport Water Works.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of eleven samples, collected monthly, with the exception of July, 1898.	.16	6.84	.0014	.0059	.50	.0192	.0000	.13	2.8	.0174

Odor in January, faintly earthy; in August, faintly unpleasant, becoming stronger on heating; at other times, none.

Chemical Examination of Water from Jackman Springs, Newburyport.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
23935	July 19	V. slight.	Slight.	.08	5.40	.0006	.0028	.42	.0070	.0000	.07	1.7	.0020

Odor, none, becoming faintly vegetable on heating.

Water Supply of Newton.

The source of supply is a covered filter-gallery or conduit, constructed of wood and vitrified clay pipe, with which many tubular wells are connected, extending along the valley of Charles River above Newton Upper Falls. Water from the filter-gallery is pumped to a covered masonry reservoir. For analyses of samples of water from the Charles River opposite the filter-gallery, see Charles River in the chapter on "Examination of Rivers," in a subsequent portion of this report.

Chemical Examination of Water from a Faucet at the Newton Water Works Pumping Station.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of twelve samples collected monthly during 1898.	.04	6.18	.0002	.0024	.47	.0364	.0000	.07	2.8	.0032

Odor, none.

NORTH ADAMS.

Water Supply of North Adams.

The sources of supply are Notch Brook in North Adams, on which a storage reservoir has been built, and Broad Brook in Pownal, Vt. The Notch Brook storage reservoir has an area of 12½ acres and a capacity of 90,000,000 gallons. When the reservoir was constructed, all of the soil and organic matter was removed from the bottom. The water-shed of the reservoir has an area of 2.43 square miles, and is uninhabited. A large portion of the water-shed is owned by the city.

Broad Brook at the point of diversion has a water-shed of 6.02 square miles and contains a population of 5 per square mile.

Chemical Examination of Water from Notch Brook Storage Reservoir, North Adams.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21766	Jan. 4	Slight.	V. slight.	.05	7.00	1.05	.0010	.0046	.0042	.0004	.10	.0080	.0000	.12	5.7
22012	Jan. 27	Slight.	Slight.	.21	6.25	1.30	.0060	.0104	.0058	.0046	.10	.0050	.0000	.46	4.9
22288	Feb. 17	Slight.	None.	.05	6.40	1.00	.0004	.0070	.0064	.0006	.09	.0040	.0000	.10	5.3
23383	June 1	None.	V. slight.	.06	6.90	1.15	.0010	.0062	.0046	.0016	.07	.0010	.0000	.12	5.0
24099	July 30	None.	V. slight.	.05	11.45	1.75	.0002	.0022	.0020	.0002	.04	.0020	.0001	.05	8.7
24871	Sept. 28	V. slight.	V. slight.	.06	8.15	1.45	.0014	.0088	.0068	.0020	.06	.0000	.0000	.14	6.4
25500	Nov. 29	V. slight.	V. slight.	.08	6.45	1.40	.0000	.0046	.0040	.0006	.08	.0050	.0000	.11	5.0
Av.*	....	....	....	.07	7.66	1.32	.0011	.0060	.0048	.0012	.07	.0031	.0000	.13	5.9

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor, none. A faintly vegetable odor was developed in two of the samples on heating.

NORTH ADAMS.

Chemical Examination of Water from Broad Brook in Pownal, Vt.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21765	Jan. 4	V. slight.	V. slight.	.03	6.20	1.05	.0002	.0020	.0018	.0002	.08	.0260	.0000	.05	5.1
22011	Jan. 26	V. slight.	V. slight.	.04	4.90	0.95	.0010	.0052	.0028	.0024	.09	.0170	.0000	.11	3.6
22289	Feb. 17	None.	None.	.12	3.75	1.30	.0002	.0060	.0054	.0006	.08	.0120	.0000	.23	1.8
23382	May 30	None.	V. slight.	.06	5.75	1.35	.0006	.0048	.0034	.0014	.06	.0080	.0000	.10	3.8
24098	July 27	V. slight.	V. slight.	.07	8.75	1.75	.0008	.0038	.0032	.0006	.05	.0130	.0001	.08	7.0
24870	Sept. 27	V. slight.	Slight.	.11	6.80	1.35	.0000	.0038	.0028	.0010	.06	.0060	.0000	.18	4.6
25501	Nov. 29	V. slight.	V. slight.	.07	5.25	1.00	.0000	.0020	.0020	.0000	.08	.0120	.0000	.12	3.8
Av.*.	....	....	....	.08	5.97	1.29	.0004	.0040	.0032	.0008	.07	.0121	.0000	.13	4.2

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor, none.

The advice of the State Board of Health to the board of health of North Adams, relative to the suitability of certain ponds as sources of domestic ice supply, may be found on pages 125 to 127 of this volume.

The results of analyses of samples of water collected from the various sources which have been investigated are given in the following table, and under Deerfield River in a subsequent chapter of this report, entitled "Examination of Rivers."

Chemical Examination of Water from Various Sources of Ice Supply in North Adams and Vicinity.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
22938	Apr. 22	Slight.	Cons.	.17	14.95	2.30	.0006	.0232	.0144	.0088	.18	.0040	.0003	.26	12.3
22939	Apr. 22	None.	Slight.	.02	8.95	1.05	.0002	.0020	.0014	.0006	.07	.0070	.0000	.05	7.6
22940	Apr. 22	Slight.	Cons.	.26	6.65	1.70	.0004	.0220	.0130	.0090	.22	.0070	.0004	.26	4.3
22941	Apr. 22	Slight.	Cons.	.28	2.50	1.00	.0008	.0146	.0090	.0056	.08	.0020	.0000	.38	0.8
22942	Apr. 22	Slight.	V. slight.	.10	3.95	1.45	.0006	.0140	.0106	.0034	.16	.0020	.0000	.26	2.5
22943	Apr. 22	V. slight.	V. slight.	.31	6.95	1.50	.0006	.0170	.0148	.0022	.06	.0000	.0000	.34	5.1

Odor of the first sample, faintly vegetable, becoming distinctly vegetable and fishy on heating; of the second, none; of the third, faintly unpleasant, becoming distinctly unpleasant on heating; of the fourth, faintly musty; of the fifth, faintly musty and unpleasant, becoming decidedly musty and disagreeable on heating; of the last, none, becoming faintly vegetable on heating. —— The first sample was collected from an artificial ice pond in the village of Zylonite in Adams; the second, from Orr's Pond in North Adams, situated just west of the south branch of the Hoosac River; the third, from a pond in the village of Blackinton, connected with the Hoosac River by a culvert beneath the railroad; the fourth, from a pond in Clarksburg known as the Stamford Reservoir, at the head waters of the north branch of the Hoosac River; the fifth, from Kemp Pond, so called, in the easterly portion of the city of North Adams; the last, from a small artificial pond near the upper distributing reservoir of the North Adams water works.

NORTHAMPTON.

Water Supply of Northampton.

The source of supply is Roberts' Meadow Brook in Northampton and Westhampton, on which three storage reservoirs have been built. The upper and lower reservoirs are quite small. The middle reservoir, which is the principal storage reservoir, has an area of 26 acres, a maximum depth of 30 feet, an average depth of 10 feet and a capacity of 84,000,000 gallons. Each of the reservoirs was prepared for the storage of water by the removal of all the soil and other organic matter.

The water-shed of Roberts' Meadow Brook above the lower reservoir has an area of 10.6 square miles and contains a population of 15 per square mile.

Chemical Examination of Water from Roberts' Meadow Brook, just above the Middle Reservoir of the Northampton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21976	Jan. 25	Slight.	V. slight.	.21	3.20	1.25	.0006	.0070	.0068	.0002	.11	.0040	.0000	.32	1.4
22328	Feb. 23	V. slight.	V. slight.	.18	3.50	1.00	.0006	.0054	.0050	.0004	.12	.0100	.0000	.20	1.3
22669	Mar. 28	V. slight.	V. slight.	.26	2.30	1.00	.0006	.0086	.0074	.0012	.07	.0080	.0000	.27	1.0
22994	Apr. 26	V. slight.	V. slight.	.35	3.20	1.10	.0002	.0072	.0062	.0010	.09	.0060	.0000	.35	1.0
23343	May 30	V. slight.	Slight.	.39	3.55	1.45	.0004	.0078	.0070	.0008	.08	.0030	.0000	.33	1.1
23682	June 23	V. slight.	Slight.	.38	4.05	1.50	.0008	.0188	.0118	.0020	.07	.0010	.0000	.41	1.7
24077	July 27	V. slight.	Slight.	.21	4.80	1.50	.0032	.0088	.0076	.0012	.09	.0020	.0003	.18	1.6
24484	Aug. 29	V. slight.	V. slight.	.40	4.85	1.85	.0030	.0196	.0182	.0014	.07	.0030	.0002	.66	1.8
24845	Sept. 27	V. slight.	V. slight.	.21	4.75	1.55	.0006	.0096	.0092	.0004	.09	.0050	.0001	.28	1.7
25178	Oct. 25	None.	V. slight.	.41	4.25	1.35	.0000	.0072	.0064	.0008	.12	.0020	.0000	.60	1.7
25495	Nov. 29	V. slight.	V. slight.	.27	3.40	1.05	.0004	.0068	.0062	.0006	.10	.0050	.0000	.28	1.4
25712	Dec. 20	None.	V. slight.	.14	3.60	1.10	.0000	.0040	.0032	.0008	.11	.0070	.0002	.18	1.4
Av...	....	....	....	.28	3.79	1.31	.0009	.0088	.0079	.0009	.09	.0047	.0001	.34	1.4

Odor, generally none, sometimes faintly vegetable. A faintly vegetable odor was developed in most of the samples on heating.

NORTHAMPTON.

Chemical Examination of Water from the Middle Storage Reservoir on Roberts' Meadow Brook, collected near the Surface.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21977	Jan. 25	Slight.	V. slight.	.23	3.05	1.15	.0002	.0062	.0054	.0008	.11	.0030	.0000	0.30	1.4
22329	Feb. 23	V. slight.	V. slight.	.20	3.55	1.05	.0006	.0062	.0044	.0018	.14	.0070	.0000	0.20	1.3
22670	Mar. 28	V. slight.	V. slight.	.20	2.25	1.00	.0004	.0080	.0068	.0012	.07	.0100	.0000	0.26	1.0
22995	Apr. 26	Slight.	Slight.	.39	3.50	1.40	.0004	.0096	.0088	.0008	.08	.0030	.0000	0.40	1.0
23344	May 30	V. slight.	Cons.	.50	3.40	1.60	.0008	.0104	.0092	.0012	.07	.0040	.0001	0.36	1.1
23683	June 23	V. slight.	Slight.	.38	4.25	1.60	.0022	.0174	.0128	.0046	.08	.0010	.0000	0.44	1.6
24078	July 27	Slight.	Slight.	.21	4.70	1.75	.0018	.0180	.0132	.0048	.10	.0000	.0000	0.28	1.6
24485	Aug. 29	V. slight.	Slight.	.41	4.90	1.95	.0032	.0264	.0218	.0046	.08	.0020	.0001	1.40	1.8
24846	Sept. 27	Slight.	Slight.	.28	4.95	1.80	.0048	.0238	.0174	.0064	.15	.0020	.0001	0.42	1.8
25179	Oct. 25	V. slight.	Slight.	.43	4.60	1.90	.0000	.0126	.0104	.0022	.14	.0010	.0000	0.64	1.7
25496	Nov. 29	V. slight.	V. slight.	.26	3.50	1.15	.0002	.0062	.0052	.0010	.11	.0040	.0000	0.29	1.4
25713	Dec. 20	None.	V. slight.	.15	3.45	1.00	.0006	.0068	.0060	.0008	.12	.0080	.0002	0.18	1.4
Av...	....	....	....	.30	3.84	1.45	.0013	.0126	.0101	.0025	.10	.0037	.0000	0.43	1.4

Odor, faintly vegetable or none.

Microscopical Examination of Water from the Middle Storage Reservoir on Roberts' Meadow Brook, collected near the Surface.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	June.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	26	24	29	28	1	27	29	31	29	27	30	22
Number of sample,	21977	22329	22670	22995	23344	23683	24078	24485	24846	25179	25496	25713
PLANTS.												
Diatomaceæ,	6	2	18	26	50	52	1,802	88	80	76	93	4
Asterionella,	0	0	0	0	0	0	0	0	4	8	68	2
Cyclotella,	0	0	0	0	1	3	1,776	16	40	0	0	0
Synedra,	2	1	6	16	30	47	16	65	23	68	11	1
Algæ,	0	0	0	1	1	0	36	21	7	0	1	0
ANIMALS.												
Infusoria,	0	2	0	0	0	7	126	44	26	72	1	0
Dinobryon,	0	0	0	0	0	7	82	16	21	62	1	0
Peridinium,	0	2	0	0	0	0	40	17	2	8	0	0
Vermes,	0	0	0	0	0	0	4	3	1	0	0	0
Crustacea, Cyclops,	0	0	0	0	0	0	0	pr.	pr.	0	0	0
Miscellaneous, Zoöglœa,	10	0	3	10	5	15	15	8	8	8	3	5
TOTAL,	16	4	21	37	56	74	1,983	164	122	156	98	9

NORTHAMPTON.

Chemical Examination of Water from the Middle Storage Reservoir on Roberts' Meadow Brook, collected near the Bottom.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21978	Jan. 25	Slight.	Slight.	0.30	3.70	1.25	.0070	.0078	.0060	.0018	.14	.0080	.0001	.30	1.7
22330	Feb. 23	Slight.	V. slight.	0.29	3.75	0.95	.0034	.0076	.0064	.0012	.14	.0080	.0000	.25	1.3
22671	Mar. 28	V. slight.	Slight.	0.20	2.55	1.30	.0008	.0068	.0058	.0010	.07	.0070	.0000	.25	1.0
22996	Apr. 26	Slight.	Slight.	0.40	3.05	1.30	.0000	.0100	.0084	.0016	.09	.0030	.0000	.40	1.0
23345	May 30	Slight.	Cons.	0.49	3.50	1.65	.0014	.0136	.0110	.0026	.07	.0030	.0000	.40	1.1
23684	June 23	Slight.	Cons.	0.38	4.00	1.45	.0010	.0138	.0110	.0028	.07	.0020	.0001	.45	1.7
24079	July 27	Slight.	Cons.	0.34	4.50	1.70	.0140	.0198	.0142	.0056	.08	.0000	.0000	.42	1.7
24486	Aug. 29	Decided.	Cons.	1.70	6.25	2.30	.0418	.0278	.0224	.0054	.08	.0020	.0003	.62	1.8
24847	Sept. 27	Decided.	Cons.	1.44	5.90	2.15	.0596	.0256	.0168	.0088	.09	.0010	.0001	.48	2.2
25180	Oct. 25	None.	Slight.	0.47	4.50	1.75	.0000	.0112	.0096	.0016	.13	.0010	.0000	.66	1.6
25497	Nov. 29	V. slight.	Slight.	0.27	3.45	1.25	.0006	.0072	.0056	.0016	.11	.0020	.0000	.31	1.4
25714	Dec. 20	V. slight.	V. slight.	0.25	3.50	1.10	.0006	.0068	.0064	.0004	.11	.0060	.0004	.26	1.1
Av...	....	....	....	0.54	4.05	1.51	.0108	.0132	.0103	.0029	.10	.0036	.0001	.40	1.5

Odor, generally faintly vegetable or none, occasionally musty or unpleasant.

Microscopical Examination of Water from the Middle Storage Reservoir on Roberts' Meadow Brook, collected near the Bottom.

[Number of organisms per cubic centimeter.]

	1898. Jan.	Feb.	Mar.	Apr.	June.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	26	24	29	28	1	27	29	31	29	27	30	22
Number of sample,	21978	22330	22671	22996	23345	23684	24079	24486	24847	25180	25497	25714
PLANTS.												
Diatomaceæ,	1	0	11	21	40	90	1,292	35	19	96	22	8
Cyclotella,	0	0	0	0	2	2	1,264	0	0	2	0	0
Synedra,	1	0	3	12	24	44	24	30	11	80	12	5
Cyanophyceæ,	0	0	0	0	0	0	0	0	0	2	0	0
Algæ,	0	0	0	1	0	0	4	6	0	4	0	1
ANIMALS.												
Infusoria,	0	1	0	0	0	1	4	24	8	2	0	0
Trachelomonas,	0	0	0	0	0	0	0	16	8	0	0	0
Miscellaneous, Zoöglœa,	5	6	5	10	12	20	40	60	60	8	5	5
TOTAL,	6	7	16	32	52	111	1,340	125	87	112	27	14

Water Supply of North Andover.

Population in 1895, 3,569. The works are owned by the town, and were completed in the latter part of the year 1898. The source of supply is Great Pond in North Andover. The pond has an area of 621 acres and a water-shed of 5.4 square miles, which contains a population of 50 per square mile. Water is pumped from the pond to an open distributing reservoir having a capacity of 1,000,000 gallons. (See also pages 43 to 45 of this volume.)

Chemical Examination of Water from Great Pond, North Andover.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
22937	1898. Apr. 21	V. slight.	V. slight.	.24	3.75	1.25	.0002	.0166	.0152	.0014	.38	.0030	.0000	.34	1.3

Odor, none, becoming faintly vegetable on heating.

Water Supply of North Attleborough.

The source of supply is a well 30 feet in diameter and 26 feet deep, located near the outlet of Whiting's Mill Pond, on the Ten Mile River, just above the village of North Attleborough.

Chemical Examination of Water from the Wells of the North Attleborough Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21882	Jan. 17	None.	None.	.01	6.60	.0000	.0016	.78	.0620	.0000	.02	2.9	.0020
22317	Feb. 22	V. slight.	Slight.	.02	6.30	.0000	.0006	.80	.0620	.0000	.02	2.9	.0020
23079	May 5	None.	Slight.	.04	7.20	.0004	.0030	.81	.0630	.0000	.03	3.1	.0040
23727	June 27	Slight.	None.	.01	8.20	.0006	.0010	.82	.0410	.0000	.03	3.5	.0060
24396	Aug. 22	None.	None.	.00	7.00	.0000	.0014	.77	.0650	.0000	.02	3.0	.0000
25223	Oct. 31	None.	None.	.01	7.60	.0000	.0004	.82	.0620	.0000	.05	2.9	.0010
25789	Dec. 27	None.	None.	.00	6.10	.0000	.0012	.75	.0540	.0000	.02	3.0	.0010
Av...	....	....	....	.01	7.00	.0001	.0013	.79	.0584	.0000	.03	3.0	.0023

Odor, none. —— No. 23079 was collected from the well, and the others from a faucet at the pumping station.

NORTHBOROUGH.

Water Supply of Northborough.

The source of supply is Cold Harbor Brook in Shrewsbury, on which two reservoirs have been constructed. The upper reservoir, which was formerly a mill pond, has an area of 8 acres and a maximum depth of 9 feet. The shores of this reservoir are sandy, but the bottom near the centre is muddy. The lower reservoir has an area of 9 acres, a maximum depth of 15 feet and a storage capacity of 30,000,000 gallons. A considerable portion of this reservoir is very shallow, and the bottom is said to be muddy. The water-shed of the lower reservoir has an area of 2.3 square miles, which contains a population of about 45 per square mile.

Chemical Examination of Water from the Upper Reservoir of the Northborough Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21957	Jan. 24	V. slight.	V. slight.	0.60	2.90	1.15	.0002	.0120	.0108	.0012	.19	.0070	.0000	0.52	0.8
22609	Mar. 21	V. slight.	V. slight.	0.66	2.50	1.20	.0006	.0158	.0150	.0008	.23	.0000	.0000	0.55	0.8
23263	May 23	Slight.	Slight.	1.80	4.05	2.00	.0016	.0312	.0304	.0008	.22	.0090	.0000	1.12	1.0
24045	July 25	V. slight.	Slight.	0.60	4.00	2.25	.0010	.0276	.0244	.0032	.19	.0010	.0001	0.71	0.8
24762	Sept. 26	V. slight.	None.	0.85	4.85	2.20	.0006	.0258	.0242	.0016	.28	.0030	.0000	0.93	0.6
25527	Dec. 1	V. slight.	None.	0.56	3.75	1.25	.0004	.0106	.0104	.0002	.21	.0030	.0000	0.63	0.6
Av...	....	....	....	0.84	3.67	1.67	.0007	.0205	.0192	.0013	.22	.0038	.0000	0.74	0.8

Odor, distinctly vegetable, sometimes faintly musty or none. On heating, a faintly unpleasant odor was developed in No. 24762.

Chemical Examination of Water from the Lower Reservoir of the Northborough Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21958	Jan. 24	V. slight.	None.	0.48	2.45	0.85	.0004	.0120	.0112	.0008	.20	.0080	.0000	.42	0.8
22610	Mar. 21	V. slight.	V. slight.	0.59	2.40	1.35	.0002	.0124	.0120	.0004	.20	.0020	.0000	.45	0.8
23264	May 23	Slight.	Slight.	1.10	3.10	1.35	.0012	.0252	.0220	.0032	.20	.0070	.0000	.72	0.8
24046	July 25	Decided.	Cons.	0.50	3.85	2.25	.0012	.0300	.0258	.0042	.17	.0000	.0000	.59	0.8
24763	Sept. 26	Slight.	Cons.	0.62	4.75	2.40	.0006	.0268	.0222	.0046	.23	.0030	.0000	.72	1.0
25528	Dec. 1	V. slight.	V. slight.	0.48	3.40	1.30	.0004	.0094	.0088	.0006	.20	.0040	.0000	.52	0.8
Av...	....	....	....	0.63	3.32	1.58	.0007	.0193	.0170	.0023	.20	.0040	.0000	.57	0.8

Odor, faintly vegetable or musty, sometimes none. A distinctly unpleasant odor was developed in No. 24763 on heating.

Water Supply of North Brookfield.

The sources of supply are Doane and North ponds and North Brook in North Brookfield. Doane Pond is an old mill pond, the level of which has been raised. The pond now has an area of 31 acres and a storage capacity of 54,000,000 gallons. The pond has a water-shed tributary to it, including the water-shed of North Pond and North Brook, of 2.51 square miles, which contains a population of 45 per square mile.

North Pond, which is situated just above Doane Pond, has an area of 70 acres and a storage capacity of 350,000,000 gallons. The maximum depth of this pond is 30 feet and the average depth 15 feet. The water of North Pond and of North Brook, which has been made tributary to North Pond, is used during much of the time to furnish power for pumping, water for the supply of the town being drawn from Doane Pond.

A filter has been constructed in Doane Pond, through which the water is passed before being pumped to the distributing reservoir. Two concentric stone walls extending from the bottom of the pond to above the high-water mark have been built well out in the pond, and the annular space between the walls, 5 feet in width, has been filled with gravel. Water is drawn from the well inside the inner wall. The results of analyses of water collected from the pond and from the filter indicate that the filter has but little influence upon the quality of the water.

Chemical Examination of Water from Doane Pond, North Brookfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21907	Jan. 19	Decided.	Cons.	.68	3.95	1.85	.0126	.0236	.0202	.0034	.21	.0120	.0001	.46	1.6
22303	Feb. 21	Decided.	Cons.	.67	3.85	1.65	.0142	.0184	.0140	.0044	.21	.0080	.0001	.46	0.8
22585	Mar. 16	Decided.	Cons.	.59	2.80	1.05	.0010	.0204	.0146	.0058	.14	.0070	.0000	.49	1.0
22906	Apr. 20	Slight.	Cons.	.39	2.65	1.20	.0000	.0218	.0162	.0056	.14	.0050	.0000	.40	1.1
23204	May 18	Slight.	Cons.	.50	2.75	1.45	.0020	.0220	.0192	.0028	.18	.0080	.0000	.45	0.8
23579	June 15	V. slight.	Slight.	.60	3.30	1.50	.0046	.0266	.0230	.0036	.17	.0010	.0000	.50	1.0
24026	July 25	Decided.	Cons.	.60	3.45	1.55	.0034	.0356	.0270	.0086	.13	.0010	.0002	.54	0.8
24344	Aug. 17	Decided.	Cons.	.50	4.65	2.05	.0026	.0264	.0246	.0018	.13	.0000	.0007	.54	0.6
24722	Sept. 21	Slight.	Cons.	.53	3.80	1.45	.0018	.0260	.0244	.0016	.14	.0000	.0000	.51	0.8
25112	Oct. 20	V. slight.	V. slight.	.63	3.95	1.65	.0102	.0228	.0204	.0024	.16	.0020	.0004	.58	0.6
25399	Nov. 16	Slight.	V. slight.	.45	3.30	1.50	.0096	.0278	.0242	.0036	.12	.0010	.0001	.61	1.0
25731	Dec. 21	Slight.	V. slight.	.51	3.50	1.50	.0206	.0178	.0168	.0010	.15	.0070	.0002	.55	0.8
Av.	....	....	....	.55	3.50	1.53	.0069	.0241	.0204	.0037	.16	.0043	.0001	.51	0.9

Odor, generally faintly vegetable or musty, becoming stronger, and in September also fishy, on heating.

NORTH BROOKFIELD.

Microscopical Examination of Water from Doane Pond, North Brookfield.

[Number of organisms per cubic centimeter.]

	1898. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	20	23	17	21	19	16	26	18	22	21	17	22
Number of sample,	21907	22303	22585	22906	23204	23579	24026	24344	24722	25112	25399	25731
PLANTS.												
Diatomaceæ,	68	10	20	720	284	7	17	6	34	42	432	22
Asterionella,	54	3	0	20	20	1	0	0	10	0	27	18
Synedra,	10	1	8	428	116	3	2	6	6	16	10	2
Tabellaria,	4	6	8	272	120	1	14	0	16	24	394	2
Cyanophyceæ,	0	0	0	0	0	1	2	0	0	0	0	0
Algæ,	20	1	4	106	16	14	47	64	8	10	7	0
Protococcus,	18	0	0	100	0	5	0	0	0	0	0	0
Raphidium,	2	1	4	4	2	1	31	60	6	4	4	0
ANIMALS.												
Rhizopoda,	0	0	0	0	0	0	1	2	0	0	0	0
Infusoria,	50	77	414	133	60	81	78	52	188	136	52	1
Dinobryon,	24	26	40	122	46	78	39	18	168	134	49	0
Mallomonas,	0	0	0	0	4	0	36	8	6	0	0	0
Peridinium,	24	48	366	6	2	0	0	2	2	0	1	1
Trachelomonas,	0	0	0	2	2	0	2	16	4	0	1	0
Vermes,	2	0	0	2	6	1	0	12	6	4	1	0
Crustacea, Cyclops,	0	0	0	pr.	pr.	pr.	pr.	0	0	0	0	0
Miscellaneous, Zoöglœa,	10	10	20	8	10	5	10	15	10	5	5	5
TOTAL,	150	98	458	969	376	109	155	151	246	197	497	28

Chemical Examination of Water from North Pond, North Brookfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21906	Jan. 19	Decided.	Cons.	.72	4.55	2.45	.0110	.0326	.0286	.0040	.25	.0140	.0002	.80	1.6
22907	Apr. 20	Slight.	Cons.	.60	3.15	1.35	.0000	.0256	.0216	.0040	.17	.0120	.0000	.50	1.1
24027	July 25	Decided.	Cons.	.41	3.10	1.80	.0010	.0308	.0230	.0078	.14	.0010	.0001	.57	0.6
25111	Oct. 20	V. slight.	V. slight.	.48	3.20	1.55	.0056	.0256	.0214	.0042	.13	.0010	.0002	.67	0.8
Av...	....	....	....	.55	3.50	1.79	.0044	.0286	.0236	.0050	.17	.0070	.0001	.63	1.0

Odor of the first sample, faintly musty, becoming stronger on heating; of the others, distinctly vegetable.

NORTH BROOKFIELD.

Microscopical Examination of Water from North Pond, North Brookfield.

[Number of organisms per cubic centimeter.]

	1898. January.	1898. April.	1898. July.	1898. October.
Day of examination,	20	21	26	21
Number of sample,	21906	22907	24027	25111
PLANTS.				
Diatomaceæ,	6	224	30	1,470
Asterionella,	0	64	0	8
Tabellaria,	2	122	30	1,436
Algæ,	72	36	400	34
Raphidium,	4	2	390	14
Zoöspores,	68	0	0	0
ANIMALS.				
Infusoria,	12	52	182	34
Dinobryon,	3	28	174	28
Euglena,	4	20	2	2
Vermes,	0	2	0	0
Crustacea, Cyclops,	0	pr.	0	pr.
Miscellaneous, Zoöglœa,	10	7	5	5
TOTAL,	100	321	617	1,543

NORTHFIELD.

The advice of the State Board of Health to the Northfield Water Company, relative to a proposed water supply from Minot and Warwick brooks in Northfield, may be found on pages 45 and 46 of this volume.

The results of analyses of samples of water collected from each of these sources are given in the following table: —

Chemical Examination of Water from Warwick and Minot Brooks, Northfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
22693	Mar. 29	Slight.	Cons.	.36	2.05	0.95	.0008	.0110	.0084	.0026	.07	.0050	.0000	.42	0.5
22694	Mar. 29	V. slight.	Slight.	.10	1.80	0.60	.0004	.0042	.0036	.0006	.06	.0090	.0000	.19	0.5

Odor, none. —— The first sample was collected from Warwick Brook, at site of the second dam above the village of Northfield, and the last from Minot Brook, just above its confluence with Warwick Brook.

NORWOOD.

Water Supply of Norwood.

The source of supply is Buckmaster Pond in Dedham. The pond has an area of 29.5 acres, a maximum depth of 29 feet, an average depth of 13 feet and a storage capacity of 123,000,000 gallons. The bottom is sandy except at the upper end, where there is a considerable amount of mud. The pond has a water-shed of 0.45 of a square mile, which contains a population of about 145 per square mile.

The water of this pond has frequently been affected during the winter months by the presence of enormous quantities of the organism *Uroglena*, which has imparted to the water an oily and fishy taste and odor.

Chemical Examination of Water from Buckmaster Pond, Dedham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21755	Jan. 4	Distinct.	Slight.	.17	3.15	1.10	.0122	.0152	.0136	.0016	.44	.0070	.0000	.18	1.3
22059	Feb. 3	Slight.	Slight.	.19	3.25	1.00	.0112	.0134	.0112	.0022	.40	.0050	.0000	.22	1.4
22399	Mar. 1	Slight.	V. slight.	.15	2.40	1.00	.0022	.0284	.0146	.0138	.33	.0030	.0001	.24	0.5
22730	Apr. 5	V. slight.	V. slight.	.12	3.25	1.25	.0024	.0190	.0180	.0010	.37	.0060	.0000	.37	0.5
23043	May 3	V. slight.	V. slight.	.20	2.65	0.65	.0020	.0150	.0134	.0016	.36	.0000	.0001	.26	0.5
23378	June 1	V. slight.	V. slight.	.28	2.70	1.15	.0014	.0178	.0142	.0036	.36	.0010	.0000	.31	0.8
23795	July 5	V. slight.	V. slight.	.17	4.45	3.05	.0006	.0194	.0180	.0014	.30	.0020	.0001	.33	0.6
24139	Aug. 2	V. slight.	V. slight.	.13	2.70	1.30	.0032	.0306	.0258	.0048	.33	.0020	.0000	.34	0.6
24546	Sept. 6	V. slight.	V. slight.	.14	2.70	1.10	.0010	.0216	.0182	.0034	.30	.0010	.0000	.35	0.5
24917	Oct. 5	V. slight.	V. slight.	.10	2.45	1.20	.0012	.0244	.0232	.0012	.35	.0010	.0000	.30	0.5
25221	Nov. 1	V. slight.	Slight.	.15	3.05	1.00	.0082	.0164	.0136	.0028	.34	.0020	.0000	.29	0.5
25537	Dec. 5	V. slight.	V. slight.	.19	2.90	1.45	.0096	.0124	.0114	.0010	.30	.0020	.0000	.25	0.6
Av...	....	....	....	.17	2.97	1.27	.0046	.0195	.0163	.0032	.35	.0027	.0000	.29	0.7

Odor, generally vegetable or none, occasionally distinctly musty, becoming stronger on heating. A fishy odor was developed in the March sample on heating.

NORWOOD.

Microscopical Examination of Water from Buckmaster Pond, Dedham.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	5	7	2	6	4	3	6	3	7	6	2	6
Number of sample,	21755	22059	22399	22730	23043	23378	23795	24139	24546	24917	25221	25537
PLANTS.												
Diatomaceæ,	258	35	0	67	22	23	53	4	1	7	31	8
Asterionella,	96	26	0	52	8	8	0	0	0	4	4	2
Synedra,	160	5	0	14	3	1	1	3	0	3	15	6
Cyanophyceæ,	3	2	0	0	1	0	3	5	1	7	3	0
Algæ,	0	0	0	1	0	5	1	33	33	0	5	0
ANIMALS.												
Infusoria,	6	8	548	13	2	0	5	7	6	2	1	0
Ciliated infusorian,	0	0	40	0	0	0	0	0	0	0	0	0
Dinobryon,	0	7	500	12	0	0	0	0	0	0	0	0
Vermes,	0	0	0	1	0	0	0	1	0	1	0	0
Crustacea,	0	0	0	pr.	0	0	0	0	0	0	0	0
Cyclops,	0	0	0	pr.	0	0	0	0	0	0	0	0
Daphnia,	0	0	0	pr.	0	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	5	5	8	3	5	3	3	3	3	3	3	5
TOTAL,	272	50	556	85	30	31	65	53	44	20	43	13

WATER SUPPLY OF ORANGE.

The sources of supply are North Pond, Coolidge Brook and a spring near Coolidge Brook.

The spring, which has furnished most of the supply for several years, is collected in an open reservoir having a capacity of 600,000 gallons. Water from this reservoir is pumped directly to an open distributing reservoir.

On Coolidge Brook two small storage reservoirs have been constructed, water for the supply of the town being taken from the upper reservoir, and the lower reservoir being used to furnish power for pumping. The upper reservoir has a drainage area

ORANGE.

of 1.38 square miles, which contains a population of 33 per square mile.

North Pond is a natural pond, the level of which has been raised 10 feet by the construction of a dam, and a connection has been made by means of which the water can be diverted into Coolidge Brook at a point between the two reservoirs, so that the water of this pond is available for power; but it is also one of the sources of water supply of the town, and has been used for a short time during dry weather for this purpose. The pond has an area of 132 acres and a drainage area of 0.66 of a square mile, which contains a population of 23 per square mile. Much of the area which was flooded when the level of the pond was raised is swampy, and the water of the pond is highly colored and contains at times enormous numbers of microscopical organisms.

The organism *Uroglena* has appeared on several occasions in the water of the open distributing reservoir, giving the water a disagreeable taste and odor.

Chemical Examination of Water from North Pond, Orange.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21923	Jan. 18	V. slight.	Slight.	.18	2.45	1.00	.0014	.0118	.0090	.0028	.19	.0060	.0001	.24	1.1
22275	Feb. 17	V. slight.	V. slight.	.20	3.05	1.25	.0034	.0076	.0074	.0002	.16	.0080	.0000	.21	0.5
22557	Mar. 15	Slight.	V. slight.	.35	2.40	1.10	.0028	.0122	.0096	.0026	.10	.0040	.0000	.36	1.1
23219	May 18	V. slight.	Cons.	.28	2.35	1.20	.0006	.0170	.0128	.0042	.14	.0000	.0000	.33	0.8
23596	June 15	V. slight.	Cons.	.25	2.40	1.20	.0004	.0240	.0172	.0068	.13	.0020	.0000	.32	0.8
23966	July 19	Decided.	Cons.	.30	2.85	1.75	.0024	.0234	.0206	.0028	.09	.0020	.0000	.40	0.3
24338	Aug. 16	Slight.	Slight.	.34	2.70	1.40	.0024	.0310	.0292	.0018	.13	.0020	.0001	.44	0.5
24712	Sept. 20	Decided.	Cons.	.30	2.45	1.15	.0010	.0248	.0206	.0042	.12	.0000	.0000	.46	0.5
25102	Oct. 18	Slight.	Slight.	.45	3.55	1.65	.0000	.0256	.0194	.0062	.15	.0010	.0001	.62	1.3
25408	Nov. 16	V. slight.	V. slight.	.30	2.35	1.05	.0004	.0176	.0152	.0024	.13	.0010	.0000	.40	0.6
25723	Dec. 20	Slight.	Slight.	.25	2.65	1.00	.0012	.0098	.0090	.0008	.13	.0060	.0001	.29	0.5
Av.	....	....	....	.29	2.65	1.25	.0015	.0186	.0155	.0031	.13	.0029	.0000	.37	0.7

Odor, faintly vegetable or none. In November, the odor became very faintly fishy on heating.

ORANGE.

Chemical Examination of Water from the Distributing Reservoir of the Orange Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21924	Jan. 18	V. slight.	V. slight.	.05	2.90	1.00	.0002	.0044	.0038	.0006	.14	.0010	.0000	.08	1.1
22276	Feb. 17	V. slight.	Slight.	.05	2.95	0.90	.0010	.0078	.0074	.0004	.17	.0030	.0000	.18	0.5
22558	Mar. 15	V. slight.	V. slight.	.11	3.20	1.00	.0000	.0040	.0036	.0004	.11	.0020	.0000	.17	1.1
22881	Apr. 18	V. slight.	Slight.	.19	2.15	0.80	.0002	.0080	.0060	.0020	.14	.0030	.0002	.20	0.5
23220	May 18	V. slight.	None.	.08	2.85	0.75	.0006	.0038	.0038	.0000	.14	.0000	.0000	.20	0.8
23597	June 15	V. slight.	V. slight.	.12	3.40	1.10	.0004	.0062	.0050	.0012	.13	.0010	.0000	.13	0.8
23967	July 19	Slight.	Slight.	.18	2.85	1.05	.0024	.0150	.0118	.0032	.07	.0040	.0000	.32	0.3
24711	Sept. 20	V. slight.	V. slight.	.10	3.25	0.70	.0004	.0048	.0038	.0010	.12	.0000	.0000	.11	0.8
25103	Oct. 18	V. slight.	V. slight.	.38	3.75	1.60	.0002	.0148	.0140	.0008	.13	.0010	.0001	.63	0.8
25409	Nov. 16	None.	None.	.12	3.00	0.95	.0000	.0048	.0046	.0002	.12	.0010	.0000	.20	0.8
25724	Dec. 20	V. slight.	V. slight.	.08	3.10	0.85	.0000	.0014	.0012	.0002	.12	.0060	.0000	.07	0.6
Av...	....	....	....	.13	3.04	0.97	.0005	.0068	.0059	.0009	.13	.0020	.0000	.21	0.7

Odor of No. 22558, faintly vegetable; of No. 23967, distinctly vegetable; of the others, none.

Microscopical Examination.

An insignificant number of organisms was found in each of these samples except in the sample collected in July, in which there were 2,372 Dinobryon per cubic centimeter.

Water Supply of Palmer Fire District, Palmer. — Palmer Water Company.

The source of supply is a small brook in Palmer, upon which two storage reservoirs have been constructed. The upper storage reservoir has an area of 4 acres, a maximum depth of 15 feet and a capacity of 6,000,000 gallons. The lower reservoir, which is situated a short distance below the upper reservoir, has an area of three-quarters of an acre, a general depth of 4 or 5 feet and a storage capacity of 2,000,000 gallons. The bottom and sides of the reservoirs are covered with sand. Water for the supply of the town is drawn from the lower reservoir.

PALMER.

Chemical Examination of Water from the Upper Reservoir of the Palmer Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
23341	May 31	Decided.	Cons.	.51	3.50	1.65	.0004	.0226	.0196	.0030	.13	.0100	.0000	.45	0.8
24072	July 27	Decided.	Slight.	.36	4.60	2.10	.0002	.0262	.0178	.0084	.10	.0010	.0000	.38	1.0
24850	Sept. 28	Slight.	V. slight.	.37	4.40	1.60	.0006	.0180	.0138	.0042	.16	.0030	.0000	.48	1.1
25469	Nov. 23	V. slight.	V. slight.	.30	3.05	1.15	.0002	.0084	.0076	.0008	.11	.0020	.0000	.27	0.5
Av...	....	....	....	.38	3.89	1.62	.0003	.0188	.0147	.0041	.12	.0040	.0000	.39	0.8

Odor of No. 23341, distinctly musty, becoming also unpleasant on heating; of the others, vegetable.

Chemical Examination of Water from the Lower Reservoir of the Palmer Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
22010	Jan. 27	Slight.	V. slight.	.20	2.60	1.00	.0014	.0060	.0046	.0014	.16	.0040	.0000	.22	1.1
22633	Mar. 23	V. slight.	Slight.	.25	2.50	0.85	.0016	.0086	.0076	.0010	.13	.0000	.0000	.22	0.5
23342	May 31	Slight.	Cons.	.50	3.65	1.50	.0004	.0136	.0098	.0038	.13	.0020	.0000	.36	1.0
24073	July 27	Decided.	Slight.	.30	4.35	1.60	.0006	.0170	.0126	.0044	.11	.0010	.0000	.29	0.8
24851	Sept. 28	Slight.	V. slight.	.36	4.05	1.50	.0004	.0188	.0144	.0044	.15	.0020	.0005	.40	1.0
25470	Nov. 23	V. slight.	V. slight.	.35	3.55	1.65	.0010	.0114	.0090	.0024	.10	.0040	.0000	.32	0.6
Av...	....	....	....	.33	3.45	1.35	.0009	.0126	.0097	.0029	.13	.0022	.0001	.30	0.8

Odor of No. 23342 distinctly musty, becoming also unpleasant on heating; of the others, vegetable. —— Nos. 22010 and 22633 were collected from a faucet in the town, and the others from the reservoir.

Water Supply of Peabody.

The sources of supply are Spring and Brown ponds in Peabody. Spring Pond has an area of about 70 acres and a water-shed of 0.25 of a square mile, which contains a population of 80 per

PEABODY.

square mile. Brown's Pond has an area of about 35 acres and a water-shed of 0.63 of a square mile, which contains a population of 130 per square mile. Water from these ponds flows to a small reservoir known as the lower basin, from which it is pumped to a stand-pipe. The water of each of these ponds has been affected at times by the presence of large numbers of the organism *Uroglena*.

Chemical Examination of Water from Brown's Pond, Peabody.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21835	Jan. 11	Slight.	Cons.	.17	3.35	1.55	.0016	.0204	.0180	.0024	.66	.0110	.0000	.28	1.0
22493	Mar. 8	Slight.	Slight.	.19	3.05	1.25	.0010	.0126	.0112	.0014	.55	.0070	.0000	.26	1.1
23086	May 9	Slight.	Cons.	.20	2.55	1.10	.0004	.0148	.0104	.0044	.57	.0060	.0001	.28	0.5
23834	July 11	Slight.	Slight.	.20	2.80	1.40	.0006	.0228	.0192	.0036	.52	.0010	.0000	.33	0.5
24607	Sept. 12	V. slight.	Slight.	.20	2.55	1.45	.0004	.0214	.0176	.0038	.52	.0000	.0000	.39	0.5
25367	Nov. 14	V. slight.	Slight.	.24	2.90	1.05	.0008	.0182	.0156	.0026	.50	.0010	.0000	.33	0.5
Av...	....	....	....	.20	2.87	1.30	.0008	.0183	.0153	.0030	.55	.0043	.0000	.31	0.7

Odor, none. On heating, the odor became faintly vegetable and musty or mouldy.

Chemical Examination of Water from Spring Pond, Peabody.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21834	Jan. 11.	Slight.	Cons.	.03	4.15	1.25	.0010	.0166	.0148	.0018	.81	.0020	.0000	.13	1.4
22492	Mar. 8.	Slight.	Cons.	.05	3.75	1.30	.0000	.0148	.0114	.0034	.74	.0070	.0000	.14	1.6
23085	May 9.	Slight.	Cons.	.05	3.75	1.40	.0000	.0182	.0118	.0064	.75	.0020	.0000	.19	1.1
23835	July 11.	Slight.	V. slight.	.04	4.00	1.85	.0034	.0164	.0152	.0012	.73	.0000	.0000	.16	1.3
24606	Sept. 12.	V. slight.	Cons.	.07	3.80	1.25	.0014	.0162	.0130	.0032	.72	.0010	.0000	.23	1.6
25368	Nov. 14.	V. slight.	Slight.	.08	4.30	1.30	.0084	.0130	.0112	.0018	.70	.0020	.0000	.15	1.4
Av...	....	....	....	.05	3.96	1.39	.0024	.0159	.0129	.0030	.74	.0023	.0000	.17	1.4

Odor of the first three samples, distinctly mouldy or musty and unpleasant, becoming in May also fishy on heating; of the fourth, none; of the last two, none, becoming musty or unpleasant on heating.

PEMBROKE.

PEMBROKE.

Chemical Examination of Water from Silver Lake, in Pembroke, collected near the Surface.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dissolved.	Sus-pended.					
	1898.														
21874	Jan. 17	V. slight.	Slight.	.07	2.55	0.90	.0000	.0118	.0112	.0006	.70	.0010	.0000	.19	0.8
22061	Feb. 3	V. slight.	Slight.	.08	2.85	0.95	.0004	.0128	.0104	.0024	.69	.0000	.0000	.21	1.1
22429	Mar. 2	V. slight.	V. slight.	.09	2.75	0.90	.0002	.0114	.0096	.0018	.67	.0030	.0000	.22	0.8
22755	Apr. 6	V. slight.	Slight.	.09	2.70	1.00	.0000	.0112	.0092	.0020	.65	.0000	.0000	.20	1.3
23120	May 11	V. slight.	V. slight.	.22	3.25	1.20	.0010	.0106	.0098	.0008	.69	.0000	.0000	.25	0.6
23368	June 1	V. slight.	Slight.	.27	2.95	0.95	.0010	.0176	.0146	.0030	.64	.0010	.0000	.28	0.6
23814	July 6	V. slight.	Slight.	.16	2.80	2.10	.0006	.0142	.0132	.0010	.58	.0030	.0000	.30	0.5
24146	Aug. 2	V. slight.	Slight.	.19	2.90	1.20	.0016	.0160	.0112	.0048	.52	.0000	.0000	.30	0.5
24544	Sept. 6	None.	V. slight.	.20	3.10	1.15	.0006	.0168	.0128	.0040	.60	.0000	.0000	.36	0.6
24926	Oct. 5	V. slight.	V. slight.	.17	3.05	1.25	.0000	.0118	.0092	.0026	.69	.0000	.0000	.29	0.6
25246	Nov. 2	V. slight.	Slight.	.20	3.50	1.25	.0000	.0108	.0092	.0016	.59	.0010	.0000	.32	0.5
25549	Dec. 6	V. slight.	Slight.	.20	3.35	1.30	.0004	.0184	.0174	.0010	.63	.0000	.0000	.36	0.6
Av...	....	....	....	.16	2.98	1.18	.0005	.0136	.0115	.0021	.64	.0007	.0000	.27	0.7

Odor, generally none. A faintly vegetable odor was developed in most of the samples on heating. —— The samples were collected from the lake, off Gunners' Point.

Chemical Examination of Water from Silver Lake, in Pembroke, collected near the Bottom.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dissolved	Sus-pended.					
	1898.														
21875	Jan. 17	V. slight.	Slight.	.07	2.60	0.95	.0002	.0122	.0104	.0018	.69	.0010	.0000	.19	0.8
22062	Feb. 3	Slight	Cons.	.08	3.00	0.90	.0000	.0114	.0094	.0020	.68	.0000	.0000	.22	1.1
22430	Mar. 2	V. slight	Slight.	.10	2.70	0.90	.0002	.0104	.0096	.0008	.67	.0030	.0000	.22	0.8
22756	Apr. 6	V slight.	Slight.	.10	3.00	1.10	.0000	.0114	.0102	.0012	.65	.0020	.0000	.22	1.3
23068	May 4	V. slight.	V. slight	.18	3.00	1.35	.0002	.0130	.0120	.0010	.64	.0020	.0000	.26	0.5
23369	June 1	V. slight.	Slight.	.27	3.10	1.00	.0006	.0168	.0144	.0024	.66	.0000	.0000	.37	0.6
23815	July 6	V. slight.	Cons.	.13	3.10	1.35	.0024	.0116	.0096	.0020	.56	.0020	.0000	.33	0.3
24147	Aug. 2	Slight.	Slight.	.18	3.45	1.15	.0020	.0112	.0086	.0026	.59	.0010	.0001	.30	0.6
24545	Sept. 6	V. slight.	V. slight	.17	3.35	1.20	.0000	.0104	.0094	.0010	.59	.0020	.0000	.32	0.6
24927	Oct. 5	Slight.	V. slight.	.18	3.35	1.25	.0000	.0102	.0078	.0024	.70	.0000	.0000	.29	0.6
25247	Nov. 2	V. slight.	Slight.	.19	3.25	1.25	.0000	.0112	.0100	.0012	.58	.0010	.0000	.33	0.5
25550	Dec. 6	V. slight.	Slight.	.20	3.00	1.35	.0000	.0080	.0064	.0016	.63	.0000	.0000	.34	0.5
Av...	....	....	....	.15	3.08	1.15	.0005	.0115	.0098	.0017	.64	.0012	.0000	.28	0.7

Odor, generally none. A faintly vegetable odor was developed in most of the samples on heating. —— The samples were collected from the lake, off Gunners' Point.

PEMBROKE.

Chemical Examination of Water from Oldham Pond.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
22097	Feb. 7	Slight.	Cons.	.30	3.60	1.45	.0056	.0222	.0178	.0044	.72	.0030	.0000	.34	1.3
22499	Mar. 8	V. slight.	Cons.	.35	3.90	1.40	.0008	.0198	.0166	.0032	.63	.0000	.0000	.38	0.5
22787	Apr. 10	V. slight.	Slight.	.35	3.40	1.35	.0006	.0126	.0096	.0030	.65	.0000	.0000	.39	1.0
23097	May 9	V. slight.	Cons.	.60	3.20	1.45	.0002	.0192	.0172	.0020	.66	.0020	.0002	.50	0.5
23414	June 6	None.	V. slight.	.65	3.80	2.00	.0012	.0204	.0184	.0020	.63	.0020	.0000	.49	0.3
23843	July 11	Slight.	Slight.	.36	4.25	2.35	.0006	.0244	.0208	.0036	.61	.0010	.0000	.46	0.5
24180	Aug. 7	V. slight.	Slight.	.38	4.10	2.15	.0010	.0222	.0190	.0032	.59	.0010	.0000	.46	0.5
24603	Sept. 11	Slight.	V. slight.	.38	3.85	1.55	.0010	.0240	.0204	.0036	.50	.0000	.0000	.54	0.6
24957	Oct. 10	V. slight.	V. slight.	.30	3.90	1.70	.0000	.0198	.0172	.0026	.52	.0010	.0000	.55	0.6
25311	Nov. 8	V. slight.	V. slight.	.40	3.85	1.70	.0008	.0216	.0202	.0014	.55	.0010	.0000	.50	0.5
25575	Dec. 7	Decided.	Cons.	.40	3.75	1.60	.0002	.0194	.0138	.0056	.61	.0010	.0000	.53	0.8
Av....	....	....	....	.41	3.78	1.70	.0011	.0205	.0174	.0031	.61	.0011	.0000	.47	0.6

Odor, vegetable or none. —— The samples were collected from the pond, at its outlet.

Water Supply of Pepperell.

The advice of the State Board of Health to the selectmen of Pepperell, relative to a proposed water supply for the town, may be found on pages 46 to 49 of this volume.

The results of chemical analyses of samples of water collected during the investigations are given in the following tables: —

Chemical Examination of Water from Unquetenassett Brook in Pepperell.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
24523	Sept. 5	Slight.	V. slight.	.37	6.65	1.85	.0010	.0100	.0082	.0018	.20	.0160	.0000	.42	2.9
24524	Sept. 5	Slight.	Slight.	.48	7.40	2.80	.0010	.0160	.0134	.0026	.20	.0170	.0000	.58	2.7
25304	Nov. 7	V. slight.	V. slight.	.73	6.15	2.45	.0000	.0168	.0166	.0002	.19	.0010	.0000	.74	2.6

Odor of the first two samples, none; of the last, faintly vegetable. —— The first sample was collected at a point about 2 miles above Cummings' Mill; the last two samples, at a place about three-quarters of a mile above Cummings' Mill.

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Chemical Examination of Water from Springs in the Valley of Unquetenassett Brook, in Pepperell.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
24448	Aug. 26	None.	Slight.	.03	4.80	.0004	.0080	.14	.0210	.0000	.21	2.0	.0100
24521	Sept. 5	V. slight.	V. slight.	.02	6.30	.0000	.0010	.38	.0550	.0000	.05	2.9	.0100
24522	Sept. 5	V. slight.	V. slight.	.18	6.20	.0014	.0030	.27	.0260	.0002	.20	2.6	.0100

Odor, none.——The first sample was collected from a large spring on the easterly side of Unquetenassett Brook, not far from Baralock Hill; the second sample was collected from a spring on the westerly side of Unquetenassett Brook, near the "willows" and about 1¼ miles above Cummings' Mill; the third sample was collected from a spring on the easterly side of the brook, about half a mile above the "willows" spring.

Chemical Examination of Water from Test Wells in the Valley of Unquetenassett Brook, in Pepperell.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
24449	Aug. 26	Decided, milky.	Slight.	.04	4.40	.0000	.0010	.16	.0320	.0006	.00	1.3	.0420
24450	Aug. 26	V. slight.	Slight.	.14	6.00	.0026	.0020	.18	.0160	.0030	.04	2.6	.1460
25305	Nov. 7	V. slight.	V. slight.	.19	5.50	.0022	.0012	.18	.0020	.0000	.04	2.6	.0170
24451	Aug. 26	Decided, milky.	Heavy.	.20	9.90	.0028	.0036	.15	.0010	.0000	.09	2.3	.3850

Odor, none.——The samples were collected from test wells located close to Unquetenassett Brook, at the highway crossing about three-quarters of a mile above Cummings' Mill. No. 24449 was collected from well No. 11; Nos. 24450 and 25305 from well No. 13; and No. 24451 from well No. 14. Well No 13 was located just below the highway, and the others just above it.

Water Supply of Pittsfield.

The sources of supply are four mountain streams, known as Sacket, Ashley, Hathaway and Mill brooks, and a pond called Ashley Pond, situated near the head waters of Ashley Brook. Ashley Pond has an area of 90.2 acres and its drainage area is 0.71 of a square mile. It was originally a natural pond, the level of which

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has been considerably raised by a dam at the outlet. An auxiliary supply is at times obtained by pumping from Sacket Brook, below the reservoir, not far from the mouth of the brook.

Chemical Examination of Water from Sacket Brook, Pittsfield.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as			
					Albuminoid.							
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
Average of four samples collected in March, June, October and December, 1898.	.17	5.79	1.34	.0004	.0081	.0070	.0011	.08	.0087	.0000	.22	4.2

Odor in March, faintly earthy; at other times, none.

Chemical Examination of Water from Sacket Brook in the Vicinity of the Pumping Station of the Pittsfield Water Works.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as			
					Albuminoid.							
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
Average of four samples collected in March, June, October and December, 1898.	.11	8.52	1.80	.0003	.0056	.0045	.0011	.07	.0155	.0000	.16	7.0

Odor in October, none; at other times, none, becoming vegetable or musty on heating.

Chemical Examination of Water from Ashley Brook, Pittsfield.

[Parts per 100,000.]

		Residue on Evaporation.		Ammonia.					Nitrogen as			
					Albuminoid.							
	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
Average of four samples collected in March, June, October and December, 1898.	.17	6.72	1.70	.0002	.0068	.0062	.0006	.07	.0122	.0000	.23	5.1

Odor, none.

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Chemical Examination of Water from Hathaway Brook, Pittsfield.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
Average of four samples collected in March, June, October and December, 1898.	.09	8.04	1.96	.0002	.0046	.0043	.0003	.08	.0160	.0000	.15	6.8

Odor, none. On heating, a faintly musty odor was developed in the June sample.

Chemical Examination of Water from Mill Brook, Pittsfield.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
Average of four samples collected in March, June, October and December, 1898.	.06	4.45	1.04	.0004	.0043	.0040	.0003	.06	.0090	.0000	.13	3.0

Odor, none.

Water Supply of Plymouth.

The sources of supply are Little South and Great South ponds in Plymouth.

Little South Pond has an area of 64 acres. Great South Pond has an area of 325 acres, and is connected with Little South Pond by an artificial channel. The soil of the lands about these ponds is gravelly and porous, and it is probable that water from Boot Pond, which is situated near Great South Pond, finds its way into the latter at times through the ground. A considerable number of summer cottages is situated on the shores of each of these ponds, but there is no permanent population on the water-shed. Lout Pond, located about half way between Little South Pond and the village of Plymouth, near the high-service pumping station, has been used as a source of supply.

PLYMOUTH.

The water of these ponds is usually of excellent quality, but the water of Little South Pond, from which the supply is drawn directly, has been affected on several occasions by large growths of the organism *Uroglena* during the winter months.

Chemical Examination of Water from Little South Pond, Plymouth.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21881	Jan. 18	V. slight.	Slight.	.02	2.50	1.00	.0020	.0164	.0146	.0018	.71	.0010	.0000	.10	0.6
22394	Mar. 1	V. slight.	V. slight.	.02	2.30	0.85	.0024	.0150	.0132	.0018	.67	.0000	.0000	.13	1.1
22806	Apr. 12	Slight.	V. slight.	.04	2.00	0.80	.0014	.0116	.0102	.0014	.64	.0000	.0000	.12	0.5
23184	May 17	V. slight.	Slight.	.04	1.90	0.60	.0014	.0138	.0128	.0010	.67	.0000	.0000	.12	0.3
23418	June 7	None.	V. slight.	.03	2.35	0.65	.0008	.0108	.0092	.0016	.66	.0000	.0000	.12	0.2
23850	July 12	Slight.	Slight.	.04	2.70	1.15	.0004	.0186	.0146	.0040	.67	.0010	.0000	.18	0.2
24206	Aug. 9	V. slight.	V. slight.	.06	2.55	1.30	.0006	.0176	.0146	.0030	.69	.0000	.0000	.11	0.0
24613	Sept. 13	V. slight	Slight.	.06	2.20	0.65	.0002	.0162	.0134	.0028	.66	.0020	.0000	.13	0.0
24960	Oct. 11	V. slight.	Slight.	.02	2.70	1.25	.0002	.0152	.0130	.0022	.66	.0000	.0000	.13	0.5
25287	Nov. 8	V. slight.	Slight.	.09	2.60	1.35	.0000	.0150	.0126	.0024	.59	.0010	.0000	.13	0.0
25605	Dec. 13	V. slight.	V. slight.	.08	2.75	1.00	.0006	.0132	.0106	.0026	.81	.0000	.0000	.14	0.3
Av...	....	....	....	.05	2.41	0.96	.0009	.0148	.0126	.0022	.68	.0005	.0000	.13	0.3

Odor, occasionally faintly vegetable or musty; at other times, none. On heating, the odor became vegetable and musty and sometimes fishy or oily.

Water Supply of Provincetown.

At the beginning of the year 1898, the source of supply was a system of six five-inch tubular wells, driven in loose, sandy soil to an average depth of about 28 feet. The water obtained from these wells contained a very large quantity of iron. Early in 1898 the water board constructed a large open basin to collect the water from the ground, and since March the water for the supply of the town has been drawn entirely from this source, and the driven wells have been abandoned. During the first months that the water was drawn from this basin the amount of iron in the water was comparatively small, but the quantity of iron present increased steadily, and at the end of the year about as much iron was found

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in the water of the basin as was formerly found in the water drawn from the tubular wells.

Chemical Examination of Water from the Tubular Wells of the Provincetown Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Sediment.	Color.	Residue on Evaporation.	Ammonia. Free.	Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1898.												
21776	Jan. 5	Decided.	Cons.	2.50	10.00	.0154	.0124	2.26	.0080	.0000	.74	5.0	.7500
22089	Feb. 7	Decided.	Cons.	-	9.50	.0140	.0102	2.32	.0060	.0001	.78	3.5	.5000
22450	Mar. 2	Decided.	Slight.	1.75	10.00	.0114	.0124	2.66	.0020	.0001	.66	2.9	.3900
Av...	....	....	....	2.12	9.83	.0136	.0117	2.41	.0053	.0001	.73	3.8	.5467

Odor, none. A faintly earthy odor was developed in the first two samples on heating. —— The samples were collected from a faucet at the pumping station.

Chemical Examination of Water from the Open Basin of the Provincetown Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Sediment.	Color.	Residue on Evaporation.	Ammonia. Free.	Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1898.												
22702	Apr. 1	Decided.	Cons.	-	9.40	.0092	.0154	2.75	.0070	.0000	.63	2.2	.2850
23071	May 4	Decided, milky.	Cons.	0.70	8.50	.0016	.0134	2.80	.0040	.0001	.51	2.2	.1900
23415	June 6	Slight.	Slight.	0.66	10.00	.0008	.0132	2.67	.0080	.0003	.48	1.4	.0400
23819	July 6	Slight.	Slight.	0.40	8.50	.0010	.0108	2.53	.0050	.0001	.59	1.8	.0200
24153	Aug. 3	Slight.	Slight.	0.32	8.20	.0032	.0268	2.20	.0040	.0000	.54	1.1	.0470
24577	Sept. 7	Decided, milky.	Cons.	0.70	8.90	.0008	.0104	2.37	.0010	.0000	.61	1.6	.1600
24928	Oct. 5	Decided, milky.	Slight.	0.90	9.00	.0052	.0166	2.18	.0030	.0003	.73	2.6	.2980
25282	Nov. 7	Decided.	Heavy.	1.10	12.10	.0182	.0148	2.54	.0060	.0002	.75	2.5	.4800
25456	Nov. 21	Decided.	Heavy.	0.90	10.00	.0016	.0138	2.42	.0080	.0000	.73	2.7	.6600
25582	Dec. 7	Decided.	Heavy.	0.50	11.00	.0122	.0122	2.63	.0010	.0000	.72	3.0	.4200
25690	Dec. 19	Decided.	Heavy.	0.70	11.50	.0212	.0186	2.50	.0060	.0001	.78	3.1	.4800
Av.*.	....	....	....	0.66	9.42	.0054	.0151	2.50	.0047	.0001	.62	2.1	.2289

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor, none. A faintly earthy or unpleasant odor was developed in some of the samples on heating. —— The samples were collected from the open basin.

Water Supply of Quincy.

The source of supply is a storage reservoir on Town Brook. The reservoir has an area of 46 acres, a maximum depth of 30 feet, an average depth of 11 feet and a storage capacity of 167,000,000 gallons. The water-shed of the reservoir has an area of 1.55 square miles, which contains a population of about 60 per square mile. There is a considerable area of meadow and swampy land on the water-shed.

The city of Quincy has entered the Metropolitan Water District, and the reservoir was abandoned, as a source of supply, Jan. 1, 1899.

Chemical Examination of Water from Town Brook, just above the Storage Reservoir of the Quincy Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
22002	Jan. 26	V. slight.	Cons.	0.48	3.80	1.55	.0002	.0118	.0114	.0004	.61	.0100	.0000	0.45	1.0
22321	Feb. 23	Slight.	Slight.	0.37	3.05	0.90	.0018	.0114	.0088	.0026	.48	.0070	.0000	0.34	0.3
22685	Mar. 30	V. slight.	V. slight.	0.70	3.55	1.50	.0012	.0170	.0160	.0010	.43	.0030	.0000	0.62	0.8
22989	Apr. 27	V. slight.	Slight.	0.66	3.25	1.45	.0002	.0130	.0122	.0008	.50	.0020	.0000	0.58	0.5
23294	May 25	Decided.	Cons.	1.85	5.15	2.75	.0024	.0326	.0288	.0038	.55	.0030	.0001	1.20	1.0
23733	June 29	Slight.	Cons.	1.40	7.05	2.95	.0072	.0424	.0358	.0066	.65	.0030	.0002	1.98	1.1
24064	July 27	Slight.	Slight.	1.00	5.35	2.40	.0012	.0320	.0284	.0036	.52	.0060	.0001	1.01	1.0
24480	Aug. 30	V. slight.	V. slight.	0.80	5.05	1.95	.0014	.0252	.0228	.0024	.50	.0070	.0002	0.78	0.8
24753	Sept. 26	Slight.	Slight.	0.73	5.35	2.25	.0010	.0270	.0260	.0010	.72	.0050	.0000	0.86	0.6
25184	Oct. 26	None.	V. slight.	1.06	5.50	2.50	.0006	.0238	.0192	.0046	.58	.0030	.0001	1.25	0.8
25489	Nov. 29	V. slight.	V. slight.	0.33	4.15	1.25	.0000	.0086	.0074	.0012	.67	.0070	.0000	0.42	1.0
25769	Dec. 27	V. slight.	V. slight.	0.35	3.60	1.35	.0000	.0072	.0068	.0004	.58	.0120	.0001	0.38	0.6
Av...	....	....	....	0.81	4.57	1.90	.0014	.0210	.0186	.0024	.57	.0057	.0001	0.82	0.8

Odor, distinctly vegetable, becoming sometimes also musty on heating.

QUINCY.

Chemical Examination of Water from the Storage Reservoir of the Quincy Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
22003	Jan. 26	Decided.	Cons.	0.50	4.00	1.55	.0034	.0166	.0146	.0020	.74	.0130	.0000	.46	1.3
22322	Feb. 23	Decided.	Slight.	0.39	3.00	1.10	.0036	.0132	.0116	.0016	.80	.0080	.0000	.34	0.8
22686	Mar. 30	Slight.	Cons.	0.40	3.35	1.10	.0010	.0220	.0144	.0076	.74	.0250	.0001	.48	0.8
22990	Apr. 27	Slight.	Slight.	0.55	3.25	1.00	.0006	.0192	.0142	.0050	.65	.0060	.0001	.41	0.6
23295	May 25	Slight.	Cons.	0.57	3.70	1.70	.0028	.0236	.0184	.0052	.60	.0050	.0001	.48	0.8
23734	June 29	V. slight.	Slight.	0.60	4.15	1.50	.0032	.0336	.0236	.0100	.65	.0000	.0000	.60	1.0
24065	July 27	Slight.	Slight.	0.60	4.50	2.05	.0022	.0296	.0258	.0038	.52	.0000	.0000	.64	0.8
24481	Aug. 30	V. slight.	Slight.	0.80	4.60	2.00	.0016	.0336	.0282	.0054	.54	.0010	.0000	.82	0.8
24754	Sept. 26	Decided.	Cons.	1.00	4.60	1.75	.0112	.0292	.0248	.0044	.62	.0010	.0000	.59	0.8
25185	Oct. 26	Decided.	Cons.	0.76	4.40	1.65	.0116	.0234	.0172	.0062	.62	.0040	.0000	.56	0.6
25490	Nov. 29	Slight.	Slight.	0.70	4.15	1.60	.0058	.0154	.0136	.0018	.62	.0070	.0001	.57	0.8
25770	Dec. 27	V. slight.	V. slight.	0.43	4.05	1.60	.0034	.0118	.0104	.0014	.60	.0120	.0002	.46	0.6

Averages by Years.

-	1889	-	-	0.91	3.76	1.19	.0116	.0303	.0238	.0065	.53	.0087	.0003	-	-
-	1890	-	-	0.70	4.56	1.76	.0085	.0249	.0178	.0071	.54	.0166	.0002	-	1.4
-	1891	-	-	0.70	3.97	1.60	.0027	.0274	.0178	.0096	.50	.0100	.0000	-	0.7
-	1892	-	-	0.62	4.07	1.41	.0051	.0237	.0175	.0062	.61	.0098	.0001	-	0.9
-	1893	-	-	0.56	3.81	1.51	.0052	.0218	.0172	.0046	.61	.0104	.0001	.51	0.8
-	1894	-	-	0.67	4.26	1.71	.0020	.0229	.0167	.0062	.67	.0053	.0000	.60	0.8
-	1895	-	-	0.66	4.22	1.77	.0008	.0301	.0187	.0114	.65	.0040	.0000	.56	0.7
-	1896	-	-	0.57	3.86	1.47	.0021	.0238	.0168	.0070	.63	.0062	.0001	.49	0.7
-	1897	-	-	0.62	3.92	1.56	.0039	.0246	.0196	.0050	.64	.0085	.0000	.48	0.7
-	1898	-	-	0.61	3.98	1.55	.0042	.0226	.0181	.0045	.64	.0068	.0000	.53	0.8

NOTE to analyses of 1898: Odor, generally vegetable, becoming sometimes musty, and in March and June fishy, on heating.

QUINCY.

Microscopical Examination of Water from the Storage Reservoir of the Quincy Water Works.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	27	24	31	28	26	30	28	31	31	28	30	28
Number of sample,	22003	22322	22686	22990	23295	23734	24065	24481	24754	25185	25490	25770
PLANTS.												
Diatomaceæ,	36	9	35	160	239	40	14	248	192	224	90	1
Asterionella,	21	2	8	56	105	40	14	76	72	134	32	1
Cyclotella,	0	0	0	0	1	0	0	126	95	10	0	0
Melosira,	0	0	0	0	7	0	0	0	0	54	0	0
Tabellaria,	13	1	22	64	108	0	0	42	7	6	11	0
Cyanophyceæ,	0	0	0	0	1	1	0	6	3	0	0	0
Algæ,	36	0	1	2	4	0	1	82	20	12	1	0
Protococcus,	0	0	0	0	0	0	0	54	0	0	0	0
ANIMALS.												
Rhizopoda,	0	0	0	0	0	0	0	4	0	0	0	0
Infusoria,	161	30	441	140	7	44	11	716	20	14	12	15
Dinobryon,	0	0	152	28	1	20	0	696	11	0	7	3
Peridinium,	160	30	288	108	4	3	4	6	3	2	5	11
Vermes,	1	0	3	4	3	0	0	0	1	0	0	0
Crustacea,	0	0	pr.	0	0	pr.	0	0	pr.	pr.	0	0
Cyclops,	0	0	pr.	0	0	pr.	0	0	pr.	pr.	0	0
Daphnia,	0	0	0	0	0	0	0	0	0	pr.	0	0
Miscellaneous, Zoöglœa,	8	5	5	7	5	3	5	5	10	15	5	3
TOTAL,	242	44	485	313	259	88	31	1,061	246	265	108	19

WATER SUPPLY OF RANDOLPH AND HOLBROOK.

The source of supply is Great Pond in Randolph and Braintree. The pond has an area of 130 acres, a maximum depth of 23 feet and a general depth of about 11 feet. At one end of the pond there is a large area of meadow land which is overflowed at times when the pond is full. The bottom is generally gravelly around the shore and muddy in the deeper portions. The pond has a drainage area

RANDOLPH AND HOLBROOK.

of 3.44 square miles, which contains a population of about 170 per square mile. There is some swamp and meadow land within the water-shed.

Chemical Examination of Water from Great Pond in Randolph and Braintree.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21785	Jan. 10	V. slight.	V. slight.	.60	5.40	2.55	.0002	.0198	.0194	.0004	.69	.0080	.0000	.59	2.1
22099	Feb. 8	Slight.	V. slight.	.64	4.75	1.80	.0002	.0184	.0180	.0004	.68	.0070	.0000	.62	1.1
22457	Mar. 7	V. slight.	V. slight.	.60	4.25	1.70	.0002	.0168	.0148	.0020	.46	.0090	.0000	.56	1.1
22793	Apr. 11	V. slight.	None.	.61	3.75	1.55	.0006	.0156	.0152	.0004	.50	.0090	.0002	.53	0.8
23095	May 9	V. slight.	V. slight.	.68	3.55	1.50	.0004	.0160	.0142	.0018	.54	.0030	.0000	.54	0.5
23464	June 8	V. slight.	V. slight.	.97	4.00	1.75	.0004	.0180	.0152	.0028	.56	.0020	.0000	.63	1.4
23859	July 12	Slight.	Slight.	.52	3.90	1.75	.0024	.0242	.0200	.0042	.52	.0000	.0000	.58	0.8
24224	Aug. 9	Slight.	V. slight.	.49	3.90	2.05	.0014	.0236	.0210	.0026	.50	.0020	.0001	.64	0.8
24602	Sept. 12	Slight.	V. slight.	.67	4.10	2.05	.0012	.0304	.0276	.0028	.45	.0000	.0000	.80	1.1
24956	Oct. 10	V. slight.	V. slight.	.49	4.80	2.55	.0002	.0234	.0228	.0006	.51	.0020	.0000	.85	1.0
25281	Nov. 7	V. slight.	None.	.68	4.85	2.55	.0010	.0222	.0216	.0006	.54	.0040	.0001	.80	1.0
25565	Dec. 7	Slight.	V. slight.	.60	4.15	1.75	.0000	.0144	.0138	.0006	.52	.0030	.0000	.71	1.0
Av...	....	....	....	.63	4.28	1.96	.0007	.0202	.0186	.0016	.54	.0041	.0000	.65	1.1

Odor, generally none, sometimes faintly vegetable or musty. On heating, the odor of most of the samples was faintly vegetable.

Water Supply of Reading.

The source of supply is a filter-gallery near the bank of the Ipswich River. The gallery is constructed beneath a meadow which is subject to being overflowed to a depth of 5 or 6 feet at times of high water in the river. The gallery is located 22 feet beneath the level of this meadow, and is constructed in two sections, one 75 feet long, parallel with the river, and the other 175 feet long, running at a right angle to the first. The gallery is $3\frac{1}{2}$ feet wide and 4 feet high.

The water obtained from the filter-gallery contains a large amount of iron, and a mechanical filter has been constructed to remove some of the iron. The water pumped from the filter-gallery is first treated with milk of lime and aerated, and then mixed with aluminum sulphate and filtered rapidly through small sand filters. By this process a large proportion of the iron is removed, but the hardness of the water is very greatly increased.

Chemical Examination of Water from the Filter-gallery of the Reading Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21811	Jan. 10	Decided.	Cons.	0.60	10.30	.0100	.0114	.58	.0030	.0001	.39	3.5	.2200
22079	Feb. 7	Decided.	Heavy, floc.	0.50	10.30	.0084	.0078	.51	.0030	.0000	.37	4.0	.1800
22464	Mar. 7	Decided, milky.	Cons.	0.53	9.40	.0076	.0084	.43	.0010	.0000	.40	3.3	.1850
22839	Apr. 12	Decided.	Cons.	0.90	9.40	.0076	.0088	.48	.0030	.0000	.43	3.0	.2100
23087	May 9	Decided.	Heavy.	-	8.50	.0076	.0130	.41	.0060	.0001	.59	2.9	.1800
23397	June 6	Decided.	Heavy.	1.00	9.00	.0076	.0140	.45	.0050	.0000	.64	2.9	.2000
23832	July 11	Decided, milky.	Heavy.	0.65	10.80	.0082	.0158	.45	.0020	.0001	.59	2.6	.1400
24190	Aug. 8	Decided.	Cons.	0.90	8.60	.0100	.0156	.40	.0010	.0000	.68	2.3	.4650
24604	Sept. 12	Decided.	Cons.	1.10	9.40	.0122	.0208	.38	.0010	.0000	.98	2.7	.2750
24953	Oct. 10	Decided.	Heavy.	1.00	9.60	.0110	.0186	.43	.0010	.0000	.90	3.1	.2100
25277	Nov. 7	Decided.	Heavy.	1.00	10.30	.0120	.0174	.43	.0040	.0000	.84	2.9	.2150
25529	Dec. 2	Decided.	Heavy.	0.85	9.70	.0120	.0178	.39	.0050	.0000	.82	3.0	.2250

Averages by Years.

-	1891	-	-	0.13	12.96	.0016	.0063	.43	.0094	.0001	-	5.1	-
-	1892	-	-	0.44	9.25	.0042	.0073	.54	.0071	.0001	-	3.4	-
-	1893	-	-	0.64	10.08	.0034	.0087	.56	.0032	.0001	.35	3.9	.1251
-	1894	-	-	0.45	12.76	.0043	.0107	.68	.0029	.0000	.35	5.0	.2642
-	1895	-	-	0.61	13.88	.0088	.0114	.72	.0048	.0000	.44	5.5	.2277
-	1896	-	-	0.52	11.50	.0080	.0089	.51	.0059	.0001	.40	4.1	.2696
-	1897	-	-	0.76	11.12	.0090	.0110	.53	.0058	.0001	.44	4.0	.2644
-	1898	-	-	0.82	9.61	.0095	.0141	.44	.0003	.0000	.64	3.0	.2254

NOTE to analyses of 1898: Odor in January and July, faintly earthy; at other times, none. On heating, the odor of the last two samples became faintly unpleasant.

READING.

Chemical Examination of Water from Reading Filter-gallery after passing through the Mechanical Filter.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21812	Jan. 10	V. slight.	None.	.18	16.20	.0016	.0090	.51	.0070	.0008	.23	12.5	.0080
22080	Feb. 7	None.	None.	.19	16.50	.0024	.0080	.48	.0170	.0009	.26	10.0	.0040
22465	Mar. 7	None.	V. slight.	.16	16.20	.0052	.0128	.46	.0030	.0013	.25	11.0	.0030
22840	Apr. 12	V. slight.	None.	.24	16.00	.0006	.0084	.46	.0070	.0007	.28	9.4	.0100
23088	May 9	V. slight.	None.	.30	14.50	.0024	.0080	.44	.0060	.0007	.30	8.4	.0080
23398	June 6	V. slight.	None.	.30	16.70	.0028	.0108	.41	.0070	.0006	.32	9.1	.0060
23833	July 11	None.	None.	.19	16.60	.0040	.0142	.43	.0040	.0005	.29	9.4	.0040
24191	Aug. 8	V. slight.	None.	.33	16.70	.0018	.0092	.43	.0020	.0006	.37	9.1	.0250
24605	Sept. 12	V. slight.	None.	.30	18.70	.0018	.0124	.45	.0060	.0001	.49	11.4	.0170
24954	Oct. 10	V. slight.	None.	.43	18.10	.0030	.0116	.46	.0030	.0005	.51	10.3	.0420
25278	Nov. 7	None.	None.	.31	18.40	.0040	.0084	.47	.0050	.0006	.39	10.0	.0110
25530	Dec. 2	V. slight.	V. slight.	.30	17.30	.0038	.0108	.46	.0050	.0005	.38	9.7	.0210

Averages by Years.

–	1896	–	–	.15	19.42	.0035	.0067	.56	.0043	.0016	.24	11.3	.0091
–	1897	–	–	.23	18.54	.0034	.0084	.52	.0082	.0010	.29	12.7	.0037
–	1898	–	–	.27	16.82	.0028	.0103	.45	.0060	.0006	.34	10.0	.0132

NOTE to analyses of 1898: Odor, none. —— The samples were collected from the weir over which the filtered water passes on its entrance to the storage tank at the pumping station.

WATER SUPPLY OF REVERE AND WINTHROP. — REVERE WATER COMPANY.

(See also *Metropolitan Water District*, pages 133–160.)

The sources of supply are wells in Revere and Saugus. The Revere wells are located in the valley of a small brook about a quarter of a mile from salt marshes. The system consists of two large wells, in the bottom of which several tubular wells have been driven, and three groups of tubular wells which are connected with the large wells. The Saugus wells are located at Cliftondale, on either side of a small brook. This system consists of 67 tubular wells, driven to depths of from 30 to 100 feet.

The water from the Revere wells is affected by the infiltration of a small amount of sea water into the wells, the result being a very decided increase in the quantity of chlorine, residue on evaporation and hardness.

Since February 9, water for the supply of Revere and Winthrop has been obtained in part from the Metropolitan Works, and the use of the Revere wells has been discontinued.

Chemical Examination of Water from Tubular Wells of the Revere Water Company at Cliftondale, Saugus.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21779	Jan. 5	None.	None.	.00	14.90	.0004	.0022	1.49	.2100	.0000	.01	7.4	.0020
22308	Feb. 18	None.	None.	.01	14.60	.0000	.0014	1.50	.2600	.0000	.05	7.4	.0010
22744	Apr. 4	None.	None.	.02	15.30	.0018	.0034	1.45	.2750	.0000	.02	7.4	.0030
23076	May 3	None.	None.	.01	14.70	.0000	.0020	1.51	.3200	.0007	.02	7.1	.0020
23605	June 7	None.	None.	.01	15.20	.0002	.0020	1.34	.2850	.0000	.02	6.9	.0010
23932	July 16	None.	None.	.01	16.00	.0002	.0014	1.34	.1950	.0012	.03	6.7	.0020
24173	July 30	None.	None.	.02	16.10	.0000	.0014	1.35	.2700	.0002	.02	6.7	.0040
24584	Sept. 5	None.	None.	.00	14.30	.0000	.0012	1.30	.2320	.0007	.05	6.6	.0020
24897	Oct. 3	None.	None.	.00	14.90	.0000	.0008	1.33	.2200	.0008	.04	7.0	.0020
25279	Nov. 5	None.	None.	.00	15.00	.0000	.0012	1.31	.2050	.0009	.02	7.0	.0030
25567	Dec. 6	None.	None.	.01	14.70	.0002	.0004	1.26	.3400	.0004	.02	7.1	.0010
Av...	....	....	....	.01	15.06	.0003	.0016	1.38	.2556	.0004	.03	7.0	.0021

Odor, none. —— The samples were collected from a tap in the pumping station.

Water Supply of Rockland.

(See *Abington.*)

ROCKPORT.

Water Supply of Rockport.

The source of supply is Cape Pond in Rockport. The pond has an area of 40 acres, a maximum depth of 26 feet and a water-shed of 0.33 of a square mile, which contains a population of 50 per square mile. The water-shed also contains a glue factory, wastes from which find their way into the pond. The water of the pond contains a large amount of organic matter, and has been subject to bad tastes and odors.

Chemical Examination of Water from Cape Pond, Rockport.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21871	Jan. 17	V. slight.	V. slight.	.30	10.60	1.85	.0016	.0218	.0176	.0042	4.96	.0000	.0000	.30	1.4
22201	Feb. 14	None.	V. slight.	.20	10.85	1.75	.0034	.0206	.0202	.0004	5.02	.0020	.0000	.30	1.1
22541	Mar. 14	Slight.	Cons.	.39	10.20	2.45	.0002	.0278	.0222	.0056	4.53	.0000	.0000	.34	0.6
22887	Apr. 18	Slight.	Cons.	.31	9.90	1.75	.0012	.0300	.0198	.0102	4.30	.0000	.0000	.36	1.0
23176	May 16	V. slight.	Slight.	.40	9.40	1.80	.0006	.0226	.0188	.0038	4.28	.0020	.0000	.32	1.3
23627	June 21	Decided.	Cons.	.43	9.70	1.70	.0002	.0338	.0210	.0128	4.22	.0030	.0000	.35	0.8
23928	July 19	Decided	V. slight.	.26	10.70	2.70	.0048	.0238	.0198	.0040	4.20	.0030	.0002	.28	1.0
24309	Aug. 15	Decided.	Cons.	.21	10.30	2.05	.0004	.0346	.0206	.0140	4.03	.0020	.0000	.37	1.3
24681	Sept. 19	Decided.	Cons., green.	.57	10.45	2.50	.0024	.0644	.0380	.0264	4.05	.0010	.0000	.52	0.8
25046	Oct. 17	Slight, green.	Slight.	.85	10.95	2.45	.0016	.0668	.0298	.0370	4.11	.0010	.0005	.54	1.1
25377	Nov. 14	Slight.	Slight.	.79	10.90	2.50	.0318	.0340	.0272	.0068	4.18	.0030	.0004	.50	1.0
25613	Dec. 13	V. slight.	V. slight.	.53	11.20	2.50	.0106	.0236	.0224	.0012	4.23	.0130	.0002	.42	1.1
Av...	....	....	....	.44	10.43	2.17	.0049	.0336	.0231	.0105	4.34	.0025	.0001	.38	1.0

Odor, generally fishy or grassy and occasionally vegetable.

ROCKPORT.

Microscopical Examination of Water from Cape Pond, Rockport.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	18	15	15	20	17	22	20	17	20	18	167	14
Number of sample,	21871	22201	22541	22887	23176	23627	23928	24309	24681	25046	2537	25613
PLANTS.												
Diatomaceæ,	6	24	2	2,228	2,534	28	26	90	20	140	152	77
Asterionella,	6	17	0	2,208	2,344	20	0	18	0	30	18	36
Melosira,	0	0	0	20	184	6	10	56	20	104	130	40
Cyanophyceæ,	0	0	0	1	0	384	26	14	864	1,408	14	0
Anabæna,	0	0	0	0	0	384	26	14	864	1,408	14	0
Algæ,	9	13	0	24	32	690	202	136	8	10	6	41
Scenedesmus,	1	0	0	0	2	612	54	16	0	0	2	0
Staurastrum,	1	0	0	0	14	52	108	108	2	2	2	0
ANIMALS.												
Infusoria,	14	14	0	63	128	4	4	96	280	136	56	13
Cryptomonas,	0	0	0	0	0	0	0	0	80	0	0	0
Dinobryon,	0	9	0	8	116	0	0	0	0	0	0	0
Mallomonas,	0	0	0	40	0	0	0	0	0	0	0	0
Peridinium,	4	0	0	9	10	0	0	0	8	2	2	0
Trachelomonas,	10	5	0	6	2	4	4	92	192	134	54	12
Vermes,	1	0	0	2	4	4	2	0	26	2	2	1
Crustacea,	0	pr.	0	pr.	0	0	0	0	pr.	pr.	pr.	pr.
Bosmina,	0	0	0	0	0	0	0	0	pr.	pr.	0	0
Cyclops,	0	pr.	0	pr.	0	0	0	0	0	pr.	0	0
Daphnia,	0	0	0	pr.	0	0	0	0	0	0	pr.	pr.
Miscellaneous, Zoöglœa,	0	5	20	8	3	5	5	100	5	3	0	0
TOTAL,	30	56	22	2,326	2,701	1,115	265	436	1,203	1,699	230	132

ROWLEY.

The advice of the State Board of Health to the board of health of Rowley, relative to the quality of the water of three wells used by the operatives in shoe factories in that town, may be found on pages 49 to 51 of this volume. The results of analyses of samples of water collected from each of the wells are given in the following table: —

ROWLEY.

Chemical Examination of Water from Wells in Rowley.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22406	Mar. 1	None.	V. slight.	.00	5.60	.0002	.0024	0.73	0.1050	.0000	.05	2.2	.0010
23016	Apr. 30	V. slight.	V. slight.	.02	7.50	.0002	.0024	0.89	0.1840	.0000	.05	3.5	.0020
22407	Mar. 1	Slight.	Slight.	.05	35.00	.0008	.0038	10.10	0.9500	.0001	.06	6.7	.0040
23014	Apr. 30	Decided, milky.	Cons., clayey.	.10	36.50	.0014	.0046	8.65	0.9200	.0003	.08	6.0	.0050
22408	Mar. 1	V. slight.	V. slight.	.05	45.50	.0004	.0104	10.40	2.1400	.0001	.10	9.1	.0010
23015	Apr. 30	V. slight.	Slight.	.05	37.60	.0004	.0088	8.85	1.6600	.0003	.10	8.1	.0030

Odor, none. —— The samples were collected from wells in Rowley, the water of which is used for drinking or other domestic purposes. The first two samples were collected from what is known as the Burke well; the third and fourth samples, from the Pickard well; the last two, from the Armitage well.

Water Supply of Rutland.

The source of supply is Lake Muschopauge in Rutland. The lake has an area of 58 acres and a watershed of 0.6 of a square mile, which contains 50 persons per square mile.

Chemical Examination of Water from Muschopauge Lake, Rutland.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21777	Jan. 6	Slight.	V. slight.	.11	2.45	0.95	.0006	.0108	.0082	.0026	.17	.0040	.0000	.12	1.1
22193	Feb. 14	V. slight.	Cons.	.07	2.65	1.00	.0014	.0120	.0102	.0018	.18	.0070	.0000	.18	1.3
22946	Apr. 20	V. slight.	V. slight.	.06	2.10	0.70	.0010	.0096	.0080	.0016	.18	.0030	.0000	.17	0.3
23452	June 8	V. slight.	V. slight.	.07	2.10	1.00	.0002	.0098	.0072	.0026	.16	.0070	.0000	.22	0.6
24096	July 29	V. slight.	V. slight.	.08	2.10	0.80	.0006	.0156	.0132	.0024	.17	.0010	.0000	.21	0.3
24929	Oct. 5	Slight.	V. slight.	.08	2.10	1.00	.0008	.0102	.0080	.0022	.18	.0000	.0000	.21	0.6
25259	Nov. 3	V. slight.	V. slight.	.08	3.05	1.55	.0010	.0134	.0114	.0020	.16	.0000	.0000	.18	0.6
25581	Dec. 7	V. slight.	V. slight.	.08	2.15	1.00	.0000	.0062	.0054	.0008	.16	.0010	.0000	.25	0.5
Av...	....	....	....	.08	2.34	1.00	.0007	.0109	.0089	.0020	.17	.0029	.0000	.19	0.7

Odor of No. 24929, distinctly musty, becoming stronger and also fishy on heating; of the others, none, becoming sometimes faintly vegetable or musty on heating. —— The first two samples were collected from a faucet at the pumping station; the remaining samples, from the lake, near the surface.

RUTLAND.

Chemical Examination of Water from Muschopauge Lake, collected near the Bottom.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
23453	June 8	V. slight.	Slight.	.05	1.95	0.80	.0004	.0104	.0080	.0024	.16	.0010	.0000	.20	0.5
24097	July 29	V. slight.	Slight, floc.	.08	2.10	0.75	.0010	.0126	.0106	.0020	.17	.0030	.0000	.20	0.5
24930	Oct. 5	V. slight.	Cons.	.07	2.15	1.15	.0036	.0114	.0092	.0022	.17	.0000	.0000	.22	0.6
25260	Nov. 3	V. slight.	V. slight.	.09	2.15	1.00	.0004	.0110	.0090	.0020	.16	.0060	.0000	.18	0.5
Av.				.07	2.09	0.92	.0013	.0113	.0092	.0021	.16	.0025	.0000	.20	0.5

Odor of the first and last samples, faintly vegetable; of the second, none, becoming faintly unpleasant on heating; of the third, faintly musty.

Water Supply of Salem and Beverly.

The sources of supply are Wenham Lake and Longham Brook Reservoir in Beverly and Wenham. Wenham Lake has an area of 251 acres and a maximum depth of 49 feet. The bottom is said to be gravelly. Its water-shed, of 3.1 square miles, contains a population of 100 per square mile.

Longham Brook Reservoir, which was constructed in 1895 as an auxiliary source of supply, has an area of 43 acres, a maximum depth of 8.5 feet and a storage capacity of 55,000,000 gallons. The area flowed contained much meadow land, from which no soil has been removed. The reservoir has a water-shed of 3.3 square miles, which contains a population of 80 per square mile. Water from Longham Brook Reservoir is discharged by gravity into Wenham Lake when necessary, but during the year 1898 only a small quantity of water from this source was used. The effect of the introduction of water from Longham Brook Reservoir on the water of Wenham Lake may be seen in the table of yearly averages of chemical anlyses of water from the lake.

SALEM AND BEVERLY.

Chemical Examination of Water from Wenham Lake, in Beverly and Wenham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21829	Jan. 11	V. slight.	Slight.	.10	5.75	1.40	.0016	.0158	.0138	.0020	.88	.0050	.0000	.26	2.6
22101	Feb. 8	V. slight.	V. slight.	.09	6.00	2.00	.0026	.0146	.0130	.0016	.88	.0070	.0000	.24	2.6
22494	Mar. 8	Slight.	Slight.	.12	5.75	1.30	.0044	.0142	.0122	.0020	.82	.0130	.0000	.24	2.3
22864	Apr. 16	V. slight.	V. slight.	.13	5.70	1.60	.0030	.0164	.0122	.0042	.79	.0080	.0002	.30	2.3
23100	May 8	Slight.	V. slight.	.20	5.15	1.45	.0018	.0130	.0126	.0004	.80	.0020	.0001	.26	2.2
23431	June 7	V. slight.	V. slight.	.21	5.30	1.65	.0026	.0130	.0108	.0022	.79	.0050	.0002	.33	2.2
23851	July 12	V. slight.	Slight.	.15	5.70	1.95	.0000	.0236	.0188	.0048	.80	.0000	.0000	.32	2.1
24236	Aug. 10	Slight.	Slight.	.12	5.65	2.40	.0036	.0314	.0256	.0058	.82	.0020	.0000	.34	2.1
24625	Sept. 13	V. slight.	Slight.	.15	5.30	1.80	.0002	.0256	.0204	.0052	.79	.0000	.0000	.37	2.1
24976	Oct. 11	V. slight.	V. slight.	.12	5.65	1.90	.0006	.0154	.0136	.0018	.76	.0000	.0001	.31	2.2
25309	Nov. 8	V. slight.	V. slight.	.17	6.20	1.60	.0072	.0184	.0156	.0028	.76	.0010	.0002	.29	2.5
25535	Dec. 5	V. slight.	Slight.	.21	5.30	1.85	.0032	.0172	.0132	.0040	.75	.0030	.0003	.28	2.3
25611	Dec. 13	V. slight.	V. slight.	.20	5.00	1.60	.0016	.0156	.0126	.0030	.74	.0060	.0002	.28	2.2

Averages by Years.

-	1888	-	-	.05	4.67	0.97	.0020	.0146	-	-	.73	.0058	.0001	-	-
-	1889	-	-	.06	4.23	1.05	.0014	.0173	.0138	.0035	.72	.0052	.0002	-	-
-	1890	-	-	.05	4.57	0.90	.0016	.0154	.0125	.0029	.74	.0104	.0001	-	2.5
-	1891	-	-	.07	4.70	1.12	.0006	.0147	.0113	.0034	.72	.0125	.0000	-	1.9
-	1892	-	-	.03	4.85	1.10	.0016	.0137	.0103	.0034	.75	.0077	.0000	-	2.2
-	1893	-	-	.04	5.49	1.26	.0033	.0130	.0100	.0030	.77	.0055	.0001	.16	2.6
-	1894	-	-	.07	6.69	1.53	.0030	.0148	.0114	.0034	.82	.0023	.0001	.14	3.0
-	1895	-	-	.21	6.75	1.97	.0026	.0177	.0146	.0031	.81	.0059	.0001	.30	3.1
-	1896	-	-	.15	6.30	1.82	.0020	.0213	.0152	.0061	.80	.0053	.0001	.28	2.7
-	1897	-	-	.13	6.09	1.60	.0027	.0206	.0170	.0036	.82	.0048	.0001	.29	2.7
-	1898*	-	-	.15	5.61	1.73	.0025	.0181	.0151	.0030	.80	.0040	.0001	.29	2.3

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

NOTE to analyses of 1898: Odor, faintly vegetable or none. On heating, the odor of most of the samples became distinctly vegetable, and in January, also fishy. —— Nos. 22101, 22494 and 25611 were collected from a faucet at the pumping station; the others, from the lake.

SALEM AND BEVERLY.

Miscroscopical Examination of Water from Wenham Lake, in Beverly and Wenham.

[Number of organisms per cubic centimeter.]

	1898.												
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Dec.
Day of examination,	13	9	9	18	11	8	13	11	14	13	9	6	14
Number of sample,	21829	22101	22494	22864	23100	23431	23851	24236	24625	24976	25309	25535	25611
PLANTS.													
Diatomaceæ,	**611**	**25**	**116**	**552**	**624**	**179**	**50**	**61**	**112**	**392**	**1,182**	**2,508**	**747**
Asterionella,	68	2	2	52	536	0	0	48	30	48	378	1,504	322
Cyclotella,	212	19	64	88	29	129	2	0	0	4	10	0	0
Melosira,	164	3	40	312	39	16	0	0	0	20	354	436	203
Stephanodiscus,	0	0	0	8	0	0	0	0	0	0	10	56	34
Synedra,	2	1	4	60	11	2	0	1	0	4	2	2	3
Tabellaria,	144	0	6	14	4	30	48	11	51	296	416	482	185
Cyanophyceæ,	**20**	**100**	**16**	**0**	**0**	**4**	**52**	**166**	**27**	**14**	**4**	**0**	**0**
Anabæna,	0	0	0	0	0	0	37	138	8	10	0	0	0
Aphanizomenon,	20	100	16	0	0	0	0	0	0	0	0	0	0
Clathrocystis,	0	0	0	0	0	0	2	22	0	0	0	0	0
Cœlosphærium,	0	0	0	0	0	4	4	6	19	4	4	0	0
Algæ,	**3**	**2**	**2**	**4**	**28**	**32**	**136**	**0**	**27**	**14**	**2**	**0**	**3**
Protococcus,	0	0	0	0	27	30	133	0	17	0	0	0	0
ANIMALS.													
Infusoria,	**3**	**9**	**12**	**122**	**277**	**20**	**12**	**1**	**30**	**42**	**21**	**8**	**1**
Dinobryon,	0	0	0	116	276	18	0	0	12	36	0	2	0
Trachelomonas,	1	6	12	2	0	0	3	0	2	2	10	2	1
Vermes,	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**0**	**0**	**0**	**0**	**0**
Crustacea,	**pr.**	**0**	**0**	**0**	**0**	**pr.**	**0**	**0**	**0**	**0**	**0**	**pr.**	**0**
Miscellaneous, Zoöglœa,	**10**	**10**	**3**	**5**	**0**	**0**	**10**	**5**	**8**	**5**	**5**	**3**	**3**
TOTAL,	647	146	149	683	929	235	261	235	204	467	1,214	2,519	754

SALEM AND BEVERLY.

Chemical Examination of Water from Longham Brook Reservoir, in Beverly and Wenham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21828	Jan. 11	Slight.	Cons., earthy.	0.90	6.75	2.40	.0210	.0238	.0214	.0024	1.16	.0280	.0002	0.71	2.1
22865	Apr. 16	V. slight.	Slight.	0.70	4.10	1.90	.0046	.0234	.0208	.0026	0.83	.0070	.0001	0.68	1.3
23101	May 8	Slight.	Cons.	0.82	4.25	1.85	.0006	.0212	.0194	.0018	0.76	.0020	.0000	0.69	1.0
23432	June 7	Slight.	Slight.	1.85	5.75	3.15	.0094	.0516	.0428	.0088	0.69	.0040	.0002	1.33	1.0
23852	July 12	Slight.	Cons.	2.50	7.85	4.10	.0032	.1028	.0644	.0384	0.80	.0010	.0000	1.47	1.6
24235	Aug. 10	Slight.	Cons.	1.80	7.65	3.70	.0078	.0528	.0476	.0052	0.77	.0020	.0001	1.04	1.7
24624	Sept. 13	Slight.	Cons.	2.60	8.35	3.90	.0350	.1160	.1050	.0110	0.74	.0150	.0012	1.38	2.2
24975	Oct. 11	Slight.	V. slight.	1.05	7.05	3.05	.0060	.0368	.0320	.0048	1.14	.0020	.0000	1.35	1.1
25308	Nov. 8	Slight.	V. slight.	1.12	5.90	2.70	.0044	.0272	.0260	.0012	0.72	.0030	.0002	1.05	1.3
25612	Dec. 13	V. slight.	V. slight.	0.53	5.30	2.15	.0024	.0160	.0146	.0014	1.04	.0210	.0000	0.56	1.4
Av...	1898	....	....	1.39	6.29	2.89	.0094	.0472	.0394	.0078	0.86	.0085	.0002	1.03	1.5
Av...	1897	....	....	1.83	6.99	3.05	.0127	.0504	.0415	.0089	0.94	.0098	.0002	1.17	1.7

NOTE to analyses of 1898: Odor, faintly vegetable, becoming stronger on heating.

Microscopical Examination of Water from Longham Brook Reservoir, in Beverly and Wenham.

[Number of organisms per cubic centimeter.]

	1898. Jan.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	13	18	11	8	13	11	14	13	9	14
Number of sample,	21828	22865	23101	23432	23852	24235	24624	24975	25308	25612
PLANTS.										
Diatomaceæ,	3	16	105	64	4	4	3	43	13	8
Synedra,	0	11	50	58	4	3	1	39	11	0
Cyanophyceæ,	0	0	0	0	0	0	0	1	1	0
Algæ,	0	0	1	6	4	2	0	1	0	0
Fungi, Crenothrix,	0	0	0	0	0	81	90	0	0	0
ANIMALS.										
Infusoria,	0	25	130	60	594	32	17	4	1	0
Dinobryon,	0	25	126	48	0	0	0	2	0	0
Raphidomonas,	0	0	0	0	572	0	0	0	0	0
Trachelomonas,	0	0	0	0	20	28	10	2	1	0
Vermes,	0	0	0	2	18	0	0	0	0	0
Miscellaneous, Zoöglœa,	10	5	7	5	0	5	8	3	5	3
TOTAL,	13	46	243	137	620	124	118	52	20	11

WATER SUPPLY OF SAUGUS.

(See *Lynn.*)

Water Supply of Sharon.

The source of supply is a well 16 feet in diameter and 16 feet deep, situated near Beaver Brook in Sharon.

Chemical Examination of Water from the Well of the Sharon Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22072	Feb. 4	None.	None.	.02	9.10	.0006	.0012	1.14	.2280	.0000	.02	3.9	.0020
22760	Apr. 6	V. slight.	V. slight.	.05	9.10	.0002	.0004	1.13	.2850	.0000	.01	3.4	.0420
23759	June 29	V. slight.	V. slight.	.00	10.30	.0012	.0030	1.07	.2360	.0000	.01	3.0	.0030
24536	Sept. 6	V. slight.	V. slight.	.05	10.00	.0000	.0010	0.97	.1380	.0000	.06	2.6	.0170
24979	Oct. 10	None.	None.	.00	9.30	.0000	.0004	1.11	.2650	.0000	.03	3.3	.0040
25583	Dec. 7	None.	None.	.00	9.50	.0000	.0000	1.10	.2700	.0000	.01	3.3	.0010
Av...	....	....	....	.02	9.55	.0003	.0010	1.09	.2370	.0000	.02	3.5	.0115

Odor, none. —— Nos. 22072 and 22760 were collected from a faucet at the pumping station; the others, from the well.

Water Supply of Sheffield. — Sheffield Water Company.

The sources of supply are two small reservoirs about a mile and a half north-east of the village of Sheffield, which are fed chiefly by springs.

The advice of the State Board of Health to the Sheffield Water Company, relative to cases of illness in one of the schools of that town which had been attributed by some persons to the public water supply, may be found on page 51 of this volume.

Chemical Examination of Water from Faucets in Sheffield, supplied from the Works of the Sheffield Water Company.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
Average of five samples collected in March, May, August, September and November, 1898.	.08	3.40	1.05	.0001	.0026	.0025	.0001	.09	.0046	.0001	.09	1.7

Odor, none. A faintly vegetable odor was developed in the last two samples on heating.

SOMERVILLE.

Water Supply of Somerville.

(See *Metropolitan Water District*, pages 133–160.)

Water Supply of Southbridge. — Southbridge Water Supply Company.

Chemical Examination of Water from the Hatchet Brook Reservoir of the Southbridge Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21833	Jan. 11	V. slight.	Slight.	.60	3.50	1.70	.0068	.0154	.0146	.0008	.23	.0030	.0000	.56	1.0
22113	Feb. 8	V. slight.	None.	.35	2.80	0.80	.0004	.0114	.0098	.0016	.21	.0000	.0000	.36	0.5
22497	Mar. 8	V. slight.	V. slight.	.30	2.50	1.00	.0004	.0112	.0092	.0020	.11	.0030	.0000	.32	0.5
23419	June 7	V. slight.	Slight.	.70	3.00	1.35	.0024	.0162	.0126	.0036	.16	.0020	.0002	.56	0.5
23857	July 12	V. slight.	Cons.	.80	3.45	1.90	.0104	.0280	.0230	.0050	.13	.0000	.0000	.84	0.8
24221	Aug. 9	Decided.	Cons.	.90	4.25	2.15	.0116	.0310	.0232	.0078	.15	.0010	.0001	.84	1.0
24614	Sept. 13	Slight.	Slight.	.55	3.35	1.80	.0006	.0286	.0204	.0082	.12	.0000	.0000	.81	0.6
24978	Oct. 11	Decided.	Slight, green.	.45	3.80	1.90	.0004	.0340	.0288	.0052	.15	.0020	.0000	.83	1.0
25310	Nov. 8	Slight.	Slight.	.75	4.05	1.75	.0006	.0238	.0184	.0054	.19	.0010	.0004	.80	0.5
25621	Dec. 13	V. slight.	None.	.30	2.80	1.00	.0000	.0112	.0104	.0008	.15	.0000	.0000	.39	0.5
Av.	....	....	....	.57	3.35	1.53	.0034	.0210	.0170	.0040	.16	.0012	.0001	.63	0.7

Odor, generally faintly vegetable, sometimes none. On heating, the odor of some of the samples became stronger and also musty.

Water Supply of South Hadley Falls Fire District, South Hadley.

The sources of supply are Buttery Brook and Leaping Well reservoirs in South Hadley.

Buttery Brook Reservoir has an area of 2 acres, a maximum depth of 12 feet and a general depth of 8 feet. The bottom of the reservoir has been cleaned and covered with sand. The water-shed contains some swampy land near its upper end, and contains a small population.

Leaping Well Reservoir has an area of 9.2 acres, a capacity of 28,000,000 gallons, a maximum depth of 26 feet and an average depth of 9 feet. Much of the soil and organic matter was removed from the bottom when the reservoir was constructed. The watershed of the reservoir is a sandy plain, from which much ground water enters the reservoir where it is exposed to light. The water of the reservoir often contains large numbers of organisms.

The advice of the State Board of Health to the water commissioners of the fire district, relative to the bad taste and odor of the water of Leaping Well Reservoir and the best method of improving its quality, may be found on pages 51 to 53 of this volume.

Chemical Examination of Water from Leaping Well Brook at its Entrance to the Storage Reservoir of the South Hadley Falls Fire District.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
24447	Aug. 26	V. slight.	None.	.04	2.85	0.60	.0000	.0022	.0022	.0000	.11	.0010	.0000	.02	0.8

Odor, none. —— The sample was collected from the brook, a short distance above its entrance to the reservoir.

Chemical Examination of Water from Leaping Well Reservoir, South Hadley.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
23411	June 6	V. slight.	V. slight.	.10	2.75	1.30	.0010	.0098	.0076	.0022	.33	.0010	.0000	.14	0.5
24042	July 25	V. slight.	Cons.	.09	3.00	1.30	.0026	.0210	.0136	.0074	.06	.0010	.0001	.18	0.5
24445	Aug. 26	V. slight.	V. slight.	.09	2.40	0.65	.0002	.0126	.0102	.0024	.11	.0010	.0000	.12	0.3
24582	Sept. 7	Slight.	V. slight.	.09	2.75	0.50	.0002	.0094	.0072	.0022	.13	.0000	.0000	.16	0.5
Av...	....	....	....	.09	2.72	0.94	.0010	.0132	.0096	.0036	.16	.0007	.0000	.15	0.4

Odor, none. A distinctly vegetable odor was developed in the second sample on heating. —— The samples were collected from the reservoir.

Microscopical Examination.

The sample collected in July contained 356 *Anabæna* per cubic centimeter. An insignificant number of organisms was found in each of the other samples.

SOUTH HADLEY.

Chemical Examination of Water from Leaping Well Reservoir, collected near the Bottom.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
24043	July 25	Slight.	Cons.	.10	2.85	1.05	.0348	.0164	.0086	.0078	.09	.0010	.0001	.14	0.6
24446	Aug. 26	Decided.	Heavy.	.42	2.85	0.80	.0132	.0372	.0268	.0104	.11	.0010	.0000	.17	0.8

Odor of the first sample, distinctly disagreeable; of the last, decidedly musty and disagreeable, becoming offensive on heating. —— The samples were collected from the bottom of the reservoir, at the gate-house.

Chemical Examination of Water from Buttery Brook Reservoir, South Hadley.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
23412	June 6	V. slight.	Cons.	.46	4.25	1.95	.0022	.0170	.0112	.0058	.23	.0480	.0006	.26	0.6
24044	July 25	V. slight.	V. slight.	.21	4.00	1.45	.0032	.0160	.0106	.0054	.17	.0280	.0002	.23	1.0
25269	Nov. 7	Slight.	V. slight.	.18	4.95	1.95	.0000	.0068	.0042	.0026	.20	.0120	.0000	.28	0.8
Av...	....	....	....	.28	4.40	1.78	.0018	.0133	.0087	.0046	.20	.0293	.0003	.26	0.8

Odor of the first sample, faintly musty, becoming distinctly musty and unpleasant on heating; of the others, none, becoming vegetable on heating. —— The first two samples were collected from the reservoir, and the last, from a faucet in the town.

Water Supply of Spencer.

The source of supply is Shaw Pond in Leicester. The pond has an area of 80 acres and a water-shed of 0.60 of a square mile, which contains a very small population. A considerable portion of the pond is quite shallow.

Chemical Examination of Water from Shaw Pond, Spencer.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
Average of four samples collected in February, June, August and November, 1898.	.07	2.32	0.92	.0004	.0134	.0114	.0020	.18	.0047	.0000	.15	0.5

Odor, none. A faintly grassy or vegetable odor was developed in the last two samples on heating. —— The June and August samples were collected from the pond, and the others, from a faucet.

Water Supply of Springfield and Ludlow.

The sources of supply are a storage reservoir and basin in Ludlow, which are fed by several brooks, and Chapin Pond in Ludlow.

Ludlow Reservoir has an area of 445 acres, a capacity of 1,992,000,000 gallons and an average depth of 13.7 feet. A considerable portion of the bottom is covered with mud. When the reservoir was constructed an area of about 6⅜ acres of the most objectionable material was covered with sand to a depth of 1.5 feet and all of the bushes and trees were removed. The shores of the reservoir as a rule are abrupt. The reservoir is fed by a direct water-shed of 2.55 square miles, and by Higher, Axe Factory and Jabish brooks, which, with the canals which convey the water to the reservoir, have a combined water-shed of 19.59 square miles, making the total water-shed tributary to Ludlow Reservoir 22.14 square miles.

The water of Ludlow Reservoir is of such a poor quality, owing to the presence of enormous numbers of organisms in the reservoir at certain seasons of the year, that a basin has been made by sepa-

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rating a small portion from the rest of the reservoir. Water from the canals is discharged into this basin without passing through the storage reservoir, and when the supply from other sources is insufficient water from the reservoir is drawn into the basin and supplied to the city. The basin has an area of 12 acres and a capacity of 50,000,000 gallons.

Chapin Pond, which is used as a supplementary source of supply, has an area of 32 acres and has no visible inlet or outlet. It is situated in a sandy plain and is largely fed by springs. The organism *Uroglena* has appeared several times in the water of this pond.

Chemical Examination of Water from the Receiving Basin of the Springfield Water Works, at Ludlow.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21804	Jan. 10	V. slight.	Slight.	.37	3.50	1.45	.0016	.0104	.0100	.0004	.22	.0120	.0001	.32	1.4
22084	Feb. 7	Slight.	Slight.	.34	3.20	0.85	.0012	.0074	.0064	.0010	.18	.0080	.0000	.30	1.0
22475	Mar. 7	V. slight.	V. slight.	.36	3.10	1.10	.0006	.0090	.0080	.0010	.12	.0050	.0000	.34	0.8
22819	Apr. 12	V. slight.	Slight.	.37	2.85	1.10	.0004	.0114	.0094	.0020	.15	.0060	.0000	.36	0.8
23090	May 9	V. slight.	Slight.	.55	2.95	1.25	.0004	.0150	.0108	.0042	.16	.0070	.0000	.14	0.8
23409	June 6	V. slight.	Cons.	.68	3.20	1.20	.0010	.0200	.0156	.0044	.13	.0020	.0001	.48	0.8
23840	July 11	V. slight.	Cons.	.38	2.75	1.25	.0004	.0264	.0194	.0070	.14	.0000	.0000	.32	0.6
24195	Aug. 8	V. slight.	Slight.	.51	4.30	2.10	.0012	.0278	.0200	.0078	.16	.0010	.0000	.58	1.1
24599	Sept. 12	V. slight.	Slight.	.50	3.65	1.75	.0010	.0236	.0188	.0048	.14	.0060	.0001	.66	1.0
24950	Oct. 10	Slight.	Slight.	.55	4.45	2.15	.0044	.0230	.0212	.0018	.14	.0020	.0000	.82	1.1
25275	Nov. 7	V. slight.	V. slight.	.49	5.25	3.00	.0006	.0138	.0128	.0010	.16	.0030	.0002	.61	0.8
25572	Dec. 7	V. slight.	V. slight.	.34	3.30	1.30	.0000	.0062	.0050	.0012	.12	.0060	.0000	.44	0.6
Av...	....	....	....	.45	3.54	1.54	.0011	.0162	.0131	.0031	.15	.0048	.0000	.45	0.9

Odor, generally faintly vegetable, occasionally none, sometimes musty.

SPRINGFIELD AND LUDLOW.

Chemical Examination of Water from Ludlow Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21805	Jan. 10	Slight.	Slight.	.32	3.10	1.50	.0030	.0288	.0212	.0076	.22	.0030	.0001	.40	1.3
22086	Feb. 7	V. slight.	Slight.	.35	3.10	1.35	.0044	.0220	.0170	.0050	.20	.0030	.0000	.40	1.4
22476	Mar. 7	Slight.	Slight.	.38	2.90	0.90	.0022	.0164	.0114	.0050	.08	.0050	.0000	.32	0.8
22818	Apr. 12	Slight.	V. slight.	.21	2.55	1.05	.0002	.0198	.0130	.0068	.14	.0010	.0000	.29	0.5
23089	May 9	V. slight.	Cons.	.25	2.35	1.15	.0002	.0210	.0148	.0062	.16	.0030	.0000	.50	0.5
23408	June 6	V. slight.	Slight.	.37	2.50	0.90	.0010	.0266	.0168	.0098	.15	.0010	.0000	.26	1.0
23841	July 11	V. slight.	Cons.	.24	2.70	1.50	.0004	.0282	.0216	.0066	.13	.0000	.0000	.32	0.6
24194	Aug. 8	Slight.	Cons.	.32	2.70	1.60	.0002	.0544	.0214	.0330	.14	.0000	.0000	.32	0.6
24598	Sept. 12	V. slight.	Cons.	.24	2.70	1.70	.0004	.0566	.0294	.0272	.12	.0000	.0001	.39	0.6
24951	Oct. 10	Slight.	Cons.	.20	3.25	1.95	.0016	.0694	.0360	.0334	.16	.0000	.0000	.46	0.6
25274	Nov. 7	Slight.	Cons.	.30	3.60	1.95	.0032	.0736	.0328	.0408	.15	.0020	.0000	.45	0.5
25571	Dec. 7	Slight.	V. slight.	.31	3.35	1.75	.0074	.0302	.0258	.0044	.12	.0010	.0000	.44	0.6

Averages by Years.

-	1888	-	-	.13	2.91	1.20	.0019	.0332	-	-	.12	.0047	.0001	-	-
-	1889	-	-	.12	2.42	1.08	.0028	.0461	.0237	.0224	.10	.0033	.0002	-	-
-	1890	-	-	.15	2.96	1.54	.0029	.0387	.0210	.0177	.10	.0065	.0001	-	0.9
-	1891	-	-	.20	3.00	1.42	.0050	.0425	.0228	.0197	.09	.0050	.0001	-	0.8
-	1892*	-	-	.25	3.41	1.41	.0006	.0277	.0189	.0088	.13	.0049	.0001	-	1.0
-	1893†	-	-	.47	4.11	2.03	.0011	.0375	.0259	.0116	.14	.0019	.0001	.58	1.2
-	1894	-	-	.37	3.39	1.47	.0009	.0221	.0165	.0056	.16	.0018	.0000	.42	1.1
-	1895	-	-	.29	3.35	1.55	.0028	.0315	.0201	.0114	.18	.0030	.0000	.41	1.1
-	1896	-	-	.26	3.25	1.41	.0042	.0404	.0220	.0184	.15	.0031	.0000	.37	1.0
-	1897	-	-	.33	3.28	1.67	.0039	.0453	.0267	.0186	.15	.0028	.0000	.43	0.8
-	1898	-	-	.29	2.90	1.44	.0020	.0373	.0218	.0155	.15	.0016	.0000	.38	0.7

* January to September. † May to December.

NOTE to analyses of 1898: Odor, generally vegetable, occasionally grassy, sometimes disagreeable.

SPRINGFIELD AND LUDLOW.

Microscopical Examination of Water from Ludlow Reservoir.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	11	8	8	13	10	7	12	9	13	12	8	8
Number of sample,	21805	22086	22476	22818	23089	23408	23841	24194	24598	24951	25274	25571
PLANTS.												
Diatomaceæ,	120	4	30	218	1,700	577	766	438	180	866	270	105
Asterionella,	108	0	2	62	1,052	35	32	0	0	6	16	36
Cyclotella,	0	1	0	0	2	0	2	142	32	14	2	11
Fragilaria,	2	0	0	22	18	70	732	288	12	198	40	44
Melosira,	0	0	0	90	380	468	0	0	112	644	198	6
Synedra,	8	1	8	32	216	3	0	2	4	4	6	6
Cyanophyceæ,	72	1	0	26	4	6	158	216	340	702	1,136	40
Anabæna,	0	0	0	2	0	0	16	32	0	648	1,120	40
Clathrocystis,	0	0	0	0	0	2	54	60	0	0	2	0
Cœlosphærium,	72	1	0	24	4	4	88	124	340	48	14	0
Algæ,	0	5	0	42	34	46	34	30	32	36	26	2
Scenedesmus,	0	0	0	6	14	14	4	6	12	16	12	0
ANIMALS.												
Rhizopoda,	0	0	0	2	0	0	0	0	0	0	0	0
Infusoria,	4	2	1	299	12	139	14	2	16	40	12	3
Dinobryon,	0	0	0	260	0	19	0	0	0	0	4	0
Mallomonas,	0	0	0	6	2	116	2	0	0	12	2	1
Peridinium,	2	1	1	6	6	0	2	0	8	22	0	0
Vorticella,	0	0	0	0	0	0	10	0	0	0	0	0
Vermes,	1	1	0	6	2	3	0	0	0	2	4	0
Crustacea,	pr.	pr.	0	0	pr.	pr.	0	pr.	0	pr.	0	pr.
Cyclops,	0	pr.	0	0	0	0	0	pr.	0	pr.	0	pr.
Daphnia,	0	0	0	0	pr.	pr.	0	0	0	0	0	0
Entomostracan ova,	pr.	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	5	5	5	10	12	5	10	50	16	12	15	0
TOTAL,	202	18	36	603	1,764	776	982	736	564	1,658	1,463	150

SPRINGFIELD AND LUDLOW.

Chemical Examination of Water from Ludlow Reservoir, collected near the Bottom.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21806	Jan. 10	Slight.	Slight.	.31	3.50	1.50	.0042	.0300	.0236	.0064	.22	.0030	.0001	.40	1.1

Odor, faintly vegetable, becoming distinctly vegetable and grassy on heating.

Chemical Examination of Water from Chapin Pond, Ludlow.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
22083	Feb. 7	V slight.	Slight.	.08	2.05	0.95	.0082	.0166	.0162	.0004	.16	.0030	.0000	.26	1.0
22479	Mar. 7	Slight.	Slight.	.10	2.15	1.05	.0082	.0204	.0186	.0018	.15	.0030	.0000	.32	0.6
22821	Apr. 12	V. slight.	Slight.	.10	2.30	1.05	.0058	.0192	.0168	.0024	.09	.0070	.0001	.26	0.5
23092	May 9	V. slight.	Slight.	.11	2.75	1.00	.0016	.0194	.0172	.0022	.15	.0070	.0001	.24	0.5
23407	June 6	V. slight.	V. slight.	.15	2.00	0.90	.0006	.0194	.0182	.0012	.15	.0020	.0001	.29	0.3
23839	July 11	Slight.	Slight.	.09	2.35	1.30	.0008	.0248	.0176	.0072	.11	.0000	.0001	.29	0.5
24193	Aug. 8	V. slight.	Slight.	.10	2.25	1.30	.0000	.0236	.0194	.0042	.08	.0010	.0000	.28	1.0
24597	Sept. 12	Slight.	Slight.	.09	2.00	1.05	.0004	.0252	.0194	.0058	.08	.0000	.0001	.31	0.5
24948	Oct. 10	Slight.	Slight.	.08	2.20	1.10	.0010	.0228	.0204	.0024	.13	.0000	.0000	.26	0.3
25273	Nov. 7	V. slight.	Slight.	.10	2.65	0.90	.0014	.0276	.0214	.0062	.15	.0010	.0000	.24	0.5
25568	Dec. 7	V. slight.	V. slight	.09	2.50	1.25	.0014	.0146	.0130	.0016	.11	.0010	.0000	.22	0.5
Av...	....	....	....	.10	2.29	1.08	.0027	.0212	.0180	.0032	.12	.0023	.0000	.27	0.6

Odor, vegetable or none. On heating, the odor in two of the samples became unpleasant, and in December distinctly fishy.

SPRINGFIELD AND LUDLOW.

Chemical Examination of Water from Loon Pond, Springfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21803	Jan. 10	V. slight.	Slight.	.04	3.00	1.50	.0028	.0374	.0342	.0032	.32	.0060	.0001	.18	1.1
22085	Feb. 7	Slight.	Cons.	.04	2.70	1.10	.0036	.0164	.0150	.0014	.25	.0080	.0000	.16	1.1
22478	Mar. 7	Slight.	Cons.	.08	2.35	1.00	.0020	.0134	.0114	.0020	.19	.0080	.0001	.18	0.8
22820	Apr. 12	V. slight.	Slight.	.05	2.30	1.00	.0008	.0152	.0124	.0028	.21	.0090	.0001	.14	0.8
23091	May 9	V. slight.	Slight	.01	2.35	0.90	.0014	.0142	.0126	.0016	.25	.0050	.0001	.22	0.8
23410	June 6	V. slight.	V. slight.	.04	2.40	0.90	.0016	.0176	.0152	.0024	.22	.0020	.0001	.20	0.6
23842	July 11	Slight.	Cons.	.08	2.65	1.20	.0004	.0244	.0184	.0060	.22	.0000	.0000	.16	0.6
24196	Aug. 8	V. slight	Slight.	.06	2.20	1.00	.0004	.0202	.0166	.0036	.20	.0000	.0000	.15	0.8
24600	Sept. 12	V slight.	Cons.	.08	2.40	1.20	.0004	.0228	.0182	.0046	.22	.0000	.0000	.23	1.0
24949	Oct. 10	V. slight.	V. slight.	.04	2.60	1.30	.0014	.0190	.0172	.0018	.21	.0000	.0001	.21	0.8
25276	Nov. 7	V. slight.	V. slight.	.05	2.85	1.40	.0000	.0186	.0178	.0008	.23	.0030	.0000	.17	0.8
25570	Dec. 7	V. slight.	Slight.	.12	2.20	1.00	.0006	.0140	.0126	.0014	.22	.0010	.0000	.16	0.6
Av...	....	....	....	.06	2.50	1.12	.0013	.0194	.0168	.0026	.23	.0035	.0000	.18	0.8

Odor, faintly vegetable or none. This pond is not used as a source of water supply.

Chemical Examination of Water from Five Mile Pond, Springfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21802	Jan. 10	V. slight.	Cons.	.16	2.45	1.55	.0016	.0374	.0352	.0022	.24	.0030	.0001	.36	0.8
22082	Feb. 7	V. slight	Slight.	.12	2.65	1.25	.0044	.0334	.0280	.0054	.24	.0030	.0000	.42	1.1
22477	Mar. 7	V slight.	V. slight.	.12	1.90	1.10	.0028	.0216	.0178	.0038	.12	.0000	.0000	.36	0.5
22822	Apr. 12	V. slight.	Cons.	.12	2.00	0.80	.0000	.0202	.0184	.0018	.14	.0020	.0000	.29	0.5
23093	May 9	V. slight.	Slight.	.17	2.85	1.10	.0006	.0202	.0178	.0024	.16	.0070	.0000	.29	0.5
23406	June 6	V. slight.	V. slight.	.17	2.05	1.10	.0008	.0238	.0206	.0032	.16	.0010	.0001	.32	0.3
23838	July 11	V. slight.	Slight.	.15	2.40	1.40	.0014	.0282	.0252	.0030	.13	.0010	.0000	.33	0.3
24192	Aug. 8	V. slight.	V. slight.	.13	2.50	1.50	.0002	.0276	.0238	.0038	.11	.0000	.0000	.35	0.3
24596	Sept. 12	V. slight.	Slight.	.12	1.75	1.25	.0010	.0268	.0228	.0040	.10	.0000	.0000	.38	0.3
24947	Oct. 10	V. slight.	V. slight.	.10	2.15	1.25	.0000	.0244	.0214	.0030	.16	.0000	.0000	.34	0.2
25272	Nov. 7	V. slight.	V. slight.	.14	2.00	1.00	.0030	.0226	.0210	.0016	.18	.0050	.0000	.32	0.5
25569	Dec. 7	V. slight.	V. slight.	.15	2.20	1.10	.0020	.0168	.0150	.0018	.11	.0010	.0000	.30	0.5
Av...	....	....	....	.14	2.24	1.20	.0015	.0252	.0222	.0030	.15	.0019	.0000	.34	0.5

Odor, vegetable. On heating, the odor of the May and December samples became distinctly fishy. This pond is not used as a source of water supply.

STOCKBRIDGE.

Water Supply of Stockbridge. — Stockbridge Water Company.

The sources of supply are a small reservoir, fed by a mountain stream, and Lake Averic in Stockbridge. The reservoir has a capacity of 94,500 gallons, and is fed by a small water-shed which is uninhabited. Lake Averic has an area of 50 acres and a water-shed of 1.8 square miles, which is uninhabited. The water of Lake Averic has been affected on several occasions by the presence in the water of large numbers of the organism *Uroglena.*

Chemical Examination of Water from Lake Averic, Stockbridge.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21989	Jan. 25	V. slight.	V. slight.	.13	6.20	1.05	.0004	.0134	.0116	.0018	.08	.0050	.0000	.30	4.0
22313	Feb. 22	V. slight.	V. slight.	.12	6.75	1.15	.0038	.0088	.0070	.0018	.10	.0130	.0000	.24	5.0
22631	Mar. 22	V. slight.	V. slight.	.12	7.15	1.40	.0008	.0114	.0098	.0016	.08	.0060	.0000	.19	5.0
22984	Apr. 26	Slight.	Slight.	.08	5.50	1.10	.0000	.0126	.0088	.0038	.06	.0020	.0000	.18	3.8
23293	May 24	Slight.	Slight.	.16	5.50	1.35	.0010	.0140	.0128	.0012	.08	.0000	.0000	.20	3.8
23673	June 21	V. slight.	Slight.	.11	5.15	0.55	.0046	.0150	.0106	.0044	.07	.0010	.0000	.26	3.6
24059	July 26	V. slight.	V. slight.	.11	6.15	1.65	.0016	.0186	.0166	.0020	.03	.0000	.0000	.27	3.5
24410	Aug. 23	V. slight.	V. slight.	.12	6.05	1.35	.0006	.0186	.0170	.0016	.04	.0020	.0000	.31	3.9
24807	Sept. 27	V. slight.	Slight.	.18	6.80	1.80	.0016	.0182	.0152	.0030	.05	.0040	.0000	.31	4.2
25163	Oct. 25	V. slight.	None.	.18	6.75	1.50	.0016	.0162	.0152	.0010	.08	.0010	.0000	.34	4.4
25467	Nov. 22	V. slight.	Slight.	.18	6.50	1.50	.0004	.0126	.0124	.0002	.06	.0030	.0000	.30	5.0
25707	Dec. 19	V. slight.	Slight.	.19	7.10	1.60	.0004	.0134	.0102	.0032	.08	.0060	.0002	.30	4.9
Av...	....	....	....	.14	6.30	1.33	.0014	.0144	.0123	.0021	.07	.0036	.0000	.27	4.3

Odor, faintly vegetable or none. On heating, the odor became generally distinctly vegetable and sometimes also mouldy or earthy; in April, fishy; and in September, faintly oily.

Microscopical Examination.

The sample collected in June contained 4,080 *Dinobryon* per cubic centimeter. An insignificant number of organisms was found in each of the other samples.

Water Supply of Stoneham.

(See *Wakefield.*)

STOUGHTON.

Water Supply of Stoughton.

The source of supply is a well near Muddy Pond Brook, about a quarter of a mile below Muddy Pond in Stoughton. The well is 6 feet in diameter and 39 feet deep, and has connected with it lines of drain pipe laid with open joints to collect the water from the ground in the vicinity of the well. Water for the supply of the town is also taken directly from the brook. The brook has a water-shed above the well of 1.83 square miles. Much of the water-shed is of porous soil, and there is a large number of springs on the shores of Muddy Pond.

Chemical Examination of Water from the Well of the Stoughton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22142	Feb. 10	V. slight.	V. slight.	.31	3.50	.0004	.0088	.41	.0100	.0000	.27	1.6	-
22298	Feb. 20	V. slight.	Slight.	.30	3.80	.0002	.0060	.39	.0080	.0000	.26	0.6	.0040
22838	Apr. 14	V. slight.	V. slight.	.25	3.80	.0010	.0074	.41	.0070	.0000	.37	0.8	-
23732	June 28	Decided.	Cons.	.10	5.90	.0008	.0152	.38	.0030	.0000	.38	0.6	.0070
24476	Aug. 29	Slight.	Slight.	.22	4.30	.0000	.0090	.33	.0020	.0000	.30	1.0	.0210
25190	Oct. 26	None.	V. slight.	.34	4.80	.0000	.0064	.36	.0040	.0000	.42	0.8	.0060
Av.*.	....	....	....	.24	4.49	.0004	.0091	.38	.0050	.0000	.35	0.9	.0095

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor, none. On heating, the odor in February became faintly vegetable, in June faintly musty, and in October faintly mouldy.

Water Supply of Swampscott and Nahant. — Marblehead Water Company.

The sources of supply are four systems of wells in Swampscott.

The original source of supply is a well 26 feet in diameter and 20 feet deep, located on the bank of Stacy's Brook in Swampscott. Seventy-two tubular wells, having an average depth of 40 feet, are located in the valley of the brook above the large well. Stacy's

Brook receives a large amount of sewage, and is highly polluted. The wells are also not far from the sea and the water drawn from them is affected at times by the infiltration of a small amount of sea water.

The second source of supply is a system of 46 tubular wells, located in Paradise Road, a short distance north-west of the pumping station. These wells have been sunk through clay and gravel to rock.

The third source is a system of 17 tubular wells, located a short distance east of the Swampscott railroad station.

The fourth source is a system of 21 tubular wells at the southerly end of Thompson Meadow, just north of the boundary line between Swampscott and Salem.

Chemical Examination of Water from the Wells of the Marblehead Water Company, Swampscott.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21772	Jan. 4	None.	None.	.01	14.40	.0008	.0008	1.84	.0690	.0001	.02	7.9	.0020
22071	Feb. 3	V. slight.	Cons.	.02	14.10	.0004	.0022	1.66	.0650	.0000	.02	8.4	.0180
22435	Mar. 2	Slight.	Cons.	.02	14.90	.0000	.0018	1.76	.0750	.0000	.01	7.7	.0270
22764	Apr. 6	V. slight.	Cons.	.01	14.90	.0000	.0020	1.92	.0750	.0000	.02	8.1	.0330
23142	May 12	None.	None.	.01	39.80	.0006	.0046	9.79	.3280	.0000	.06	17.0	.0020
23379	June 2	None.	None.	.03	41.20	.0000	.0020	11.39	.2680	.0000	.08	16.5	.0010
23805	July 5	None.	V. slight.	.03	16.20	.0000	.0016	1.64	.0550	.0001	.02	8.3	.0010
24136	Aug. 2	None.	None.	.00	18.10	.0008	.0022	1.68	.0590	.0000	.02	7.6	.0000
24611	Sept. 12	None.	None.	.00	18.40	.0004	.0018	2.49	.2160	.0003	.03	8.4	.0030
24934	Oct. 7	None.	None.	.03	87.90	.0002	.0044	29.75	.3900	.0002	.11	35.0	.0030
25293	Nov. 7	None.	None.	.09	30.00	.0000	.0016	7.56	.0940	.0000	.06	12.4	.0020
25552	Dec. 6	None.	None.	.01	23.90	.0000	.0006	5.50	.3040	.0000	.06	11.8	.0030
Av. . .	. . . .	. . . .	. . . .	.02	27.82	.0003	.0021	6.41	.1665	.0001	.04	12.4	.0079

Odor, none.——Nos. 23142 and 24611 were collected from a faucet at the pumping station; the others, from a faucet in the town. The samples generally represent water from the large well, mixed with water from the wells in Paradise Road.

SWAMPSCOTT AND NAHANT.

Chemical Examination of Water from a System of Tubular Wells a Short Distance East of the Swampscott Station on the Boston & Maine Railroad.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21773	Jan. 4	None.	None.	.01	14.80	.0002	.0008	1.85	.0690	.0004	.02	8.0	.0020
22070	Feb. 3	None.	None.	.00	13.90	.0002	.0016	1.62	.0750	.0002	.02	8.1	.0000
22437	Mar. 2	None.	None.	.00	14.40	.0004	.0016	1.74	.0750	.0000	.01	7.9	.0010
22763	Apr. 6	None.	None.	.00	14.40	.0000	.0006	1.85	.0780	.0001	.02	8.0	.0070
23170	May 16	None.	None.	.04	15.00	.0004	.0014	1.79	.0920	.0001	.02	8.0	.0010
23381	June 2	None.	None.	.01	14.60	.0008	.0020	1.66	.0340	.0000	.03	7.9	.0040
23804	July 5	None.	None.	.00	15.30	.0000	.0016	1.73	.0830	.0006	.03	7.9	.0020
24137	Aug. 2	None.	None.	.00	15.90	.0010	.0012	1.69	.0790	.0007	.02	8.0	.0010
Av...	....	....	....	.01	14.79	.0004	.0013	1.74	.0731	.0003	.02	8.0	.0022

Odor, none. —— The samples were collected from a faucet at the pumping station.

Chemical Examination of Water from Tubular Wells at the Southerly End of Thompson Meadow in Swampscott and Salem.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21771	Jan. 4	None.	None.	.01	31.50	.0004	.0032	1.28	.0420	.0001	.08	17.0	.0020
22069	Feb. 3	None.	None.	.01	28.90	.0000	.0024	1.30	.0300	.0000	.02	18.0	.0000
22436	Mar. 2	None.	None.	.02	20.40	.0004	.0016	1.60	.0730	.0002	.02	12.1	.0010
22765	Apr. 6	None.	V. slight.	.00	23.40	.0002	.0020	1.28	.0180	.0000	.03	13.3	.0040
23143	May 12	None.	None.	.02	22.80	.0006	.0030	1.19	.0220	.0001	.02	13.0	.0070
23380	June 2	None.	None.	.02	21.70	.0000	.0026	1.21	.0230	.0000	.06	11.0	.0010
23803	July 5	None.	None.	.00	21.60	.0000	.0028	1.23	.0270	.0001	.04	10.9	.0040
24135	Aug. 2	None.	None.	.05	21.50	.0010	.0030	1.32	.0420	.0003	.05	10.0	.0110
24610	Sept. 12	None.	Slight.	.09	21.20	.0014	.0056	1.26	.0480	.0000	.15	11.1	.0080
24935	Oct. 7	None.	V. slight.	.06	21.10	.0004	.0048	1.35	.0420	.0001	.10	11.0	.0050
25294	Nov. 5	None.	V. slight.	.03	18.80	.0000	.0018	1.39	.0270	.0000	.02	9.1	.0020
25553	Dec. 6	None.	None.	.00	22.70	.0002	.0012	1.09	.0340	.0000	.06	12.6	.0020
Av...	....	....	....	.03	22.97	.0004	.0028	1.29	.0357	.0001	.05	12.4	.0039

Odor, none. —— The samples were collected from a faucet at the pumping station in Thompson Meadow.

Water Supply of Taunton.

The sources of supply are Elder's and Assawompsett ponds in Lakeville. Elder's Pond has an area of 145 acres, a maximum depth of 55 feet and a water-shed of 0.53 of a square mile, containing a population of 50 per square mile. Assawompsett Pond is the lowest in a chain of several large ponds. It has an area of 2,488 acres and a total contributing water-shed of 50.4 square miles, which contains considerable swampy land and several other large ponds. There is a population of about 35 per square mile on the water-shed. Water for the supply of the city is taken from Elder's Pond, and water from Assawompsett Pond is pumped to Elder's Pond.

Chemical Examination of Water from Assawompsett Pond, Lakeville.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21878	Jan. 17	Slight.	Slight.	.40	3.70	1.60	.0006	.0186	.0176	.0010	.62	.0010	.0000	.52	0.8
22209	Feb. 14	V. slight.	V. slight.	.60	3.80	1.90	.0004	.0196	.0186	.0010	.64	.0020	.0000	.66	1.8
22546	Mar. 14	V. slight.	Slight.	.56	3.40	1.65	.0006	.0210	.0162	.0048	.51	.0000	.0000	.62	0.5
22900	Apr. 18	V. slight.	Slight.	.60	3.40	1.50	.0002	.0180	.0154	.0026	.52	.0030	.0000	.60	0.5
23174	May 16	V. slight.	Slight.	.60	3.30	1.45	.0008	.0188	.0164	.0024	.54	.0030	.0000	.59	0.5
23635	June 21	Slight.	Slight.	.47	3.25	1.65	.0006	.0170	.0152	.0018	.51	.0010	.0000	.62	0.6
23921	July 18	V. slight.	V. slight.	.41	3.40	1.45	.0002	.0200	.0176	.0024	.50	.0010	.0000	.56	1.0
24332	Aug. 16	Slight.	V. slight.	.37	3.00	1.45	.0018	.0194	.0170	.0024	.48	.0010	.0000	.51	0.6
24690	Sept. 19	Slight.	Slight.	.30	3.20	1.55	.0000	.0214	.0172	.0042	.53	.0000	.0001	.66	0.6
25052	Oct. 17	None.	V. slight.	.30	3.05	1.65	.0004	.0202	.0178	.0024	.53	.0020	.0000	.55	0.6
25372	Nov. 14	V. slight.	V. slight.	.41	3.65	1.75	.0014	.0222	.0184	.0038	.46	.0010	.0000	.65	0.5
25600	Dec. 12	Decided.	Slight.	.61	3.45	1.95	.0010	.0216	.0184	.0032	.50	.0000	.0000	.70	0.5
Av...	....	....	....	.47	3.38	1.63	.0007	.0198	.0171	.0027	.53	.0012	.0000	.60	0.7

Odor, faintly vegetable or none. On heating, the odor became vegetable and sometimes earthy or musty.

TAUNTON.

Chemical Examination of Water from Elder's Pond, Lakeville.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21879	Jan. 17	V.slight.	Slight.	.06	3.00	1.05	.0012	.0158	.0150	.0008	.64	.0010	.0000	.23	0.8
22208	Feb. 14	None.	V.slight.	.06	3.00	1.25	.0004	.0162	.0156	.0006	.65	.0020	.0000	.23	0.8
22545	Mar. 14	V.slight.	V.slight.	.09	2.65	1.15	.0002	.0150	.0134	.0016	.54	.0020	.0000	.28	0.5
22899	Apr. 18	V.slight.	Slight.	.05	2.65	0.90	.0000	.0160	.0140	.0020	.54	.0030	.0000	.24	0.5
23175	May 16	V.slight	V.slight.	.08	2.60	1.00	.0014	.0166	.0158	.0008	.56	.0000	.0000	.26	0.5
23634	June 20	Slight.	V.slight.	.10	2.95	1.20	.0012	.0174	.0140	.0034	.54	.0020	.0000	.27	0.5
23922	July 18	V.slight.	V.slight.	.08	2.65	0.85	.0002	.0178	.0168	.0010	.50	.0010	.0000	.28	0.3
24331	Aug. 16	V.slight.	V.slight.	.05	2.50	1.05	.0004	.0180	.0154	.0026	.52	.0010	.0000	.23	0.4
24689	Sept. 19	V.slight.	Slight.	.10	2.65	1.40	.0002	.0184	.0154	.0030	.54	.0000	.0000	.26	0.5
25051	Oct. 17	None.	V.slight.	.11	2.65	1.05	.0014	.0184	.0166	.0018	.55	.0010	.0000	.26	1.0
25371	Nov. 14	V.slight.	V.slight.	.10	2.60	0.95	.0010	.0172	.0146	.0026	.53	.0010	.0000	.26	0.5
25601	Dec. 12	V.slight.	Slight.	.11	2.60	1.05	.0006	.0144	.0142	.0002	.53	.0010	.0000	.23	0.5
Av...	....	....	....	.08	2.71	1.07	.0007	.0168	.0151	.0017	.55	.0012	.0000	.25	0.6

Odor, generally faintly vegetable or musty, sometimes none. On heating, the odor became stronger, and in July and September also fishy.

Water Supply of Tisbury.—Vineyard Haven Water Company.

Chemical Examination of Water from the Filter-gallery at Tashmoo Spring.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albu-minoid.		Nitrates.	Nitrites.			
Average of six samples collected in February, April, June, August, October and December, 1898.	.02	4.42	.0000	.0010	1.01	.0058	.0000	.02	0.5	.0035

Odor, none. —— The samples were collected from a faucet at the pumping station, while pumping.

Water Supply of Uxbridge.

Chemical Examination of Water from the Reservoir of the Uxbridge Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
24395	1898. Aug. 22	None.	None.	.00	2.65	0.65	.0000	.0016	.0012	.0004	.19	.0040	.0000	.02	0.5

Odor, none.

Water Supply of Wakefield and Stoneham. — Wakefield Water Company.

The source of supply is Crystal Lake in Wakefield. The lake has an area of 85 acres, a maximum depth of 26 feet and a general depth of 13 feet. Its bottom is said to be gravelly except at one end, where there is considerable mud. The water-shed of the pond has an area of 0.94 of a square mile, and contains a population of 356 per square mile.

Chemical Examination of Water from Crystal Lake, Wakefield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
22666	1898. Mar. 28	V. slight.	V. slight.	.12	4.20	1.50	.0016	.0140	.0116	.0024	.62	.0330	.0001	.21	1.6
23735	June 29	V. slight.	V. slight.	.20	4.60	1.35	.0024	.0180	.0164	.0016	.72	.0060	.0003	.37	1.7
24848	Sept. 28	Slight.	Slight.	.25	4.90	1.70	.0028	.0214	.0176	.0038	.58	.0020	.0001	.31	1.7
25808	Dec. 31	Slight.	Slight.	.17	4.65	1.55	.0000	.0172	.0138	.0034	.64	.0120	.0002	.27	1.8
Av...	....	....	....	.18	4.59	1.52	.0017	.0176	.0148	.0028	.64	.0132	.0002	.29	1.7

Odor of the second sample, faintly musty; of the others, vegetable. A disagreeable odor was developed in the last sample on heating. —— The samples were collected from a faucet in the pumping station.

WALPOLE.

WATER SUPPLY OF WALPOLE.

The source of supply is a system of 40 tubular wells in the valley of Low Brook in Walpole. The wells are from 35 to 60 feet deep.

Chemical Examination of Water from the Wells of the Walpole Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22338	Feb. 24	None.	None.	.02	4.20	.0000	.0016	.35	.0120	.0000	.02	1.3	.0040
22988	Apr. 27	None.	None.	.03	4.50	.0000	.0004	.34	.0040	.0000	.01	1.3	.0030
23780	June 30	None.	None.	.01	3.60	.0000	.0006	.30	.0020	.0000	.02	0.5	.0000
24472	Aug. 29	None.	None.	.04	3.50	.0002	.0010	.28	.0060	.0000	.03	0.8	.0130
25169	Oct. 26	None.	None.	.01	3.80	.0000	.0010	.31	.0120	.0000	.02	0.8	.0010
25787	Dec. 28	None.	None.	.00	3.80	.0000	.0000	.30	.0050	.0000	.02	1.0	.0010
Av...	....	....	....	.02	3.90	.0000	.0008	.31	.0068	.0000	.02	0.9	.0037

Odor, none.—— The first sample was collected from a faucet at the pumping station, and the remaining samples from the wells.

WATER SUPPLY OF WALTHAM.

The source of supply is a well and filter-gallery situated on the left bank of the Charles River, above the city. The filter-gallery is irregular in shape, covering an area of about a quarter of an acre, and in the deepest place is about 8.4 feet below the average level of the river opposite the gallery. The well is 40 feet in diameter and is sunk in the centre of the filter-gallery to a depth of 18 feet below the bottom of the gallery. Water is pumped from the well and gallery to an open distributing reservoir, and, being exposed to light, large numbers of organisms are developed which cause disagreeable tastes and odors. The results of examinations of the water of Charles River in the vicinity of the well and filter-gallery of the Waltham Water Works are given in a subsequent chapter, entitled "Examination of Rivers."

WALTHAM.

Chemical Examination of Water from the Well and Filter-gallery of the Waltham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21904	Jan. 19	None.	V. slight.	.07	7.90	.0048	.0034	.62	.0150	.0000	.05	3.6	.0220
22242	Feb. 16	V. slight.	None.	.07	7.00	.0040	.0038	.60	.0180	.0000	.07	3.6	.0090
22574	Mar. 16	V. slight.	None.	.10	7.40	.0040	.0022	.56	.0230	.0000	.05	3.5	.0150
22929	Apr. 21	V. slight	V. slight.	.07	6.70	.0034	.0014	.60	.0270	.0000	.06	3.4	.0180
23202	May 18	V. slight.	V. slight.	.05	7.30	.0046	.0024	.60	.0270	.0000	.06	3.5	.0350
23581	June 15	None.	None.	.06	7.80	.0038	.0022	.58	.0260	.0000	.06	3.4	.0180
23969	July 20	None.	None.	.10	7.50	.0046	.0020	.55	.0200	.0000	.08	3.5	.0150
24334	Aug. 17	None.	None.	.08	7.20	.0038	.0030	.58	.0270	.0000	.09	3.6	.0180
24724	Sept. 21	None.	None.	.02	7.20	.0004	.0036	.62	.0560	.0000	.07	2.9	.0040
25094	Oct. 19	None.	V. slight.	.10	7.10	.0048	.0054	.59	.0230	.0000	.08	3.5	.0150
25407	Nov. 16	V. slight.	None.	.12	7.70	.0032	.0030	.56	.0210	.0000	.08	3.5	.0320
25737	Dec. 21	None.	None.	.01	6.90	.0000	.0016	.59	.0530	.0000	.07	3.3	.0040

Averages by Years.

-	1888	-	-	.00	6.70	.0009	.0054	.46	.0273	.0003	-	-	-
-	1892	-	-	.00	6.81	.0033	.0027	.45	.0162	.0000	-	3.4	.0034
-	1893	-	-	.01	6.86	.0036	.0022	.47	.0179	.0000	.06	3.4	.0020
-	1894	-	-	.02	6.75	.0028	.0019	.51	.0192	.0000	.06	3.1	.0044
-	1895	-	-	.03	7.15	.0036	.0024	.53	.0198	.0000	.05	3.4	.0082
-	1896	-	-	.03	7.36	.0034	.0018	.55	.0194	.0000	.06	3.6	.0157
-	1897	-	-	.04	7.15	.0031	.0035	.57	.0222	.0001	.06	3.6	.0108
-	1898	-	-	.07	7.31	.0034	.0028	.59	.0280	.0000	.07	3.4	.0162

NOTE to analyses of 1898: Odor, none. —— Nos. 22242, 22574, 22929 and 23202 were collected from the well; the others, from a faucet at the pumping station.

WALTHAM.

Chemical Examination of Water from the Distributing Reservoir of the Waltham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21903	Jan. 19	V.slight.	V.slight.	.05	7.50	.0018	.0090	.63	.0130	.0000	.06	3.6	.0050
22241	Feb. 16	Slight.	Cons.	.09	6.80	.0008	.0094	.61	.0180	.0000	.07	3.4	.0080
22573	Mar. 16	V.slight.	Slight.	.09	8.00	.0008	.0076	.59	.0190	.0000	.07	3.6	.0080
22928	April 21	Slight.	Slight.	.07	7.00	.0018	.0112	.62	.0180	.0000	.09	3.4	.0070
23201	May 18	Slight.	Slight.	.07	8.00	.0008	.0134	.65	.0250	.0001	.13	3.4	.0050
23582	June 15	None.	Slight.	.06	8.20	.0014	.0098	.59	.0160	.0002	.10	3.4	.0040
23970	July 20	Decided, milky.	Slight.	.08	7.00	.0034	.0120	.56	.0150	.0002	.12	3.3	.0040
24335	Aug. 17	Slight.	Slight.	.06	6.60	.0010	.0162	.56	.0070	.0001	.13	3.1	.0000
24725	Sept. 21	V. slight.	V. slight.	.05	7.10	.0014	.0124	.56	.0010	.0000	.09	3.0	.0040
25095	Oct. 19	V.slight.	V.slight.	.10	7.30	.0006	.0092	.61	.0120	.0000	.14	3.4	.0060
25406	Nov. 16	Slight.	V.slight.	.14	7.30	.0010	.0162	.57	.0130	.0001	.10	3.3	.0240
25736	Dec. 21	Slight.	Cons., floc.	.15	7.40	.0006	.0100	.57	.0110	.0000	.09	3.3	.0100
Av...	....	....	....	.08	7.35	.0013	.0114	.59	.0140	.0001	.10	3.3	.0071

Odor, generally none, sometimes faintly vegetable. On heating, the odor of some of the samples became vegetable or earthy, and in May faintly oily.

Microscopical Examination of Water from the Distributing Reservoir of the Waltham Water Works.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec.
Day of examination, . . .	20	17	17	22	19	16	21	18	22	20	17	22
Number of sample, ...	21903	22241	22573	22928	23201	23582	23970	24335	24725	25095	25406	25736
PLANTS.												
Diatomaceæ, ...	6	116	3,278	397	145	5	5	1	6	12	270	11,000
Asterionella, ...	0	2	30	9	2	0	0	0	0	0	53	11,000
Synedra, ...	6	114	3,248	386	131	4	0	0	2	8	213	0
Algæ, ...	0	0	0	4	1	0	25	255	0	0	12	0
Selenastrum, ...	0	0	0	0	0	0	0	220	0	0	12	0

WALTHAM.

Microscopical Examination of Water from the Distributing Reservoir of the Waltham Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Rhizopoda,	0	0	0	0	1	0	0	0	0	0	0	0
Infusoria,	0	6	7	1	26	892	0	2	1	5	0	0
Dinobryon,	0	6	7	1	26	892	0	0	0	5	0	0
Vermes,	0	0	0	0	0	1	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	3	3	0	3	3	0	3	3	0	5	3	0
TOTAL,	9	125	3,285	405	176	898	33	261	7	22	285	11,000

WATER SUPPLY OF WARE.

The sources of supply are a large well and tubular wells in the valley of Muddy Brook in Ware. The large well is 26 feet in diameter and 23 feet deep. About 500 feet north of this well the water of a spring is collected in a small well, and about it 12 tubular wells have been sunk. Water from the spring and tubular wells flows by gravity to the large well, from which it is pumped to an open distributing reservoir.

Chemical Examination of Water from the Large Well of the Ware Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22236	Feb. 16	V. slight	None.	.01	6.20	.0000	.0024	0.48	.2100	.0000	.02	2.3	.0030
22973	Apr. 26	None.	None.	.00	11.30	.0000	.0010	1.19	.5700	.0000	.01	3.6	.0020
23591	June 15	None.	None.	.00	8.60	.0002	.0010	0.71	.3160	.0000	.01	2.7	.0000
25229	Nov. 1	None.	None.	.00	8.20	.0002	.0006	0.69	.3100	.0000	.02	2.7	.0010
25740	Dec. 21	None.	None.	.00	8.00	.0000	.0000	0.68	.2320	.0000	.01	3.0	.0010
Av...	....	....	....	.00	8.46	.0001	.0010	0.75	.3276	.0000	.01	2.9	.0014

Odor, none. —— The samples were collected from a faucet at the pumping station, while pumping from the large well and tubular wells, and represent a mixture of water from the large well with a varying amount of water from the tubular wells.

WARE.

Chemical Examination of Water from the Tubular Wells of the Ware Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22235	Feb. 16	Slight.	Cons.	.06	5.40	.0002	.0020	0.18	.0140	.0000	.02	1.6	.0110
22974	Apr. 26	V. slight.	Slight.	.03	4.30	.0000	.0006	0.16	.0170	.0000	.03	1.4	.0090
23592	June 15	None.	Cons.	.00	6.00	.0002	.0006	0.16	.0160	.0000	.01	1.7	.0020
25230	Nov. 1	None.	Slight.	.00	5.70	.0002	.0006	0.16	.0100	.0000	.02	1.8	.0070
Av.	....	....	....	.02	5.35	.0001	.0009	0.16	.0142	.0000	.02	1.6	.0072

Odor, none.

Water Supply of Onset Bay Fire District, Wareham. — Onset Water Company.

The source of supply is Jonathan's Pond in Wareham. This pond has an area of 16 acres and a maximum depth of 25 feet. It is located in a sandy territory, and its water-shed is indeterminate.

The advice of the State Board of Health to Joseph K. Nye, relative to a proposed extension of the water supply of Onset to that part of the town of Wareham known as the Narrows, may be found on pages 53 and 54 of this volume.

Chemical Examination of Water from Jonathan's Pond, Wareham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
24413	1898. Aug. 23	Slight.	None.	.08	2.05	0.70	.0002	.0090	.0076	.0014	.64	.0020	.0000	.13	0.0

Odor, none.

Water Supply of Watertown and Belmont.

During the greater part of the year 1898 the towns of Watertown and Belmont were supplied with water from a filter-gallery and wells located on the left bank of the Charles River above Watertown. Since Nov. 30, 1898, water for the supply of these towns has been obtained from the Metropolitan Water Works. The following table gives the results of analyses of samples of water from the filter-gallery. For a description of the sources of supply of the Metropolitan Water District and analyses of the water, see pages 133 to 160.

Chemical Examination of Water from a Faucet in the Pumping Station of the Watertown Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21902	Jan. 19	Slight.	Slight.	.08	9.40	.0034	.0094	.93	.2560	.0000	.06	4.3	.0130
22231	Feb. 16	V. slight.	Slight.	.07	7.90	.0008	.0086	.83	.1900	.0000	.12	3.5	.0060
22575	Mar. 16	None.	None.	.10	5.00	.0006	.0076	.74	.0330	.0000	.02	2.9	.0050
22903	Apr. 20	None.	None.	.03	8.60	.0006	.0116	.89	.1340	.0000	.09	3.8	.0030
23203	May 18	None.	None.	.06	7.70	.0010	.0092	.72	.0380	.0000	.16	3.1	.0110
23569	June 15	V. slight.	V. slight.	.19	7.80	.0058	.0088	.56	.0290	.0000	.18	3.1	.0250
23996	July 22	Decided, milky.	V. slight.	.21	8.30	.0074	.0064	.58	.0370	.0000	.22	3.0	.0650
24336	Aug. 17	Decided, milky.	V. slight.	.28	7.80	.0078	.0082	.64	.0490	.0003	.18	3.5	.0550
24833	Sept. 28	Decided, milky.	Slight.	.30	8.90	.0060	.0054	.63	.0250	.0001	.22	3.3	.1050
25096	Oct. 19	Decided, milky.	Slight.	.43	8.40	.0174	.0104	.72	.0360	.0000	.33	3.9	.1380
25402	Nov. 16	Decided, milky.	None.	.33	8.60	.0102	.0082	.74	.0700	.0001	.24	3.3	.0900

Averages by Years.

-	1888	-	-	.00	7.22	.0000	.0040	.63	.0647	.0000	-	-	-
-	1893	-	-	.19	7.95	.0063	.0061	.66	.0489	.0001	.13	3.5	.0315
-	1894	-	-	.11	8.82	.0048	.0054	.70	.0542	.0001	.12	3.8	.0516
-	1895	-	-	.20	8.75	.0051	.0077	.69	.0669	.0003	.16	3.7	.0527
-	1896	-	-	.40	8.61	.0147	.0070	.71	.0492	.0001	.17	3.8	.1372
-	1897	-	-	.18	8.74	.0059	.0122	.80	.1243	.0000	.16	3.7	.0276
-	1898	-	-	.19	8.04	.0055	.0085	.73	.0815	.0000	.17	3.4	.0469

Note to analyses of 1898: Odor in September, faintly musty; at other times, none.

WAYLAND.

Water Supply of Wayland.

The source of supply is a filter-gallery located close to a small storage reservoir on Snake Brook in Wayland. The storage reservoir has an area of 13 acres, and a storage capacity of 16,000,000 gallons. The filter-gallery is 400 feet long, 12 inches wide and 18 inches high, with two branches each 80 feet long extending under the reservoir. The gallery is covered with from 4 to 10 feet of gravel. The water obtained from the filter-gallery contains an excessive amount of iron and enormous numbers of the organism *Crenothrix.*

Chemical Examination of Water from the Filter-gallery of the Wayland Water Works.

[Part per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21759	Jan. 4	Slight.	Slight.	1.15	5.75	.0054	.0192	.40	.0280	.0001	0.87	2.1	.0600
22496	Mar. 8	V. slight.	V. slight.	0.55	4.00	.0046	.0106	.22	.0390	.0000	0.49	1.4	-
23070	May 4	V. slight.	Slight.	0.70	3.90	.0012	.0158	.34	.0320	.0001	0.54	1.1	-
23825	July 8	Slight.	V. slight.	0.80	4.90	.0072	.0292	.32	.0080	.0000	0.67	1.4	.0270
24568	Sept. 7	Slight.	Slight.	0.80	5.05	.0124	.0280	.31	.0120	.0000	0.89	1.7	-
25253	Nov. 2	Slight.	Slight.	1.00	5.85	.0046	.0310	.31	.0170	.0000	1.21	2.1	-
Av...	....	....	....	0.83	4.91	.0059	.0223	.32	.0227	.0000	0.78	1.6	-

Odor of the first three samples, vegetable, becoming also fishy in the first sample on heating; of the last three, none. —— The samples were collected from a faucet in the gate-house.

WAYLAND.

Chemical Examination of Water from the Storage Reservoir of the Wayland Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21758	Jan. 4	Slight.	Slight.	1.15	5.70	2.40	.0040	.0326	.0292	.0034	.45	.0160	.0000	0.51	2.1
22495	Mar. 8	V. slight.	V. slight.	0.69	3.20	1.20	.0010	.0140	.0136	.0004	.20	.0050	.0000	0.52	0.8
23069	May 4	V. slight.	V. slight.	0.98	3.50	1.95	.0004	.0194	.0174	.0020	.25	.0030	.0001	0.72	1.0
23824	July 8	V. slight	Slight.	0.85	4.55	1.50	.0022	.0356	.0302	.0054	.28	.0010	.0000	0.73	1.6
24567	Sept. 7	Slight.	Slight.	0.98	5.10	2.90	.0068	.0348	.0300	.0048	.24	.0000	.0000	1.04	1.7
25252	Nov. 2	Slight.	Slight.	1.08	5.25	2.80	.0026	.0386	.0296	.0090	.29	.0030	.0000	1.42	1.7
Av...	....	....	....	0.95	4.55	2.12	.0028	.0292	.0250	.0042	.28	.0047	.0000	0.82	1.5

Odor, vegetable or none. On heating, the odor of all of the samples became vegetable, and of the first sample also fishy.

Water Supply of Webster.

The source of supply is a well 25 feet in diameter, 30 feet deep, located 300 feet from the north-westerly shore of Lake Chaubunagungamaug.

Chemical Examination of Water from the Well of the Webster Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22171	Feb. 11	V. slight.	V. slight.	.02	4.00	.0002	.0028	.27	.0180	.0001	.02	1.3	.0020
22801	Apr. 11	None.	V. slight.	.00	3.40	.0000	.0006	.26	.0270	.0000	.02	1.1	.0060
23386	June 3	None.	None.	.02	4.30	.0006	.0012	.27	.0160	.0000	.04	1.7	.0020
23912	July 18	None.	None.	.01	4.20	.0000	.0008	.24	.0170	.0000	.01	1.7	.0000
24297	Aug. 15	None.	None.	.02	5.00	.0000	.0010	.23	.0250	.0000	.02	2.3	.0020
25099	Oct. 19	None.	None.	.00	4.50	.0000	.0010	.26	.0120	.0000	.04	1.4	.0020
25585	Dec. 9	None.	None.	.01	4.50	.0000	.0008	.26	.0310	.0000	.01	1.3	.0010
Av...	....	....	....	.01	4.27	.0001	.0012	.26	.0209	.0000	.02	1.5	.0021

Odor, none.

WELLESLEY.

Water Supply of Wellesley.

The sources of supply are a filter-gallery, a well, known as the Williams Spring, and a system of 33 tubular wells, all located in the valley of Rosemary Brook.

The original source of supply was the filter-gallery, built in 1884, located 33 feet from Rosemary Brook and 400 feet from Charles River. The gallery is 63 feet long and 16 feet in depth below the level of the water in the river.

The well at Williams Spring was built soon after the construction of the filter-gallery, and is located close to the brook, 1,000 feet up the valley from the filter-gallery. It is 22 feet in diameter and 20 feet in depth below the level of the brook.

The tubular wells are located in the valley of the brook in the Burnett Meadow, so called. The wells cover an area about 1,500 feet long and about 500 feet in width, the nearest well to Williams Spring being distant from it about 900 feet. The wells are each 2½ inches in diameter, and range in depth from 30 to 60 feet. The system of wells was completed in the year 1898, and at the same time a new covered reservoir was built so as to protect the water from exposure to light. There are no direct connections by which water may be drawn either from Rosemary Brook or Charles River.

Chemical Examination of Water from the Filter-gallery of the Wellesley Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21740	Jan. 3	None.	V. slight.	.00	8.20	.0030	.0016	.57	.0660	.0000	.02	4.3	.0020

Odor, none.

WELLESLEY.

Chemical Examination of Water from the Well of the Wellesley Water Works at Williams Spring.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21742	Jan. 3	V. slight.	Slight.	.00	8.90	.0002	.0024	.62	.2550	.0000	.03	4.3	.0020
23916	July 18	None.	None.	.02	10.40	.0002	.0010	.70	.3500	.0000	.02	3.1	.0010
24478	Aug. 30	None.	None.	.00	9.70	.0000	.0014	.72	.3100	.0000	.06	3.5	.0100
24816	Sept. 28	None.	None.	.00	10.10	.0000	.0006	.72	.2550	.0000	.03	3.3	.0020
25217	Oct. 31	None.	None.	.00	8.60	.0000	.0006	.67	.3700	.0000	.04	3.1	.0010
25491	Nov. 29	None.	V. slight.	.05	10.30	.0000	.0006	.84	.5300	.0000	.02	4.0	.0020
25791	Dec. 28	None.	None.	.00	9.70	.0004	.0012	.94	.5100	.0000	.02	4.3	.0000
Av...	....	....	....	.01	9.67	.0001	.0011	.74	.3686	.0000	.03	3.7	.0026

Odor of the first sample, faintly earthy; of the others, none.

Chemical Examination of Water from the Driven Wells of the Wellesley Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
22634	Mar. 24	V. slight.	Cons., earthy.	.05	8.80	.0004	.0010	.59	.0750	.0000	.03	2.7	.0130
23274	May 23	None.	None.	.02	6.70	.0006	.0008	.58	.0620	.0000	.02	2.9	.0010
24119	Aug. 1	V. slight.	None.	.05	7.30	.0118	.0012	.55	.0600	.0068	.03	2.7	.0150
24818	Sept. 28	None.	None.	.00	7.30	.0000	.0000	.54	.0540	.0001	.01	2.7	.0040
25492	Nov. 29	None.	None.	.03	7.20	.0000	.0002	.53	.0520	.0000	.01	3.0	.0010
Av...	....	....	....	.03	7.46	.0026	.0006	.56	.0606	.0014	.02	2.8	.0068

Odor, none. —— The samples were collected from a faucet at the pumping station.

WELLESLEY.

Chemical Examination of Water from the Covered Reservoir of the Wellesley Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21741	Jan. 3	Slight.	Slight.	.03	10.20	.0428	.0186	.71	.2650	.0002	.12	4.3	.0020
21917	Jan. 19	Slight.	Slight.	.05	12.10	.0762	.0344	.73	.2400	.0001	.24	3.8	.0010
22096	Feb. 7	Slight.	Slight.	.05	10.30	.0040	.0076	.70	.1850	.0003	.06	3.9	.0020
22786	Apr. 11	None.	None.	.01	6.90	.0002	.0014	.57	.0830	.0000	.02	3.4	.0060
23273	May 23	Slight.	Slight.	.05	6.70	.0020	.0158	.63	.0830	.0000	.30	2.9	.0350
24120	Aug. 1	None.	None.	.00	7.00	.0000	.0012	.58	.0740	.0000	.01	2.7	.0020
24817	Sept. 28	None.	None.	.00	6.90	.0000	.0032	.57	.0450	.0000	.02	2.7	.0050
25493	Nov. 29	None.	None.	.02	6.70	.0014	.0056	.58	.0640	.0000	.04	2.9	.0020
Av.*.	....	....	....	.02	7.95	.0096	.0088	.62	.1124	.0001	.09	3.2	.0076

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor of the first sample, faintly mouldy, becoming stronger on heating; of the others, none. —— The samples were collected from the reservoir. The cause of an excessive amount of ammonia in the samples first collected from the reservoir was not discovered.

Water Supply of Westborough.

The sources of supply are Upper and Lower Sandra ponds in Westborough. The Upper Pond has an area of 49 acres and a water-shed of 1.25 square miles, which contains a population of 45 per square mile. The Lower Pond is small, and is separated from the Upper Pond by a dam, and water is obtained principally by filtration through the dam from the Upper Pond. All of the soil and organic matter has been removed from the Lower Pond, but only a portion of the stumps and other vegetation was removed from the bottom of the Upper Pond.

WESTBOROUGH.

Chemical Examination of Water from a Faucet supplied from the Westborough Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1898.												
22302	Feb. 21	V. slight.	Slight.	.05	2.50	.0002	.0038	.26	.0030	.0000	.09	1.6	.0030
23272	May 23	None.	None.	.06	2.80	.0008	.0064	.23	.0030	.0000	.09	1.1	.0050
24416	Aug. 24	V. slight.	None.	.06	3.00	.0000	.0056	.19	.0020	.0000	.07	1.1	.0110
25536	Dec. 5	V. slight.	V. slight.	.09	3.00	.0000	.0032	.23	.0010	.0000	.08	1.3	.0040
Av.	....	....	....	.06	2.82	.0002	.0047	.23	.0022	.0000	.08	1.3	.0057

Odor, none. A vegetable odor was developed in the first and last samples on heating.

Water Supply of Westborough Insane Hospital, Westborough.

Chemical Examination of Water from the Westborough Insane Hospital.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1898.												
22301	Feb. 21	Slight.	Slight.	.61	5.10	.0204	.0266	.48	.0070	.0004	.80	1.7	.0070
22954	Apr. 23	Slight.	Slight.	.60	5.00	.0080	.0260	.44	.0220	.0003	.62	1.6	.0230
23658	June 22	Decided.	Slight.	.45	7.10	.0180	.0270	.43	.0030	.0003	.57	2.3	.0350
24415	Aug. 24	Decided.	Cons.	.47	8.00	.0424	.0376	.40	.0020	.0000	.56	3.6	.1300
25584	Dec. 8	Decided, milky.	Slight.	.38	11.40	.1040	.0020	.38	.0000	.0000	.19	5.7	.0850
25708	Dec. 19	Decided.	Cons.	.50	12.20	.1044	.0020	.38	.0000	.0002	.17	5.3	.1450
Av.*	....	....	....	.51	7.42	.0386	.0238	.43	.0068	.0002	.55	2.9	.0620

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor of the first two samples, vegetable; of the third, distinctly musty; of the last three, unpleasant. —— The samples were collected from a faucet at the pumping station. During a part of the time water is drawn from Chauncy Pond; at other times, from tubular wells in the vicinity of the pond.

Water Supply of Westfield.

The source of supply is Moose Meadow Brook in Montgomery, on which a storage reservoir and a distributing reservoir have been constructed. The storage reservoir has an area of 38 acres, an

WESTFIELD.

average depth of 15 feet, a maximum depth of 30 feet, and a capacity of 184,000,000 gallons. The bottom of the reservoir was originally meadow land, but considerable of the organic matter was removed before the area was flooded. The distributing reservoir is situated on the brook, 2.2 miles below the reservoir. The brook above the distributing reservoir has a drainage area of 4.8 square miles, which contains a population of 30 per square mile. Works are now being constructed for taking an additional supply of water from Tillottson Brook in Granville.

Chemical Examination of Water from the Storage Reservoir of the Westfield Water Works.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
Average of seven samples collected in January, February, March, May, July, September and October, 1898.	.51	2.67	1.29	.0026	.0208	.0167	.0041	.11	.0031	.0000	.54	0.5

Odor, generally vegetable, occasionally musty or none, sometimes grassy.

Chemical Examination of Water from Tillottson Brook, in Granville.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
22013	Jan. 27	V. slight.	Slight.	.10	2.00	0.75	.0004	.0050	.0038	.0012	.16	.0050	.0001	.18	0.8
22638	Mar. 23	Slight.	Cons., earthy.	.24	2.00	0.85	.0004	.0070	.0058	.0012	.08	.0000	.0000	.31	0.5
22993	Apr. 27	V. slight.	V. slight.	.12	2.45	0.75	.0000	.0036	.0032	.0004	.12	.0030	.0000	.16	0.5
23332	May 31	None.	Slight.	.19	1.75	0.50	.0004	.0054	.0044	.0010	.12	.0050	.0000	.18	0.5
23678	June 22	None.	Slight.	.16	3.00	0.80	.0004	.0066	.0046	.0020	.10	.0020	.0000	.22	0.5
24100	July 28	None.	Slight.	.16	3.70	1.05	.0004	.0052	.0052	.0000	.09	.0120	.0001	.19	0.5
24444	Aug. 25	None.	V. slight.	.25	3.30	0.95	.0006	.0106	.0076	.0030	.10	.0020	.0000	.28	1.1
24873	Sept. 28	V. slight.	V. slight.	.08	2.95	0.85	.0002	.0034	.0026	.0008	.14	.0030	.0000	.12	0.6
25292	Nov. 7	None.	None.	.18	3.10	1.05	.0000	.0040	.0038	.0002	.15	.0020	.0000	.22	0.5
25504	Nov. 28	V. slight.	V. slight.	.17	2.80	1.00	.0000	.0036	.0032	.0004	.14	.0020	.0000	.16	0.5
Av...	....	....	....	.16	2.70	0.85	.0003	.0054	.0044	.0010	.12	.0036	.0000	.20	0.6

Odor, generally none, sometimes faintly vegetable or unpleasant, becoming musty on heating.

Water Supply of Weston. — Weston Aqueduct Company.

The source of supply is a well 11 feet in diameter and 25 feet deep, situated in the valley of Cherry Brook in Weston.

Chemical Examination of Water from the Well of the Weston Aqueduct Company.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of six samples collected in February, April, June, August, October and December, 1898.	.05	6.80	.0002	.0031	.48	.0338	.0000	.07	3.2	.0028

Odor, none.—— The first sample was collected from a faucet, and the others from the well.

The advice of the State Board of Health to C. W. Hubbard of Weston, relative to a proposed water supply for a part of the town of Weston, may be found on pages 54 and 55 of this volume.

Water Supply of West Springfield.

The sources of supply are a storage reservoir on Darby Brook and a well in the valley of the brook below the reservoir. The Darby Brook storage reservoir has an area of 3.5 acres, an average depth of 9 feet and a capacity of 10,000,000 gallons. It has a water-shed of 0.35 of a square mile, which contains no population. The yield of the reservoir has been increased by the diversion into it of the water of a spring in another water-shed. The well in the valley of Darby Brook is 25 feet in diameter and 14 feet deep. Water from this source is used to supply the higher portions of the town.

The advice of the State Board of Health to the water commissioners of West Springfield, relative to increasing the water supply of that town and relative to the quality of the water of the present sources, may be found on pages 55 to 61 of this volume.

The advice to the board of health of West Springfield, relative to the use of the water of the Westfield River for the supply of the town at times when water is being used for extinguishing fires,

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may be found on page 57 of this volume. The results of chemical analyses of samples of water from the Westfield River may be found in a chapter on the "Examination of Rivers," in a subsequent portion of this report.

Chemical Examination of Water from a Faucet supplied from Darby Brook Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dissolved.	Sus-pended.					
	1898.														
22684	Mar. 29	V. slight.	V. slight.	.19	5.50	1.45	.0008	.0066	.0048	.0018	.12	.0050	.0000	.17	2.3
23314	May 26	Slight.	Slight.	.30	5.35	1.60	.0008	.0130	.0082	.0048	.18	.0070	.0000	.28	2.7
24325	Aug. 16	Slight.	V. slight.	.24	5.80	1.45	.0008	.0146	.0118	.0028	.22	.0030	.0001	.26	3.1
24852	Sept. 28	Slight.	Slight.	.19	5.90	1.95	.0016	.0140	.0090	.0050	.14	.0060	.0001	.21	3.0
Av...	....	....	....	.23	5.64	1.61	.0010	.0120	.0084	.0036	.16	.0052	.0000	.23	2.8

Odor, distinctly vegetable and sometimes grassy or musty.

Chemical Examination of Water from the Receiving Well of the West Springfield Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid		Nitrates.	Nitrites.			
	1898.												
22683	Mar. 29	None.	None.	.00	7.80	.0000	.0018	.42	.2120	.0000	.17	3.8	.0050
23315	May 26	None.	V. slight.	.00	7.80	.0006	.0024	.49	.2200	.0000	.02	3.6	.0050
24324	Aug. 16	Slight.	V. slight.	.02	8.00	.0000	.0022	.41	.1060	.0000	.02	4.0	.0090
24853	Sept. 28	V. slight.	None.	.00	7.70	.0000	.0010	.45	.1620	.0000	.01	3.1	.0040
Av...	....	....	....	.00	7.82	.0001	.0018	.44	.1750	.0000	.05	3.6	.0057

Odor, none.—— The samples were collected from a faucet at the pumping station.

WEST SPRINGFIELD.

Chemical Examination of Water from Various Sources in West Springfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21830	Jan. 11	Decided.	Cons.	.10	7.10	1.30	.0014	.0040	.0028	.0012	.18	.0080	.0001	.06	4.3
21831	Jan. 11	Slight.	Slight.	.48	7.10	2.20	.0016	.0200	.0172	.0028	.23	.0090	.0000	.50	3.6
21832	Jan. 11	Slight.	Cons., earthy.	.17	4.45	1.65	.0012	.0112	.0056	.0056	.20	.0120	.0000	.17	2.0
22140	Feb. 7	Slight.	Cons., earthy.	.18	4.50	1.25	.0014	.0088	.0062	.0026	.22	.0130	.0000	.20	2.0
22103	Feb. 7	Slight.	Slight.	.20	6.25	1.50	.0004	.0070	.0066	.0004	.14	.0120	.0000	.24	3.6
22102	Feb. 7	V. slight.	Heavy.	.05	7.60	–	.0004	.0070	–	–	.19	.0020	.0000	.11	4.9

Odor of the first three samples, vegetable; of the last three, none, becoming faintly vegetable or earthy on heating. —— The first sample was collected from Pepper or Thompson Brook; the second, from Block Brook near Dewey Street; the third and fourth, from Hyde Brook; the fifth, from Bear Hole Brook near Massasoit Spring; the last, from Massasoit Spring.

Water Supply of Weymouth.

The source of supply is Great Pond in Weymouth. The pond has an area of 290 acres and a general depth of 12 feet. The water-shed of the pond has an area of 2.85 square miles, which contains a population of about 85 per square mile. There is considerable swamp upon the water-shed in the vicinity of the pond, and there are large portions of the pond which are flowed to a slight depth.

Chemical Examination of Water from Great Pond in Weymouth.

[Parts per 100,000.]

Number	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
22001	Jan. 26	V. slight.	V. slight.	1.02	4.40	2.30	.0002	.0218	.0206	.0012	.74	.0050	.0000	0.96	1.1
22687	Mar. 30	V. slight.	Slight.	0.99	3.85	2.00	.0006	.0178	.0170	.0008	.57	.0070	.0000	0.90	0.6
23280	May 24	V. slight.	V. slight.	1.00	3.25	1.50	.0006	.0196	.0162	.0034	.48	.0030	.0000	0.76	0.3
24075	July 28	Slight.	Cons.	0.75	4.15	2.35	.0008	.0232	.0198	.0034	.52	.0010	.0000	0.87	1.0
24811	Sept. 28	Slight.	Cons.	0.98	4.60	2.75	.0010	.0238	.0204	.0034	.54	.0050	.0000	0.96	0.5
25506	Dec. 1	Slight.	Slight.	1.30	5.30	3.10	.0014	.0276	.0250	.0026	.53	.0020	.0000	1.36	0.8
Av...	....	....	....	1.01	4.26	2.33	.0008	.0223	.0198	.0025	.56	.0038	.0000	0.97	0.7

Odor, generally faintly vegetable, becoming stronger on heating; at other times, none. —— The samples were collected from faucets in the town, supplied with water from the pond.

WHITMAN.

Water Supply of Whitman.

The source of supply is a filter-gallery on the shore of Hobart's Pond in Whitman. The filter-gallery is in two sections, the first being 100 feet long and fifteen feet wide, the second 416 feet long and 1½ feet wide. The yield of the filter gallery is insufficient for the supply of the town, and a considerable quantity of water is taken directly from the pond. The pond has an area of 175 acres, much of which is very shallow. Its water-shed of 6.4 square miles contains about 670 persons per square mile, many of whom live upon the shores of the pond or upon the banks of the feeders of the pond.

The advice of the State Board of Health to the water commissioners of Whitman, relative to the use of the water of Maquam Pond in Hanson as a source of water supply for the town, may be found on pages 61 to 64 of this volume.

Chemical Examination of Water from the Filter-gallery of the Whitman Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21991	Jan. 26	Decided.	Cons.	.50	5.30	.0060	.0164	.83	.0280	.0001	.54	2.3	.0300
22767	Apr. 7	Decided.	Cons.	.50	6.20	.0036	.0114	.91	.0420	.0001	.44	2.3	.0450
23808	July 6	Slight.	Cons.	.70	8.10	.0050	.0406	.96	.0010	.0001	.88	2.6	.0350
24910	Oct. 5	Decided.	Slight.	.90	7.60	.0292	.0272	.97	.0050	.0001	.65	2.5	.2600
Av...	....	....	....	.65	6.80	.0109	.0239	.92	.0190	.0001	.63	2.4	.0925

Odor of the first sample, none; of the second, distinctly vegetable; of the third, distinctly musty; of the last, none, becoming faintly earthy on heating.

Chemical Examination of Water from Hobart's Pond, Whitman.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
21990	Jan. 26	Slight.	Slight.	.60	4.75	2.25	.0026	.0280	.0260	.0020	0.70	.0130	.0001	.66	1.4
22766	Apr. 7	Decided.	Slight.	.70	6.15	2.20	.0028	.0210	.0202	.0008	0.85	.0090	.0001	.66	1.8
23807	July 6	Slight.	Cons.	.90	7.90	3.12	.0034	.0508	.0440	.0068	0.97	.0030	.0000	.94	2.5
24909	Oct. 5	Slight.	Slight.	.55	7.90	2.95	.0012	.0448	.0370	.0078	1.00	.0010	.0001	.90	2.5
Av...	....	....	....	.69	6.67	2.63	.0025	.0361	.0318	.0043	0.88	.0065	.0001	.79	2.0

Odor, distinctly vegetable and sometimes also musty.

WHITMAN.

The advice of the State Board of Health to the Commonwealth Shoe and Leather Company of Whitman, relative to the use of the water of certain wells upon the premises of that Corporation, may be found on pages 64 and 65 of this volume. Analyses of samples of water collected from the wells are given in the following table: —

Chemical Examination of Water from the Wells of the Commonwealth Shoe and Leather Company, Whitman.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
25566	Dec. 7	V. slight.	None.	.10	20.50	.0080	.0018	4.17	1.0400	.0011	.11	6.1	.0110
25595	Dec. 10	None.	V. slight.	.10	21.40	.0074	.0016	4.30	0.9500	.0012	.08	6.6	.0060
25750	Dec. 21	V. slight.	V slight.	.11	21.00	.0090	.0032	4.15	0.8250	.0015	.07	6.6	.0300

Odor, none. —— The samples were collected from a faucet in the pump room of the factory.

Water Supply of Williamstown. — Williamstown Water Company.

The sources of supply are Cold and Sherman springs, Paul Brook and Flora Glen Reservoir. The springs are situated on uninhabited mountain sides; Paul Brook has an uninhabited water-shed, and the water-shed of Flora Glen Reservoir contains a very small population.

Chemical Examination of Water from Cold Spring Reservoir, Williamstown.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of six samples collected in February, April, June, August, October and December, 1898.	.01	12.97	.0002	.0010	.05	.0387	.0000	.02	11.6	2.0

Odor, none. —— The samples were collected from faucets in the town.

WILLIAMSTOWN.

Chemical Examination of Water from Sherman Spring Reservoir, Williamstown.

[Parts per 100,000.]

	Color.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
			Free.	Albuminoid.		Nitrates.	Nitrites.			
Average of six samples collected in February, April, June, August, October, and December, 1898.	0.3	8.70	.0015	.0037	.07	.0085	.0000	.06	6.1	.0017

Odor in June, distinctly musty and unpleasant; at other times, none.

Chemical Examination of Water from Flora Glen Reservoir, Williamstown.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
Average of six samples collected in February, April, June, August, October and December, 1898.	.10	4.47	0.92	.0003	.0055	.0044	.0011	.08	.0057	.0001	.12	2.7

Odor in February, April and December, none; in June, faintly musty; in August, none, becoming distinctly musty and fishy on heating; in October, faintly unpleasant.

Chemical Examination of Water from Paul Brook Reservoir, Williamstown.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Albuminoid.							
		Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
Average of six samples collected in February, April, June, August, October and December.	.03	3.59	0.76	.0003	.0032	.0022	.0010	.08	.0103	.0000	.07	2.5

Odor, none.

Wilmington.

The advice of the State Board of Health to the board of health of Wilmington, relative to the purity of the water of a well intended for use for drinking purposes in a new school-house in that town, may be found on page 65 of this volume. The results of the analysis of a sample of water collected from the well are given in the following table: —

WILMINGTON.

Chemical Examination of Water from a Well in Wilmington.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1898.												
25580	Dec. 8	Slight.	V. slight.	.08	4.60	.0070	.0048	.94	.0110	.0020	.08	2.0	.0040

Odor, faintly unpleasant. —— The sample was collected from a well near the new school-house on Butter's Row, in the "South District."

Water Supply of Winchendon.

The source of supply is a well 28½ feet in diameter and 25 feet deep, situated in Prentiss Meadow in the valley of Miller's River. About 1,065 feet of earthen pipe with open joints have been laid in the vicinity of the well, 5 feet beneath the surface of the ground, and connected with the well.

Chemical Examination of Water from the Well of the Winchendon Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1898.												
22337	Feb. 23	None.	None.	.00	3.30	.0006	.0012	.13	.0070	.0000	.03	1.6	.0000
22992	Apr. 27	None.	None.	.02	3.30	.0010	.0010	.14	.0070	.0001	.03	1.0	.0030
23723	June 27	V. slight.	V. slight.	.00	3.40	.0002	.0022	.11	.0020	.0000	.03	1.3	.0000
24428	Aug. 24	None.	None.	.01	3.00	.0006	.0014	.09	.0030	.0000	.02	1.8	.0050
25128	Oct. 24	Slight, milky.	None.	.35	3.80	.0000	.0020	.10	.0010	.0000	.07	1.7	.0600
25802	Dec. 28	None.	None.	.03	3.60	.0000	.0006	.12	.0020	.0001	.04	1.6	.0010
Av...	....	....	....	.07	3.40	.0004	.0014	.11	.0037	.0000	.04	1.5	.0115

Odor of No. 25128 decidedly tarry and disagreeable; of the others, none. —— Nos. 24428 and 25128 were collected from faucets in the village, and the others from the well.

Water Supply of Winchester.

The sources of supply are three storage reservoirs situated in Middlesex Fells in the towns of Winchester and Stoneham. The North Reservoir has an area of 59 acres, a storage capacity of 259,000,000 gallons and an independent water-shed of 0.78 of a

WINCHESTER.

square mile. The water-shed of this reservoir contains a population of 524 per square mile.

The South Reservoir has an area of 82 acres, an average depth of 20 feet and a water-shed of 0.44 of a square mile, which is uninhabited.

The Middle Reservoir has an area of 58 acres, an average depth of 13 feet and a water-shed of 0.3 of a square mile, which is uninhabited.

The land on which the reservoirs were constructed was swampy, and the bottoms of the reservoirs are covered with mud and organic matter. The water of the reservoirs, especially of the Middle Reservoir, contains a large amount of organic matter at times.

The advice of the State Board of Health to the water board of Winchester, relative to the protection of the water supply of that town from pollution from houses situated on the water-shed of the North Reservoir, may be found on pages 121 and 122 of this volume.

Chemical Examination of Water from the North Reservoir of the Winchester Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21749	Jan. 4	Slight.	Slight.	.09	7.80	2.15	.0014	.0256	.0244	.0012	.94	.0130	.0000	.36	3.0
22060	Feb. 4	Decided.	Slight.	.16	5.00	1.55	.0062	.0170	.0142	.0028	.66	.0160	.0000	.24	2.5
22390	Mar. 1	V. slight.	V. slight.	.04	2.05	0.70	.0022	.0064	.0060	.0004	.30	.0010	.0000	.12	1.0
22727	Apr. 5	V. slight.	V. slight.	.08	5.70	1.85	.0006	.0216	.0144	.0072	.73	.0190	.0001	.24	2.6
23046	May 3	Decided.	Cons.	.10	5.80	1.75	.0010	.0268	.0200	.0068	.75	.0090	.0002	.27	2.6
23352	June 1	Decided.	Cons.	.15	6.05	1.55	.0034	.0304	.0240	.0064	.70	.0050	.0002	.29	2.5
23788	July 5	V. slight.	Slight.	.10	6.20	2.50	.0006	.0248	.0200	.0048	.44	.0010	.0000	.24	2.6
24132	Aug. 2	V. slight.	Slight.	.09	6.45	2.45	.0012	.0264	.0216	.0048	.71	.0020	.0000	.31	2.5
24563	Sept. 7	Slight.	Slight.	.11	6.25	2.30	.0026	.0234	.0210	.0024	.68	.0000	.0001	.34	2.5
24901	Oct. 4	V. slight.	V. slight.	.11	6.25	1.90	.0088	.0244	.0226	.0018	.62	.0010	.0000	.31	2.6
25218	Nov. 1	V. slight.	V. slight.	.18	5.95	1.95	.0110	.0230	.0202	.0028	.65	.0040	.0001	.38	2.6
25606	Dec. 13	Slight.	V. slight.	.17	6.00	1.75	.0062	.0244	.0212	.0032	.68	.0110	.0001	.33	2.6
Av...	....	....	....	.11	5.79	1.87	.0038	.0228	.0191	.0037	.65	.0068	.0001	.29	2.5

Odor, generally vegetable, becoming stronger and occasionally grassy or unpleasant on heating.

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Microscopical Examination of Water from the North Reservoir of the Winchester Water Works.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	5	4	2	6	4	2	5	3	8	5	2	14
Number of sample,	21749	22060	22390	22727	23046	23352	23788	24132	24563	24901	25218	25606
PLANTS.												
Diatomaceæ,	88	0	1	466	1,530	26	9	3	14	68	63	63
Asterionella,	52	0	0	32	84	0	0	0	0	50	10	35
Cyclotella,	12	0	0	356	800	16	5	2	1	0	37	5
Synedra,	4	0	1	44	520	8	3	0	1	2	13	18
Tabellaria,	20	0	0	10	90	2	0	0	0	1	0	4
Cyanophyceæ,	2	0	0	0	0	8	4	6	18	9	4	0
Anabæna,	0	0	0	0	0	0	2	0	17	0	3	0
Algæ,	52	0	1	14	76	30	46	5	2	5	15	28
Raphidium,	48	0	1	12	44	30	46	0	0	5	11	27
ANIMALS.												
Rhizopoda,	2	0	0	0	0	0	0	0	0	1	0	0
Infusoria,	0	57	1	78	6	4	1	9	97	4	41	5
Dinobryon,	0	0	0	56	4	2	0	1	86	0	0	4
Mallomonas,	0	26	0	2	0	0	0	0	1	0	33	1
Trachelomonas,	0	21	1	2	0	0	1	0	4	3	7	0
Vermes,	0	1	1	2	2	0	1	0	0	1	2	0
Crustacea, Cyclops,	0	0	0	0	0	0	0	pr.	pr.	0	0	0
Miscellaneous, Zoöglœa,	10	3	0	5	10	5	5	5	5	3	5	8
TOTAL,	154	61	4	565	1,624	73	66	28	136	91	130	104

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Chemical Examination of Water from the South Reservoir of the Winchester Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21751	Jan. 4	Decided.	Cons.	.36	5.05	1.75	.0108	.0312	.0298	.0014	.56	.0070	.0001	.44	2.5
22391	Mar. 1	V.slight.	V.slight.	.10	3.10	0.90	.0074	.0180	.0178	.0002	.37	.0030	.0000	.22	1.0
22728	Apr. 5	V.slight.	V.slight.	.21	3.35	1.65	.0030	.0284	.0244	.0040	.38	.0070	.0001	.28	1.6
23047	May 3	Decided.	Cons.	.15	3.60	1.35	.0006	.0260	.0186	.0074	.36	.0050	.0001	.30	1.3
23384	June 3	V.slight.	V.slight.	.11	6.30	2.00	.0020	.0270	.0212	.0058	.68	.0020	.0000	.30	2.6
23789	July 5	Slight.	Slight.	.11	3.40	1.95	.0012	.0266	.0250	.0016	.36	.0010	.0000	.31	1.3
24133	Aug. 2	Slight.	Slight.	.08	3.70	2.00	.0002	.0230	.0204	.0026	.34	.0010	.0000	.30	1.3
24564	Sept. 7	Slight.	Slight.	.10	3.55	1.65	.0014	.0222	.0202	.0020	.40	.0000	.0000	.33	1.3
24902	Oct. 4	V.slight.	V.slight.	.11	3.20	1.55	.0002	.0212	.0188	.0024	.32	.0010	.0000	.31	1.4
25219	Nov. 1	Slight.	Slight.	.30	3.65	1.65	.0138	.0264	.0218	.0046	.33	.0010	.0000	.34	1.3
25607	Dec. 13	Slight.	V.slight.	.22	3.70	1.60	.0112	.0294	.0256	.0038	.31	.0010	.0000	.30	1.7
Av....	....	....	....	.17	3.87	1.64	.0047	.0254	.0221	.0033	.40	.0026	.0000	.31	1.6

Odor, generally vegetable, sometimes none. On heating, the odor of most of the samples became distinctly vegetable and sometimes grassy.

Microscopical Examination of Water from the South Reservoir of the Winchester Water Works.

[Number of organisms per cubic centimeter.]

	1898.										
	Jan.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, ...	5	2	6	4	3	5	3	8	5	2	14
Number of sample, ...	21751	22391	22728	23047	23384	23789	24133	24564	24902	25219	25607
PLANTS.											
Diatomaceæ, ...	357	0	36	260	44	2	6	28	177	6	13
Asterionella, ...	356	0	30	16	0	0	3	24	174	0	8
Cyclotella, ...	0	0	0	144	30	0	1	0	1	0	0
Synedra, ...	1	0	6	100	12	1	1	0	2	4	5
Cyanophyceæ, ...	1	0	0	2	44	0	9	12	12	42	54
Anabæna, ...	0	0	0	0	38	0	9	10	3	35	54
Algæ, ...	12	0	8	74	80	11	23	118	12	30	53
Raphidium, ...	12	0	8	58	66	10	23	94	8	29	51

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Microscopical Examination of Water from the South Reservoir of the Winchester Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1898.										
	Jan.	Mar.	Apr.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.											
Rhizopoda,	0	0	0	0	0	1	0	0	0	0	0
Infusoria,	0	0	12	12	4	17	5	44	16	111	85
Dinobryon,	0	0	0	4	4	11	0	44	14	37	77
Mallomonas,	0	0	2	0	0	2	0	0	0	64	0
Vermes,	1	0	0	0	0	1	0	0	1	0	1
Crustacea, Cyclops,	0	0	0	pr.	0	0	0	0	0	pr.	0
Miscellaneous, Zoöglœa,	0	0	8	10	3	5	5	3	5	12	3
TOTAL,	371	0	64	358	175	37	48	205	223	201	209

Chemical Examination of Water from the Middle Reservoir of the Winchester Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
21750	Jan. 4	Decided.	Cons.	.36	4.25	2.10	.0036	.0402	.0352	.0050	.46	.0110	.0000	.54	1.3
22392	Mar. 1	V. slight.	V. slight.	.12	2.50	1.00	.0172	.0190	.0180	.0010	.30	.0030	.0000	.22	1.0
22729	Apr. 5	Slight.	Slight.	.32	3.25	1.60	.0002	.0446	.0314	.0132	.38	.0090	.0001	.46	1.1
23048	May 3	Decided.	Cons.	.31	3.25	1.70	.0004	.0422	.0262	.0160	.31	.0030	.0000	.42	1.0
23353	June 1	Decided.	Cons.	.30	3.70	1.75	.0010	.0560	.0310	.0250	.37	.0000	.0002	.48	1.1
23790	July 5	Slight.	Cons., green.	.30	4.30	2.85	.0020	.0682	.0406	.0276	.24	.0020	.0004	.50	1.3
24134	Aug. 2	Slight.	Cons.	.25	4.50	2.55	.0002	.0630	.0348	.0282	.30	.0030	.0000	.48	1.0
24565	Sept. 7	Decided.	Cons.	.24	4.05	2.30	.0076	.0688	.0364	.0324	.28	.0000	.0000	.52	1.4
24903	Oct. 4	Slight.	Cons.	.18	3.95	2.10	.0006	.0758	.0340	.0418	.35	.0010	.0000	.54	1.4
25220	Nov. 1	Decided.	Cons.	.20	3.75	1.90	.0004	.0536	.0294	.0242	.31	.0000	.0000	.51	1.4
25608	Dec. 13	Decided.	Slight.	.23	4.75	2.15	.0006	.0422	.0340	.0082	.28	.0010	.0000	.56	1.3
Av.	....	....	....	.26	3.84	2.00	.0031	.0521	.0319	.0202	.33	.0030	.0001	.48	1.2

Odor, generally distinctly vegetable, becoming sometimes also grassy or disagreeable on heating.

WINCHESTER.

Microscopical Examination of Water from the Middle Reservoir of the Winchester Water Works.

[Number of organisms per cubic centimeter.]

	1898.										
	Jan.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	5	2	6	4	2	5	3	8	5	2	14
Number of sample,	21750	22392	22729	23048	23353	23790	24134	24565	24903	25220	25608
PLANTS.											
Diatomaceæ,	198	1	36	68	174	924	3	0	55	1,034	25
Asterionella,	94	0	6	8	42	46	0	0	0	8	14
Cyclotella,	0	0	0	0	2	844	0	0	0	2	0
Synedra,	96	1	26	14	116	2	1	0	49	1,000	6
Cyanophyceæ,	40	2	6	24	32	334	747	354	393	212	12
Anabæna,	0	0	0	0	20	314	592	92	126	62	4
Clathrocystis,	0	0	0	0	0	20	14	6	5	0	0
Cœlosphærium,	40	2	6	24	12	0	138	256	262	150	8
Algæ,	216	2	204	78	44	62	34	6	31	112	119
Raphidium,	164	2	172	50	44	20	27	0	0	30	42
Selenastrum,	52	0	0	0	0	0	0	0	0	4	46
ANIMALS.											
Infusoria,	0	2	32	5	24	30	20	4	32	40	47
Ciliated infusorian,	0	0	0	0	0	6	11	0	0	0	0
Dinobryon,	0	0	24	0	2	20	0	0	0	0	26
Peridinium,	0	0	0	0	20	0	2	4	0	0	8
Trachelomonas,	0	2	4	0	2	2	4	0	29	38	12
Vermes,	2	0	1	1	0	4	3	2	2	2	1
Crustacea, Cyclops,	0	0	0	pr.	pr.	0	0	pr.	pr.	0	0
Miscellaneous, Zoöglœa,	15	3	5	7	25	20	10	10	3	10	3
TOTAL,	471	10	284	183	299	1,374	817	376	516	1,410	207

WATER SUPPLY OF WINTHROP.

(See *Revere* and *Metropolitan Water District.*)

WATER SUPPLY OF WOBURN.

The source of supply is a filter-gallery situated 130 feet from the shore of Horn Pond in Woburn. The filter-gallery is 82 feet long, 12 feet wide, and the bottom is 8 feet below the level of high water in the pond. Water from the filter-gallery is pumped to an open distributing reservoir. Horn Pond has an area of 103 acres and a water-shed of 7.4 square miles, which contains a very large population.

The advice of the State Board of Health to the board of health of Woburn, relative to the pollution of the water of Horn Pond by water flowing into it from Put Fowle Brook, so called, may be found on pages 122 and 123 of this volume.

Chemical Examination of Water from the Filter-gallery of the Woburn Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
21914	Jan. 19	None.	V. slight.	.02	10.00	.0054	.0034	1.38	.0170	.0000	.05	5.6	.0010
22233	Feb. 16	None.	None.	.02	10.00	.0036	.0036	1.38	.0180	.0000	.07	4.7	.0010
22584	Mar. 16	None.	None.	.02	10.10	.0042	.0022	1.31	.0260	.0000	.06	4.4	.0030
22917	Apr. 20	None.	None.	.01	9.90	.0076	.0020	1.29	.0320	.0000	.06	4.6	.0010
23212	May 18	None.	None.	.01	9.70	.0040	.0028	1.28	.0370	.0000	.05	4.6	.0010
23575	June 15	None.	None.	.05	9.50	.0030	.0022	1.24	.0280	.0000	.04	4.6	.0020
23987	July 21	None.	None.	.02	10.10	.0040	.0024	1.22	.0260	.0000	.10	4.3	.0030
24348	Aug. 17	V. slight	None.	.00	10.20	.0018	.0042	1.23	.0190	.0001	.08	3.4	.0000
24735	Sept. 22	None.	None.	.01	10.50	.0048	.0022	1.24	.0210	.0000	.04	4.3	.0030
25098	Oct. 19	None.	None.	.00	10.70	.0034	.0022	1.31	.0140	.0000	.12	4.9	.0010
25431	Nov. 18	None.	V. slight.	.04	10.80	.0046	.0022	1.19	.0300	.0000	.06	4.4	.0010
25730	Dec. 21	None.	None.	.01	10.30	.0028	.0016	1.18	.0350	.0000	.05	4.3	.0010

Averages by Years.

-	1888	-	-	.00	12.00	.0012	.0032	2.50	.0346	.0000	-	-	-
-	1889	-	-	.00	10.84	.0010	.0022	2.07	.0372	.0000	-	-	-
-	1890	-	-	.01	11.06	.0012	.0023	1.91	.0481	.0000	-	5.0	-
-	1891	-	-	.00	10.85	.0008	.0015	1.79	.0668	.0000	-	4.9	-
-	1892	-	-	.00	11.27	.0012	.0024	1.95	.0542	.0000	-	5.1	-
-	1893	-	-	.00	11.50	.0022	.0018	2.04	.0447	.0000	.05	5.3	.0004
-	1894	-	-	.01	11.02	.0026	.0018	1.94	.0262	.0000	.05	5.0	.0021
-	1895	-	-	.01	10.82	.0031	.0022	1.74	.0204	.0000	.06	4.9	.0023
-	1896	-	-	.01	10.49	.0033	.0031	1.56	.0242	.0000	.04	5.0	.0011
-	1897	-	-	.01	10.06	.0041	.0032	1.36	.0202	.0000	.04	5.0	.0012
-	1898	-	-	.02	10.15	.0041	.0026	1.27	.0252	.0000	.06	4.5	.0015

NOTE to analyses of 1898: Odor, none.

WOBURN.

Chemical Examination of Water from Horn Pond, Woburn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21913	Jan. 19	V. slight.	Slight.	.40	8.10	2.50	.0014	.0290	.0208	.0082	1.13	.0660	.0006	.45	3.5
22232	Feb. 16	Slight.	Slight.	.42	7.50	2.00	.0062	.0408	.0226	.0182	0.99	.0960	.0010	.47	2.7
22583	Mar. 16	Slight.	Slight.	.43	7.65	2.05	.0064	.0182	.0148	.0034	0.98	.1040	.0056	.42	2.9
22916	Apr. 20	Slight.	Cons.	.38	7.80	2.55	.0024	.0248	.0160	.0088	1.03	.0870	.0019	.38	3.0
23211	May 18	V. slight.	Slight.	.52	7.00	2.15	.0024	.0266	.0182	.0084	0.93	.0820	.0007	.43	3.1
23574	June 15	Decided.	Cons., floc.	.46	7.65	2.45	.0040	.0286	.0208	.0078	0.96	.0620	.0015	.45	2.9
23986	July 21	Slight.	Cons.	.30	8.00	1.95	.0018	.0288	.0236	.0052	0.89	.0330	.0018	.44	3.0
24347	Aug. 17	Decided.	Cons.	.38	7.70	2.10	.0040	.0386	.0270	.0116	0.88	.0140	.0024	.53	3.0
24734	Sept. 22	Decided.	Cons.	.38	7.50	1.85	.0040	.0326	.0256	.0070	0.88	.0160	.0006	.55	3.1
25097	Oct. 19	Slight.	Slight.	.32	8.25	2.70	.0092	.0282	.0242	.0040	1.06	.0200	.0011	.62	3.4
25430	Nov. 18	Slight.	Cons.	.38	8.15	2.50	.0016	.0296	.0200	.0096	0.94	.0450	.0007	.56	3.1
25729	Dec. 21	V. slight.	Slight.	.41	8.30	3.05	.0014	.0180	.0142	.0038	0.89	.1140	.0006	.45	2.7
Av...	....	....	....	.40	7.80	2.32	.0037	.0286	.0206	.0080	0.96	.0616	.0015	.48	3.0

Odor, generally distinctly vegetable, occasionally none, becoming sometimes mouldy or unpleasant on heating.

Microscopical Examination of Water from Horn Pond, Woburn.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	20	17	17	21	19	16	22	18	23	20	21	22
Number of sample,	21913	22232	22583	22916	23211	23574	23986	24347	24734	25097	25430	25729
PLANTS.												
Diatomaceæ,	2,158	92	240	4,498	3,876	64	1,342	2,368	2,246	752	1,044	269
Asterionella,	392	33	28	3,088	728	12	0	16	1,576	176	28	104
Cyclotella,	0	2	0	2	8	6	0	6	22	68	152	2
Fragilaria,	6	0	0	114	24	14	1,332	2,276	140	96	12	0
Melosira,	32	4	19	36	0	0	0	30	24	264	814	136
Synedra,	1,728	52	169	1,152	3,064	24	8	40	484	148	38	24
Tabellaria,	0	0	2	106	40	2	0	0	0	0	0	1
Cyanophyceæ,	4	0	0	0	0	20	0	20	6	4	0	0
Clathrocystis,	0	0	0	0	0	2	0	10	6	4	0	0
Cœlosphærium,	4	0	0	0	0	4	0	10	0	0	0	0
Algæ,	180	5	10	12	48	84	368	50	32	96	114	24
Scenedesmus,	180	4	9	10	24	12	6	2	0	0	8	3
Staurastrum,	0	0	0	0	4	28	354	40	32	96	98	17

WOBURN.

Microscopical Examination of Water from Horn Pond, Woburn — Concluded.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept.	Oct.	Nov	Dec.
ANIMALS.												
Rhizopoda,	0	0	0	0	0	0	0	0	2	0	0	0
Infusoria,	46	88	13	30	34	2	0	66	164	92	36	3
Cryptomonas,	0	70	1	18	2	0	0	0	0	0	2	2
Mallomonas,	0	0	0	0	0	0	0	0	108	0	4	0
Peridinium,	2	0	0	4	8	0	0	0	36	0	0	0
Trachelomonas,	36	3	9	6	8	2	0	60	20	92	18	1
Vermes,	0	0	0	6	12	2	6	2	6	4	10	0
Crustacea,	pr.	pr.	0	0	pr.	0	0	0	0	pr.	pr.	0
Miscellaneous, Zoöglœa,	10	10	10	10	10	3	5	10	10	12	10	7
TOTAL,	2,398	195	273	4,556	3,982	175	1,721	2,516	2,466	960	1,214	303

Chemical Examination of Water from Cummingsville Brook and Gardner's Brook in Woburn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
23110	May 10	V. slight.	Cons.	.60	9.90	3.50	.0038	.0152	.0136	.0016	1.22	.2520	.0010	.47	3.3
23111	May 10	V. slight.	Cons.	.60	5.25	1.85	.0010	.0140	.0120	.0020	0.58	.0730	.0001	.48	2.5

Odor of the first sample, faintly vegetable, becoming stronger on heating; of the last, none, becoming faintly vegetable on heating. —— The samples were collected from branches of Put Fowle Brook, so called, the first from the Cummingsville branch and the last from Gardner's Brook.

Water Supply of Worcester.

The sources of supply are Lynde and Kettle brooks in Leicester and Tatnuck Brook in Holden, on which storage reservoirs have been constructed. Lynde Brook Reservoir has an area of 143 acres, a maximum depth of 37.4 feet, an average depth of 14.6 feet and a capacity of 681,000,000 gallons. The shores of the

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reservoir are steep, and much of the soil has been removed from the bottom. The reservoir is fed by a direct water-shed of 2.9 square miles, which contains a population of 20 per square mile.

The water of Kettle Brook is diverted into the Lynde Brook storage reservoir. The brook has a water-shed at the point of diversion of 4 square miles, which contains a population of 50 per square mile. There are several storage reservoirs on the brook above the point of diversion, some of which are shallow and contain large amounts of organic matter.

Tatnuck Brook storage reservoir has an area of 149.5 acres, an average depth of 15.2 feet and a capacity of 742,000,000 gallons. Its drainage area of 4.6 square miles contains a population of 16 per square mile. Water from Tatnuck Brook Reservoir flows to a small distributing reservoir on the brook a short distance below the dam, which has a small additional water-shed.

Chemical Examination of Water from Lynde Brook Storage Reservoir, at Inlet.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21892	Jan. 18	V. slight.	Slight.	.40	3.65	1.35	.0004	.0102	.0088	.0014	.23	.0080	.0001	.38	1.1
22221	Feb. 15	V. slight.	Cons.	.41	2.95	1.20	.0002	.0122	.0092	.0030	.21	.0090	.0000	.38	0.6
22566	Mar. 15	Slight.	Cons.	.40	2.70	1.15	.0006	.0124	.0094	.0030	.14	.0030	.0000	.35	0.5
22893	Apr. 19	V. slight.	Slight.	.48	2.80	1.20	.0000	.0112	.0098	.0014	.18	.0020	.0000	.46	0.8
23189	May 17	V. slight.	Slight.	.76	3.50	1.50	.0010	.0180	.0162	.0018	.19	.0030	.0000	.31	1.0
23543	June 14	Slight.	Cons.	.98	4.20	2.05	.0012	.0282	.0276	.0006	.14	.0040	.0000	.94	1.0
23937	July 19	Slight.	Slight.	.18	2.75	1.25	.0012	.0198	.0148	.0050	.16	.0030	.0000	.34	0.6
24317	Aug. 15	V. slight.	Slight.	.27	2.90	1.35	.0030	.0238	.0182	.0056	.16	.0020	.0001	.47	0.8
24705	Sept. 20	None.	None.	.31	4.60	2.35	.0010	.0154	.0148	.0006	.15	.0000	.0000	.48	1.1
25087	Oct. 18	None.	V. slight.	.57	3.75	1.60	.0002	.0156	.0146	.0010	.21	.0020	.0000	.70	0.8
25383	Nov. 15	V. slight.	None.	.34	3.25	1.20	.0002	.0084	.0082	.0002	.18	.0010	.0000	.44	0.6
25744	Dec. 21	V. slight.	V. slight.	.26	3.35	1.20	.0002	.0062	.0056	.0006	.17	.0110	.0001	.30	0.5
Av...	....	....	....	.45	3.37	1.45	.0008	.0151	.0131	.0020	.18	.0040	.0000	.46	0.8

Odor, faintly vegetable or none. On heating, the odor of all of the samples became vegetable and sometimes musty.

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Chemical Examination of Water from Lynde Brook Storage Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21893	Jan. 18	Slight.	Slight.	.65	4.95	2.15	.0094	.0210	.0182	.0028	.32	.0160	.0002	.61	1.6
22222	Feb. 15	V. slight.	None.	.30	2.95	1.15	.0034	.0126	.0120	.0006	.22	.0140	.0001	.32	0.8
22567	Mar. 15	Slight.	None.	.37	2.90	1.00	.0012	.0150	.0132	.0018	.21	.0040	.0001	.31	0.8
22894	Apr. 19	Slight.	Cons.	.29	3.05	1.00	.0014	.0098	.0084	.0014	.20	.0080	.0001	.31	0.5
23190	May 17	Slight.	Slight.	.30	2.80	0.95	.0012	.0142	.0104	.0038	.20	.0070	.0000	.31	0.8
23544	June 14	V. slight.	V. slight.	.22	3.05	1.10	.0014	.0158	.0132	.0026	.18	.0030	.0001	.32	0.8
23938	July 19	V. slight.	V. slight.	.20	2.75	1.10	.0022	.0176	.0164	.0012	.16	.0050	.0000	.36	0.5
24318	Aug. 15	V. slight.	V. slight.	.20	3.10	1.45	.0008	.0174	.0172	.0002	.22	.0020	.0003	.36	0.8
24706	Sept. 20	V. slight.	V. slight.	.21	3.25	1.80	.0010	.0186	.0162	.0024	.15	.0000	.0000	.39	0.8
25088	Oct. 18	V. slight.	V. slight.	.29	3.10	1.40	.0062	.0156	.0148	.0008	.18	.0010	.0000	.44	0.8
25384	Nov. 15	V. slight.	V. slight.	.34	3.55	1.40	.0046	.0154	.0142	.0012	.18	.0050	.0000	.46	0.8
25745	Dec. 21	V. slight.	V. slight.	.31	3.40	1.40	.0028	.0138	.0136	.0002	.18	.0060	.0001	.42	0.6
Av.	....	....	....	.31	3.24	1.32	.0030	.0156	.0140	.0016	.20	.0059	.0001	.38	0.8

Odor, generally faintly vegetable or none, occasionally musty. On heating, the odor of all of the samples became distinctly vegetable or musty, in May distinctly oily, and in September distinctly fishy.

Microscopical Examination of Water from Lynde Brook Storage Reservoir.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	19	16	16	20	18	15	20	17	22	20	16	23
Number of sample,	21893	22222	22567	22894	23190	23544	23938	24318	24706	25088	25384	25745
PLANTS.												
Diatomaceæ,	**10**	**0**	**4**	**16**	**17**	**118**	**3**	**6**	**10**	**3**	**43**	**4**
Cyclotella,	0	0	0	0	6	90	2	2	0	1	0	0
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**10**	**13**	**5**	**5**	**0**
Anabæna,	0	0	0	0	0	4	0	3	0	0	5	0
Merismopœdia,	0	0	0	0	0	4	0	7	13	5	0	0
Algæ,	**0**	**0**	**0**	**0**	**3**	**112**	**6**	**33**	**40**	**10**	**5**	**0**
Raphidium,	0	0	0	0	0	102	0	11	40	9	0	0

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Microscopical Examination of Water from Lynde Brook Storage Reservoir — Concluded.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Rhizopoda,	0	0	0	0	0	0	2	0	0	1	1	0
Infusoria,	1	1	19	1	21	29	17	2	16	61	6	16
Dinobryon,	0	0	18	1	16	28	14	0	15	59	4	1
Vermes,	0	0	0	0	0	0	1	1	0	0	0	0
Miscellaneous, Zoöglœa,	10	0	8	3	3	3	3	3	3	3	5	3
TOTAL,	21	1	31	20	44	272	32	55	82	83	65	23

Chemical Examination of Water from Kent Reservoir on Kettle Brook in Leicester.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21895	Jan. 18	V. slight.	V. slight.	.45	3.65	1.55	.0026	.0144	.0126	.0018	.22	.0140	.0001	.45	1.4
22224	Feb. 15	Slight.	V. slight.	.40	2.70	1.20	.0026	.0180	.0166	.0014	.18	.0070	.0000	.42	0.6
22569	Mar. 15	Decided.	V. slight	.38	2.90	1.30	.0018	.0108	.0082	.0026	.14	.0060	.0001	.36	1.1
22896	Apr. 19	Slight.	Cons.	.30	2.50	0.95	.0000	.0100	.0088	.0012	.14	.0030	.0001	.33	0.5
23192	May 17	Slight.	Slight.	.39	2.80	1.20	.0006	.0162	.0138	.0024	.18	.0030	.0000	.38	0.8
23548	June 14	Slight.	Slight.	.35	2.60	1.00	.0014	.0212	.0174	.0038	.15	.0020	.0002	.41	0.8
23941	July 19	Slight.	Slight.	.28	3.30	1.80	.0010	.0220	.0182	.0038	.13	.0000	.0000	.40	0.8
24320	Aug. 15	Slight.	Slight.	.35	3.20	1.50	.0008	.0214	.0174	.0040	.13	.0020	.0001	.52	0.8
24709	Sept. 20	Slight.	Cons.	.38	3.75	1.90	.0018	.0280	.0234	.0046	.15	.0000	.0000	.61	1.0
25090	Oct. 18	Slight.	Slight.	.34	3.85	1.65	.0006	.0196	.0168	.0028	.17	.0010	.0000	.58	0.8
25388	Nov. 15	V. slight.	V. slight.	.35	3.75	1.35	.0004	.0134	.0112	.0022	.18	.0040	.0000	.46	0.8
25747	Dec. 21	V. slight.	V. slight.	.41	3.35	1.45	.0014	.0158	.0154	.0004	.16	.0090	.0001	.56	0.6
Av...	....	....	....	.36	3.20	1.40	.0012	.0176	.0150	.0026	.16	.0042	.0001	.46	0.8

Odor, generally none, sometimes musty. On heating, the odor of most of the samples became vegetable or musty, and in September also fishy.

WORCESTER.

Microscopical Examination of Water from Kent Reservoir on Kettle Brook in Leicester.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct	Nov.	Dec.
Day of examination,	19	16	16	20	18	15	20	17	22	20	16	23
Number of sample,	21895	22224	22569	22896	23192	23548	23941	24320	24709	25090	25388	25747
PLANTS.												
Diatomaceæ,	8	4	6	120	250	352	61	96	228	244	116	26
Asterionella,	3	3	2	7	8	8	9	0	20	60	2	9
Melosira,	0	0	0	35	106	73	28	48	168	130	40	0
Synedra,	0	1	2	74	115	260	14	36	14	8	62	17
Cyanophyceæ,	0	0	0	0	0	0	1	0	6	0	0	0
Algæ,	0	0	0	4	5	11	8	58	18	18	6	0
ANIMALS.												
Rhizopoda,	0	0	0	0	0	0	0	0	2	0	0	0
Infusoria,	1	1	4	30	6	36	3	50	1,526	91	4	3
Dinobryon,	0	0	3	23	1	23	0	44	1,500	86	4	1
Peridinium,	1	1	0	5	3	10	0	0	24	4	0	2
Vermes,	0	0	0	0	1	8	1	4	0	0	0	0
Crustacea, Cyclops,	0	0	0	0	0	0	pr.		0	0	0	0
Miscellaneous, Zoöglœa,	0	3	0	5	5	15	8	10	12	18	10	5
TOTAL,	9	8	10	159	267	422	82	218	1,792	371	136	34

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Chemical Examination of Water from Bottomly Pond, on Kettle Brook, Paxton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21894	Jan. 18	Slight.	V. slight.	.59	3.60	1.75	.0028	.0182	.0176	.0006	.23	.0120	.0001	.60	1.4
22223	Feb. 15	Slight.	V. slight.	.51	3.30	1.40	.0040	.0180	.0170	.0010	.20	.0130	.0000	.50	1.0
22568	Mar. 15	Slight.	V. slight.	.09	2.45	1.00	.0022	.0056	.0054	.0002	.07	.0930	.0000	.13	0.8
22895	Apr. 19	Slight.	Cons.	.40	2.55	1.10	.0000	.0148	.0108	.0040	.13	.0050	.0000	.39	0.8
23191	May 17	Slight.	Cons.	.40	2.60	1.15	.0008	.0180	.0134	.0046	.15	.0020	.0000	.42	0.8
23547	June 14	Slight.	Slight.	.43	2.95	1.15	.0008	.0210	.0182	.0028	.13	.0000	.0000	.47	0.8
23936	July 19	Slight.	Slight.	.30	2.55	1.25	.0006	.0246	.0216	.0030	.16	.0010	.0006	.44	0.6
24319	Aug. 15	V. slight.	Slight.	.30	2.60	1.10	.0004	.0238	.0186	.0052	.14	.0020	.0000	.46	0.5
24708	Sept. 20	Slight.	Cons.	.43	3.60	2.10	.0004	.0304	.0246	.0058	.10	.0020	.0000	.66	0.6
25089	Oct. 18	V. slight.	V. slight.	.40	3.25	1.50	.0002	.0262	.0220	.0042	.12	.0010	.0000	.73	0.8
25387	Nov. 15	V. slight.	V. slight.	.46	3.60	1.60	.0010	.0212	.0178	.0034	.14	.0010	.0000	.68	0.8
25746	Dec. 21	V. slight.	V. slight.	.50	3.80	1.70	.0016	.0214	.0192	.0022	.16	.0060	.0002	.70	0.8
Av...	....	....	....	.40	3.07	1.40	.0012	.0203	.0172	.0031	.14	.0115	.0001	.51	0.8

Odor, generally vegetable or none, sometimes musty or mouldy. On heating, the odor of most of the samples became vegetable and occasionally musty, and in September also fishy.

Microscopical Examination of Water from Bottomly Pond, on Kettle Brook, Paxton.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, ...	19	16	16	20	18	15	20	17	22	20	16	23
Number of sample, ...	21894	22223	22568	22895	23191	23547	23936	24319	24708	25089	25387	25746
PLANTS.												
Diatomaceæ, ...	46	34	121	176	326	375	304	354	206	322	520	26
Asterionella, ...	46	25	6	52	136	33	190	232	20	210	154	5
Cyclotella, ...	0	0	0	8	6	11	52	100	22	30	104	0
Melosira, ...	0	0	0	38	104	35	42	0	12	10	10	0
Synedra, ...	0	8	108	76	76	294	5	18	2	50	230	21
Tabellaria, ...	0	0	3	0	1	1	15	4	150	8	18	0
Cyanophyceæ, ...	0	0	0	0	0	0	0	68	10	2	0	0
Anabæna, ...	0	0	0	0	0	0	0	68	0	0	0	0
Algæ, ...	12	1	0	12	9	8	10	44	12	20	14	2
Raphidium, ...	0	0	0	8	4	3	6	8	8	10	8	0

WORCESTER.

Microscopical Examination of Water from Bottomly Pond, on Kettle Brook, Paxton — Concluded.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Infusoria, ...	6	2	1	434	27	18	17	48	828	334	60	18
Dinobryon, ...	0	1	0	414	12	0	1	8	824	324	56	16
Peridinium, ...	5	0	1	8	9	17	14	36	2	8	4	1
Vermes, ...	2	0	0	4	2	4	1	6	2	4	2	0
Crustacea, ...	0	0	0	0	pr.	0	0	0	pr.	pr.	0	0
Cyclops, ...	0	0	0	0	pr.	0	0	0	pr.	pr.	0	0
Daphnia, ...	0	0	0	0	pr.	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa, ...	3	5	5	8	8	8	5	10	10	5	10	3
TOTAL, ...	69	42	127	634	372	413	337	530	1,068	687	606	49

Chemical Examination of Water from Tatnuck Brook Storage Reservoir, at Inlet.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved	Suspended.		Nitrates.	Nitrites.		
	1898.														
21890	Jan. 18	V. slight.	None.	.41	2.90	1.25	.0002	.0098	.0088	.0010	.28	.0080	.0000	.39	1.1
22219	Feb. 15	V. slight	V. slight.	.47	2.45	1.25	.0000	.0084	.0072	.0012	.23	.0080	.0000	.36	0.2
22564	Mar. 15	V. slight.	None.	.36	2.20	1.00	.0006	.0090	.0074	.0016	.14	.0020	.0000	.32	0.5
22891	Apr. 19	None.	V. slight.	.18	2.00	0.60	.0000	.0054	.0042	.0012	.15	.0070	.0000	.23	0.5
23187	May 17	V. slight.	Cons.	.30	2.00	0.90	.0004	.0152	.0132	.0020	.19	.0000	.0000	.25	0.5
23545	June 14	Slight.	Slight.	.48	2.85	1.30	.0022	.0214	.0174	.0040	.14	.0010	.0000	.51	0.8
23939	July 19	Slight.	Slight.	.19	2.05	0.80	.0010	.0174	.0136	.0038	.15	.0010	.0000	.30	0.2
24315	Aug. 15	Slight.	Slight.	.20	1.90	0.90	.0006	.0172	.0154	.0018	.15	.0010	.0000	.34	0.5
24703	Sept. 20	Slight.	Slight.	.19	2.75	1.50	.0010	.0192	.0146	.0046	.13	.0000	.0000	.36	0.6
25085	Oct. 18	V. slight.	V. slight.	.19	2.30	0.80	.0002	.0128	.0114	.0014	.18	.0010	.0000	.33	0.5
25385	Nov. 15	V. slight.	V. slight.	.19	2.65	1.00	.0000	.0052	.0046	.0006	.17	.0010	.0000	.34	0.5
25742	Dec. 21	V. slight.	V. slight.	.10	2.40	1.10	.0002	.0026	.0024	.0002	.15	.0040	.0000	.16	0.3
Av...	....	....	....	.27	2.37	1.03	.0005	.0120	.0100	.0020	.17	.0028	.0000	.32	0.5

Odor, generally none, sometimes faintly vegetable. On heating, the odor of most of the samples became vegetable, and in September also fishy.

WORCESTER.

Chemical Examination of Water from Tatnuck Brook Storage Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21891	Jan. 18	V. slight.	None.	.36	2.60	1.00	.0004	.0132	.0118	.0014	.21	.0020	.0001	.38	0.8
22220	Feb. 15	V. slight.	None.	.25	2.35	1.10	.0010	.0088	.0076	.0012	.18	.0050	.0000	.24	0.3
22565	Mar. 15	V. slight.	V. slight.	.22	1.95	0.75	.0004	.0084	.0070	.0014	.14	.0000	.0000	.26	0.5
22892	Apr. 19	Slight.	Slight.	.17	1.85	0.65	.0000	.0082	.0062	.0020	.17	.0030	.0000	.22	0.5
23188	May 17	Slight.	Slight.	.20	2.00	0.85	.0004	.0150	.0118	.0032	.17	.0000	.0000	.24	0.5
23546	June 14	Slight.	V. slight.	.21	2.40	1.00	.0018	.0150	.0118	.0032	.15	.0030	.0000	.29	0.8
23940	July 19	V. slight.	Slight.	.17	2.05	1.10	.0018	.0164	.0146	.0018	.16	.0010	.0001	.28	0.2
24316	Aug. 15	Slight.	Slight.	.19	1.80	0.75	.0006	.0206	.0168	.0038	.16	.0020	.0000	.34	0.5
24704	Sept. 20	Slight.	Slight.	.19	2.70	1.40	.0006	.0202	.0154	.0048	.14	.0000	.0000	.34	0.6
25086	Oct. 18	V. slight.	Slight.	.19	2.05	0.90	.0004	.0198	.0152	.0046	.17	.0020	.0000	.39	0.6
25386	Nov. 15	V. slight.	Slight.	.25	2.50	1.00	.0004	.0148	.0124	.0024	.15	.0010	.0000	.34	0.5
25743	Dec. 21	V. slight.	V. slight.	.23	2.65	1.00	.0000	.0088	.0068	.0020	.17	.0050	.0002	.34	0.3
Av...	....	....	....	.22	2.24	0.96	.0006	.0141	.0114	.0027	.16	.0020	.0000	.30	0.5

Odor, frequently none, occasionally faintly vegetable. On heating, the odor became vegetable, and in September and December fishy.

Microscopical Examination of Water from Tatnuck Brook Storage Reservoir.

[Number of organisms per cubic centimeter.]

	1898. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	19	16	16	20	18	15	20	17	22	20	16	23
Number of sample,	21891	22220	22565	22892	23188	23546	23940	24316	24704	25086	25386	25743
PLANTS.												
Diatomaceæ,	**0**	**1**	**19**	**14**	**1,020**	**51**	**62**	**184**	**480**	**1,392**	**446**	**3**
Asterionella,	0	0	0	0	40	5	22	118	308	104	6	0
Melosira,	0	0	3	0	852	0	11	0	12	1,216	316	0
Synedra,	0	0	6	1	8	10	3	6	120	46	88	1
Tabellaria,	0	1	7	4	118	16	25	54	38	20	34	0
Cyanophyceæ,	**0**	**0**	**0**	**0**	**1**	**5**	**8**	**16**	**10**	**2**	**0**	**0**
Anabæna,	0	0	0	0	1	5	6	14	8	0	0	0
Algæ,	**0**	**0**	**0**	**0**	**9**	**19**	**5**	**4**	**8**	**24**	**14**	**0**

WORCESTER.

Microscopical Examination of Water from Tatnuck Brook Storage Reservoir — Concluded.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
ANIMALS.												
Rhizopoda,	0	0	0	0	0	0	1	0	0	0	0	0
Infusoria,	2	0	0	0	55	16	17	46	170	24	16	94
Dinobryon,	0	0	0	0	21	1	15	38	148	0	0	79
Peridinium,	2	0	0	0	29	7	1	6	18	22	14	15
Vermes,	0	0	1	0	1	0	2	4	4	0	0	0
Crustacea,	0	0	0	0	0	0	0	0	pr.	0	pr.	0
Miscellaneous, Zoöglœa,	3	0	3	3	5	3	5	5	8	5	5	3
TOTAL,	5	1	23	17	1,091	94	100	259	680	1,447	481	100

The advice of the State Board of Health to the Curtis Manufacturing Company of Worcester, relative to the use of Curtis Pond in that city as a source of ice supply for domestic purposes, may be found on pages 127 and 128 of this volume. The results of a chemical analysis of a sample of water collected from the pond are given in the following table: —

Chemical Examination of Water from Curtis Pond in Worcester.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
25762	1898. Dec. 23	Slight.	V. slight.	.50	4.10	1.60	.0014	.0180	.0144	.0036	.22	.0080	.0001	.52	1.0

Odor, very faintly vegetable.

EXAMINATION OF RIVERS.

EXAMINATION OF RIVERS.

Regular monthly examinations have been made during the year 1898 of the waters of the Assabet, Blackstone, Charles, Hoosac, Housatonic, Merrimack, Miller's, Nashua, Neponset, Saugus, Sudbury, Taunton and Ware rivers, and occasional examinations of other rivers in the State. Most of the results of these examinations will be found arranged alphabetically by rivers in the pages which follow, but some of them are given on preceding pages in connection with the examinations of water supplies under the names of the towns where the samples were collected, as follows: —

	PAGE
Merrimack at Lowell,	248
Merrimack at Lawrence,	233
Saugus at Saugus,	260
Sudbury at Framingham,	156

The flow of the streams during the summer months was very high, and consequently the quality of the water of the sewage-polluted rivers was much better than it would be in an ordinary season.

Assabet River.

The Westborough sewage filtration area is situated on the banks of this river above Northborough, and owing to faulty construction of sewers and filter-beds a considerable quantity of sewage has been discharged into the stream. The river also receives sewage and manufacturing wastes directly or indirectly from the towns of Hudson and Maynard, through which it passes.

The advice of the State Board of Health to the town of Northborough relative to the pollution of the Assabet River by the discharge into it of unpurified sewage from the Westborough sewage disposal works may be found on pages 119 and 120 of this volume. A communication from the State Board of Health to the town of Westborough relative to the discharge of unpurified sewage into the river may be found on pages 120 and 121 of this volume.

ASSABET RIVER.

Chemical Examination of Water from Assabet River, below the Sewage Filtration Area at Westborough.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21897	Jan. 18	V. slight.	V. slight.	0.87	4.60	2.00	.0010	.0200	.0188	.0012	.34	.0030	.0000	0.71	2.1
22287	Feb. 18	V. slight.	None.	0.90	4.10	2.00	.0006	.0210	.0204	.0006	.27	.0030	.0000	0.70	1.1
22605	Mar. 18	V. slight.	V. slight.	0.70	2.95	1.45	.0000	.0188	.0160	.0028	.23	.0000	.0000	0.64	1.0
22898	Apr. 18	V. slight.	V. slight.	0.90	3.85	1.70	.0002	.0240	.0228	.0012	.26	.0020	.0000	0.31	1.3
23226	May 19	V. slight.	V. slight.	1.30	4.45	2.35	.0016	.0326	.0304	.0022	.32	.0000	.0000	1.06	1.3
23621	June 20	Slight.	V slight.	0.80	4.70	2.55	.0010	.0302	.0294	.0008	.23	.0010	.0000	0.82	1.8
23983	July 18	Slight.	Cons.	0.60	4.75	2.00	.0026	.0312	.0286	.0026	.31	.0000	.0001	0.70	1.3
24378	Aug. 18	V slight.	V. slight.	1.50	6.50	3.70	.0070	.0538	.0490	.0048	.26	.0020	.0001	1.69	1.6
24748	Sept. 22	Slight.	Slight.	0.52	5.60	2.40	.0008	.0318	.0276	.0042	.43	.0010	.0001	0.67	1.6
25108	Oct. 18	None.	V. slight.	1.52	6.65	3.75	.0004	.0358	.0350	.0008	.33	.0020	.0000	1.94	1.6
25224	Nov. 1	V. slight.	None.	1.06	5.75	2.75	.0012	.0286	.0276	.0010	.34	.0010	.0000	1.44	1.4
25429	Nov. 18	V. slight.	V. slight.	0.95	5.00	2.60	.0044	.0234	.0222	.0012	.24	.0020	.0000	1.08	1.4
25717	Dec. 20	V. slight.	Slight.	0.58	5.05	1.85	.0134	.0158	.0148	.0010	.31	.0090	.0004	0.62	1.6
Av.*	....	....	....	0.93	4.88	2.37	.0026	.0284	.0265	.0019	.30	.0020	.0001	0.93	1.5

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Odor, generally faintly vegetable, sometimes faintly musty, becoming stronger on heating. —— The samples were collected from the river at the bridge on Belmont Street, about 1,000 feet below the filter-beds of the town of Westborough.

Chemical Examination of Water from Assabet River, below Hudson.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21865	Jan. 17	Slight.	Slight.	0.60	4.80	2.05	.0036	.0224	.0186	.0038	.62	.0140	.0002	0.57	1.4
22195	Feb. 14	Slight.	Slight.	0.51	4.20	1.75	.0032	.0180	.0164	.0016	.36	.0140	.0001	0.48	1.3
22577	Mar. 16	Slight.	Slight.	0.60	3.65	1.65	.0014	.0206	.0200	.0006	.36	.0040	.0001	0.56	1.0
23181	May 17	Decided.	Cons.	0.85	5.10	2.10	.0122	.0412	.0358	.0054	.61	.0070	.0001	0.78	1.7
23506	June 13	Slight.	Cons.	1.10	6.25	2.40	.0070	.0338	.0296	.0042	.33	.0090	.0003	0.76	2.1
23926	July 19	Decided.	Heavy.	0.55	5.75	2.30	.0132	.0402	.0324	.0078	.47	.0030	.0006	0.67	1.6
24288	Aug. 15	V. slight.	Cons	1.20	6.10	3.25	.0058	.0500	.0466	.0034	.30	.0020	.0002	1.41	1.6
24670	Sept. 19	Slight.	Slight.	0.46	5.25	2.00	.0098	.0266	.0220	.0046	.33	.0150	.0006	0.60	1.6
25041	Oct. 17	V. slight.	Slight.	0.75	5.45	2.35	.0010	.0306	.0262	.0044	.51	.0060	.0002	0.98	1.4
25415	Nov. 17	Slight.	V. slight.	0.66	4.85	2.00	.0002	.0196	.0176	.0020	.42	.0030	.0002	0.79	1.4
25609	Dec. 13	Slight.	Cons.	0.41	4.20	1.70	.0010	.0156	.0140	.0016	.32	.0230	.0001	0.54	1.1
Av...	....	....	....	0.70	5.05	2.14	.0053	.0290	.0254	.0036	.42	.0091	.0021	0.74	1.5

Odor, faintly vegetable or musty, sometimes none. On heating, the odor of all of the samples was vegetable or musty and sometimes unpleasant. —— The samples were collected from the river at the O'Neil bridge, so called, about a mile below the village of Hudson.

ASSABET RIVER.

Chemical Examination of Water from Assabet River, below Maynard.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21885	Jan. 18	Decided.	Cons.	0.60	4.80	2.00	.0022	.0290	.0220	.0070	.41	.0140	.0002	0.62	2.1
22550	Mar. 15	Decided.	Cons.	0.65	3.25	1.40	.0010	.0210	.0188	.0022	.26	.0020	.0000	0.58	0.8
22880	Apr. 19	Decided.	Cons.	0.72	4.20	1.90	.0006	.0280	.0250	.0030	.36	.0030	.0001	0.72	1.1
23180	May 17	Decided.	Cons.	0.92	4.95	2.45	.0066	.0380	.0314	.0066	.44	.0050	.0001	0.78	1.4
23664	June 22	Decided.	Cons.	0.82	6.40	2.75	.0010	.0476	.0328	.0148	.47	.0020	.0004	0.82	1.7
23923	July 19	Decided.	Cons.	0.49	6.30	2.35	.0012	.0512	.0356	.0156	.55	.0010	.0004	0.65	1.4
24310	Aug. 16	Slight.	Slight.	1.20	6.20	3.25	.0030	.0406	.0366	.0040	.30	.0070	.0002	1.38	1.4
24717	Sept. 21	Decided.	Cons.	0.66	6.75	2.80	.0052	.0476	.0340	.0136	.47	.0010	.0005	0.83	1.6
25053	Oct. 18	V. slight.	Slight.	0.78	5.35	2.45	.0006	.0270	.0242	.0028	.47	.0050	.0002	0.93	1.8
25428	Nov. 18	V. slight.	V. slight.	0.70	4.60	1.95	.0010	.0182	.0176	.0006	.32	.0020	.0002	0.76	1.1
25691	Dec. 20	Decided.	Slight.	0.46	5.00	1.75	.0004	.0178	.0138	.0040	.32	.0130	.0003	0.56	1.3
Av...	....	....	....	0.73	5.25	2.28	.0021	.0333	.0265	.0068	.40	.0050	.0002	0.78	1.4

Odor, musty and sometimes unpleasant or disagreeable, becoming stronger on heating. —— The samples were collected from the river, near the works of the American Powder Company.

Blackstone River.

The regular monthly examinations of the water of the Blackstone River have been continued as in previous years and the results are given in the tables which follow. The first of the tables is taken from the report of the superintendent of sewers of the city of Worcester for the year ending Nov. 30, 1898, and contains the monthly averages of analyses, made by the city, of samples of sewage and effluent collected at the Worcester Precipitation Works, and the percentage of matters removed from the sewage by treatment at these works.

According to the above-mentioned report, there were treated during the year ending Nov. 30, 1898, an average of about 17,700,000 gallons per day of mingled sewage and brook water taken from the Mill Brook channel, and about 1,073 pounds of quick-lime were used for each million gallons of sewage treated. The effluent from the precipitation works and the excess of flow of Mill Brook over the amount treated were discharged into the Blackstone River.

The second and third tables show the averages for each year and for the six dry months of each year of the chemical analyses of samples of water collected at various points along the river.

BLACKSTONE RIVER.

Worcester Sewage Purification Works.

Abstract of Analyses of Sewage and Effluent made by the City of Worcester.

[Taken from the annual report of the superintendent of sewers of the city of Worcester for the year ending Nov. 30, 1898.]

[Parts per 100,000.]

DATE OF COLLECTION.	Ammonia.				Oxygen Consumed.		
		Albuminoid.					
	Free.	Total.	Dissolved.	Suspended.	Unfiltered.	Filtered.	Chlorine.
Sewage, December, 1897,	.812	.369	.185	.184	4.76	2.77	4.10
Effluent, December, 1897,	.761	.183	.156	.027	2.55	2.55	4.10
Per cent. removed,	6.28	50.41	15.68	85.33	46.43	7.94	0.00
Sewage, January, 1898,	.692	.327	.159	.168	3.33	1.86	3.92
Effluent, January, 1898,	.658	.163	.153	.010	1.99	1.99	3.92
Per cent. removed,	4.91	50.16	3.77	94.06	40.24	—6.99	0.00
Sewage, February, 1898,	.533	.286	.141	.145	2.75	1.55	3.47
Effluent, February, 1898,	.493	.171	.162	.009	1.57	1.57	3.45
Per cent. removed,	7.50	40.21	—14.89	93.78	42.91	—1.29	0.58
Sewage, March, 1898,	.436	.278	.148	.130	2.71	1.40	3.35
Effluent, March, 1898,	.397	.142	.139	.003	1.40	1.40	3.37
Per cent. removed,	8.95	48.56	6.08	97.70	48.34	0.00	—0.60
Sewage, April, 1898,	.670	.365	.183	.182	3.09	1.65	4.07
Effluent, April, 1898,	.624	.197	.190	.007	1.69	1.69	4.09
Per cent. removed,	6.87	46.03	—3.89	96.14	45.30	—2.45	—0.49
Sewage, May, 1898,	.816	.442	.243	.199	3.62	1.84	4.41
Effluent, May, 1898,	.770	.228	.217	.011	1.84	1.84	4.39
Per cent. removed,	5.64	48.42	10.70	94.48	49.17	0.00	0.45
Sewage, June, 1898,	1.239	.560	.268	.292	3.94	1.79	6.14
Effluent, June, 1898,	1.114	.268	.252	.016	1.84	1.84	6.22
Per cent. removed,	10.09	52.14	5.97	96.72	53.30	—2.79	—1.33
Sewage, July, 1898,	1.616	.734	.382	.352	5.44	3.55	7.63
Effluent, July, 1898,	1.416	.318	.285	.033	2.99	2.99	7.89
Per cent. removed,	12.38	56.67	25.39	90.63	45.04	15.78	—3.41

BLACKSTONE RIVER.

WORCESTER SEWAGE PURIFICATION WORKS — *Concluded.*

[Parts per 100,000.]

DATE OF COLLECTION.	Ammonia.				Oxygen Consumed.		Chlorine.
	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.	Unfiltered.	Filtered.	
Sewage, August, 1898,	.876	.489	.232	.257	5.07	2.94	5.68
Effluent, August, 1898,	.781	.235	.218	.017	2.65	2.65	5.87
Per cent. removed,	10.85	51.94	6.03	93.40	47.73	9.87	—3.35
Sewage, September, 1898,	1.068	.543	.267	.276	4.95	2.35	6.10
Effluent, September, 1898,	.945	.240	.219	.021	2.03	2.03	6.13
Per cent. removed,	11.55	55.80	17.98	92.39	59.00	8.64	—0.49
Sewage, October, 1898,	.869	.521	.254	.267	4.60	2.23	5.12
Effluent, October, 1898,	.803	.222	.199	.023	2.25	2.25	5.20
Per cent. removed,	7.59	57.40	22.05	91.39	51.09	—0.90	—1.56
Sewage, November, 1898,	.564	.334	.182	.152	3.94	2.04	3.00
Effluent, November, 1898,	.519	.166	.150	.016	1.85	1.85	3.02
Per cent. removed,	7.98	50.30	17.68	89.48	50.52	9.31	—0.67
Sewage for year ending Dec. 1, 1898,	.851	.438	.221	.217	4.03	2.17	4.76
Effluent for year ending Dec. 1, 1898,	.775	.211	.195	.016	2.06	2.06	4.81
Per cent. removed,	8.93	51.82	11.77	92.62	48.89	5.07	—1.05

NOTE. — Monthly averages are made from daily analyses of sewage and effluent. The daily sewage samples consist of forty-eight portions taken half-hourly. Sewage samples are taken as nearly as possible in proportion to the amount of sewage being received at the time of sampling. Effluent samples consist of twenty-four portions taken hourly.

BLACKSTONE RIVER.

Averages of Chemical Analyses of Water from the Blackstone River for the Years 1888 to 1898, inclusive.

Blackstone River between Mill Brook Channel and the Sewage Precipitation Works.

[Parts per 100,000.]

YEAR.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
1888,	0.64	-	-	.2112	.1040	-	-	1.21	.0370	.0029	-
1889,	0.76	-	-	.2841	.1198	.0629	.0569	1.06	.0235	.0024	-
1890,	0.82	-	-	.1800	.1024	.0549	.0475	1.03	.0367	.0014	-
1891,	0.80	13.54	4.00	.3340	.1563	.0840	.0723	1.73	.0333	.0032	4.6
1892,	0.71	16.28	4.85	.2530	.1262	.0627	.0635	1.84	.0312	.0061	4.9
1893,	0.68	17.95	4.88	.1429	.0603	.0325	.0277	1.04	.0180	.0012	4.5
1894,	0.86	17.17	5.58	.0739	.0570	.0304	.0266	0.88	.0195	.0006	3.7
1895,	0.84	13.40	4.02	.0507	.0374	.0229	.0145	0.86	.0175	.0007	2.9
1896,	0.75	12.69	3.37	.0759	.0486	.0309	.0177	1.01	.0187	.0010	2.9
1897,	0.94	17.62	5.31	.0715	.0533	.0306	.0227	0.77	.0151	.0015	2.9
1898,	0.50	13.52	4.34	.0762	.0557	.0259	.0298	0.83	.0167	.0011	3.5

Blackstone River below Sewage Precipitation Works.

1888,	0.64	-	-	.2112	.1040	-	-	1.21	.0370	.0029	-
1889,	0.76	-	-	.2841	.1198	.0629	.0569	1.06	.0235	.0024	-
1890,	0.74	-	-	.2253	.1177	.0581	.0596	1.26	.0381	.0016	-
1891,	0.80	15.62	4.52	.4080	.1303	.0695	.0608	1.91	.0358	.0031	4.6
1892,	0.53	19.35	5.29	.3633	.1442	.0737	.0705	2.21	.0278	.0033	7.2
1893,	0.74	25.65	6.54	.3757	.1447	.0864	.0583	1.98	.0369	.0070	7.4
1894,	0.60	25.75	6.61	.4228	.1309	.0946	.0363	2.13	.0316	.0047	7.9
1895,	0.79	19.14	4.78	.2298	.0840	.0573	.0267	1.52	.0347	.0040	5.8
1896,	0.40	24.28	6.36	.2645	.0930	.0615	.0315	1.91	.0356	.0071	8.3
1897,	0.75	19.94	4.59	.2447	.0843	.0630	.0213	1.33	.0300	.0047	5.4
1898,	0.49	19.41	5.20	.2260	.0725	.0473	.0252	1.30	.0264	.0072	6.6

Blackstone River at Uxbridge.

1888,	0.45	-	-	.0979	.0284	-	-	0.61	.0322	.0008	-
1889,	0.28	-	-	.0992	.0300	.0191	.0109	0.60	.0253	.0009	-
1890,	0.25	-	-	.1168	.0214	.0152	.0062	0.66	.0272	.0006	-
1891,	0.27	8.32	1.94	.1647	.0272	.0197	.0075	0.77	.0396	.0008	2.8
1892,	0.21	8.59	1.90	.2113	.0222	.0153	.0069	0.82	.0326	.0007	2.8
1893,	0.40	9.45	1.91	.1603	.0256	.0167	.0089	1.00	.0424	.0029	3.2
1894,	0.51	10.80	1.97	.1372	.0242	.0187	.0055	1.22	.0460	.0032	4.0
1895,	0.64	10.56	2.44	.1081	.0315	.0243	.0072	1.05	.0439	.0037	3.9
1896,	0.42	10.77	2.50	.1209	.0308	.0249	.0059	1.09	.0405	.0054	4.2
1897,	0.59	10.31	2.50	.1126	.0298	.0248	.0050	1.04	.0481	.0035	3.8
1898,	0.58	8.72	2.30	.0818	.0305	.0232	.0073	0.84	.0360	.0046	3.2

Blackstone River at Millville.

1888,	0.47	-	-	.0444	.0253	-	-	0.44	.0242	.0005	-
1889,	0.38	-	-	.0450	.0277	.0206	.0071	0.43	.0160	.0004	-
1890,	0.34	-	-	.0587	.0211	.0162	.0049	0.46	.0240	.0004	-
1891,	0.32	6.05	1.83	.0807	.0293	.0194	.0099	0.55	.0275	.0005	1.9
1892,	0.35	6.03	1.62	.0896	.0249	.0180	.0069	0.54	.0218	.0004	1.8
1893,	0.40	6.23	1.53	.0899	.0288	.0225	.0063	0.66	.0289	.0008	2.0
1894,	0.49	6.37	1.90	.0528	.0219	.0173	.0046	0.73	.0232	.0008	2.5
1895,	0.58	7.47	2.27	.0501	.0253	.0189	.0064	0.74	.0278	.0016	2.7
1896,	0.40	7.34	1.64	.0549	.0248	.0185	.0063	0.76	.0347	.0018	2.8
1897,	0.53	7.07	2.14	.0528	.0262	.0219	.0043	0.73	.0332	.0014	2.6
1898,	0.55	6.43	1.95	.0456	.0256	.0201	.0055	0.61	.0222	.0016	2.3

BLACKSTONE RIVER.

Averages of Chemical Analyses of Water from the Blackstone River for Six Months, from June to November, inclusive, of Each Year from 1887 to 1898, inclusive.

Blackstone River between Mill Brook Channel and the Sewage Precipitation Works.

[Parts per 100,000.]

Months.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	
June-Nov., 1887,	0.91	-	-	.2686	.1741	-	-	1.35	.0160	-	-
" " 1888,	0.76	-	-	.2658	.1112	.0557	.0555	1.50	.0382	.0041	-
" " 1889,	0.86	-	-	.3980	.1430	.0772	.0658	1.32	.0177	.0026	-
" " 1890,	1.14	9.92	3.03	.2107	.1246	.0673	.0573	1.07	.0250	.0015	2.9
" " 1891,	1.10	17.42	5.59	.4913	.1950	.1127	.0823	2.29	.0192	.0037	5.0
" " 1892,	0.52	20.75	6.30	.3547	.1433	.0708	.0725	2.43	.0227	.0108	6.1
" " 1893,	0.40	16.98	4.55	.1480	.0588	.0240	.0348	1.01	.0115	.0015	6.3
" " 1894,	0.66	16.93	4.76	.0548	.0380	.0236	.0144	0.74	.0115	.0005	4.4
" " 1895,	0.49	14.17	4.50	.0613	.0414	.0243	.0171	0.92	.0163	.0006	3.4
" " 1896,	0.51	12.90	2.93	.0780	.0415	.0282	.0133	0.97	.0147	.0015	3.4
" " 1897,	0.85	26.45	7.68	.1130	.0674	.0362	.0312	0.89	.0090	.0024	4.2*
" " 1898,	0.33	17.42	5.62	.0857	.0619	.0260	.0359	0.96	.0053	.0010	4.6

Blackstone River below Sewage Precipitation Works.

Months.	Color.	Residue: Total.	Residue: Loss on Ignition.	Ammonia: Free.	Albuminoid: Total.	Albuminoid: Dissolved.	Albuminoid: Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
June-Nov., 1887,	0.91	-	-	.2686	.1741	-	-	1.35	.0160	-	-
" " 1888,	0.76	-	-	.2658	.1112	.0557	.0555	1.50	.0382	.0041	-
" " 1889,	0.86	-	-	.3980	.1430	.0772	.0658	1.32	.0177	.0026	-
" " 1890,	0.97	11.36	3.10	.2907	.1492	.0722	.0770	1.46	.0270	.0018	3.9
" " 1891,	1.05	22.25	6.60	.6367	.1508	.0883	.0625	2.61	.0233	.0040	6.2
" " 1892,	0.63	26.80	7.75	.5240	.1810	.0958	.0852	3.13	.0137	.0050	10.3
" " 1893,	0.51	30.00	7.13	.5680	.1453	.0900	.0553	2.76	.0285	.0126	10.9
" " 1894,	0.40	29.30	5.86	.6189	.1390	.1113	.0277	2.63	.0212	.0071	10.6
" " 1895,	0.71	22.15	5.18	.3246	.0898	.0597	.0301	1.86	.0267	.0063	7.3
" " 1896,	0.30	26.03	6.53	.2831	.0898	.0600	.0298	2.10	.0217	.0118	9.7
" " 1897,	0.73	25.98	4.97	.3650	.1122	.0782	.0340	1.61	.0207	.0063	6.9
" " 1898,	0.23	25.63	6.73	.3064	.0868	.0560	.0308	1.55	.0132	.0119	9.2

Blackstone River at Uxbridge.

Months.	Color.	Residue: Total.	Residue: Loss on Ignition.	Ammonia: Free.	Albuminoid: Total.	Albuminoid: Dissolved.	Albuminoid: Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
June-Nov., 1887,	0.39	-	-	.1129	.0271	-	-	0.79	.0360	-	-
" " 1888,	0.38	6.42	1.52	.1155	.0288	.0222	.0066	0.68	.0310	.0007	-
" " 1889,	0.32	-	-	.1133	.0296	.0192	.0104	0.66	.0333	.0009	-
" " 1890,	0.26	8.86	2.12	.1629	.0231	.0174	.0057	0.79	.0259	.0005	2.9
" " 1891,	0.20	10.16	2.61	.2280	.0175	.0117	.0058	1.04	.0425	.0007	3.6
" " 1892,	0.13	9.36	1.88	.2840	.0227	.0162	.0065	0.99	.0313	.0007	3.1
" " 1893,	0.24	11.74	2.37	.1985	.0207	.0140	.0067	1.20	.0623	.0050	4.2
" " 1894,	0.35	13.07	2.03	.1456	.0243	.0183	.0060	1.57	.0673	.0050	4.9
" " 1895,†	0.56	12.95	2.69	.0906	.0258	.0182	.0076	1.34	.0631	.0065	4.7
" " 1896,	0.33	12.68	2.67	.1129	.0257	.0221	.0036	1.38	.0477	.0091	5.0
" " 1897,	0.48	11.60	2.47	.1029	.0280	.0215	.0065	1.32	.0652	.0051	4.3
" " 1898,	0.49	10.59	2.78	.0801	.0264	.0219	.0045	1.00	.0470	.0076	3.8

Blackstone River at Millville.

Months.	Color.	Residue: Total.	Residue: Loss on Ignition.	Ammonia: Free.	Albuminoid: Total.	Albuminoid: Dissolved.	Albuminoid: Suspended.	Chlorine.	Nitrates.	Nitrites.	Hardness.
June-Nov., 1887,	0.31	-	-	.0468	.0220	-	-	0.51	.0210	-	-
" " 1888,	0.41	5.22	1.40	.0467	.0296	.0233	.0063	0.50	.0278	.0004	-
" " 1889,	0.38	-	-	.0499	.0273	.0213	.0060	0.45	.0167	.0003	-
" " 1890,	0.26	6.71	2.24	.0736	.0196	.0152	.0044	0.53	.0229	.0003	2.3
" " 1891,	0.24	7.48	2.35	.1105	.0384	.0234	.0150	0.72	.0308	.0006	2.2
" " 1892,	0.37	6.70	1.62	.1143	.0294	.0210	.0084	0.63	.0217	.0002	2.0
" " 1893,	0.23	7.43	1.73	.0677	.0119	.0087	.0031	0.77	.0385	.0011	2.6
" " 1894,	0.47	8.42	2.16	.0510	.0172	.0139	.0033	0.89	.0273	.0012	2.8
" " 1895,	0.51	8.67	2.55	.0356	.0233	.0180	.0053	0.90	.0383	.0024	3.2
" " 1896,	0.35	8.53	1.69	.0484	.0237	.0180	.0057	0.97	.0413	.0027	3.3
" " 1897,	0.45	7.66	1.98	.0509	.0258	.0210	.0048	0.92	.0445	.0019	3.1
" " 1898,	0.51	7.12	2.17	.0325	.0240	.0193	.0047	0.63	.0240	.0023	2.5

* Average of five months. † Average of five months. No sample was obtained in June.

BLACKSTONE RIVER.

Chemical Examination of Water from Blackstone River, between

[Parts per 100,000.]

			Appearance.			Residue on Evaporation.					
						Total Residue.			Loss on Ignition.		
	Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.
		1898.									
1	21915	Jan. 19	Decided.	Cons.	1.10	10.30	7.50	2.80	3.30	1.55	1.75
2	22334	Feb. 22	Decided.	Cons.	1.00	9.70	7.10	2.60	3.50	2.50	1.00
3	22589	Mar. 16	Decided.	Cons.	0.70	8.80	6.50	2.30	3.00	2.00	1.00
4	22918	Apr. 20	Decided.	Heavy.	0.87	8.40	5.20	3.20	2.80	1.70	1.10
5	23216	May 18	Slight.	Heavy, floc.	0.05	10.00	7.00	3.00	2.70	1.30	1.40
6	23594	June 15	Decided.	Heavy.	0.90	10.20	7.30	2.90	2.90	1.70	1.20
7	23992	July 21	Decided.	Heavy.	0.18	30.10	29.00	1.10	9.70	9.40	0.30
8	24367	Aug. 18	Decided, milky.	Heavy.	0.10	14.10	10.25	3.85	4.50	2.70	1.80
9	24718	Sept. 21	Decided.	Heavy.	0.28	15.00	9.40	5.60	4.35	2.40	1.95
10	25109	Oct. 19	Slight.	Heavy, brown.	0.17	19.95	11.85	8.10	6.25	2.10	4.15
11	25419	Nov. 17	Decided.	Cons.	–	15.20	12.80	2.40	6.00	5.80	0.20
12	25755	Dec. 21	Decided.	Heavy.	0.14	10.50	8.50	2.00	3.10	2.50	0.60
13	Av..	....	....	....	0.50	13.52	10.20	3.32	4.34	2.97	1.37

Odor, distinctly musty and unpleasant or disagreeable. —— The samples were collected from the 25419 on Thursday, and the other samples on Wednesday. The samples were collected between 9.30

Chemical Examination of Water from Blackstone

[Parts per 100,000.]

			Appearance.			Residue on Evaporation.					
						Total Residue.			Loss on Ignition.		
	Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.
		1898.									
1	21916	Jan. 19	Decided.	Cons.	1.15	11.80	10.20	1.60	4.00	3.10	0.90
2	22335	Feb. 22	Decided.	Cons.	1.05	9.50	6.50	3.00	3.20	2.30	0.90
3	22590	Mar. 16	Decided.	Cons.	1.10	10.60	8.70	1.90	3.40	2.70	0.70
4	22919	Apr. 20	Decided.	Heavy.	0.72	14.70	10.70	4.00	4.20	3.20	1.00
5	23217	May 18	Decided.	Heavy, floc.	0.06	16.80	13.80	3.00	3.80	3.40	0.40
6	23595	June 15	Decided.	Heavy.	0.30	26.30	24.10	2.20	4.80	4.30	0.50
7	23993	July 21	Decided.	Heavy.	0.13	40.80	36.40	4.40	9.50	6.90	2.60
8	24368	Aug. 18	Decided, milky.	Heavy.	0.22	21.00	18.15	2.85	6.50	4.50	2.00
9	24719	Sept. 21	Decided.	Heavy.	0.30	17.55	13.60	3.95	4.75	3.50	1.25
10	25110	Oct. 19	Decided.	Heavy, brown.	0.19	33.15	27.80	5.35	8.85	7.20	1.65
11	25420	Nov. 17	Decided.	Cons.	–	15.00	14.20	0.80	6.00	5.60	0.40
12	25756	Dec. 21	Decided.	Heavy.	0.22	15.70	11.70	4.00	3.40	2.40	1.00
13	Av..	....	....	....	0.49	19.41	16.32	3.09	5.20	4.09	1.11

Odor, distinctly musty and unpleasant or disagreeable, sometimes offensive. —— The samples were Sewage Precipitation Works enters the river. No. 22335 was collected on Tuesday, Nos. 23993, 24368 9.45 and 10.45 A.M.

BLACKSTONE RIVER.

Mill Brook Channel and the Worcester Sewage Precipitation Works.

[Parts per 100,000.]

Ammonia.					Nitrogen as		Oxygen Consumed.		Iron.			
	Albuminoid.											
Free.	Total.	Dis-solved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Un-filtered.	Filtered.	Unfiltered.	Filtered.	Hardness.	
.0700	.0416	.0240	.0176	0.77	.0330	.0013	0.66	0.53	0.68	0.24	2.6	1
.0760	.0580	.0388	.0192	0.94	.0320	.0009	0.79	0.56	0.31	0.15	2.3	2
.1228	.0772	.0488	.0284	0.66	.0520	.0014	0.70	0.69	0.28	0.12	2.3	3
.0272	.0444	.0156	.0288	0.54	.0230	.0012	0.66	0.45	0.17	0.09	2.0	4
.0290	.0375	.0115	.0260	0.65	.0130	.0006	0.71	0.26	1.26	0.37	2.3	5
.0380	.0572	.0264	.0308	0.69	.0100	.0004	0.67	0.30	0.57	0.08	2.1	6
.1900	.0500	.0310	.0190	–	.0000	.0001	1.10	0.34	3.15	0.20	11.5	7
.0800	.0430	.0200	.0230	0.98	.0140	.0020	0.58	0.30	0.60	0.02	3.1	8
.0385	.0630	.0255	.0375	1.31	.0010	.0009	1.01	0.41	0.47	0.18	3.1	9
.0650	.0980	.0180	.0800	1.08	.0010	.0016	1.70	0.51	0.54	0.02	4.6	10
.1030	.0600	.0350	.0250	0.73	.0060	.0012	2.91	2.56	0.66	0.30	3.1	11
.0748	.0390	.0164	.0226	0.74	.0160	.0018	0.98	0.24	0.28	0.08	2.5	12
.0762	.0557	.0259	.0298	0.83	.0167	.0011	1.04	0.60	0.75	0.15	3.5	13

river, about 200 feet below the iron bridge. No. 22334 was collected on Tuesday, Nos. 23992, 24367 and and 10.30 A.M.

River, below the Worcester Sewage Precipitation Works.

[Parts per 100,000.]

Ammonia.					Nitrogen as		Oxygen Consumed.		Iron.			
	Albuminoid.											
Free.	Total.	Dis-solved.	Sus-pended.	Chlorine.	Nitrates.	Nitrites.	Un-filtered.	Filtered.	Unfiltered.	Filtered.	Hardness.	
.1864	.0472	.0372	.0100	1.06	.0520	.0024	0.62	0.60	0.70	0.29	4.0	1
.0756	.0536	.0368	.0168	0.80	.0320	.0009	0.74	0.58	0.30	0.16	2.2	2
.1268	.0808	.0548	.0260	1.06	.0380	.0015	0.77	0.61	0.31	0.19	3.0	3
.1840	.0640	.0480	.0160	1.13	.0450	.0028	1.09	0.66	0.21	0.09	4.7	4
.1890	.0660	.0350	.0310	1.34	.0530	.0040	0.74	0.43	1.08	0.07	5.3	5
.4800	.1550	.1060	.0490	2.60	.0100	.0520	0.90	0.61	0.29	0.01	10.3	6
.5900	.1185	.0890	.0295	1.05	.0000	.0002	1.54	1.02	2.20	1.12	15.0	7
.2750	.0620	.0350	.0270	1.60	.0380	.0064	0.54	0.38	0.34	0.04	7.4	8
.1445	.0660	.0345	.0315	1.62	.0100	.0032	0.74	0.36	0.41	0.05	4.4	9
.2410	.0710	.0390	.0320	1.60	.0000	.0076	1.58	1.00	3.43	0.45	14.1	10
.1080	.0485	.0325	.0160	0.82	.0210	.0024	2.67	2.35	0.55	0.32	3.8	11
.1114	.0378	.0198	.0180	0.87	.0180	.0027	0.83	0.27	0.62	0.07	4.7	12
.2260	.0725	.0473	.0252	1.30	.0264	.0072	1.06	0.74	0.87	0.25	6.6	13

collected from the river, above Millbury and below the point where the effluent from the Worcester and 25420 on Thursday, and the other samples on Wednesday. The samples were collected between

BLACKSTONE RIVER.

Chemical Examination of Water from Blackstone River at Uxbridge.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21956	Jan. 24	Decided.	Cons.	.90	6.05	1.55	.0580	.0342	.0278	.0064	0.60	.0220	.0005	.45	2.6
22243	Feb. 17	Decided, milky.	Slight.	.85	6.65	2.00	.0586	.0358	.0290	.0068	0.60	.0300	.0008	.44	2.6
22598	Mar. 17	Decided.	Cons.	.63	4.85	1.50	.0344	.0214	.0154	.0060	0.42	.0200	.0006	.39	2.1
22905	Apr. 20	Decided.	Heavy.	.60	7.50	1.85	.1092	.0448	.0204	.0244	0.84	.0290	.0017	.38	3.0
23223	May 19	Decided.	Cons.	.55	7.95	1.90	.1680	.0390	.0280	.0110	0.91	.0320	.0032	.35	3.4
23560	June 15	Decided.	Cons.	.51	9.50	2.50	.0892	.0296	.0232	.0064	0.91	.0580	.0080	.39	3.6
23985	July 21	Slight.	Cons.	.29	11.60	2.50	.0526	.0266	.0208	.0058	1.16	.0790	.0170	.41	4.0
24358	Aug. 18	Decided.	Cons.	.64	9.95	3.15	.0096	.0260	.0218	.0042	0.86	.0550	.0100	.48	3.5
24733	Sept. 22	Decided.	Cons.	.23	12.80	2.80	.1010	.0216	.0188	.0028	1.16	.0330	.0056	.28	4.3
25115	Oct. 21	Decided.	Cons.	.55	11.85	3.15	.1592	.0228	.0204	.0024	1.22	.0350	.0040	.54	4.3
25414	Nov. 17	Slight.	V. slight.	.70	7.85	2.60	.0688	.0318	.0264	.0054	0.67	.0220	.0013	.55	2.9
25754	Dec. 22	Decided.	V. slight.	.51	8.20	2.15	.0728	.0320	.0262	.0058	0.69	.0170	.0022	.40	2.7
Av...	....	....	....	.58	8.72	2.30	.0818	.0305	.0232	.0073	0.84	.0360	.0046	.42	3.2

Odor, generally musty and occasionally disagreeable or unpleasant, becoming stronger on heating. —— The samples were collected from the canal leading from the upper dam of the Calumet Woolen Company to the mill, just before the water passed the screens.

Chemical Examination of Water from Blackstone River at Millville, Blackstone.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21925	Jan. 20	Decided.	Slight.	.62	6.50	2.05	.0776	.0314	.0254	.0060	.74	.0220	.0008	.41	2.7
22245	Feb. 17	Slight.	Cons., earthy.	.66	5.20	2.00	.0374	.0290	.0186	.0104	.48	.0240	.0002	.47	2.0
22597	Mar. 17	Slight.	V. slight.	.60	4.20	1.50	.0212	.0176	.0132	.0044	.37	.0150	.0004	.39	1.8
22904	Apr. 20	Decided.	Cons.	.59	6.10	1.55	.0724	.0296	.0228	.0068	.69	.0230	.0009	.30	2.3
23222	May 19	Decided.	Slight.	.50	6.25	1.60	.0960	.0320	.0240	.0080	.71	.0180	.0016	.37	2.5
23598	June 16	Slight.	Cons.	.48	6.90	2.10	.0326	.0248	.0212	.0036	.60	.0250	.0026	.40	2.1
23984	July 21	Decided.	Slight.	.45	7.50	1.70	.0190	.0286	.0220	.0066	.71	.0360	.0070	.41	2.3
24357	Aug. 18	Decided.	Cons.	.62	6.30	2.60	.0024	.0276	.0232	.0044	.45	.0130	.0009	.60	2.1
24736	Sept. 22	Slight.	Slight.	.32	7.70	1.75	.0292	.0208	.0188	.0020	.70	.0200	.0010	.32	3.0
25119	Oct. 22	V. slight.	V. slight	.53	7.85	2.50	.0710	.0226	.0172	.0054	.82	.0330	.0016	.55	3.0
25418	Nov. 17	Decided.	V. slight.	.69	6.50	2.35	.0408	.0196	.0136	.0060	.50	.0170	.0008	.53	2.3
25753	Dec. 22	Decided.	V. slight.	.51	6.15	1.65	.0478	.0232	.0208	.0024	.53	.0210	.0009	.41	2.1
Av...	....	....	....	.55	6.43	1.95	.0456	.0256	.0201	.0055	.61	.0222	.0016	.43	2.3

Odor, musty and unpleasant or disagreeable, becoming generally stronger on heating. —— The samples were collected from the river, just above the dam in the village of Millville.

CHARLES RIVER.

Chemical Examination of Water from Charles River, below Milford.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
23522	June 13	Slight.	Heavy.	.70	8.75	3.15	.1280	.0580	.0445	.0135	1.83	.0580	.0068	.68	2.2
23919	July 18	Decided.	Cons., floc.	.60	6.90	2.80	.0580	.0688	.0444	.0244	1.03	.0190	.0024	.78	1.4
24328	Aug. 16	Decided, milky.	Cons., iron.	.59	15.75	3.30	.1726	.0522	.0376	.0146	4.55	.0650	.0100	.61	3.6
Av...	....	....	....	.63	10.47	3.08	.1195	.0597	.0422	.0175	2.47	.0473	.0064	.69	2.4

Odor, distinctly musty and disagreeable.

Chemical Examination of Water from Charles River, opposite the Filter-gallery of the Brookline Water Works at West Roxbury.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21876	Jan. 17	Slight.	Slight.	0.70	4.95	1.95	.0006	.0238	.0224	.0014	.47	.0090	.0000	0.65	1.6
22210	Feb. 14	V. slight.	V. slight.	0.70	4.65	1.85	.0030	.0246	.0224	.0022	.44	.0160	.0001	0.65	1.4
22543	Mar. 14	V. slight.	V. slight.	0.69	3.50	1.50	.0002	.0200	.0172	.0028	.32	.0000	.0000	0.62	1.4
22901	Apr. 18	V. slight.	V. slight.	0.80	3.90	1.75	.0000	.0194	.0180	.0014	.40	.0030	.0001	0.65	1.1
23172	May 16	V. slight.	Slight.	1.00	4.05	1.85	.0022	.0244	.0218	.0026	.40	.0000	.0000	0.75	1.7
23523	June 13	V. slight.	V. slight.	1.30	4.55	2.25	.0016	.0376	.0322	.0054	.33	.0030	.0000	1.13	1.4
23947	July 19	Slight.	V. slight.	0.59	4.35	1.90	.0012	.0266	.0246	.0020	.36	.0010	.0001	0.79	1.1
24302	Aug. 15	Slight.	Slight.	1.20	6.45	3.35	.0032	.0400	.0376	.0024	.32	.0030	.0001	1.33	1.6
24691	Sept. 19	V. slight.	V. slight.	0.68	5.55	2.50	.0006	.0292	.0282	.0010	.41	.0020	.0001	0.59	1.6
25049	Oct. 17	None.	V. slight.	0.63	5.50	2.05	.0000	.0246	.0226	.0020	.55	.0070	.0001	0.76	1.7
25375	Nov. 14	V. slight.	V. slight.	0.82	4.95	2.35	.0006	.0240	.0232	.0008	.36	.0050	.0000	0.94	1.3
25603	Dec. 12	V. slight.	V. slight.	0.67	4.60	2.10	.0004	.0148	.0146	.0002	.37	.0170	.0000	0.71	1.1
Av...	....	....	....	0.81	4.75	2.12	.0011	.0257	.0237	.0020	.39	.0055	.0000	0.80	1.4

Odor, generally vegetable, becoming stronger and sometimes musty on heating.

CHARLES RIVER.

Chemical Examination of Water from Charles River, near the Pumping Station of the Newton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21863	Jan. 17	V. slight.	V. slight.	0.71	4.70	1.95	.0018	.0196	.0178	.0018	.48	.0120	.0000	0.66	2.1
22161	Feb. 11	Slight.	V. slight.	0.89	5.25	2.15	.0006	.0218	.0200	.0018	.50	.0070	.0000	0.70	2.2
22535	Mar. 10	V. slight.	V. slight.	0.62	3.50	1.65	.0004	.0204	.0186	.0018	.38	.0100	.0001	0.56	0.8
22870	Apr. 18	V. slight.	Slight.	0.70	3.95	1.40	.0006	.0206	.0194	.0012	.40	.0050	.0001	0.69	1.1
23167	May 16	V. slight.	V. slight.	1.00	4.35	2.10	.0016	.0250	.0228	.0022	.39	.0020	.0000	0.82	1.1
23507	June 13	V. slight.	Slight.	1.40	4.90	2.50	.0022	.0394	.0346	.0048	.34	.0020	.0002	1.19	1.4
23914	July 18	Slight.	V. slight.	0.65	4.65	2.15	.0010	.0284	.0256	.0028	.43	.0030	.0000	0.66	1.6
24295	Aug. 15	V. slight.	V. slight.	1.30	6.35	3.50	.0052	.0476	.0436	.0040	.40	.0040	.0000	1.38	1.8
24679	Sept. 19	V. slight.	V. slight.	0.72	5.45	2.65	.0012	.0284	.0260	.0024	.43	.0040	.0001	0.84	2.1
25035	Oct. 17	None.	V. slight.	0.63	5.65	2.15	.0002	.0266	.0254	.0012	.49	.0030	.0001	0.82	2.0
25362	Nov. 14	V. slight.	V. slight.	0.85	5.15	2.10	.0002	.0258	.0236	.0022	.46	.0050	.0000	0.96	1.4
25598	Dec. 12	V. slight.	V. slight.	0.69	4.40	2.05	.0006	.0184	.0168	.0016	.29	.0140	.0000	0.73	1.3
Av...	....	....	....	0.85	4.86	2.20	.0013	.0268	.0245	.0023	.42	.0059	.0000	0.83	1.6

Odor, vegetable, becoming stronger and also musty on heating; in November, fishy.

Chemical Examination of Water from Charles River, opposite the Well of the Waltham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid Total.	Albuminoid Dissolved.	Albuminoid Suspended.		Nitrates.	Nitrites.		
	1898.														
21905	Jan. 19	Slight.	Slight.	0.70	5.95	2.20	.0028	.0368	.0344	.0024	.54	.0170	.0002	0.62	2.0
22240	Feb. 16	Decided.	Cons., earthy.	0.70	4.65	1.65	.0028	.0262	.0234	.0028	.46	.0180	.0002	0.64	1.4
22572	Mar. 16	Slight.	V. slight.	0.72	4.20	1.70	.0008	.0262	.0222	.0040	.39	.0050	.0001	0.59	1.7
22927	Apr. 21	V. slight.	Slight.	0.70	4.40	2.00	.0010	.0234	.0212	.0022	.45	.0080	.0001	0.65	1.6
23200	May 18	Slight.	V. slight.	1.05	4.75	2.30	.0040	.0274	.0236	.0038	.44	.0070	.0001	0.77	1.4
23580	June 15	V. slight.	Cons.	1.25	5.35	2.45	.0070	.0410	.0344	.0066	.38	.0030	.0001	0.98	1.6
23968	July 20	Decided.	Slight.	0.55	5.10	2.20	.0066	.0288	.0248	.0040	.40	.0020	.0002	0.63	1.6
24333	Aug. 17	V. slight.	Slight.	1.16	6.30	2.95	.0066	.0444	.0416	.0028	.39	.0020	.0001	1.27	1.4
24723	Sept. 21	V. slight.	V. slight.	0.65	6.35	2.30	.0060	.0292	.0282	.0010	.46	.0020	.0002	0.65	1.7
25093	Oct. 19	Slight.	Slight.	0.52	5.80	2.35	.0028	.0282	.0248	.0034	.57	.0060	.0001	0.67	2.0
25405	Nov. 16	Slight.	V. slight.	0.75	5.55	2.50	.0008	.0256	.0240	.0016	.47	.0110	.0001	0.89	1.6
25735	Dec. 21	Slight.	V. slight.	0.68	6.75	2.50	.0024	.0298	.0260	.0038	.49	.0190	.0005	0.73	2.0
Av...	....	....	....	0.79	5.43	2.26	.0036	.0306	.0274	.0032	.45	.0083	.0002	0.76	1.7

Odor, generally vegetable, sometimes musty, becoming stronger on heating.

Deerfield River.

The advice of the State Board of Health to the board of health of North Adams relative to the use of the Deerfield River as a source of ice supply may be found on page 127 of this volume.

The results of analyses of samples of water collected at various points on the stream above the place from which it is proposed to take the ice are given in the following table: —

Chemical Examination of Water from Deerfield River.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
25459	Nov. 22	None.	V. slight.	–	2.80	1.80	.0024	.0096	.0084	.0012	–	.0130	.0000	–	–
25458	Nov. 22	V. slight.	Slight.	–	2.90	1.90	.0020	.0120	.0096	.0024	–	.0020	.0000	–	–
25457	Nov. 22	V. slight.	V. slight.	.37	2.85	1.85	.0004	.0110	.0092	.0018	.05	.0120	.0000	.66	0.5

Odor, none. —— The first sample was collected from the river a short distance above Readsborough, Vt.; the second, from the river above the village of Monroe Bridge; the last, from the river at the village of Hoosac Tunnel in the town of Florida.

French River.

Chemical Examination of Water from French River at Webster.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
23520	June 13	Decided.	Heavy.	.55	5.25	2.00	.0328	.0560	.0328	.0232	.45	.0080	.0016	.57	1.6
23982	July 20	Decided.	Cons.	.55	5.90	2.85	.0024	.0460	.0306	.0154	.20	.0020	.0001	.67	1.0

Odor, distinctly unpleasant. —— The samples were collected from the river below the village of Webster, near the boundary line between the States of Massachusetts and Connecticut.

Hoosac River.

This river receives sewage from the city of North Adams and the town of Adams. Sewage from Adams and a small portion of the sewage of North Adams are discharged into the South Branch. The North Branch receives manufacturing wastes and some sewage from North Adams, but the principal outlet for the sewers of North Adams is into the river below the junction of the two branches, in North Adams.

HOOSAC RIVER.

Chemical Examination of Water from the South Branch of the Hoosac River, near its Confluence with the North Branch at North Adams.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21861	Jan. 14	Slight.	Cons.	.20	8.20	1.90	.0104	.0168	.0132	.0036	.21	.0370	.0004	.23	5.7
22592	Mar. 16	Slight.	Cons.	.20	6.15	1.35	.0014	.0130	.0092	.0038	.14	.0220	.0003	.24	4.2
22936	Apr. 21	V. slight.	Cons.	.18	7.75	1.70	.0014	.0114	.0090	.0024	.16	.0190	.0003	.22	5.4
23215	May 18	Slight.	Cons.	.19	8.50	1.75	.0024	.0152	.0124	.0028	.16	.0180	.0003	.25	6.3
23603	June 16	Decided.	Cons.	.21	9.40	1.85	.0132	.0222	.0158	.0064	.16	.0190	.0006	.32	6.6
24095	July 29	Slight.	Cons.	.18	11.70	2.05	.0090	.0230	.0158	.0072	.18	.0170	.0010	.31	9.1
24439	Aug. 25	Decided.	Cons., earthy.	.51	7.70	2.55	.0058	.0328	.0202	.0126	.12	.0120	.0004	.69	4.6
24727	Sept. 21	Slight.	Cons.	.21	14.15	2.85	.0040	.0342	.0212	.0130	.33	.0380	.0010	.20	10.6
25118	Oct. 21	V. slight.	Slight.	.21	9.65	3.00	.0004	.0198	.0118	.0080	.18	.0230	.0007	.35	7.1
25411	Nov. 16	Slight.	V. slight.	.18	9.00	2.00	.0006	.0170	.0106	.0064	.20	.0320	.0003	.26	7.0
25732	Dec. 21	Decided.	Slight.	.11	11.50	2.50	.0026	.0166	.0110	.0056	.26	.0390	.0006	.21	8.9
Av...	....	....	....	.22	9.43	2.14	.0047	.0202	.0137	.0065	.19	.0251	.0005	.30	6.9

Odor, generally faintly musty, occasionally disagreeable, becoming sometimes stronger on heating. —— The samples were collected from the river, about a quarter of a mile above its confluence with the North Branch.

Chemical Examination of Water from the North Branch of the Hoosac River, near its Confluence with the South Branch at North Adams.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21860	Jan. 14	Decided.	Cons.	0.42	5.90	2.05	.0036	.0212	.0182	.0030	0.34	.0160	.0005	0.69	2.7
22591	Mar. 16	Decided.	Cons., earthy.	0.41	4.85	1.25	.0042	.0144	.0128	.0016	0.19	.0180	.0003	0.50	2.6
22935	Apr. 21	Decided.	Cons.	0.32	3.80	1.40	.0058	.0136	.0100	.0036	0.22	.0070	.0001	0.53	1.3
23214	May 18	Decided.	Heavy.	0.80	6.00	2.75	.0082	.0186	.0148	.0038	0.44	.0120	.0008	0.73	2.2
23602	June 16	Decided.	Cons.	0.30	10.75	2.85	.0330	.0360	.0180	.0180	0.43	.0880	.0018	0.48	5.1
24094	July 29	Decided.	Heavy, red.	0.90	14.85	0.35	.0020	.0972	.0392	.0580	1.20	.0010	.0001	2.13	8.1
24438	Aug. 25	Decided.	Cons., earthy.	0.58	5.95	2.80	.0044	.0344	.0236	.0108	0.26	.0080	.0022	0.89	2.5
24726	Sept. 21	Decided.	Heavy.	1.00	17.85	5.70	.0200	.0500	.0320	.0180	1.57	.0050	.0016	1.42	6.0
25117	Oct. 21	Slight.	Slight.	0.30	8.15	4.55	.0020	.0128	.0116	.0012	0.26	.0180	.0007	0.50	2.5
25410	Nov. 16	Decided.	Slight.	0.27	5.50	2.00	.0032	.0188	.0152	.0036	0.18	.0310	.0001	0.46	2.5
25733	Dec. 21	Decided.	Heavy, earthy.	0.25	6.10	1.80	.0058	.0120	.0082	.0038	0.27	.0240	.0002	0.44	2.3
Av...	....	....	....	0.50	8.15	2.50	.0084	.0299	.0185	.0114	0.49	.0207	.0008	0.80	3.4

Odor, generally musty, occasionally unpleasant or disagreeable, becoming sometimes stronger on heating. —— The samples were collected from the river, about a quarter of a mile above its confluence with the South Branch.

HOOSAC RIVER.

Chemical Examination of Water from the Hoosac River at North Adams.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21862	Jan. 14	Decided.	Cons.	.29	8.50	2.50	.0146	.0216	.0172	.0044	.31	.0230	.0004	.38	4.9
22593	Mar. 16	Decided.	Cons.	.34	6.45	2.00	.0060	.0262	.0212	.0050	.23	.0230	.0003	.38	3.5
22934	Apr. 21	Decided.	Cons.	.29	6.75	2.10	.0034	.0214	.0150	.0064	.31	.0130	.0003	.57	3.5
23213	May 18	Decided.	Cons.	.30	9.50	2.80	.0030	.0324	.0202	.0122	.43	.0170	.0006	.52	5.4
23604	June 16	Decided.	Cons.	.30	9.20	2.30	.0006	.0414	.0210	.0204	.35	.0060	.0028	.46	5.0
24093	July 29	Decided.	Cons., floc.	.21	15.25	3.55	.0016	.0556	.0256	.0300	.51	.0160	.0022	.46	10.0
24437	Aug. 25	Decided.	Cons., earthy.	.53	7.50	2.80	.0032	.0412	.0236	.0176	.16	.0090	.0007	.74	4.0
24728	Sept. 21	Slight.	Cons.	.20	14.25	3.25	.0194	.0468	.0284	.0184	.41	.0130	.0012	.29	9.7
25116	Oct. 21	Slight.	Slight.	.23	9.45	2.75	.0048	.0204	.0130	.0074	.30	.0160	.0008	.46	6.3
25412	Nov. 16	Decided.	Slight.	.27	9.10	2.40	.0006	.0222	.0142	.0080	.27	.0250	.0006	.38	6.3
25734	Dec. 21	Decided.	Cons., earthy.	.23	10.20	2.95	.0170	.0222	.0156	.0066	.37	.0280	.0004	.39	6.0
Av...	....	....	....	.29	9.65	2.67	.0067	.0319	.0195	.0124	.33	.0172	.0009	.46	5.9

Odor, generally faintly musty, occasionally unpleasant or disagreeable, becoming stronger on heating. —— The samples were collected from the river, near the barn of the North Adams Manufacturing Company in Braytonville, about a mile below the confluence of the North and South branches and below the point of discharge of the principal sewer in North Adams.

Chemical Examination of Water from Hoosac River at Williamstown.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21898	Jan. 18	Decided.	Cons.	.18	8.15	2.00	.0130	.0160	.0130	.0030	.23	.0270	.0006	.33	5.7
22218	Feb. 15	Slight, milky.	Cons.	.17	8.05	1.75	.0036	.0164	.0134	.0030	.20	.0280	.0003	.22	5.4
22561	Mar. 15	Decided.	Heavy, earthy.	.35	6.65	1.80	.0048	.0492	.0104	.0388	.16	.0230	.0003	.24	3.5
22879	Apr. 18	Slight.	V. slight.	.21	5.70	1.70	.0006	.0180	.0130	.0050	.15	.0080	.0003	.34	3.5
23197	May 17	Decided.	Cons.	.20	6.40	1.50	.0126	.0166	.0112	.0054	.14	.0120	.0002	.25	4.2
23540	June 14	Decided.	Heavy, earthy.	.58	6.80	2.00	.0092	.0408	.0244	.0164	.10	.0160	.0003	.55	4.0
23944	July 19	Decided.	Cons.	.22	14.55	2.90	.0640	.0344	.0252	.0092	.49	.0160	.0006	.32	9.1
24314	Aug. 16	Decided.	Cons.	.20	11.10	2.05	.0352	.0230	.0162	.0068	.31	.0180	.0008	.25	8.0
24729	Sept. 20	Slight.	Cons.	.23	14.65	3.30	.0202	.0432	.0298	.0134	.59	.0120	.0018	.38	8.7
25137	Oct. 24	Slight.	Slight.	.21	7.75	2.30	.0054	.0246	.0176	.0070	.17	.0160	.0002	.32	4.7
25391	Nov. 15	Decided.	Cons.	.19	7.90	1.75	.0000	.0208	.0128	.0080	.18	.0240	.0003	.24	5.3
25709	Dec. 20	Decided, clayey.	Slight, earthy.	.20	11.90	3.30	.0138	.0408	.0296	.0112	.38	.0250	.0006	.42	7.9
Av...	....	....	....	.24	9.13	2.20	.0152	.0286	.0180	.0106	.26	.0187	.0005	.32	5.8

Odor, generally musty, sometimes unpleasant or disagreeable, becoming stronger on heating —— The samples were collected from the river, at the bridge near the Williamstown station on the Fitchburg railroad.

Housatonic River.

This river receives the sewage of the city of Pittsfield, which in 1895 had a population of 20,461. The sewage in an unpurified state is discharged into the river in the vicinity of the junction of the east and west branches.

Chemical Examination of Water from the East Branch of the Housatonic River, at Pittsfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21983	Jan. 25	Decided.	Cons., floc.	.31	6.50	1.85	.0024	.0138	.0112	.0026	.16	.0160	.0001	.40	4.6
22213	Feb. 15	Slight.	Slight.	.32	6.75	1.95	.0018	.0170	.0106	.0064	.16	.0170	.0001	.50	4.2
22571	Mar. 15	Slight.	Cons., floc.	.40	4.00	1.25	.0016	.0154	.0114	.0040	.07	.0050	.0001	.46	2.2
22926	Apr. 20	Slight.	Cons., floc.	.34	6.75	2.15	.0020	.0166	.0148	.0018	.12	.0120	.0000	.44	4.3
23205	May 17	V. slight	Cons.	.50	6.75	2.30	.0024	.0168	.0156	.0012	.10	.0130	.0001	.47	4.0
23606	June 18	Slight.	Cons.	.36	8.50	2.30	.0046	.0202	.0162	.0040	.13	.0160	.0002	.51	5.9
24066	July 26	Slight.	Cons.	.30	11.20	3.30	.0274	.0246	.0190	.0056	.18	.0140	.0009	.48	7.4
24323	Aug. 16	Slight.	Slight.	.38	9.90	2.65	.0082	.0206	.0174	.0032	.16	.0180	.0002	.46	7.7
24731	Sept. 20	Decided.	Cons.	.32	10.15	2.75	.0108	.0242	.0192	.0050	.19	.0110	.0003	.42	7.0
25104	Oct. 18	V. slight.	Slight.	.42	9.25	3.20	.0006	.0190	.0164	.0026	.19	.0110	.0006	.70	5.3
25392	Nov. 15	Slight.	Cons.	.37	7.55	2.45	.0018	.0194	.0162	.0032	.10	.0140	.0001	.52	4.6
25716	Dec. 20	Slight.	Cons., floc.	.25	8.55	1.85	.0032	.0168	.0124	.0044	.13	.0240	.0004	.27	5.9
Av...	....	....	....	.36	7.99	2.33	.0056	.0187	.0150	.0037	.14	.0142	.0003	.47	5.3

Odor, generally faintly musty, sometimes vegetable, becoming stronger and sometimes also unpleasant on heating. —— The samples were collected from the river at Hathaway bridge, above the thickly settled portion of the city.

HOUSATONIC RIVER.

Chemical Examination of Water from the West Branch of the Housatonic River, at Pittsfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21985	Jan. 25	Decided.	Cons.	–	9.90	2.40	.0080	.0236	.0134	.0102	.18	.0130	.0004	.46	7.0
22594	Mar. 15	Decided.	Cons.	.14	7.00	1.55	.0008	.0176	.0068	.0108	.11	.0180	.0001	.21	5.3
22868	Apr. 16	Decided.	Slight.	–	8.75	1.45	.0042	.0152	.0086	.0066	.15	.0100	.0004	.42	5.9
23161	May 14	Slight.	Cons.	.09	8.05	1.30	.0020	.0164	.0100	.0064	.15	.0130	.0002	.32	6.1
23590	June 14	Slight.	Cons.	.18	8.65	1.15	.0090	.0196	.0122	.0074	.14	.0030	.0002	.18	6.3
23933	July 19	Slight.	Cons.	.14	8.70	2.05	.0004	.0242	.0156	.0086	.10	.0050	.0002	.28	6.1
24346	Aug. 16	Decided.	Cons.	.20	9.45	1.85	.0074	.0262	.0168	.0094	.16	.0010	.0018	.26	6.6
24730	Sept. 20	Slight.	Slight.	.11	9.20	1.70	.0016	.0162	.0116	.0046	.09	.0010	.0001	.18	6.6
25078	Oct. 18	Slight.	Slight.	.12	9.90	1.70	.0030	.0170	.0160	.0010	.13	.0050	.0001	.26	7.4
25404	Nov. 15	V. slight.	V. slight.	.10	8.85	1.70	.0010	.0100	.0070	.0030	.08	.0070	.0001	.15	7.1
25715	Dec. 20	Decided, milky.	V. slight.	.13	10.00	1.65	.0030	.0156	.0098	.0058	.10	.0110	.0002	.18	7.9
Av...	....	....	....	.13	8.95	1.68	.0037	.0183	.0116	.0067	.13	.0079	.0003	.26	6.6

Odor, generally musty, sometimes unpleasant, becoming stronger on heating. —— The samples were collected from the river, a short distance below the junction of the brooks from Onota and Pontoosuc lakes.

Chemical Examination of Water from the South-west Branch of the Housatonic River, at Pittsfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21984	Jan. 25	Decided.	Slight.	.11	11.00	1.90	.0014	.0086	.0070	.0016	.13	.0200	.0001	.18	8.9
22249	Feb. 15	Slight.	Slight.	.10	11.25	1.95	.0068	.0138	.0088	.0050	.15	.0200	.0001	.22	8.1
22705	Apr. 1	V. slight.	Slight.	.10	10.00	1.80	.0052	.0158	.0116	.0042	.12	.0150	.0001	.30	7.4
23050	May 2	Decided.	Cons.	.12	10.55	1.90	.0034	.0150	.0066	.0084	.11	.0130	.0001	.18	8.3
Av...	....	....	....	.11	10.70	1.89	.0042	.0133	.0085	.0048	.13	.0170	.0001	.22	8.2

Odor of the first sample, none; of the second, none, becoming faintly unpleasant on heating; of the third, distinctly unpleasant; of the last, faintly musty. —— The samples were collected from the river, at the first road crossing above its confluence with the North Branch.

HOUSATONIC RIVER.

Chemical Examination of Water from the Housatonic River at New Lenox.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21982	Jan. 25	Decided.	Slight, floc.	.20	9.50	2.35	.0038	.0148	.0108	.0040	.17	.0230	.0004	.36	7.1
22244	Feb. 15	Decided.	Cons.	.29	8.85	1.95	.0036	.0184	.0116	.0068	.18	.0260	.0004	.29	6.9
22563	Mar. 15	Decided.	Cons.	.38	4.95	1.55	.0034	.0154	.0116	.0038	.09	.0100	.0003	.38	3.3
22890	Apr. 16	Slight.	Cons., earthy.	.25	8.50	1.65	.0006	.0138	.0110	.0028	.16	.0090	.0005	.34	0.6
23218	May 17	Slight.	Cons.	.29	8.30	2.00	.0046	.0186	.0132	.0054	.14	.0130	.0004	.33	6.3
23550	June 14	Decided.	Heavy, earthy.	.40	7.65	2.30	.0152	.0548	.0212	.0336	.08	.0190	.0006	.59	5.0
23943	July 19	Decided.	Cons.	.30	10.90	2.55	.0352	.0300	.0188	.0112	.22	.0220	.0006	.42	7.6
24322	Aug. 16	Decided.	Cons., iron.	.21	11.70	2.30	.0256	.0288	.0162	.0126	.17	.0160	.0030	.29	9.0
24710	Sept. 20	Decided.	Cons.	.21	11.75	2.55	.0162	.0236	.0160	.0076	.18	.0120	.0016	.34	8.1
25092	Oct. 18	V. slight.	Cons.	.32	10.25	2.65	.0068	.0182	.0170	.0012	.16	.0170	.0007	.48	7.4
25390	Nov. 15	Slight.	Cons.	.23	9.50	2.25	.0034	.0144	.0114	.0030	.16	.0220	.0004	.34	6.7
25718	Dec. 20	Decided.	Slight.	.20	11.00	2.00	.0086	.0166	.0108	.0058	.14	.0250	.0009	.25	8.4
Av...	....	....	....	.27	9.40	2.17	.0106	.0223	.0141	.0082	.15	.0178	.0008	.37	6.4

Odor, musty.

Merrimack River.

This river receives the unpurified sewage of the cities of Concord, Manchester and Nashua in New Hampshire, and Lowell, Lawrence and Haverhill in Massachusetts. The population of these cities at the time of the last census was as follows: —

City.	Population.	City.	Population.
Concord, ...	17,004*	Lowell, ...	84,367†
Manchester, ...	44,126*	Lawrence, ...	52,164†
Nashua, ...	19,311*	Haverhill, ...	30,209†

* 1890 census. † 1895 census.

MERRIMACK RIVER.

In addition to the sewage of these cities, which are situated directly on the main stream in the order named, the river receives much pollution from cities and towns situated upon its tributaries. The usual monthly examinations of the water of this river just above the city of Lowell and just above the city of Lawrence have been continued during 1898, detailed results of which may be found on pages 248 and 233 of this volume.

The city of Lowell is situated about 10 miles above the city of Lawrence, and the sewage from the former city is discharged directly into the river at several points in and below the city. In the following table a comparison is given of the average analyses of samples of water collected from the river above Lowell and Lawrence during 1898 : —

Table comparing the Analyses above Lowell with those above Lawrence, 1898.

[Parts per 100,000.]

	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.	
					Total.	Dissolved.	Suspended.				
Number of determinations compared,	12	12	12	12	12	12	12	12	12	12	12
Mean of analyses above Lowell,	.42	3.53	1.56	.0026	.0173	.0150	.0023	.173	.0048	.0001	1.0
Mean of analyses above Lawrence,	.45	3.90	1.63	.0050	.0212	.0169	.0043	.217	.0058	.0003	1.1
Increase,	.03	0.37	0.07	.0024	.0039	.0019	.0020	.044	.0010	.0002	0.1

In order to compare these results with similar ones obtained in previous years, another table is presented, which shows the increase in impurities as the water passes from a point above Lowell to Lawrence, as given in the last line of the above table, and the corresponding increase in previous years : —

MERRIMACK RIVER.

Increase in the Amount of Impurities in the Merrimac River Water, from a Point above Lowell to Lawrence, as determined by the Regular Monthly Examinations of Different Years.

[Parts per 100,000.]

DATE.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
Increase, 1887-1889,	0.01	0.23	0.09	.0007	.0027	.0017	.0010	.026	.0003*	.0000	-
Increase, 1890,	0.05	0.62	0.22*	.0016	.0023	.0017	.0006	.028	.0020*	.0000	0.2
Increase, 1891,	0.02*	0.29	0.07	.0021	.0023	.0021	.0002	.035	.0030*	.0000	0.1
Increase, 1892,	0.06	0.48	0.12	.0019	.0037	.0037	.0000	.039	.0013*	.0000	0.0
Increase, 1893,	0.09	0.47	0.30	.0031	.0032	.0021	.0011	.035	.0002*	.0001	0.0
Increase, 1894,	0.02	0.15	0.04	.0028	.0032	.0032	.0000	.049	.0000	.0000	0.1
Increase, 1895,	0.11	0.52	0.33	.0022	.0063	.0046	.0017	.063	.0005	.0001	0.1
Increase, 1896,	0.02	0.51	0.24	.0034	.0053	.0047	.0006	.070	.0017	.0002	0.2
Increase, 1897,	0.06	0.30	0.08	.0019	.0051	.0033	.0018	.050	.0000	.0000	0.1
Increase, 1898,	0.03	0.37	0.07	.0024	.0039	.0019	.0020	.044	.0010	.0002	0.1

* Decrease.

The average flow of the river at Lawrence, for twenty-four hours, during the days on which samples were collected, was for the above periods, respectively, at the rate of 9,145, 9,948, 7,931, 5,434, 8,126, 5,459, 11,634, 5,886, 8,230 and 9,402 cubic feet per second.

Chemical Examination of Water from the Merrimack River, above Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
23853	July 12	Decided.	Cons.	.40	4.85	2.30	.0140	.0334	.0242	.0092	.39	.0070	.0006	.54	1.3
24586	Sept. 9	V. slight.	Slight.	.48	5.45	2.30	.0066	.0294	.0232	.0062	.40	.0070	.0003	.65	1.4

Odor, faintly musty, becoming stronger in the last sample on heating. —— The samples were collected from the river, about a mile above the Boston & Maine railroad bridge. The samples were made up of several equal portions collected at different points in the river.

MERRIMACK RIVER.

Chemical Examination of Water from the Merrimack River, below Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
23854	July 12	Distinct.	Cons.	.40	4.70	2.10	.0122	.0304	.0214	.0090	.34	.0030	.0004	.49	1.3
24587	Sept. 9	V. slight.	Cons.	.54	6.05	2.75	.0116	.0306	.0236	.0070	.40	.0070	.0004	.71	1.7

Odor of the first sample, none; of the last, none, becoming faintly musty on heating. —— The samples were collected from the river, at the bridge between Haverhill and Groveland. The samples were made up of four equal portions collected at different points in the river.

Miller's River.

Chemical Examination of Water from Miller's River, at Orange.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21899	Jan. 18	V. slight.	Slight.	0.90	4.00	1.95	.0092	.0208	.0194	.0014	.22	.0090	.0001	0.74	1.1
22246	Feb. 17	V. slight.	Slight.	0.97	3.85	1.50	.0140	.0190	.0172	.0018	.22	.0080	.0000	0.73	0.5
22588	Mar. 15	Decided.	Cons., earthy.	0.68	3.25	1.25	.0024	.0182	.0144	.0038	.13	.0060	.0000	0.65	0.5
22947	Apr. 22	V. slight.	Slight.	1.00	3.05	1.45	.0012	.0188	.0156	.0032	.15	.0030	.0002	0.74	0.5
23221	May 17	V. slight.	Slight.	1.12	2.95	1.85	.0118	.0232	.0196	.0036	.18	.0020	.0000	0.87	0.8
23578	June 14	Slight.	Cons.	0.98	3.75	2.00	.0326	.0292	.0224	.0068	.15	.0010	.0001	0.83	0.8
24019	July 22	V slight.	Slight.	0.69	3.45	1.85	.0166	.0266	.0220	.0046	.15	.0010	.0001	0.75	0.8
24345	Aug. 16	Slight.	Cons.	0.76	3.95	2.00	.0090	.0278	.0256	.0022	.25	.0010	.0003	0.78	0.6
24749	Sept. 22	Slight.	Cons.	0.90	4.25	2.20	.0080	.0280	.0244	.0036	.18	.0030	.0002	1.05	0.8
25153	Oct. 25	V slight.	Slight.	1.08	5.10	3.00	.0044	.0272	.0246	.0026	.13	.0020	.0001	1.37	0.6
25650	Dec. 13	V. slight.	Cons.	0.65	3.50	1.60	.0026	.0228	.0152	.0076	.14	.0080	.0002	0.76	0.6
Av...	....	....	....	0.88	3.74	1.88	.0102	.0238	.0200	.0038	.17	.0040	.0001	0.84	0.7

Odor, vegetable. —— The samples were collected from the river, about a mile below the central portion of the village of Orange.

Nashua River.

The North Branch of the Nashua River receives the unpurified sewage of the city of Fitchburg, which had in 1895 a population of 26,409, and of the town of Lancaster, which had in 1895 a population of 9,211. The South Branch of the river, at Clinton, is used as one of the sources of supply of the Metropolitan Water District, and analyses of samples of water from the river at this point and of Stillwater and Quinepoxet rivers, its two principal tributaries, may be found on pages 137 and 138 of this volume. Below the point where the water is taken for the Metropolitan Water District the South Branch receives sewage from the town of Clinton, having in 1895 a population of 11,497.

Chemical Examination of Water from the North Branch of the Nashua River, above Fitchburg.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
21920	Jan. 19	V. slight.	Slight.	0.58	3.40	1.35	.0004	.0134	.0122	.0012	.25	.0130	.0001	0.52	1.4
22216	Feb. 15	V. slight.	Slight.	0.59	3.20	1.30	.0010	.0138	.0132	.0006	.20	.0070	.0000	0.55	0.6
22559	Mar. 15	V. slight.	Slight.	0.60	2.85	1.50	.0008	.0130	.0122	.0008	.11	.0040	.0000	0.57	1.1
22930	Apr. 20	V. slight.	V. slight.	0.69	2.80	1.30	.0018	.0140	.0122	.0018	.15	.0000	.0000	0.63	0.3
23198	May 17	V. slight.	Cons.	0.95	3.25	1.60	.0010	.0174	.0164	.0010	.19	.0020	.0000	0.77	0.8
23538	June 14	Slight.	Cons.	1.02	3.30	1.55	.0026	.0290	.0244	.0046	.13	.0050	.0001	0.86	0.8
23962	July 19	Slight.	Slight.	0.59	3.10	1.60	.0014	.0214	.0186	.0028	.09	.0060	.0001	0.68	0.5
24405	Aug. 23	V. slight.	V. slight.	0.95	5.00	2.80	.0032	.0290	.0264	.0026	.18	.0020	.0000	1.20	0.7
24701	Sept. 20	V. slight.	Slight.	0.58	3.90	1.90	.0010	.0248	.0220	.0028	.18	.0000	.0001	0.65	0.8
25056	Oct. 18	V. slight.	V. slight.	0.79	3.80	2.05	.0006	.0190	.0182	.0008	.22	.0020	.0000	0.98	1.0
25400	Nov. 16	V. slight.	V. slight.	0.47	3.75	1.65	.0004	.0138	.0126	.0012	.15	.0020	.0000	0.66	0.8
25720	Dec. 20	V. slight.	V. slight.	0.48	3.25	1.50	.0004	.0102	.0096	.0006	.15	.0070	.0003	0.48	0.6
Av...	....	....	....	0.69	3.47	1.67	.0012	.0182	.0165	.0017	.17	.0042	.0001	0.71	0.8

Odor, vegetable or none, sometimes musty. On heating, the odor of all of the samples became vegetable or musty. —— The samples were collected from the river, a short distance above the Snow mill pond.

NASHUA RIVER.

Chemical Examination of Water from the North Branch of the Nashua River, below Fitchburg.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21919	Jan. 19	Decided.	Cons.	.50	7.00	2.60	.0424	.0502	.0338	.0164	.69	.0180	.0005	.82	2.2
22217	Feb. 15	Slight.	Slight.	.43	4.75	1.75	.0248	.0258	.0196	.0062	.40	.0160	.0003	.51	1.3
22560	Mar. 15	Decided.	Cons., earthy.	.45	3.10	1.10	.0082	.0180	.0144	.0036	.19	.0060	.0003	.46	0.8
22931	Apr. 20	Decided.	Heavy.	.55	5.25	1.75	.0040	.0276	.0200	.0076	.38	.0120	.0003	.57	1.0
23199	May 17	Decided.	Cons.	.55	3.95	1.45	.0060	.0274	.0176	.0098	.34	.0060	.0003	.54	1.1
23539	June 14	Decided.	Heavy.	.55	5.95	2.05	.0384	.0648	.0340	.0308	.49	.0080	.0006	.57	1.7
23963	July 19	Decided.	Heavy, earthy.	.52	7.55	2.30	.1660	.0925	.0480	.0445	.63	.0070	.0028	.69	1.8
24406	Aug. 23	Decided.	Cons., floc.	.67	7.45	2.40	.0354	.0700	.0488	.0212	.54	.0150	.0024	.93	1.9
24702	Sept. 20	Decided.	Heavy, floc.	.56	9.55	3.05	.1395	.0670	.0470	.0200	.77	.0120	.0022	.61	2.3
25057	Oct. 18	Decided.	Cons.	.62	6.50	2.40	.0222	.0454	.0362	.0092	.55	.0060	.0009	.89	1.6
25401	Nov. 16	Decided.	Cons.	.43	5.15	2.00	.0114	.0380	.0256	.0124	.40	.0100	.0005	.62	1.6
25721	Dec. 20	Decided.	Heavy, floc.	.33	5.75	2.25	.0238	.0336	.0244	.0092	.39	.0240	.0001	.52	1.6
Av...	....	....	....	.51	6.00	2.09	.0435	.0467	.0308	.0159	.48	.0117	.0009	.64	1.6

Odor, generally distinctly musty, sometimes earthy and unpleasant or disagreeable, becoming stronger on heating. —— The samples were collected from the river, about half a mile below the point where water from the tail-race of the Falulah Paper Company enters the stream.

Chemical Examination of Water from the North Branch of the Nashua River, just above its Confluence with the South Branch at Lancaster.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21911	Jan. 19	Slight.	Cons.	.40	4.65	1.50	.0138	.0236	.0178	.0058	.43	.0170	.0004	.42	2.1
22247	Feb. 17	Decided.	Cons., earthy.	.45	4.95	1.75	.0110	.0274	.0174	.0100	.41	.0170	.0003	.43	1.1
22599	Mar. 17	Decided.	Cons., earthy.	.40	3.35	1.50	.0058	.0172	.0136	.0036	.26	.0060	.0001	.39	1.0
22944	Apr. 22	Slight.	Cons., earthy.	.49	4.30	1.20	.0070	.0186	.0150	.0036	.38	.0090	.0004	.44	1.0
23209	May 18	Slight.	Cons.	.59	4.70	1.70	.0198	.0272	.0196	.0076	.42	.0130	.0004	.47	1.3
23577	June 15	Decided.	Cons.	.50	5.85	1.85	.0378	.0338	.0246	.0092	.52	.0080	.0015	.49	1.6
23974	July 20	Decided.	Cons.	.51	6.40	2.30	.0492	.0326	.0280	.0046	.54	.0360	.0052	.56	1.7
24720	Sept. 21	Decided.	Cons.	.44	6.75	2.15	.0356	.0372	.0264	.0108	.62	.0240	.0032	.48	1.8
25662	Dec. 16	Decided.	Slight.	.29	4.70	1.70	.0198	.0234	.0172	.0062	.38	.0210	.0004	.50	1.7
Av...	....	....	....	.45	5.07	1.74	.0222	.0268	.0200	.0068	.44	.0168	.0013	.46	1.5

Odor, musty or unpleasant, sometimes earthy or disagreeable. —— The samples were collected from the river, at the railroad bridge, a short distance above its mouth.

NASHUA RIVER.

Chemical Examination of Water from the South Branch of the Nashua River, just above its Confluence with the North Branch at Lancaster.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21912	Jan. 19	Slight.	Cons.	.49	4.10	1.75	.0034	.0180	.0146	.0034	.29	.0170	.0003	.46	2.0
22248	Feb. 17	Decided.	Cons., earthy.	.48	4.25	1.65	.0060	.0194	.0132	.0062	.27	.0170	.0001	.42	1.0
22600	Mar. 17	Decided.	Cons., earthy.	.49	2.45	1.00	.0034	.0144	.0114	.0030	.18	.0030	.0001	.42	0.6
22945	Apr. 22	V. slight.	Slight.	.52	3.65	1.25	.0020	.0184	.0152	.0032	.32	.0080	.0003	.45	1.1
23210	May 18	Slight.	Slight.	.60	3.50	1.70	.0070	.0204	.0164	.0040	.27	.0080	.0003	.46	1.1
23576	June 15	Decided.	Cons.	.42	3.85	1.65	.0072	.0248	.0168	.0080	.26	.0070	.0003	.38	1.0
23975	July 20	Decided.	Cons.	.52	7.25	2.20	.1232	.0452	.0328	.0124	.55	.0020	.0048	.56	1.8
24343	Aug. 17	Decided.	Cons.	.55	5.35	2.35	.0020	.0312	.0272	.0040	.28	.0020	.0002	.75	1.1
24721	Sept. 21	Decided.	Cons.	.47	9.00	3.00	.1550	.0630	.0465	.0165	.66	.0010	.0036	.50	2.1
25663	Dec. 16	Slight.	Slight.	.42	4.30	1.60	.0174	.0138	.0118	.0020	.25	.0330	.0005	.41	1.4
Av...	....	....	....	.50	4.77	1.81	.0327	.0269	.0206	.0063	.33	.0098	.0010	.48	1.3

Odor, musty and unpleasant or disagreeable. —— The samples were collected from the river, at the Atherton bridge, a short distance above its mouth.

Nemasket River.

Chemical Examination of Water from the Nemasket River, below Middleborough.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1898.														
23593	June 15	V. slight.	Slight.	0.92	3.80	2.00	.0016	.0230	.0200	.0030	.52	.0020	.0000	0.76	0.6
23910	July 18	V. slight.	Slight.	1.10	5.00	3.00	.0024	.0308	.0278	.0030	.49	.0020	.0000	1.22	1.0
24286	Aug. 15	V. slight.	V. slight.	1.80	5.90	3.50	.0052	.0364	.0356	.0008	.43	.0000	.0001	2.02	1.0
Av...	....	....	....	1.27	4.90	2.83	.0031	.0301	.0278	.0023	.48	.0013	.0000	1.33	0.9

Odor of the second sample, faintly musty, becoming stronger on heating; of the others, distinctly vegetable. —— The samples were collected from the river, at Muttock Dam.

Neponset River.

Chemical Examination of Water from the Neponset River, at Hyde Park.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
21883	Jan. 18	Decided.	Cons., floc.	1.00	6.65	2.45	.0016	.0284	.0244	.0040	0.84	.0160	.0003	0.80	2.3
22214	Feb. 15	V.slight.	V.slight.	0.70	5.10	1.75	.0006	.0210	.0186	.0024	0.63	.0130	.0001	0.68	2.2
22552	Mar. 15	Slight.	Cons.	1.00	4.90	2.05	.0012	.0276	.0250	.0026	0.70	.0010	.0001	0.91	1.8
22909	Apr. 20	Decided.	Cons.	1.05	6.00	2.35	.0028	.0280	.0246	.0034	0.76	.0050	.0001	0.87	2.9
23185	May 17	Decided.	Cons.	1.20	5.50	2.25	.0134	.0340	.0276	.0064	0.75	.0030	.0001	0.90	1.8
23541	June 14	Slight.	Heavy.	1.80	6.95	3.20	.0200	.0552	.0420	.0132	0.65	.0030	.0002	1.31	2.3
23945	July 20	Decided.	Cons., floc.	1.30	10.70	4.10	.0188	.0668	.0544	.0124	1.66	.0030	.0001	1.57	3.3
24300	Aug. 16	Slight.	Cons.	1.75	8.35	4.40	.0054	.0528	.0478	.0050	0.61	.0020	.0000	1.74	2.0
24693	Sept. 20	Decided.	Cons.	0.85	13.10	3.85	.0434	.0602	.0374	.0228	1.60	.0000	.0001	0.89	4.7
25054	Oct. 18	Slight.	Slight.	1.00	7.35	2.85	.0066	.0408	.0322	.0086	0.95	.0030	.0008	1.17	2.2
25373	Nov. 15	Slight.	V.slight.	1.00	6.50	2.70	.0024	.0274	.0250	.0024	0.66	.0030	.0000	1.11	1.7
25705	Dec. 20	Slight.	Cons.	0.70	6.40	2.70	.0004	.0218	.0186	.0032	0.72	.0200	.0005	0.83	2.0
Av...	....	....	....	1.11	7.29	2.89	.0097	.0387	.0315	.0072	0.88	.0060	.0002	1.06	2.4

Odor, distinctly musty and sometimes unpleasant or disagreeable. —— The samples were collected from the river, opposite the works of the Hyde Park Water Company, above the thickly settled portions of the town of Hyde Park.

Quinebaug River.

Chemical Examination of Water from the Quinebaug River, below Southbridge.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1898.														
23521	June 13	Decided.	Cons.	.50	3.65	1.75	.0080	.0292	.0254	.0038	.20	.0060	.0002	.45	1.0
23917	July 18	Slight.	Cons.	.55	4.00	2.00	.0064	.0360	.0236	.0124	.19	.0050	.0004	.56	1.0
24299	Aug. 15	Decided.	Cons.	.86	4.90	2.25	.0048	.0464	.0438	.0026	.16	.0040	.0002	.98	1.1
Av...	....	....	....	.64	4.18	2.00	.0064	.0372	.0309	.0063	.18	.0050	.0003	.66	0.8

Odor, faintly musty or unpleasant. —— The samples were collected from the river, between the villages of Southbridge and Saundersdale.

SALISBURY PLAIN RIVER.

Salisbury Plain River.

Chemical Examination of Water from Salisbury Plain River, below Brockton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dissolved.	Suspended.					
	1898.														
23503	June 13	Slight.	Cons.	1.12	9.50	3.25	.0868	.0416	.0376	.0040	1.33	.1100	.0025	0.66	2.9
23913	July 18	Decided.	Slight.	0.72	10.40	3.95	.1040	.0256	.0224	.0032	1.25	.1300	.0048	0.77	3.0
24294	Aug. 15	Slight.	Cons.	1.05	7.80	3.55	.0238	.0486	.0396	.0090	0.70	.0350	.0080	1.22	1.8
Av...	....	....	....	0.96	9.23	3.58	.0715	.0386	.0332	.0054	1.09	.0917	.0051	0.88	2.6

Odor, distinctly musty and disagreeable. —— The samples were collected from the river below Plain Street bridge and above the sewage pumping station.

Taunton River.

Chemical Examination of Water from the Taunton River, below Taunton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dissolved.	Suspended.					
	1898.														
21880	Jan. 17	Slight.	Cons.	1.10	6.10	2.50	.0134	.0256	.0224	.0032	.80	.0170	.0007	0.85	2.0
22196	Feb. 14	Decided.	Cons., earthy.	1.05	5.20	2.10	.0112	.0260	.0218	.0042	.67	.0030	.0001	0.83	0.8
22539	Mar. 14	Slight.	Cons.	1.18	4.50	2.15	.0056	.0256	.0232	.0024	.58	.0060	.0001	0.92	1.1
22878	Apr. 18	Slight.	Cons.	1.30	4.75	2.35	.0060	.0246	.0232	.0014	.61	.0080	.0002	1.06	1.1
23169	May 16	V. slight.	Cons.	1.70	4.90	2.40	.0078	.0284	.0268	.0016	.62	.0080	.0002	1.16	0.8
23622	June 21	V. slight.	Slight.	1.50	5.60	2.95	.0084	.0336	.0300	.0036	.59	.0070	.0004	1.32	1.6
23911	July 18	Slight.	Cons.	1.44	6.45	3.15	.0090	.0374	.0356	.0018	.49	.0070	.0003	1.52	1.0
24313	Aug. 16	Slight.	Cons.	2.40	8.25	4.90	.0112	.0532	.0452	.0080	.48	.0040	.0004	2.35	1.1
24678	Sept. 19	V. slight.	Cons.	1.20	6.45	2.60	.0178	.0298	.0276	.0022	.88	.0120	.0002	1.04	1.8
25040	Oct. 17	V. slight.	V. slight.	1.27	6.80	3.20	.0108	.0264	.0248	.0016	.68	.0160	.0004	1.34	1.3
25366	Nov. 14	Slight.	Slight.	1.56	6.30	3.00	.0084	.0268	.0256	.0012	.56	.0030	.0003	1.52	1.3
25594	Dec. 12	V. slight.	V. slight.	1.00	5.40	2.60	.0046	.0174	.0162	.0012	.72	.0140	.0002	1.03	1.8
Av...	....	....	....	1.39	5.89	2.82	.0095	.0296	.0269	.0027	.64	.0087	.0003	1.24	1.3

Odor, generally vegetable, sometimes musty, becoming stronger on heating. —— The samples were collected from the river, at the wharf of the Taunton Gas Works, below the bridge at Weir.

Ware River.

Chemical Examination of Water from Ware River, at Cold Brook Station, Barre.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21730	Jan. 3	Slight.	Slight.	0.58	3.50	1.40	.0018	.0152	.0146	.0006	.22	.0080	.0000	0.56	1.3
22040	Jan. 31	V. slight.	Slight.	0.60	3.35	1.35	.0018	.0154	.0134	.0020	.20	.0070	.0000	0.54	1.0
22362	Feb. 28	Slight.	Slight.	0.70	3.05	1.35	.0014	.0148	.0128	.0020	.15	.0040	.0000	0.52	0.6
22725	Apr. 4	V. slight.	V. slight.	0.60	2.80	1.05	.0002	.0116	.0114	.0002	.11	.0000	.0000	0.54	0.3
23037	May 2	V. slight.	Slight.	0.72	2.65	1.15	.0002	.0154	.0136	.0018	.13	.0020	.0001	0.62	0.5
23373	June 1	V. slight.	Slight.	1.28	3.55	1.95	.0010	.0260	.0236	.0024	.12	.0000	.0001	0.94	0.8
23778	June 30	V. slight.	Slight.	0.82	3.55	1.85	.0026	.0258	.0238	.0020	.11	.0020	.0000	0.84	0.8
24121	Aug. 1	Decided.	Cons.	0.52	4.15	1.85	.0012	.0268	.0218	.0050	.12	.0020	.0000	0.57	0.6
24509	Aug. 31	V. slight.	V. slight.	1.10	4.60	2.60	.0016	.0294	.0272	.0022	.13	.0030	.0001	1.47	0.8
24894	Oct. 3	V. slight.	V. slight.	0.73	3.85	1.85	.0006	.0240	.0216	.0024	.12	.0000	.0000	0.79	0.8
25214	Oct. 31	V. slight.	V. slight.	0.90	4.10	2.10	.0008	.0194	.0182	.0012	.17	.0010	.0000	1.08	0.5
25525	Dec. 1	V. slight.	V. slight.	0.55	3.00	1.50	.0004	.0122	.0110	.0012	.12	.0040	.0001	0.66	0.6
Av...	....	....	....	0.76	3.51	1.67	.0011	.0196	.0177	.0019	.14	.0027	.0000	0.76	0.7

Odor, faintly vegetable or none. On heating, the odor of all of the samples was vegetable. —— The samples were collected from the river, at the railroad bridge, near Cold Brook station, in the southeasterly part of the town of Barre.

Chemical Examination of Water from Ware River, below Ware.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
21979	Jan. 25	Slight.	Cons.	.50	3.30	1.35	.0020	.0166	.0134	.0032	.20	.0090	.0001	0.50	0.8
22234	Feb. 15	Decided.	Cons.	.49	3.10	1.35	.0002	.0190	.0136	.0054	.20	.0100	.0000	0.45	0.8
22562	Mar. 15	Slight.	Slight.	.50	2.75	1.25	.0010	.0160	.0126	.0034	.13	.0030	.0000	0.44	1.1
22889	Apr. 18	Slight.	Cons., earthy.	.50	3.05	1.05	.0006	.0178	.0156	.0022	.17	.0030	.0002	0.50	1.0
23196	May 17	Slight.	Cons.	.80	3.85	1.85	.0010	.0264	.0200	.0064	.19	.0030	.0001	0.63	0.8
23573	June 14	Decided.	Cons.	.62	4.30	1.55	.0016	.0408	.0268	.0140	.22	.0030	.0002	0.58	1.1
23934	July 19	Slight.	Cons., floc.	.53	4.50	1.80	.0004	.0408	.0268	.0140	.22	.0020	.0002	0.56	1.0
24327	Aug. 15	Decided.	Cons.	.62	4.30	1.75	.0034	.0350	.0258	.0092	.18	.0030	.0004	0.78	1.1
24700	Sept. 20	Decided.	Cons.	.70	4.85	2.40	.0048	.0332	.0272	.0060	.19	.0020	.0005	0.86	1.0
25060	Oct. 18	Slight.	V. slight.	.83	4.85	2.30	.0030	.0300	.0270	.0030	.20	.0030	.0001	1.06	1.0
25382	Nov. 15	Slight.	Slight.	.56	3.75	1.85	.0034	.0196	.0164	.0032	.16	.0020	.0002	0.80	0.6
25711	Dec. 20	Decided.	Cons., earthy.	.40	3.85	1.50	.0094	.0168	.0146	.0022	.21	.0150	.0004	0.51	0.8
Av...	....	....	....	.59	3.87	1.67	.0026	.0260	.0200	.0060	.19	.0048	.0002	0.64	0.9

Odor, generally faintly musty or vegetable, sometimes none, becoming stronger in some of the samples on heating. —— The samples were collected from the river, at the Boston & Maine railroad bridge.

WESTFIELD RIVER.

Westfield River.

The advice of the State Board of Health to the town of West Springfield, with reference to a proposed plan for pumping the water of the Westfield River into the pipes of the public water supply, in case of necessity, for the purpose of extinguishing fires, may be found on page 57 of this volume. The results of an analysis of a sample of water collected at the point from which it was proposed to take water for this purpose are given in one of the following tables: —

Chemical Examination of Water from Westfield River, above Westfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
23512	June 13	V. slight.	Slight.	.27	3.85	1.15	.0012	.0118	.0104	.0014	.09	.0030	.0002	.26	1.4
23930	July 18	V. slight.	Slight.	.14	4.55	1.30	.0028	.0114	.0084	.0030	.13	.0040	.0002	.24	1.8
24311	Aug. 15	Slight.	Slight.	.33	3.95	1.65	.0006	.0158	.0116	.0042	.10	.0010	.0000	.47	1.7
Av...	....	....	....	.25	4.12	1.03	.0015	.0130	.0101	.0029	.11	.0027	.0001	.32	1.6

Odor, none, becoming faintly musty or vegetable in the first two samples on heating. —— The samples were collected from the river, above the thickly settled portions of the town.

Chemical Examination of Water from Westfield River, below Westfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
23513	June 13	V. slight.	Cons.	.28	3.35	1.35	.0048	.0152	.0106	.0046	.11	.0060	.0002	.27	1.6
23931	July 18	V. slight.	Slight.	.10	4.65	1.50	.0092	.0128	.0104	.0024	.18	.0170	.0004	.18	2.0
24312	Aug. 15	Slight.	Slight.	.33	3.95	1.70	.0068	.0162	.0130	.0032	.12	.0030	.0001	.48	1.4
Av...	....	....	....	.24	3.98	1.52	.0069	.0147	.0113	.0034	.14	.0087	.0002	.31	1.7

Odor of the first sample, faintly musty; of the second, none, becoming faintly vegetable on heating; of the last, none. —— The samples were collected from the river, below the thickly settled portions of the town.

WESTFIELD RIVER.

Chemical Examination of Water from the Westfield River, at West Springfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
24326	1898. Aug. 16	V. slight.	V. slight.	.35	5.40	1.85	.0034	.0146	.0138	.0008	.09	.0080	.0001	.41	2.3

Odor, none. —— The sample was collected from the canal at No. 1 paper mill of the Agawam Paper Company, in the village of Mittineague.

SUMMARY

OF

WATER SUPPLY STATISTICS;

ALSO

RECORDS OF RAINFALL AND FLOW OF STREAMS.

SUMMARY OF WATER SUPPLY STATISTICS.

During the year 1898 a public water supply was introduced for the first time into the towns of Billerica and North Andover, and important changes were made in the water supplies of other cities and towns. At the end of the year the State contained 32 cities and 321 towns, and of these all of the cities and 130 of the towns were provided with public water supplies.

The following table gives a classification by population of cities and towns having and not having a public water supply Dec. 31, 1898. The populations are taken from the census of 1895 : —

Population (1895).	Number of Places of Given Population having a Public Water Supply.	Total Population of Places in Preceding Column.	Number of Places of Given Population not having a Public Water Supply.	Total Population of Places in Preceding Column.
Under 500,	0	0	36	13,287
500-1,000,	4	3,301	55	42,503
1,000-1,500,	10	11,912	38	46,354
1,500-2,000,	9	15,722	30	51,754
2,000-2,500,	10	22,182	13	28,882
2,500-3,000,	8	22,444	10	27,047
3,000-3,500,	10	32,515	7	22,599
3,500-4,000,	6	21,788	0	0
4,000-4,500,	9	39,006	1	4,055
Above 4,500,	96	2,088,793	1	6,039
Totals,	162	2,257,663	191	242,520

From the totals given in the preceding table it will be seen that only 45.9 per cent. of the total number of cities and towns have public water supplies, but that 90.3 per cent. of the whole population of the State is contained within these cities and towns. The number of people to whom a public water supply is available is, of course, somewhat less than the total population of the municipalities supplied, but the difference is not large.

There are now 9 towns having, by the census of 1895, a population exceeding 3,000 which are not provided with a public water supply. These are given in the following table: —

Towns.	Population in 1895.	Towns.	Population in 1895.
Blackstone,	6,039	Dudley,	3,203
Barnstable,	4,055	Chelmsford,	3,162
Sutton,	3,420	Dartmouth,	3,107
Tewksbury,	3,379	Deerfield,	3,007
Pepperell,	3,321		

In the following table the various water supplies are classified according to the dates when a fairly complete system was first introduced into a city or town: —

Years.	Number of Places supplied.	Years.	Number of Places supplied.
Previous to 1850,	6	1893,	3
1850–1859,	4	1894,	3
1860–1869,	10	1895,	5
1870–1879,	44	1896,	5
1880–1889,	68	1897,	2
1890,	4	1898,	2
1891,	5	Total,	162
1892,	1		

At the end of the year 1898 all of the 32 cities in the State, having an aggregate population of 1,640,503, own their water works. Of the 130 towns having a public water supply, 82, with a population of 406,570, own their works, while 48, having a population of 210,590, are supplied by private companies. The total population in both cities and towns owning their works is 2,047,073, against 210,590 in those supplied by private companies.

The following table gives statistics with regard to the consumption of water in the cities and towns in this State where such records are kept. The populations for 1898 as given in the table were obtained by adding three-fifths of the increase in population from 1890 to 1895 to the population as determined by the census taken in the latter year. The daily consumption of water per inhabitant has been obtained by dividing the average daily consumption by the estimated total population of the city or town in 1898. The amount obtained in this manner is somewhat less than the average amount used per consumer, because there are in all cities and towns a greater or less number of people who do not use the public water supply. The difference between the number of inhabitants and consumers would account to a large extent for the low rate per inhabitant in some of the towns where works have been in operation for a short time only, and where, in consequence, water has not been generally introduced. In some towns the population during the summer months is much greater than that which is shown by census returns, and in such cases the consumption per inhabitant as given in the table is somewhat higher than it would be if allowance were made for the increased population in the summer.

Statistics relating to the Consumption of Water in Various Cities and Towns.

City or Town.	Estimated Population in 1898.	Average Daily Consumption. Gallons. 1898.	Daily Consumption per Inhabitant. Gallons. 1898.	City or Town.	Estimated Population in 1898.	Average Daily Consumption. Gallons. 1898.	Daily Consumption per Inhabitant. Gallons. 1898.
Metropolitan Water District.	767,700	79,274,000	103	Fairhaven, . .	3,589	211,000	59
Abington and Rockland.	9,882	355,000	36	Fall River, . .	98,086	3,136,000	32
Amesbury, . .	10,099	298,000	30	Foxborough, . .	3,391	151,000	45
Andover, . .	6,147	310,000	50	Framingham, .	9,676	344,000	36
Attleborough, .	8,715	358,000	41	Franklin, . .	5,319	144,000	27
Avon, . . .	1,771	40,000	23	Gardner, . .	9,637	729,000	76
Ayer, . . .	2,073	94,000	45	Gloucester, . .	30,347	855,000	28
Beverly, . . .	12,397	899,000	73	Grafton, . .	5,160	84,000	16
Braintree, . .	5,589	385,000	69	Groton, . . .	2,273	67,000	29
Bridgewater and E. Bridgewater.	7,832	200,000	26	Hyde Park, . .	12,806	672,000	52
Brockton, . .	36,688	1,012,000	28	Ipswich, . . .	4,889	69,000	14
Brookline, . .	18,601	1,469,000	79	Lawrence, . .	56,670	3,305,000	58
Cambridge, . .	88,612	7,758,000	88	Lexington, . .	3,679	135,000	37
Canton, . . .	4,695	180,000	38	Longmeadow, .	625	47,000	75
Cohasset, . .	2,490	78,000	31	Lowell, . . .	88,370	6,725,000	76
Danvers and Middleton.	9,403	636,000	68	Lynn and Saugus, .	71,321	4,746,000	67
Dedham, . .	7,264	513,000	71	Manchester, . .	1,928	167,000	87
Easton, . . .	4,427	97,000	22	Mansfield, . .	3,896	135,000	35

Statistics relating to the Consumption of Water in Various Cities and Towns — Concluded.

City or Town.	Estimated Population in 1898.	Average Daily Consumption. Gallons. 1898.	Daily Consumption per Inhabitant. Gallons. 1898.	City or Town.	Estimated Population in 1898.	Average Daily Consumption. Gallons. 1898.	Daily Consumption per Inhabitant. Gallons. 1898.
Marblehead, . .	7,352	414,000	56	Reading, . .	5,094	113,000	22
Marlborough, .	15,680	537,000	34	Revere and Winthrop.	13,547	675,000	50
Maynard, . .	3,324	117,000	35	Rockport, . .	6,010	133,000	22
Medford, . .	16,511	1,095,000	66	Rutland, . . .	977	19,000	19
Methuen, . .	6,216	230,000	37	Salem, . . .	36,676	2,298,000	63
Middleborough, .	7,063	214,000	30	Sharon, . . .	1,767	47,000	27
Milford and Hopedale.	10,564	559,000	53	Stoughton, . .	5,524	260,000	47
Milton, . . .	6,262	161,000	26	Swampscott and Nahant.	4,152	460,000	111
Montague, . .	5,915	412,000	70	Taunton, . .	28,115	1,302,000	46
Nantucket, . .	2,865	87,000	30	Tisbury, . .	700	46,000	66
Natick, . . .	8,632	369,000	43	Wakefield and Stoneham.	15,458	774,000	50
Needham, . .	3,797	212,000	56	Walpole, . .	3,228	89,000	28
New Bedford, .	63,962	5,908,000	92	Waltham, . .	22,177	1,699,000	77
Newburyport, .	14,915	518,000	35	Ware, . . .	7,844	262,000	33
Newton, . . .	29,517	1,758,000	60	Wareham, Onset Bay.	3,317	19,000	6
No. Attleborough,	6,485	–	–	Webster, . .	8,260	304,000	37
No. Brookfield, .	5,093	155,000	30	Wellesley, . .	4,606	167,000	36
Norwood, . .	5,079	405,000	80	Weston, . . .	1,738	27,000	16
Orange, . . .	5,837	42,000	7	Whitman, . .	6,526	139,000	21
Peabody, . .	10,716	967,000	90	Winchendon, . .	4,550	57,000	13
Provincetown, .	4,502	126,000	28	Woburn, . .	14,585	995,000	68
Quincy, . . .	23,104	1,363,000	59	Worcester, . .	107,234	6,785,000	63
Randolph and Holbrook.	5,735	284,000	50				

Rainfall.

The rainfall in Massachusetts for the year 1898 was 9.34 inches more than the normal. An excess of rainfall occurred during eight months of the year, the greatest excess being 3.06 inches in October. A deficiency occurred during the months of March, June, September and December, the greatest deficiency being 1.84 inches in March.

The average rainfall in Massachusetts, as deduced from long-continued observations in various parts of the State, is given in the following table, together with the rainfall for each month in 1898 and the departures from the normal :*—

Month.	Normal Rainfall. Inches.	Rainfall 1898. Inches.	Excess or Deficiency. 1898. Inches.	Month.	Normal Rainfall. Inches.	Rainfall 1898. Inches.	Excess or Deficiency. 1898. Inches.
January,	3.93	5.53	+1.60	August,	4.40	7.24	+2.84
February,	3.65	4.58	+0.93	September,	3.31	2.33	—0.98
March,	3.91	2.07	—1.84	October,	4.07	7.13	+3.06
April,	3.35	4.88	+1.53	November,	4.17	6.62	+2.45
May,	3.71	4.72	+1.01	December,	3.58	2.78	—0.80
Jnne,	3.28	2.27	—1.01	Total,	45.36	54.70	+9.34
July,	4.00	4.55	+0.55				

To show the condition of the streams or sources of water supply from which samples of water have been collected for analysis during 1898, the following tables are presented, which give the daily rainfall in inches at 9 stations scattered throughout the State :*—

* Prepared from the records of the New England Weather Service.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected.

January, 1898.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	0.26	-	-	0.63	-	-	0.05
2, . .	-	-	-	-	-	-	-	-	-
3, . .	-	-	-	-	-	-	-	-	-
4, . .	-	0.06	-	*	*	*	-	-	-
5, . .	-	0.26	0.20	0.17	0.09	0.18	0.17	0.10	0.10
6, . .	0.50	-	-	-	-	-	-	-	-
7, . .	-	*	0.33	0.20	0.25	0.17	0.20	0.53	1.00
8, . .	-	0.64	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	2.00	0.17	0.09	*	0.06	*	-	0.15	*
13, . .	-	0.04	0.11	0.10	-	0.14	0.07	-	0.07
14, . .	-	-	-	-	-	-	-	-	-
15, . .	0.40	0.47	0.37	*	*	0.34	-	0.55	*
16, . .	-	0.13	-	0.36	0.34	-	0.42	-	0.48
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	-	*	-	-	-	-	-	-	-
20, . .	-	1.66	1.58	1.27	1.15	*	-	1.16	1.08
21, . .	1.00	0.05	-	-	-	1.39	1.36	-	-
22, . .	-	0.05	-	-	-	-	-	0.20	-
23, . .	1.15	1.05	1.47	1.04	1.24	1.13	1.25	1.35	1.24
24, . .	-	-	-	-	-	-	-	-	-
25, . .	-	0.05	-	-	-	-	-	-	-
26, . .	0.75	0.52	0.65	0.75	0.91	0.73	0.85	0.30	0.73
27, . .	0.02	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	-
29, . .	-	-	-	-	-	-	-	-	0.03
30, . .	-	-	-	-	-	-	-	-	-
31, . .	0.30	0.70	0.46	2.65	1.56	-	0.70	-	1.00
Totals,	6.12	5.85	5.52	6.54	5.60	4.71	5.02	4.34	5.78

February, 1898.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	1.31	0.84	0.35	1.37	4.06	1.14	1.25	0.98
2, . .	-	-	-	-	-	-	-	-	-
3, . .	-	-	-	-	-	-	-	-	-
4, . .	-	-	-	-	-	-	-	-	-
5, . .	-	*	-	0.14	-	0.17	0.18	-	-
6, . .	-	0.09	0.12	-	0.24	-	-	0.30	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	0.15	0.30	0.13	0.15	0.13	0.16	0.14	0.03	-
13, . .	-	-	-	-	-	-	-	-	0.32
14, . .	-	0.05	-	0.02	-	-	-	-	-
15, . .	0.30	0.30	0.15	0.03	0.04	*	-	-	-
16, . .	-	0.32	0.15	0.30	0.10	0.21	0.34	0.20	0.16
17, . .	-	-	-	-	-	-	-	-	-
18, . .	0.10	*	-	-	-	-	-	-	-
19, . .	-	*	-	-	-	-	-	-	-
20, . .	1.40	1.00	0.64	*	*	*	-	*	0.03
21, . .	-	1.32	1.35	*	*	*	1.56	*	2.75
22, . .	1.00	0.14	0.44	3.14	3.48	*	1.95	4.50	0.93
23, . .	-	-	0.19	0.14	0.22	0.32	0.19	0.15	0.11
24, . .	-	-	-	-	-	-	-	-	-
25, . .	-	-	-	-	-	-	-	-	-
26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	-
Totals,	2.95	4.83	4.01	4.27	5.58	4.92	5.50	6.43	5.28

* Precipitation included in that of following day.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

March, 1898.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	-	-	-	-	-	-	-	-	-
3, . .	0.15	0.04	0.02	0.06	0.13	0.04	0.11	0.35	0.44
4, . .	-	*	0.14	0.67	*	*	-	*	*
5, . .	-	0.08	0.19	-	0.56	0.30	0.43	0.60	0.60
6, . .	-	-	-	-	-	-	-	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	0.40	0.27	0.10	0.19	0.05	0.11	0.13	-	-
13, . .	-	0.02	-	-	-	0.02	-	-	*
14, . .	-	-	-	-	-	-	-	-	0.05
15, . .	-	-	-	-	-	-	-	-	-
16, . .	-	-	-	-	-	-	-	-	-
17, . .	0.10	0.03	0.01	0.03	0.03	0.03	0.04	-	0.34
18, . .	-	-	-	-	-	-	-	-	-
19, . .	0.50	0.36	0.25	0.41	0.41	0.33	0.33	-	0.47
20, . .	0.08	-	-	0.05	0.03	-	0.08	0.35	-
21, . .	-	-	-	-	-	-	-	-	-
22, . .	-	0.14	0.05	*	*	*	-	0.35	*
23, . .	0.44	0.05	0.04	0.18	0.15	0.06	0.08	-	0.44
24, . .	-	-	-	-	-	-	-	-	-
25, . .	-	-	-	-	-	-	-	-	-
26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	-
29, . .	-	0.13	0.15	0.36	*	*	-	*	*
30, . .	0.30	0.06	0.08	-	0.34	0.23	0.31	*	*
31, . .	0.25	-	0.34	0.45	0.50	0.29	0.47	1.15	1.16
Totals,	2.22	1.18	1.37	2.40	2.20	1.41	1.98	2.80	3.50

April, 1898.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	0.15	0.03	0.12	0.23	0.19	0.12	-	0.28	0.04
3, . .	-	-	-	-	-	-	0.14	-	-
4, . .	-	0.10	-	-	-	-	-	-	-
5, . .	-	0.21	0.23	0.32	*	0.02	-	0.20	*
6, . .	0.45	-	0.07	-	0.42	*	0.42	-	0.60
7, . .	-	-	-	-	-	0.34	-	-	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	0.04	0.04	0.09	*	*	-	-	*
11, . .	0.15	-	-	-	0.14	0.02	0.08	0.35	0.45
12, . .	-	-	-	-	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	-	-	-	-	*	0.02	-	*	-
15, . .	-	*	0.93	0.65	*	*	0.13	*	0.15
16, . .	0.33	0.37	0.08	-	1.05	0.78	1.17	0.35	0.01
17, . .	-	-	-	0.02	-	0.01	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	-	0.16	0.24	*	*	*	-	0.42	*
20, . .	0.35	0.20	0.29	0.50	0.62	0.57	0.56	-	0.42
21, . .	-	-	0.03	-	-	0.10	-	-	-
22, . .	-	*	-	-	*	-	-	-	-
23, . .	0.20	0.21	0.32	*	*	0.25	0.13	0.05	0.03
24, . .	1.20	1.33	1.49	*	2.42	*	0.89	*	*
25, . .	0.20	0.19	0.05	*	-	2.04	1.60	*	1.77
26, . .	-	-	0.01	2.27	0.15	0.06	-	3.37	0.33
27, . .	-	-	-	-	-	-	-	-	-
28, . .	0.48	0.67	0.44	*	*	*	-	*	*
29, . .	0.70	0.28	0.05	0.65	1.18	*	1.14	1.15	1.36
30, . .	-	-	-	-	-	0.60	-	-	0.13
Totals,	4.21	3.79	4.39	4.73	6.17	4.93	6.26	6.17	5.29

* Precipitation included in that of following day.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

May, 1898.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	-	-	-	-	-	-	-	-	-
3, . .	0.35	0.33	0.06	*	*	-	-	0.15	-
4, . .	0.05	0.11	0.15	0.10	0.23	0.23	0.11	-	-
5, . .	-	0.12	0.06	*	*	-	-	0.42	-
6, . .	0.40	0.40	0.25	0.33	0.34	0.45	0.31	-	0.66
7, . .	-	-	-	-	-	-	-	0.15	0.11
8, . .	-	-	-	-	-	-	-	0.25	-
9, . .	-	-	-	-	-	-	-	-	0.88
10, . .	-	-	-	-	-	-	-	-	-
11, . .	0.10	0.10	0.01	0.02	-	0.03	-	-	-
12, . .	-	0.92	0.14	0.02	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	-	-	-	-	-	0.02	-	-	-
15, . .	0.65	0.37	0.36	-	0.48	-	-	*	-
16, . .	-	0.15	0.30	0.50	0.08	-	-	0.87	0.25
17, . .	0.50	-	-	-	-	0.52	0.51	-	0.64
18, . .	-	-	-	-	-	-	-	-	-
19, . .	-	0.05	0.13	-	-	0.19	0.02	-	-
20, . .	0.20	-	-	0.06	0.07	-	-	0.17	0.23
21, . .	-	-	-	-	-	-	-	-	-
22, . .	-	-	-	-	-	-	-	-	-
23, . .	0.40	0.38	0.12	*	*	*	-	*	-
24, . .	-	0.48	0.29	*	*	*	-	*	-
25, . .	0.75	1.14	0.49	*	1.60	*	1.25	*	-
26, . .	0.15	0.40	-	*	*	*	0.73	*	2.76
27, . .	0.60	0.25	0.98	*	1.65	*	1.39	2.38	1.24
28, . .	0.45	0.16	0.02	2.00	-	2.08	-	-	-
29, . .	0.05	-	-	-	-	-	-	-	-
30, . .	-	-	-	-	-	-	-	-	-
31, . .	-	-	-	0.02	-	-	-	-	0.05
Totals,	4.65	5.36	3.36	3.05	4.45	3.52	4.32	4.39	6.82

June, 1898.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	*	-	0.02	-	*	-
2, . .	-	-	-	*	*	0.03	0.05	*	-
3, . .	-	-	0.21	0.07	*	*	0.06	*	0.05
4, . .	-	-	0.26	0.79	1.07	0.35	0.53	*	0.07
5, . .	-	-	-	-	-	-	-	0.84	0.11
6, . .	0.10	0.12	-	0.01	-	0.07	-	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	0.22	0.04	0.03	-	-	-	-	-
9, . .	0.25	-	-	-	-	0.11	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	0.05	0.15	-	0.02	-	-	-	-	-
12, . .	0.05	0.12	-	-	-	-	-	-	-
13, . .	0.85	*	0.43	0.27	*	*	-	*	-
14, . .	0.30	1.06	0.50	-	0.20	0.73	0.49	0.60	0.29
15, . .	-	-	-	-	-	-	-	-	-
16, . .	-	-	-	-	-	-	-	-	-
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	*	-	-	-	*	-	-	-
19, . .	0.55	1.07	0.82	0.72	0.84	0.73	0.42	-	-
20, . .	-	0.15	-	0.14	*	*	-	-	-
21, . .	0.40	-	0.15	-	0.20	0.05	0.16	0.31	0.09
22, . .	0.25	0.05	0.26	0.14	-	-	-	-	-
23, . .	-	-	-	-	-	0.01	-	-	-
24, . .	-	0.03	-	-	-	-	-	-	-
25, . .	-	-	0.20	-	-	0.37	-	-	-
26, . .	-	-	-	-	-	-	0.06	-	-
27, . .	-	0.22	-	-	-	-	-	-	-
28, . .	0.20	0.02	0.19	0.05	0.05	0.18	-	-	*
29, . .	-	-	-	-	-	0.03	0.10	-	0.33
30, . .	-	-	-	-	-	-	-	-	-
Totals,	3.00	3.21	3.06	2.24	2.36	2.68	1.87	1.75	0.94

* Precipitation included in that of following day.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

July, 1898.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	-	-	-	-	-	-	-	-	-
2, . .	-	-	-	-	-	-	-	-	-
3, . .	-	-	-	-	-	-	-	-	-
4, . .	-	0.04	-	0.03	0.75	-	0.88	0.79	*
5, . .	0.13	-	-	-	-	-	0.08	-	0.05
6, . .	-	-	-	-	-	-	-	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	0.04	-	-	-	-	-	-	-
9, . .	0.10	-	-	0.18	0.31	-	0.20	0.11	0.38
10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	-	*	-	-	-	-	-	*	*
13, . .	-	0.60	0.89	2.21	2.55	1.20	1.87	5.08	*
14, . .	1.00	-	-	-	-	-	0.12	-	4.48
15, . .	-	-	-	-	-	-	-	-	-
16, . .	-	-	-	-	-	-	-	-	-
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	*	-	*	-	-	-	*	*
19, . .	1.90	0.21	0.83	0.50	0.59	0.30	0.21	0.65	0.68
20, . .	-	-	-	-	-	-	-	-	-
21, . .	-	0.01	0.14	0.44	0.57	0.70	0.44	0.04	0.14
22, . .	-	-	-	-	-	-	-	-	-
23, . .	-	-	-	-	-	-	-	-	-
24, . .	-	-	-	-	-	0.03	-	-	-
25, . .	-	-	-	-	-	-	-	-	-
26, . .	0.15	0.22	0.07	0.08	0.20	0.21	0.29	-	-
27, . .	-	0.24	-	-	-	-	-	-	0.05
28, . .	0.29	-	0.31	-	0.37	*	0.20	1.25	0.13
29, . .	0.90	0.02	-	0.38	-	0.21	-	-	-
30, . .	0.20	1.07	0.67	0.10	0.20	0.09	0.14	-	-
31, . .	-	0.20	0.32	0.06	0.03	-	-	1.60	0.13
Totals,	4.67	2.65	3.23	3.98	5.57	2.74	4.43	9.52	6.04

August, 1898.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	0.02	0.21	-	-	-	-	-	-	-
2, . .	-	-	-	-	-	-	-	-	-
3, . .	-	-	-	-	-	-	-	-	-
4, . .	0.40	0.40	0.25	0.43	0.32	0.43	0.31	0.18	0.26
5, . .	1.22	1.08	1.00	1.52	1.15	0.92	1.57	1.73	0.34
6, . .	-	-	-	-	-	-	-	-	-
7, . .	-	0.03	-	-	-	-	-	-	-
8, . .	0.15	0.11	0.09	0.24	0.30	0.52	-	-	-
9, . .	0.30	*	-	0.11	-	0.03	-	-	0.09
10, . .	-	0.30	0.39	*	*	*	-	*	*
11, . .	1.45	0.70	0.95	2.33	2.22	*	2.63	1.75	4.67
12, . .	-	*	-	*	0.14	2.00	0.29	*	*
13, . .	0.14	0.19	0.06	0.23	0.25	0.09	-	0.75	1.76
14, . .	-	-	-	-	-	-	-	-	-
15, . .	-	-	-	0.02	-	-	-	-	-
16, . .	0.90	0.58	-	-	-	-	-	-	-
17, . .	-	0.19	0.79	1.46	0.19	0.14	-	0.17	0.15
18, . .	-	*	0.42	*	0.86	*	0.14	-	-
19, . .	1.55	1.01	2.27	0.57	0.10	*	1.62	0.17	0.17
20, . .	-	-	-	-	-	2.15	-	-	-
21, . .	-	-	-	-	-	-	-	-	-
22, . .	-	-	-	-	-	-	-	-	-
23, . .	-	0.21	0.36	*	*	*	-	0.32	0.19
24, . .	0.40	1.31	0.91	0.44	0.44	0.45	0.48	-	-
25, . .	0.90	0.03	0.18	0.03	0.09	0.83	0.34	-	-
26, . .	0.80	0.06	-	-	-	-	-	-	-
27, . .	0.07	-	-	0.04	-	-	-	-	0.05
28, . .	-	-	-	-	-	-	-	-	-
29, . .	-	-	-	-	-	-	-	-	-
30, . .	-	-	-	-	-	-	-	-	-
31, . .	-	-	-	-	-	-	-	-	-
Totals,	8.30	6.41	7.67	7.42	6.06	7.56	7.38	5.07	7.68

* Precipitation included in that of following day.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

September, 1898.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	0.03	0.21	0.82	0.46	0.03	-	-	0.27	0.01
2, . .	0.20	0.14	0.20	0.03	0.09	0.63	-	0.10	-
3, . .	-	-	-	-	-	-	0.54	-	0.13
4, . .	0.03	0.17	-	-	-	-	-	-	-
5, . .	-	-	-	-	-	-	-	-	-
6, . .	-	-	-	-	-	-	-	-	-
7, . .	0.65	1.30	0.50	0.49	0.44	1.03	-	0.19	*
8, . .	-	-	-	-	-	-	0.37	-	0.16
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	-	-	-	-	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	-	-
14, . .	-	-	-	-	-	-	-	-	-
15, . .	-	-	-	-	-	-	-	-	-
16, . .	0.05	-	-	0.13	0.04	0.01	0.09	-	-
17, . .	0.48	-	-	-	-	-	-	-	-
18, . .	-	0.45	-	0.03	0.03	-	-	-	-
19, . .	-	-	-	-	-	-	0.22	-	-
20, . .	-	-	-	-	-	-	-	-	-
21, . .	-	-	-	-	-	-	-	-	-
22, . .	-	-	-	*	-	-	-	-	-
23, . .	1.33	0.69	0.61	0.64	0.75	0.86	-	2.00	0.58
24, . .	0.38	0.52	0.41	*	*	0.12	0.57	-	*
25, . .	-	-	-	0.19	0.12	-	0.27	0.08	0.06
26, . .	0.05	-	-	0.12	-	-	-	-	-
27, . .	-	-	-	-	0.27	0.02	0.26	0.02	0.34
28, . .	-	-	-	-	-	-	-	-	-
29, . .	-	-	-	-	-	-	-	-	-
30, . .	-	-	-	-	-	-	-	-	-
Totals,	3.20	3.48	2.54	2.09	1.77	2.67	2.32	2.66	1.28

October, 1898.

Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, .	-	-	-	-	-	-	-	-	-
2, .	-	-	-	-	-	-	-	-	-
3, .	-	-	-	-	-	-	-	-	-
4, .	-	-	-	-	-	-	-	-	-
5, .	2.50	1.85	2.09	1.00	1.22	2.40	0.96	1.05	1.26
6, .	-	-	-	-	-	-	0.73	-	-
7, .	-	-	-	-	-	-	-	-	-
8, .	0.22	0.50	0.52	0.19	0.22	0.44	0.26	0.20	0.35
9, .	-	-	-	-	-	-	-	-	-
10, .	-	-	-	-	-	-	-	-	-
11, .	-	-	-	-	-	-	0.73	-	-
12, .	0.40	0.12	0.13	0.97	0.75	0.39	-	1.19	0.92
13, .	-	-	-	-	-	-	-	-	-
14, .	-	0.20	-	*	-	-	-	-	-
15, .	0.72	0.46	0.96	1.07	0.92	0.70	-	0.90	1.04
16, .	-	-	-	-	-	-	0.57	-	-
17, .	-	-	-	-	-	-	-	-	-
18, .	-	-	-	-	-	-	-	-	-
19, .	0.70	0.60	0.68	*	0.88	0.79	-	0.90	*
20, .	-	0.03	0.18	0.79	-	-	0.81	-	1.16
21, .	-	-	0.05	*	*	*	-	*	2.09
22, .	0.85	0.85	1.27	1.21	1.49	1.13	1.67	4.35	-
23, .	-	-	-	-	-	-	-	-	-
24, .	-	-	-	-	-	-	-	-	-
25, .	-	-	-	-	-	-	-	-	-
26, .	-	0.37	0.79	*	*	*	-	*	*
27, .	1.50	0.71	0.16	1.49	1.76	1.14	1.67	2.80	2.76
28, .	-	-	-	-	-	-	-	-	-
29, .	-	-	0.07	*	-	*	-	*	*
30, .	0.15	0.11	0.09	0.29	0.14	0.09	0.20	0.12	0.09
31, .	-	-	-	-	-	-	-	-	0.16
Totals,	7.04	5.80	6.99	7.01	7.38	7.08	7.60	11.51	9.83

* Precipitation included in that of following day.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Concluded.

November, 1898.										December, 1898.									
Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.	Day of Month.	Ludlow.	Amherst.	Fitchburg.	Framingham.	Chestnut Hill.	Lawrence.	Salem.	Taunton.	New Bedford.
1, .	–	–	–	–	–	–	–	–	–	1, .	–	–	–	–	–	–	–	–	–
2, .	–	–	–	–	–	–	–	–	–	2, .	–	–	–	–	–	–	–	–	–
3, .	–	–	–	–	–	–	–	–	–	3, .	–	–	–	–	–	–	–	–	–
4, .	–	–	–	–	–	–	–	–	–	4, .	–	0.04	0.22	*	*	*	–	*	*
5, .	–	–	–	–	–	–	–	–	–	5, .	0.50	0.41	0.74	0.93	0.88	1.21	0.73	0.88	0.44
6, .	0.25	0.12	0.18	0.26	0.39	0.18	0.34	0.40	0.62	6, .	–	–	–	–	–	–	–	–	–
7, .	–	–	–	–	–	–	–	–	–	7, .	–	–	–	–	–	–	–	–	–
8, .	–	–	–	–	–	–	–	–	–	8, .	–	–	–	–	–	–	–	–	–
9, .	–	–	–	–	–	–	–	–	–	9, .	–	–	–	–	–	–	–	–	–
10, .	–	2.00	1.77	1.82	1.50	*	–	*	*	10, .	–	–	–	–	–	–	–	–	–
11, .	1.90	0.15	0.53	–	–	1.49	1.54	1.76	1.24	11, .	–	–	–	–	–	–	–	–	–
12, .	–	–	–	–	–	–	–	–	–	12, .	0.30	0.31	0.40	0.32	0.30	*	–	0.20	*
13, .	–	–	–	0.16	–	–	–	–	–	13, .	–	–	0.03	–	–	0.31	0.39	–	0.10
14, .	0.20	0.12	0.12	–	0.18	0.19	0.18	0.35	0.56	14, .	–	–	–	–	–	–	–	–	–
15, .	–	–	–	–	–	–	–	–	–	15, .	–	–	–	–	–	–	–	–	–
16, .	–	–	–	–	–	–	–	–	–	16, .	–	–	–	–	–	–	–	–	–
17, .	0.30	0.17	0.15	*	*	*	–	*	*	17, .	–	–	–	–	–	–	–	–	–
18, .	–	0.23	0.14	*	0.32	*	0.21	*	0.52	18, .	–	–	–	–	–	–	–	–	–
19, .	2.15	1.56	1.26	1.92	1.35	1.39	0.42	2.20	–	19, .	–	–	–	–	–	–	–	–	–
20, .	–	–	–	–	–	–	1.09	–	1.80	20, .	0.40	0.47	0.44	*	0.44	*	–	*	0.42
21, .	–	–	–	–	–	–	–	–	–	21, .	–	0.18	0.04	0.49	–	*	0.52	*	–
22, .	–	–	–	–	–	–	–	–	–	22, .	–	0.07	0.02	–	*	0.53	–	*	–
23, .	–	–	–	–	–	–	–	–	–	23, .	0.80	0.47	0.66	0.62	0.57	0.51	0.57	1.05	1.12
24, .	0.70	0.63	0.31	*	*	0.46	–	0.45	*	24, .	–	–	–	–	–	–	–	–	–
25, .	–	–	0.29	0.36	0.38	–	0.32	–	0.32	25, .	–	–	–	–	–	–	–	–	–
26, .	–	*	0.06	*	–	–	–	*	*	26, .	–	–	–	–	–	–	–	–	–
27, .	–	0.72	1.93	2.22	2.76	*	0.83	*	2.00	27, .	–	–	0.03	0.04	–	–	–	–	–
28, .	0.20	–	0.02	–	–	0.85	0.58	2.00	–	28, .	–	–	–	–	–	–	–	–	–
29, .	–	–	–	–	–	–	–	–	–	29, .	–	–	–	–	–	0.02	–	–	–
30, .	0.25	0.05	–	0.50	0.54	0.07	0.42	1.00	0.92	30, .	–	–	–	–	–	–	–	–	–
										31, .	1.25	0.28	0.39	0.90	0.64	–	0.60	0.35	0.10
Tot.,	5.95	5.75	6.76	7.24	7.42	4.63	5.93	8.16	7.98	Tot.,	3.25	2.23	2.97	3.30	2.83	2.58	2.81	2.48	2.18
Totals for the Year, ...											55.56	50.54	51.87	54.27	57.39	49.43	55.42	65.28	62.60

* Precipitation included in that of following day.

Flow of Streams.

The flow of streams for the year 1898, as indicated by the records of the Sudbury River, was very much in excess of the normal for twenty-four years, and was exceeded in only two years during that time. The flow was less than normal during the months of March and April, but was considerably in excess of the normal during each of the remaining months. The flow of the river during the driest six months of the year has only been exceeded in those months in two of the twenty-four years during which the flow of the Sudbury River has been measured.

In order to show the relation between the flow of the Sudbury River during each month of 1898 and the normal flow of the same river as deduced from twenty-four years' observations, from 1875 to 1899 inclusive, the following table has been prepared. The area of the water-shed of the Sudbury River above the point of measurement is 75.2 square miles.

Table showing the Average Monthly Flow of Sudbury River for the Year 1898, in Cubic Feet per Second per Square Mile of Drainage Area and in Gallons per Day per Square Mile of Drainage Area, also Departures from the Normal Flow.

Month.	Normal Flow.		Actual Flow in 1898.		Excess or Deficiency.	
	Cubic Feet per Second per Square Mile.	Gallons per Day per Square Mile.	Cubic Feet per Second per Square Mile.	Gallons per Day per Square Mile.	Cubic Feet per Second per Square Mile.	Gallons per Day per Square Mile.
January,	1.870	1,209,000	2.535	1,638,000	+0.665	+429,000
February,	2.936	1,897,000	4.676	3,022,000	+1.740	+1,125,000
March,	4.405	2,847,000	4.029	2,604,000	−0.376	−243,000
April,	3.092	1,998,000	2.830	1,829,000	−0.262	−169,000
May,	1.717	1,110,000	1.928	1,246,000	+0.211	+136,000
June,	0.762	492,000	0.820	530,000	+0.058	+38,000
July,	0.317	205,000	0.357	231,000	+0.040	+26,000
August,	0.500	323,000	1.713	1,107,000	+1.213	+784,000
September,	0.385	249,000	0.571	369,000	+0.186	+120,000
October,	0.856	553,000	1.795	1,160,000	+0.939	+607,000
November,	1.516	980,000	3.073	1,986,000	+1.557	+1,006,000
December,	1.665	1,076,000	2.783	1,799,000	+1.118	+723,000
Average,	1.662	1,074,000	2.244	1,450,000	+0.582	+376,000

The next table shows the weekly fluctuations during 1898 in the flow of two of the streams which were carefully measured, namely, the Sudbury and the Merrimack. The flow of these streams, particularly the Sudbury, serves to indicate the flow of the other streams in eastern Massachusetts.

Week ending Sunday.	Sudbury River. Cubic Feet per Second per Square Mile.	Merrimack River. Cubic Feet per Second per Square Mile.	Week ending Sunday.	Sudbury River. Cubic Feet per Second per Square Mile.	Merrimack River. Cubic Feet per Second per Square Mile.
1898.			**1898.**		
Jan. 2,	1.296	1.222	July 10,	—0.111	0.589
9,	1.468	1.304	17,	0.717	0.538
16,	2.106	1.509	24,	0.502	0.580
23,	3.297	1.729	31,	0.499	0.547
30,	3.560	2.040	Aug. 7,	0.884	0.558
Feb. 6,	1.664	1.183	14,	2.566	0.739
13,	2.578	1.382	21,	2.838	0.835
20,	3.081	1.912	28,	1.022	1.107
27,	11.233	2.132	Sept. 4,	1.188	0.743
Mar. 6,	4.196	1.959	11,	0.407	0.613
13,	5.108	2.443	18,	0.172	0.506
20,	4.304	6.358	25,	0.405	0.490
27,	2.798	5.078	Oct. 2,	0.414	0.873
Apr. 3,	2.870	3.896	9,	0.926	0.949
10,	2.309	2.415	16,	1.532	0.984
17,	2.336	2.573	23,	2.409	1.389
24,	2.181	3.064	30,	2.811	2.388
May 1,	5.104	4.919	Nov. 6,	1.466	1.556
8,	2.113	2.783	13,	3.563	1.910
15,	1.544	2.178	20,	3.686	2.350
22,	1.197	1.907	27,	3.617	2.952
29,	2.721	2.352	Dec. 4,	2.493	1.814
June 5,	1.708	2.041	11,	4.898	2.803
12,	0.742	1.404	18,	1.326	1.459
19,	0.413	1.343	25,	2.599	1.592
26,	1.140	1.390	**1899.**		
July 3,	0.110	0.874	Jan. 1,	2.085	-

The following table gives the records of the rainfall upon the Sudbury River water-shed and its total yield expressed in inches in depth on the water-shed (inches of rainfall collected) for the year 1898, together with the average of the records of the twenty-four years from 1875 to 1898 inclusive: —

Rainfall received and collected on the Sudbury River Water-shed.

Month.	1898.			Mean for 24 Years, 1875-1898.		
	Rainfall.	Rainfall collected.	Per Cent. collected.	Rainfall.	Rainfall collected.	Per Cent. collected.
January,	6.83	2.922	42.78	4.34	2.156	49.68
February,	4.49	4.869	108.44	4.23	3.084	72.91
March,	2.40	4.645	193.54	4.30	5.078	118.09
April,	4.66	3.158	67.77	3.30	3.450	104.55
May,	3.22	2.222	69.01	3.41	1.979	58.04
June,	2.48	0.915	36.90	2.95	0.850	28.81
July,	4.09	0.411	10.05	3.79	0.365	9.63
August,	8.17	1.974	24.16	4.27	0.577	13.51
September,	2.62	0.637	24.31	3.20	0.430	13.44
October,	6.71	2.069	30.83	4.44	0.987	22.23
November,	6.93	3.429	49.48	4.30	1.691	39.33
December,	3.28	3.208	97.80	3.66	1.920	52.46
Totals and averages,	55.88	30.459	54.51	46.19	22.567	48.86

The Sudbury River records are particularly valuable as a basis for estimating the yield of other water-sheds in Massachusetts, both on account of the accuracy with which the measurements have been made and the absence of abnormal conditions which would unfavorably affect the results. The following table gives the records relating to the yield of this water-shed for each of the past twenty-three years, the flow from the water-shed being expressed in gallons per day per square mile, instead of inches in depth of rainfall collected, in order to render the table more convenient for use in estimating the probable yields of water-sheds used as sources of water supply: —

*Yield of the Sudbury River Water-shed in Gallons per Day per Square Mile.**

Month.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
January,	103,000	643,000	658,000	1,810,000	700,000	1,121,000	415,000	1,241,000
February,	1,496,000	1,368,000	949,000	2,465,000	1,711,000	1,787,000	1,546,000	2,403,000
March,	1,604,000	4,435,000	4,813,000	3,507,000	2,330,000	1,374,000	4,004,000	2,839,000
April,	3,049,000	3,292,000	2,394,000	1,626,000	3,116,000	1,168,000	1,546,000	867,000
May,	1,188,000	1,139,000	1,391,000	1,394,000	1,114,000	514,000	965,000	1,292,000
June,	870,000	222,000	597,000	506,000	413,000	176,000	1,338,000	529,000
July,	321,000	183,000	202,000	128,000	158,000	177,000	276,000	86,000
August,	396,000	405,000	121,000	475,000	395,000	119,000	148,000	55,000
September,	207,000	184,000	60,000	160,000	141,000	80,000	197,000	306,000
October,	646,000	234,000	632,000	516,000	71,000	101,000	186,000	299,000
November,	1,302,000	1,088,000	1,418,000	1,693,000	206,000	205,000	395,000	210,000
December,	584,000	454,000	1,289,000	3,177,000	462,000	175,000	775,000	314,000
Average for whole year,	972,000	1,135,000	1,214,000	1,452,000	894,000	578,000	979,000	862,000
Av. for driest six months,	574,000	384,000	502,000	532,000	230,000	143,000	330,000	211,000

Month.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.
January,	335,000	995,000	1,235,000	1,461,000	2,589,000	1,053,000	2,782,000	1,254,000
February,	1,033,000	2,842,000	1,354,000	4,800,000	2,829,000	1,951,000	1,195,000	1,529,000
March,	1,611,000	3,785,000	1,572,000	2,059,000	2,868,000	3,237,000	1,339,000	3,643,000
April,	1,350,000	2,853,000	1,815,000	1,947,000	2,620,000	2,645,000	1,410,000	1,875,000
May,	938,000	1,030,000	1,336,000	720,000	1,009,000	1,632,000	880,000	1,366,000
June,	300,000	417,000	426,000	203,000	414,000	422,000	653,000	568,000
July,	115,000	224,000	62,000	115,000	114,000	117,000	633,000	108,000
August,	78,000	257,000	240,000	94,000	214,000	380,000	1,432,000	132,000
September,	91,000	44,000	121,000	118,000	111,000	1,155,000	824,000	458,000
October,	186,000	83,000	336,000	146,000	190,000	1,999,000	1,230,000	2,272,000
November,	205,000	175,000	1,178,000	673,000	368,000	2,758,000	1,941,000	1,215,000
December,	193,000	925,000	1,174,000	1,020,000	643,000	3,043,000	2,241,000	997,000
Average for whole year,	533,000	1,129,000	901,000	1,087,000	1,154,000	1,697,000	1,383,000	1,285,000
Av. for driest six months,	145,000	200,000	391,000	223,000	234,000	953,000	944,000	747,000

Month.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Mean for 24 Years, 1875-98, inclusive.
January,	3,018,000	1,870,000	433,000	693,000	1,034,000	1,084,000	845,000	1,638,000	1,209,000
February,	3,486,000	943,000	1,542,000	991,000	541,000	2,676,000	1,067,000	3,022,000	1,897,000
March,	4,453,000	1,955,000	3,245,000	2,238,000	2,410,000	3,835,000	2,565,000	2,604,000	2,847,000
April,	2,397,000	871,000	2,125,000	1,640,000	2,515,000	1,494,000	1,515,000	1,829,000	1,998,000
May,	582,000	1,259,000	2,883,000	840,000	636,000	360,000	915,000	1,246,000	1,110,000
June,	414,000	428,000	440,000	419,000	174,000	399,000	962,000	530,000	492,000
July,	149,000	214,000	158,000	161,000	231,000	95,000	658,000	231,000	205,000
August,	163,000	280,000	181,000	209,000	229,000	57,000	591,000	1,107,000	323,000
September,	203,000	229,000	108,000	150,000	89,000	388,000	182,000	369,000	249,000
October,	210,000	126,000	221,000	374,000	1,379,000	592,000	94,000	1,160,000	553,000
November,	305,000	697,000	319,000	836,000	2,777,000	659,000	909,000	1,986,000	980,000
December,	544,000	485,000	797,000	716,000	1,782,000	657,000	1,584,000	1,799,000	1,076,000
Av. for whole year,	1,315,000	781,000	1,037,000	770,000	1,152,000	1,019,000	991,000	1,450,000	1,074,000
Av. for driest six months.	239,000	327,000	237,000	356,000	460,000	314,000	564,000	777,000	465,000

* The area of the Sudbury River water-shed used in making up these records included water surfaces amounting to about 1 per cent. of the whole area, from 1875 to 1878 inclusive, and subsequently increasing by the construction of storage reservoirs to about 3 per cent. in 1886. The water-shed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

EXPERIMENTS

UPON THE

PURIFICATION OF SEWAGE AND WATER

AT THE

LAWRENCE EXPERIMENT STATION,

DURING THE YEAR 1898.

EXPERIMENTS UPON THE PURIFICATION OF SEWAGE AND WATER AT THE LAWRENCE EXPERIMENT STATION.*

By Harry W. Clark, Chemist in Charge.

The year 1898 is the eleventh that the investigations of the Lawrence Experiment Station have been continued. The work has been carried on under the general supervision of Hiram F. Mills, A.M., C.E., member of the State Board of Health, with the writer in direct charge. The following report presents a summary of the investigations and results obtained. Besides the regular chemical and bacterial analyses of sewage, water and sand, made in connection with these investigations, about 500 samples of sand, soils, etc., have been examined at the station, in connection with the investigation of the sewage-disposal areas of the various towns and cities of the State.

Purification of Sewage.

Recognizing the great value of all information upon methods by which the area necessary for the disposal of a given volume of sewage can be reduced and still have the sewage satisfactorily purified, much of the work for a number of years has been along lines which tended to increase our knowledge of this particular problem. Especially during the past four years have the results of investigations and observations upon this interesting subject been given a conspicuous place in the annual reports of the work of the Board at Lawrence. New and promising work along this line has been carried on during the past year.

Character and Composition of Sewage.

We call sewage either strong or weak according to the amount of organic matter in the volume of water going to make up a given

* A full account of the work done at the Lawrence Experiment Station for the years 1888 and 1889 is contained in a special report of the State Board of Health upon the Purification of Sewage and Water, 1890. A similar account for the years 1890 and 1891 is contained in the twenty-third annual report of the Board for the year 1891. Since 1891 the results have been published yearly in the annnal reports.

volume of sewage. At Lawrence, the sewage used in our investigations is taken from a sewer which drains the houses, stores and streets of the most thickly populated portion of the city. It is undoubtedly a much stronger sewage than the average sewage of the whole city; and, as nearly all that pumped to the experiment station is day sewage, it is somewhat stronger than the average for the twenty-four hours. The sewage experimented with at Lawrence is also much stronger than that which is disposed of upon the filtration areas of the State. Investigations in regard to these areas, made during the past summer, have given us exceedingly interesting and valuable figures in regard to the strength of the sewage, as well as the approximate volume of sewage reaching each area. (See paper beyond.)

Fresh, Stale and Septic Sewage.

Sewage is the filth flowing in our sewers, consisting of wastes from houses, stores and streets, together with the water used for washing these wastes into the sewers. In many places, waste liquors from industrial establishments largely augment the volume of sewage.

It is evident that, when this mixture of filth and organic matters of all kinds, with the waste water of a town, has just occurred, and little time has been given for mechanical, chemical and bacterial actions to take place in the sewers, we have a liquid containing organic matter quite differently constituted — that is, of a different mechanical and chemical composition — from the same matter in the sewage when opportunity has been given for these various actions to take place. The sewage at first contains generally free oxygen and nitrogen in the form of nitrates and nitrites, and the proportion of organic matters in suspension is comparatively large. Such a liquid we call *fresh sewage.*

As this fresh sewage flows along the sewers, mechanical, chemical and bacterial forces act upon it, and the composition of its organic constituents undergoes a distinct change. This change is practically the breaking up of the organic matter into simpler forms, and is the initial step in the process by which the organic matter is finally changed to inorganic matter. The change carried on in fresh sewage containing free oxygen is as follows: the carbon, under bacterial influences in the presence of free oxygen, is oxidized, the nitrogen and hydrogen unite to form ammonia, and this unites with the carbon dioxide to form ammonium carbonate. Thus, until the dissolved oxygen is exhausted, the free ammonia increases, while the crude organic matter decreases. Sewage when its free oxygen has just become exhausted and its free ammonia increased to the maximum possible by the exhaustion of its oxygen we designate as *stale sewage.*

Sewage containing free oxygen and for this reason comparatively free from putrefying actions has not a particularly offensive odor, and the same can be said, though in a less degree, of stale sewage. When the oxygen is exhausted bacterial life continues active and chemical changes go on and continue the breaking up of the organic matter into simpler forms. But, as oxygen is not present, the action by which the organic matter is still further changed is a putrefying one, and the sewage becomes very ill-smelling on account of the generation and escape of hydrogen compounds of carbon, sulphur and phosphorus. Nitrogen is also set free in this putrefying process. The result of all these changes is to decrease the amount of carbonaceous and nitrogenous matter in the sewage. Sewage when in this state is now known, since the results of certain English experiments have been published, as *septic sewage;* not a very appropriate term, but one which we shall probably have to accept on account of its general use at the present time. This action, resulting in the change of stale sewage into septic sewage, can probably, if sufficient time is given, be continued until nearly all the organic matter in suspension is changed into soluble forms.

The fact that the organic matter in suspension in sewage is the chief source of difficulty in sewage purification by intermittent filtration was early made clear by the work at Lawrence, and all our investigations upon rapid methods of sewage purification have dealt with processes of getting rid of or destroying in some manner this organic matter in suspension. The fact that the percentage of suspended organic matter present in a sewage decreases with the increased age of the sewage, and that stale sewage was more easily disposed of upon sand filters than fresh sewage, on account of this fact, has been known and the results of experiments upon this matter have been given in the last four reports of the Board. For instance, in the report for 1895 it was stated that if sewage is stale when reaching the filter the organic matter in suspension is finely divided and hence a much larger percentage of it will enter the pores of the filtering material, and the filter surface will not become so quickly clogged as it will when fresh sewage, with less finely divided sludge, is applied to a filter. It was also stated at that time that the organic matter decreases as the sewage increases in age, and that which remains is more easily attacked by the bacteria always present in the filter. In the report for 1896, experiments showing the different work of filters receiving in one case fresh and in the other stale sewage were given in detail, and further discussion of this matter was given in the report for 1897.

The two following tables show the average analysis of fresh sewage taken directly from a manhole in the Lawrence Street sewer, and the average analysis of the sewage pumped at the station after having passed through a 2.5-inch pipe 4,300 feet long and reaching from this manhole to the experiment station. The samples collected directly from the sewer were all taken during the forenoon, when the strongest sewage is running in the sewer, while the samples collected at the station represent more nearly the average of the twenty-four-hour flow.

The proportion of suspended organic matter in the two sewages is not, however, fairly shown by the albuminoid ammonia determinations, as this determination when applied to the fresh Lawrence Street sewage detects only about 25 per cent. of the organic matter in suspension, while when applied to the stale station sewage it detects about 50 per cent. of the organic matter in suspension. That is, in this older sewage the organic matter is more easily oxidized by the alkaline permanganate used in the process of analysis.

Monthly Average of Analyses of Sewage from the Lawrence Street Sewer.

[Parts per 100,000.]

1898.	Temperature, Deg. F.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. In Solution.	Albuminoid Ammonia. In Suspension.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January,	49	2.65	1.22	.87	.35	10.21	.167	.0155	7.75	1,975,000
February,	49	2.48	1.23	.86	.47	9.43	.226	.0207	7.60	1,707,000
March,	50	2.42	1.08	.75	.33	11.52	.325	.0148	8.85	2,430,000
April,	55	2.62	1.18	.94	.24	8.76	.180	.0213	8.53	1,953,000
May,	58	2.41	0.88	.63	.25	12.27	.226	.0325	6.18	1,493,000
June,	63	2.55	0.84	.54	.30	12.20	.261	.0300	5.88	1,724,000
July,	70	2.89	0.97	.56	.41	12.23	.093	.0115	6.85	3,190,000
August,	73	2.23	0.62	.48	.14	9.41	.148	.0000	5.05	1,505,000
September,	71	2.97	0.86	.54	.32	10.11	.107	.0226	6.06	2,326,000
October,	66	2.65	1.04	.56	.48	8.28	.164	.0250	7.55	1,920,000
November,	58	2.61	0.99	.59	.40	6.65	.213	.0235	8.15	2,690,000
December,	44	2.75	1.06	.72	.34	13.46	.306	.0188	7.94	2,004,000
Average,	59	2.60	1.00	.67	.34	10.38	.201	.0197	7.20	2,076,000

Monthly Averages of Analyses of Regular Sewage Samples.

[Parts per 100,000.]

1898.	Temperature, Deg. F.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. In Solution.	Albuminoid Ammonia. In Suspension.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January,	45	2.50	.57	.34	.23	5.59	3.14	2,350,000
February,	47	2.58	.56	.31	.25	6.01	2.91	2,173,000
March,	46	2.71	.56	.34	.22	6.16	2.87	1,569,000
April,	45	2.73	.69	.37	.32	6.26	3.65	1,953,000
May,	55	3.07	.61	.29	.32	6.81	3.20	1,915,000
June,	66	3.23	.56	.24	.32	8.07	3.06	1,641,000
July,	73	3.09	.46	.22	.24	8.40	2.42	1,076,000
August,	74	2.19	.40	.18	.22	8.59	2.75	885,000
September,	68	2.91	.55	.22	.33	7.72	3.26	1,756,000
October,	58	4.08	.65	.31	.34	7.77	3.56	2,308,000
November,	49	3.93	.77	.33	.44	7.32	4.41	2,404,000
December,	46	2.90	.59	.31	.28	6.14	3.46	2,309,000
Average,	56	2.99	.58	.29	.29	7.07	3.22	1,862,000

Monthly Averages of Mixed Samples representing all of the Sewage applied to Filters 1, 6 and 9 A.

[Parts per 100,000.]

1898.	Free Ammonia. Filter No. 1.	Free Ammonia. Filter No. 6.	Free Ammonia. Filter No. 9 A.	Albuminoid Ammonia. Filter No. 1.	Albuminoid Ammonia. Filter No. 6.	Albuminoid Ammonia. Filter No. 9 A.	Oxygen Consumed. Filter No. 1.	Oxygen Consumed. Filter No. 6.	Oxygen Consumed. Filter No. 9 A.	Chlorine. Filter No. 1.	Chlorine. Filter No. 6.	Chlorine. Filter No. 9 A.
January,	2.48	2.13	2.18	.60	0.52	.50	2.76	2.30	2.52	4.40	4.22	4.75
February,	3.64	2.20	2.35	.95	0.52	.65	4.58	2.75	2.98	6.96	4.35	4.78
March,	3.73	2.16	2.46	.72	0.44	.52	4.28	2.63	3.00	5.73	3.67	4.30
April,	3.54	2.42	2.46	.90	0.60	.68	4.34	2.86	3.58	4.69	3.40	3.85
May,	3.45	3.51	2.75	.84	0.80	.78	3.30	3.78	3.00	4.73	5.01	4.47
June,	3.40	4.25	3.30	.82	0.78	.72	4.18	4.03	3.50	5.48	7.97	7.23
July,	2.48	3.67	2.64	.57	0.89	.54	3.00	3.58	2.38	5.58	8.73	7.29
August,	2.69	3.00	2.20	.59	0.57	.34	3.90	3.68	2.45	7.82	10.74	7.07
September,	2.39	3.01	2.18	.55	0.44	.36	3.48	2.98	2.30	6.39	7.64	5.49
October,	3.81	4.30	3.40	.79	1.01	.82	4.55	4.88	4.30	7.48	9.10	7.47
November,	3.85	4.20	3.58	.90	0.92	.86	5.28	5.45	4.65	7.17	7.92	6.65
December,	4.00	4.46	2.82	.98	0.77	.65	5.70	4.06	3.72	7.56	6.04	6.74
Average,	3.29	3.28	2.69	.77	0.69	.62	4.11	3.58	3.20	6.17	6.57	5.84

Septic Tank System.

The processes by which the percentage of suspended organic matter can be reduced are now being taken advantage of by the so-called septic tank system (first in operation in Exeter, Eng.), the main feature of which is an air-tight tank into which the sewage passes to be retained for a time in order to allow the bacteria of decomposition, and subsequently those of putrefaction, to break up the organic matters into simpler forms.

During the year we have studied this method with very interesting results. An air-tight wooden tank, divided into two compartments by a partition midway in the tank, has been used as a septic tank. The sewage flows into one compartment, and over this partition into the other, from which it is withdrawn by means of a faucet midway between the top and bottom of the side of the tank. Thus we avoid drawing out either the sediment from the bottom of the tank or the fat and fatty matters which accumulate upon the surface of the sewage. The sewage remains in the tank from twenty-four to thirty-six hours, and the tank is always kept full, sewage being run into the tank when any is withdrawn, and at the same rate.

The two following tables give the average analyses for the year of the sewage that enters the tank and the average analyses of the effluent from the tank: —

Sewage as it enters Septic Tank.

[Parts per 100,000.]

1898.	Ammonia.			Chlorine.	Oxygen Consumed.
	Free.	Albuminoid.			
		Total.	In Solution.		
April,	4.64	1.18	.72	6.56	4.64
May,	4.40	0.88	.52	6.96	3.83
June,	4.38	0.74	.44	7.32	3.93
July,	4.00	0.69	.41	12.21	3.20
August,	3.83	0.58	.34	12.36	3.30
September,	4.63	0.64	.38	12.13	3.75
October,	4.80	0.70	.42	8.74	3.74
November,	5.23	0.86	.51	8.94	5.03
December,	4.02	0.84	.50	7.65	4.62
Average,	4.44	0.79	.47	9.21	4.00

Septic Sewage — Effluent of the Septic Tank.

[Parts per 100,000.]

1898.	Temperature, Deg. F.	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Total.	In Solution.	In Suspension.			
January,	52	4.16	.34	.28	.06	6.86	1.83	234,000
February,	51	5.03	.40	.32	.08	8.61	2.10	260,000
March,	48	4.89	.48	.37	.11	10.97	2.62	255,000
April,	45	5.13	.55	.40	.15	7.54	2.64	249,000
May,	52	5.21	.47	.37	.10	8.97	2.34	525,000
June,	66	4.87	.33	.28	.05	11.89	2.40	164,000
July,	72	4.48	.34	.27	.07	14.26	1.80	217,000
August,	72	4.15	.31	.24	.07	12.48	1.87	184,000
September,	66	5.10	.43	.27	.16	12.40	2.30	307,000
October,	60	4.97	.39	.29	.10	8.86	2.04	350,000
November,	48	5.36	.45	.37	.08	10.21	2.86	557,000
December,	49	4.92	.44	.34	.10	8.32	2.64	592,000
Average,	57	4.86	.41	.32	.09	10.11	2.29	324,500

The sewage, when drawn from the tank, is generally of an exceedingly offensive odor and darker colored than when it enters, but always clearer than the ordinary sewage. It contains a comparatively small amount of nitrogenous organic matter in suspension, only about 22 per cent. of the organic nitrogen in the tank effluent being in suspension, as compared with 40 per cent. when the sewage enters the tank. It is also evident from inspection that this suspended matter is much more finely divided than that in the fresher sewage. The free ammonia is increased but slightly, owing to the fact that the dissolved oxygen primarily present in the sewage is nearly exhausted in the station sewage before it enters the tank. The total albuminoid ammonia is decreased about 48 per cent. and the carbonaceous matters, indicated by the determination of oxygen consumed from permanganate, about 43 per cent. No nitrification, of course, takes place within this tank, and we have found that the nitrifying and oxidizing bacteria — that is, those bacteria depending upon the presence of oxygen for their life and functional activities — are destroyed while the sewage is passing through the tank. The number of organisms present in the tank effluent is only about

15 per cent. of the number in the sewage as it enters the tank, as determined by ordinary plate cultures. The bacteria living through this period and present in the effluent of the tank, moreover, are almost all facultative bacteria, that is, those capable of living either with or without the presence of oxygen. A greater proportion of the bacteria in the tank effluent are liquefying bacteria than of the total number of bacteria in the sewage as it enters the tank.

Application of Septic Sewage to Filters.

Filter No. 100.

On the first of January, 1898, a filter containing 5 feet in depth of sand, with an effective size of 0.26 millimeter, — that is, a sand very favorable for the purification of sewage by intermittent filtration, — was constructed to receive this septic sewage. The rate of operation of this filter for the first seven months was 100,000 gallons per acre daily, and upon September 10 the rate was doubled. The filter is located within the buildings, and, although started in mid-winter, was kept at an average temperature for the month of about 46 degrees, as shown by the temperature of the filter effluent. Nitrification was very slow in starting, however, much slower than would have been the case with a filter receiving sewage in a less advanced state of putrefaction than this septic sewage. During the first month of operation the nitrates did not reach .10 of a part per 100,000, and not until the middle of February did they reach 1.00 part per 100,000, the free ammonia at this time being 3.50 parts. Since that time, however, nitrification has been active within the filter, although not until the 19th of July did the free ammonia in the effluent become less than 1.00 part per 100,000 and the nitrites lower than .10 of a part per 100,000. The albuminoid ammonia during all this period averaged more than .10 of a part, and since the last date mentioned (July 19), while the results have been better than those previously obtained, still the effluent of the filter is always somewhat turbid, and generally decidedly so, and also has a disagreeable odor. If the ordinary stale sewage pumped at the station had been applied at the same rate to this filter as the septic sewage was during the first eight months of the year, we should certainly have obtained an effluent clear, practically colorless, with little turbidity and without appreciable odor. Owing to the small amount of organic matter in suspension in the sewage applied, the surface of the filter has been in good condition during the year, and the sewage has passed below the surface almost immediately. The average analysis of the effluent of this filter for the year was as follows: —

Effluent of Filter No. 100.

[Parts per 100,000.]

1898.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.*	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January, .	100,000	52	44	1m.	Decided.	.15	2.26	.0585	6.68	0.05	.0268	0.39	365,000
February, .	100,000	51	43	1m.	Decided.	.34	3.77	.1125	7.86	0.88	.1215	0.67	84,600
March, .	100,000	48	45	1m.	Decided.	.43	2.02	.1330	10.76	2.04	.1900	0.96	92,400
April, .	100,000	45	43	2m.	Decided.	.44	1.44	.1275	7.68	2.67	.2700	1.08	128,400
May, . .	100,000	52	52	2m.	Decided.	.46	1.47	.1340	9.05	2.66	.2867	1.18	92,700
June, . .	100,000	66	64	1m.	Great.	.48	1.60	.1475	11.80	2.48	.1575	1.03	78,400
July, . .	100,000	72	73	1m.	Decided.	.37	1.15	.0987	13.99	3.01	.0467	0.73	34,000
August. .	100,000	72	74	1m.	Decided.	.28	0.40	.0647	11.48	2.92	.0067	0.53	25,300
September,	165,000	66	66	1m.	Decided.	.24	0.39	.0653	11.15	3.39	.0037	0.47	37,200
October, .	200,000	60	60	2m.	Decided.	.22	0.64	.0740	8.81	2.83	.0025	0.54	30,900
November, .	200,000	48	48	2m.	Decided.	.30	0.88	.1050	9.80	3.28	.0121	0.77	43,500
December, .	200,000	49	45	2m.	Decided.	.38	0.83	.1055	8.13	2.92	.0088	0.74	44,000
Average, .	130,000	57	55	-	-	.34	1.40	.1022	9.77	2.43	.0944	0.76	88,000

Surface raked 3 inches deep each week.

* Nearly all of the sewage filters are flooded six days in the week; none are flooded Sundays. The figures given in this column are calculated upon the exact volumes applied.

The comparatively poor qualitative results obtained by the intermittent filtration of this septic sewage through this filter are undoubtedly due to a number of different influences. The principal one is that, although the nitrifying bacteria finally became established within the filter, yet each application of sewage, as it passes down, has set free from it the gases generated in the septic tank and retained in solution in the sewage until this time; and the bacterial results obtained from the septic tank make clear that the gases in solution in the septic sewage must be inimical to the life of oxidizing bacteria, or prevent them from performing their usual efficient work. The gases and the easily attacked organic matter in the sewage also rapidly exhaust the air held in the pores of the filter. This is shown by the fact that the filter effluent very seldom contains any dissolved oxygen, in distinction from the effluent of filters receiving ordinary fresh or stale sewage.

Sludge in Tubes.

It is also probable that various toxins are produced by the bacteria in the tank. An experiment illustrative of this was made by filling with very strong sewage two glass tubes about 5 feet long and 2 inches in diameter, and allowing the tubes to stand for the actions to occur in the sewage which should result in the change of the suspended matters into soluble forms, according to the septic tank theory, one of these tubes being open and the other sealed. For a few days gases were generated in this sludge, bubbles passed to the top of the tubes and more or less movement of the sludge took place. Shortly, however, the actions almost ceased, and samples taken for bacterial analysis showed an almost entire absence of bacterial life in the sewage. A very few bacteria developed upon our culture plates, but forms may have been present which would only grow on plates from which air was entirely excluded. That this was probably true is shown by the fact that after a period of stagnation bacterial life again became active in these tubes, and gases — largely marsh gas — were generated, and the sludge gradually became disintegrated, helped in the open tube by an abundant growth of Pleurococcus. In the septic tank the complete destruction of aerobic bacteria does not occur, on account of the daily change of sewage.

Filter No. 103.

A second filter receiving this septic sewage is a bacterial filter, so called, containing 5 feet in depth of small pieces of coke of such a size that all will pass through a sieve with a quarter-inch mesh, and but a few of the pieces through a sieve with an eighth-inch mesh. The method of operating this filter is as follows: —

In the morning the outlet is closed, and sewage is applied once an hour until the entire open space of the filter is filled, and the sewage just covers its surface. Operating in this way the filter is filled in eight hours. The sewage is allowed to remain in it two hours after the last application, when the outlet is opened and the filter allowed to drain very slowly. Its rate of operation for the past ten months has been 800,000 gallons per acre daily. The advantage of having the filter of such material as this, and of operating it in the way mentioned, is that, owing to the coarseness of the material and the large open space, not only is surface clogging prevented, but the entire depth of the filter is brought into active use with the sewage applied each day. Another advantage, especially with the septic sewage, is that, in passing rapidly down over the coarse material, not only is the sewage aerated to a certain extent, and thus the foul gases removed from it, but also, by the method of operation, air is introduced through the entire depth of the filter each day. During the first three months of operation of this filter the free ammonia of the applied sewage was reduced but little, while the albuminoid ammonia was reduced about 70 per cent. The greatest reduction, however, was of the carbonaceous matters, as shown by the determination of oxygen consumed.

Beginning in May, however, nitrification became active within the filter; the free ammonia present in the effluent was very much reduced compared with the amount present in the sewage applied, the albuminoid ammonia became very much less, and the effluent of the filter comparatively clear and odorless. In fact, for the past seven months this filter, although operating at a rate many times as great as the intermittent filter just described, has given a better appearing effluent than the intermittent filter, and one which contains less organic matter, as shown by the analyses, and only about one-half as many bacteria. Even during the pre-nitrification period of this filter the effluent was quite clear and almost without odor; and when allowed to stand in bottles in the laboratory for months no odor developed, showing that, without doubt, the organic matter still present had been so worked over by the bacteria in the filter that it was not capable of further putrefaction. The results obtained with this filter were much better than results at corresponding rates in similar filters with fresher sewage. These other filters and their results are described further on in this report.

The following table gives the average analysis for the year of the effluent of the filter just described: —

Effluent of Filter No. 103.

[Parts per 100,000.]

1898.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
March,	852,000	48	49	Decided	.41	4.88	.1887	11.68	0.02	.0007	.73	97,800
April,	800,000	45	43	Decided.	.49	4.32	.1690	7.45	0.05	.0028	.76	59,400
May,	800,000	52	54	Decided.	.43	3.24	.1375	9.43	1.29	.0050	.67	41,200
June,	800,000	66	67	Decided.	.34	0.93	.0880	12.70	2.07	.0047	.71	22,600
July,	800,000	72	74	Slight.	.24	0.45	.0653	13.92	2.10	.0127	.42	13,500
August,	800,000	72	76	Decided.	.27	0.53	.0630	12.13	2.26	.0123	.46	22,100
September,	800,000	66	68	Slight.	.30	0.64	.0627	11.06	3.02	.0074	.47	19,700
October,	800,000	60	62	Slight.	.25	0.51	.0640	8.82	2.77	.0057	.53	18,200
November,	800,000	48	48	Decided.	.39	1.15	.1050	10.16	2.35	.0031	.80	76,000
December,	800,000	49	45	Decided.	.40	0.72	.0945	7.97	2.05	.0011	.60	70,800
Average,	805,000	58	59	-	.35	1.74	.1038	10.53	1.80	.0056	.62	44,100

Filter No. 116.

During the last week of September, 1898, a third filter was put in operation to receive septic sewage. This filter contains 5 feet in depth of sand with an effective size of 0.17 millimeter. The rate of operation at first was 100,000 gallons per acre daily, and on November 9 this rate was doubled. Owing to the sand in this filter being finer than the sand in Filter No. 100, and the consequent slower passage of the sewage through the filter, a better-strained and better-purified effluent has been obtained than the effluent from Filter No. 100. This result being aided also by the slower passage of the sewage into the filter, allowing an opportunity for the escape of marsh gas before the sewage passes below the surface of the sand.

The following table presents the average of the analyses : —

Effluent of Filter No. 116.

[Parts per 100,000.]

1898.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
September,	100,000	66	64	-	V. slight.	.09	0.7400	.0280	9.69	0.07	.0024	.16	9,000
October,	100,000	60	62	9m.	None.	.07	1.2750	.0280	9.15	2.73	.2675	.33	4,500
November,	173,000	48	51	8m.	None.	.10	0.3956	.0302	9.67	3.44	.0496	.28	1,500
December,	200,000	49	49	13m.	None.	.12	0.2345	.0282	8.22	3.27	.0310	.29	247
Average,	143,000	56	57	10m.	-	.10	0.6613	.0286	9.18	2.38	.0876	.27	3,812

Surface raked 3 inches deep each week.

Conclusions.

The results obtained from these three filters are very instructive, and show that the septic-tank process for the initiation of the purification of sewage is one of much interest. With intermittent Filter No. 100 as good qualitative results were not obtained as would have been obtained with fresher sewage; but with the bacterial filter better results were obtained than we have ever been able to achieve with bacterial filters receiving fresher sewage. Moreover, it was thought probable that if the sewage, before being applied to the intermittent sand filter, had been aerated in some such manner as running over steps or being forced in jets upon the filter, the gases, which have evidently been detrimental to good results, would have been removed, and better results could have been expected. To study if this were so or not, another filter was put in operation toward the end of the year, which is a duplicate in every respect of Filter No. 100, except that the septic sewage is aerated before application to the filter. The results so far obtained indicate quite strongly that the filter will purify sewage to a greater degree than Filter No. 100 and at a much greater rate.

Our studies have also indicated that it is probable that a much smaller septic tank can be used, in proportion to the volume of sewage flowing, especially where this volume is large, than has been proposed abroad, for this reason: a sewage of ordinary age — that is, one which has travelled for any considerable distance in the sewers — will, when it reaches its point of disposal, be practically free from dissolved oxygen, all having been exhausted before reaching this point. If such a sewage is run into a properly built septic tank, no air will be carried in with it, and the length of time which it remains within the tank need be only long enough to allow a precipitation of the organic matters in suspension and the accumulation of the fats upon the surface of the sewage. These matters can remain in the tank for an indefinite time, — being added to, of course, each day by the sewage flowing through, — and, by the action of the bacteria of decomposition and putrefaction, a large percentage of the sludge will be slowly changed to the soluble form, and pass away to a large extent, perhaps, in the effluent of the tank. It seems to be doubtful if it is necessary to have this tank air-tight; it is also doubtful if it is necessary to exclude light, experiments made at Lawrence seeming to show that the action goes on as well in the presence of air over the surface of the sewage and with light as it does without air and without light. Of course, with an air-tight tank the gases can be prevented from escaping into the air until just before running upon the sewage filters, and at that time they can be taken care of, and thus prevented, perhaps, from making the tank and its surroundings a nuisance. It is also probable that higher rates of filtration of the tank effluent can be maintained than followed during 1898.

Removal of Organic Matters in Suspension by straining through Coke.

Purification of Strained Sewage by Filtration through Sand or Coke (Filters Nos. 14 A and 65).

In the discussion of the character and composition of sewage, mention was made of the fact that the suspended organic matter was the difficult factor with which we have to deal. That this is true is perhaps made more evident by a comparison of the volume of sewage which a filter is able to purify after the removal of a given percentage of sludge, with the volume which it is able to purify without the removal of sludge. This is shown quite clearly, for instance, by results obtained year after year with Filter No. 14.

This filter contains 5 feet in depth of sand of an effective size of 0.19 millimeter, and to it has been applied, during the past four and one-half years, sewage which has first been strained through a layer of coke. During the first nine months of operation of this filter in 1898 the depth of coke, in the strainer through which the sewage applied to the filter was first passed, was 6 inches, and the top layer, of practically 1½ inches, was fine coke breeze. Through this, sewage was passed at a rate of 1,000,000 gallons per acre daily. As a result of this straining, 48 per cent of the total organic matter in the sewage was removed. This 48 per cent. included, moreover, 73 per cent. of the organic matters originally in suspension in the sewage. Owing to this, the surface of the filter did not become clogged, and a rate approximating 320,000 gallons per acre daily was easily maintained by the filter during these nine months as in previous years, and we obtained a well-purified effluent, without turbidity, with very little color and without odor, the average analysis of which was as follows: —

Effluent of Filter No. 14 A.

[Parts per 100,000.]

Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed	Bacteria per Cubic Centimeter.
	Free.	Albuminoid.		Nitrates.	Nitrites.		
.13	.0145	.0207	7.08	2.38	.0001	.23	85

In October, the coke strainer was so changed that, although the depth was the same, no coke dust was present in it, but the entire depth consisted of small, well-defined pieces of coke. The rate at which the strainer was operated was also increased to 2,000,000 gallons per acre daily, a rate greater than could be maintained with the former strainer, owing to the fineness of the coke breeze. As a result of this, while the strainer continued to remove a very large percentage of the total organic matter of the applied sewage, the percentage of finely divided sludge passing through was increased greatly; and after a month's operation of Filter No. 14 with this less clarified sewage, it had become so badly clogged that the rate had to be reduced one-half, or to 160,000 gallons per acre daily. Upon reducing the rate of operation of the strainer again to 1,000,000 gallons per acre daily, better results were obtained, and they seem to indicate that a considerable saving in the amount of coke used in the strainer per 1,000,000 gallons of sewage strained can be effected by the use of coke somewhat coarser than coke breeze.

The second filter to receive this strained sewage was Filter No. 65, constructed Jan. 4, 1896. This filter contained, over the usual gravel underdrains, 5 feet in depth of coke breeze. The average rate of filtration during 1896 was 290,000 gallons per acre daily. During 1897 the average rate was 311,000 gallons per acre daily, and during 1898 the average rate was 509,000 gallons per acre daily. During the entire period of operation of this filter it produced a fairly well purified effluent. It was operated without difficulty at the rates given for over two years. During 1898 surface clogging occurred, and on March 25, 2 inches of coke was scraped from its surface and the filter was dug over to a depth of 6 inches; and on April 13, 6 inches in depth of coke was taken from the surface of the filter, but the remaining depth of filtering material was in good condition. The filter was put out of operation at the end of September, 1898.

The four tables beyond show the average analysis of (1) the sewage applied to the strainer, (2) the effluent from the strainer, (3) the effluent of the sand Filter No. 14 A, and (4) the effluent of the coke Filter No. 65.

Sewage applied to the Coke Strainer.

[Parts per 100,000.]

1898.	Temperature. Deg. F.	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
			Total.	In Solution.	In Suspension.			
January,	44	2.73	.72	.39	.33	6.60	4.05	2,488,000
February,	48	2.41	.50	.29	.21	5.31	2.43	2,255,000
March,	49	2.59	.62	.37	.25	5.91	3.28	1,510,000
April,	45	2.48	.76	.38	.38	4.84	4.17	1,480,000
May,	55	3.37	.72	.33	.39	7.65	3.74	2,522,000
June,	66	3.15	.70	.23	.47	8.34	3.50	1,338,000
July,	72	2.65	.45	.19	.26	6.57	2.20	798,000
August,	74	2.08	.36	.16	.20	7.25	2.20	698,000
September,	68	3.14	.59	.25	.34	8.33	3.43	1,833,000
October,	59	4.15	.68	.33	.35	8.35	3.63	2,790,000
November,	45	4.34	.81	.34	.47	7.97	4.58	2,218,000
December,	45	2.59	.44	.26	.18	4.86	2.88	2,038,000
Average,	56	2.97	.61	.29	.32	6.83	3.34	1,831,000

Monthly Averages of Analyses of Sewage strained through Coke for Filter No. 14 A.

[Parts per 100,000.]

1898.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. In Solution.	Albuminoid Ammonia. In Suspension.	Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January,	2.59	.26	.24	.02	5.30	1.50	565,000
February,	2.28	.31	.25	.06	4.83	1.70	970,000
March,	2.59	.33	.29	.04	5.39	1.65	698,000
April,	2.49	.31	.27	.04	7.45	1.43	688,000
May,	3.54	.38	.30	.08	8.32	1.66	730,000
June,	3.00	.30	.19	.11	8.72	1.85	510,000
July,	2.42	.23	.20	.03	7.99	1.07	538,000
August,	1.63	.16	.14	.02	8.67	1.20	82,600
September,	2.44	.38	.22	.16	7.67	1.74	660,000
October,	3.38	.44	.28	.16	7.76	1.98	591,000
November,	3.98	.49	.30	.19	8.11	2.72	763,700
December,	1.99	.34	.24	.10	4.81	2.33	557,000
Average,	2.69	.33	.24	.09	7.09	1.74	613,000

Effluent of Filter No. 14 A.

[Parts per 100,000.]

1898.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January,	320,000	45	45	43m.	None.	.11	.0271	.0180	4.69	1.56	.0002	.19	70
February,	320,000	47	48	50m.	None.	.11	.0163	.0190	5.51	1.88	.0001	.23	52
March,	317,000	51	48	46m.	None.	.14	.0035	.0177	5.16	1.97	.0000	.21	54
April,	320,000	50	48	51m.	None.	.16	.0112	.0180	6.23	2.51	.0001	.23	48
May,	320,000	59	58	36m.	None.	.14	.0150	.0193	5.81	2.77	.0001	.20	30
June,	320,000	69	67	36m.	V. slight.	.11	.0207	.0222	7.07	3.29	.0000	.24	58
July,	320,000	76	68	27m.	None.	.12	.0384	.0234	10.77	3.00	.0000	.20	45
August,	320,000	76	76	55m.	None.	.10	.0027	.0201	8.12	2.40	.0000	.23	69
September,	305,000	71	63	50m.	None.	.12	.0017	.0228	7.18	2.40	.0001	.22	308
October,	320,000	62	61	53m.	None.	.19	.0083	.0261	10.26	2.38	.0000	.35	118
November,	249,000	52	56	1h. 2m.	None.	.39	.6130	.0464	7.94	2.42	.0050	.52	243
December,	142,200	50	47	1h. 30m.	None.	.39	.4526	.0435	5.72	2.07	.0007	.37	722
Average,	298,000	59	57	-	-	.17	.1009	.0247	7.04	2.39	.0005	.27	152

Surface raked to the depth of 3 inches twice each week; spaded to the depth of 6 inches April 8, November 23 and December 3.

Effluent of Filter No. 65.

[Parts per 100,000.]

1898.	Quantity Applied. — Gallons per acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January,	480,000	45	46	1h. 10m.	Slight.	.25	.1173	.0427	5.26	1.32	.0006	.31	65,500
February,	527,000	47	48	1h. 54m.	V. slight.	.24	.2404	.0361	5.15	1.48	.0017	.28	10,700
March,	640,000	51	50	3h. 20m.	Slight.	.37	.8221	.0600	5.10	0.97	.0041	.47	27,300
April,	591,000	50	49	51m.	Decided.	.44	.5833	.0867	4.85	1.46	.0033	.47	39,900
May,	480,000	59	49	41m.	Decided.	.45	.5718	.0726	4.53	1.45	.0050	.43	88,000
June,	480,000	69	66	1h. 9m.	Decided.	.25	.5350	.0510	7.74	2.49	.0035	.36	45,000
July,	480,000	76	68	42m.	Decided.	.23	.1733	.0437	10.38	2.02	.0051	.30	47,200
August,	480,000	76	75	1h. 8m.	Decided.	.32	.1815	.0540	8.06	1.58	.0165	.54	56,300
September,	427,000	71	64	55m.	Decided.	.27	.1300	.0500	6.91	1.76	.0008	.31	603,000
Average,	509,000	60	57	-	-	.31	.3727	.0552	6.44	1.61	.0045	.39	109,200

Surface raked 3 inches deep twice each week.

Straining Sewage through Coal.

During the past four months, an experiment has been carried on upon the result that can be obtained in removing sludge from sewage by passing the sewage through a layer of soft coal at the same rate at which we have passed it through coke, and the results have been as follows: —

Effluent of Coal Strainer.

[Parts per 100,000.]

	Ammonia.		Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
	Free.	Albuminoid.			
Sewage applied,	3.95	.66	7.00	3.74	2,100,000
Strained sewage,	3.90	.33	5.69	1.90	472,000

Bacterial Filters.

The so-called bacterial filters are always constructed of coarse material and the entire depth of the filter is brought into contact with the sewage applied each day.

Seven bacterial filters have been in operation during the year, namely, Filters Nos. 81, 82, 103, 104, 105, 107 and 108. Filter No. 103 has been described in connection with the discussion upon septic sewage. All the bacterial filters have been operated in a manner approximating that followed with Filter No. 103 previously described, but the others have received the ordinary station sewage instead of the septic sewage. It is evident, of course, that in order to operate a filter in the manner in which the bacterial filters are operated the filtering material must be of so coarse a nature that the open space between the particles will be large enough for the sewage to pass, with a measurable degree of readiness, from the top to the bottom of the filter within a short time. With filters of fine sand, upon which the sewage remains for a number of hours, and at best only passes a few inches below the surface in the course of a day, the method successful in operating the coarser filters could not be followed. The fact that these bacterial filters are constructed of coarse material prevents the formation of a scum of organic matter on the surface of the filter, as sometimes occurs with a filter of finer material, and which results in excluding air and preventing the sewage from passing below the surface. Also, on account of the coarseness of the material, clogging cannot easily occur by the closing up of the pores within the filter with organic matter. With the materials used of late, such as cinders and coke, the open space approximates 55 per cent. of the total volume of the filter; whereas in the ordinary intermittent sand filter, the open space is usually from 35 to 40 per cent. of the total volume of the filter. In the filter of coarse material, moreover, owing to the fact that a much smaller number of particles is necessary to fill a given volume, each division of the open space is much larger than these divisions when innumerable small particles like sand grains form the body of the filter.

Rates of Operation of Bacterial Filters.

In stating the rates of operation of bacterial filters, we have followed the usual rule of calculating the rates by the surface area to which a given volume of sewage is applied. This is, perhaps, not the best method to be followed with filters operated in this way, as the rate really increases with the depth of the filter; and a filter 2 feet in depth, if receiving two-thirds the volume of sewage applied to one of the same area 3 feet in depth, is being operated at an equal rate with the latter, when the actual volume of filtering material is taken into consideration.

Filter No. 81.

This filter, of ashes and cinders, was first put in operation during 1897, and had applied to it during that year, at the rate of 880,000 gallons per acre daily, sewage which had first been strained through a layer of coke at the rate of 1,000,000 gallons per acre daily. Good results were obtained during this first year of operation, considering the rate of filtration, and nitrification was active within the filter, the average amount of nitrates present in the effluent during the year being 1.39 parts. The same rate of filtration was continued during the first part of 1898, but it had to be gradually decreased, owing to the fact that the pores of the filter were becoming filled and clogged with organic matter removed from the sewage, this organic matter evidently accumulating faster than the filter was able to take care of it. The nitrates in the effluent became less, until in April nitrification practically ceased, and a reducing action took place in the filter; and as a result, the effluent was highly colored with iron; that is to say, this bacterial filter, operated at the rate named and without rest for a period of sixteen months, reached such a condition that a period of rest, or some other method of removing clogging, was necessary. The filter was allowed to rest for two weeks in May, and air was drawn through it constantly during this time. It was then put into operation again at the same rate as previously followed. At first, good nitrification took place, but in a few days the filter became clogged again, and the reducing action was again apparent, showing that the period of rest had not been sufficient for the removal of much of the clogging material. During June it was still kept in operation, but the effluent was always colored with iron, and nitrification had practically ceased. During July a period of rest was again allowed the filter, and, following this, better results were obtained for a short time; but as they did not continue, the filter remained out of operation during a large part of the month of August; and in September the results were still so poor that the filter was discontinued. This experiment made it evident that, with the material in the filter and the percentage of open space, the rate maintained was too great, and the filter had become so badly clogged that it could not, by any process tried, be again restored to a condition for suitable purification to take place within it; that is, within a reasonable period of time.

The following table presents the average analyses of the effluent of this filter: —

Effluent of Filter No. 81.

[Parts per 100,000.]

1898.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature Deg. F.		Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
							Albuminoid.						
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Total.	In Solution.		Nitrates.	Nitrites.		
January, .	888,000	43	45	Decided.	0.45	1.2950	.2520	.1855	7.02	0.73	.0014	1.42	397,000
February, .	888,000	45	47	Decided.	0.49	1.1080	.2216	.1788	8.36	0.49	.0018	1.32	424,000
March, .	822,000	47	51	Decided.	0.52	1.4933	.2080	.1600	8.59	0.42	.0020	1.04	325,500
April, .	474,000	45	50	Decided.	1.13	1.7600	.2133	.1773	5.35	0.19	.0013	1.29	298,500
May, . .	299,000	55	59	Great.	0.50	2.1567	.2533	.1873	7.09	1.78	.0060	1.80	194,000
June, . .	384,000	66	69	Great.	-*	3.6000	.1920	.1520	6.51	0.01	.0040	2.10	17,000
July, . .	-	-	-	-	-	-	-	-	-	-	-	-	-
August, .	469,000	73	76	Great.	0.68	1.7100	.1600	.1480	7.51	1.76	.0313	1.17	173,000
September,	444,000	69	71	Great.	1.60	2.4400	.1540	.0920	8.07	0.01	.0015	1.41	113,800
Average,	584,000	55	59	-	-	1.9454	.2068	.1601	7.31	0.67	.0062	1.44	243,000

* Reddish brown.

Filter No. 82.

This is a bacterial filter containing 5 feet in depth of cinders. The sewage applied has not been treated in any way, and goes to the surface of the filter in the following manner: across the filter, and about 10 inches above its surface, an iron pipe is placed, with small orifices extending along its lower half. The pipe is parallel to the surface. The sewage is pumped to a tank above the filter, to which the delivery pipe is attached, and, when the gate is opened, the pressure causes the sewage to rush from the pipe in a number of streams. By this means air is introduced into the sewage. This filter was put in operation in April, 1897, and the results for 1898 are given below: —

Effluent of Filter No. 82.

[Parts per 100,000.]

1898.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January,	623,000	52	43	Great.	.48	1.4250	.2230	8.42	1.24	.3475	1.49	318,000
February,	623,000	51	45	Great.	.49	1.2300	.2220	8.01	1.11	.1525	1.30	293,900
March,	623,000	48	47	Great.	.52	1.4200	.2227	12.48	1.34	.0583	1.16	270,000
April,	623,000	45	44	Great.	.53	1.4000	.2293	7.47	1.28	.0013	1.29	311,000
May,	479,000	52	56	Great.	.49	1.3100	.2130	10.63	1.45	.0103	1.07	390,000
June,	623,000	66	66	Decided.	.51	1.3000	.1760	20.32	0.63	.0085	0.89	265,300
July,	623,000	72	70	Decided.	.43	1.4200	.1500	15.56	1.05	.0175	0.89	200,800
August,	623,000	72	73	Decided.	.42	0.9300	.1560	17.82	1.37	.0240	0.86	269,800
September,	623,000	66	66	Decided.	.42	1.1100	.1527	11.76	1.41	.0170	0.97	297,800
October,	623,000	60	60	Decided.	.45	0.9000	.1420	9.79	1.67	.0150	0.97	354,500
November,	623,000	48	49	Great.	.49	0.7500	.1680	9.36	2.12	.0103	1.09	445,700
December,	554,000	49	45	Decided.	.43	0.6200	.1760	7.33	1.42	.0085	1.13	358,600
Average,	605,000	57	55	-	.47	1.1513	.1859	11.58	1.34	.0559	1.09	314,600

Filters Nos. 107 and 108.

Filter No. 107 contains 24 inches in depth of cinders, and Filter No. 108 contains 24 inches in depth of coke. The cinder filter contains 61 per cent. of open space and the coke filter 51 per cent. They have been operated as bacterial filters, and Filter No. 108 has received the effluent of Filter No. 107. Regular station sewage has been applied to them, and they are operated for six weeks and then allowed to rest for one week. By this method of procedure, if the filters were in sets of seven, six would be operating at all times, and the working capacity of such a plant would be six-sevenths of its apparent capacity. Operating in this way the filters have kept in good condition, and no clogging is yet apparent. The average rate of operation of Filter No. 107 has been 685,000 gallons per acre daily. Filter No. 108, which has received the entire effluent of Filter No. 107, but has a larger surface area, has been operated at the rate of 565,000 gallons per acre daily; but, owing to the small open space of this coke filter, this volume has filled the filter to its surface. The average analyses of the effluents of the two filters are here given: —

Effluent of Filter No. 107.

[Parts per 100,000.]

1898.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
April, . . .	800,000	45	45	Decided.	.55	0.9200	.1160	1.87	.03	.0080	0.96	250,000
May, . . .	738,000	55	53	Great.	.60	1.6000	.2200	4.70	.26	.0257	1.25	394,000
June, . . .	677,000	66	64	Decided.	.64	1.0900	.1420	4.35	.41	.0215	0.88	168,000
July, . . .	615,000	71	68	Great.	.47	2.0000	.2320	8.63	.33	.0365	0.97	268,500
August, . . .	622,000	72	73	Decided.	.45	0.9000	.1280	5.72	.36	.1000	1.12	195,000
September, . .	646,000	68	61	Decided.	.55	1.4200	.1560	5.22	.48	.0080	1.08	280,000
October, . .	769,000	55	64	Decided.	.85	1.7500	.1600	5.75	.64	.0090	1.07	309,500
November, . .	615,000	47	49	Great.	.80	2.4000	.3480	6.86	.84	.0050	2.38	558,000
December, . .	622,000	45	45	Great.	.63	2.4500	.3514	8.24	.68	.0083	2.66	920,000
Average, .	678,000	58	58	-	.62	1.6144	.2059	5.70	.45	.0247	1.37	371,000

Effluent of Filter No. 108.

[Parts per 100,000.]

1898.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
April, . . .	660,000	45	44	Slight.	.41	1.0000	.0720	1.68	0.05	.0120	0.56	111,000
May, . . .	609,000	53	52	Decided.	.55	1.0333	.1160	4.40	0.65	.0373	0.86	141,000
June, . . .	559,000	64	65	Decided.	.53	0.5100	.0890	4.06	0.70	.0440	0.58	170,800
July, . . .	507,000	68	69	Decided.	.28	0.9100	.0950	7.21	0.80	.0080	0.72	98,000
August, . .	513,000	73	74	Slight.	.38	0.4200	.0960	5.58	0.89	.0500	0.64	218,000
September, . .	533,000	61	61	Slight.	.42	0.5000	.0960	4.89	0.82	.0030	0.68	228,000
October, . .	634,000	64	63	Slight.	.54	0.6750	.0880	6.92	1.58	.0050	0.65	144,000
November, . .	507,000	49	49	Great.	.65	1.2000	.2400	5.94	1.52	.0050	1.64	462,500
December, . .	513,300	45	46	Decided.	.54	1.1000	.1845	7.74	1.35	.0068	1.37	260,000
Average, .	559,500	58	58	-	.48	0.8165	.1196	5.38	0.93	.0190	0.86	203,700

Effect of the Nature of Filtering Material upon Results obtained by Bacterial Filters.

Filters Nos. 104 and 105.

In order to study the different action of rough and smooth materials, these two filters were started; Filter No. 104 containing 5 feet in depth of small pieces of coke, and Filter No. 105 containing the same depth of glass beads. The open space of each filter was approximately 50 per cent., and hence they were operated at the same rates, as it took the same volume of sewage to fill the open space in each. These filters have been in operation nine months up to the present time, and the effluent of Filter No. 104 has been much better purified than the effluent of Filter No. 105, as shown by the following tables: —

Effluent of Filter No. 104.

[Parts per 100,000.]

1898.	Quantity Applied. Gallons per Acre Daily for six Days in a Week.	Temperature. Deg. F.		Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.	Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
March, . . .	1,061,000	47	-	Slight.	.36	3.6800	.2440	6.02	.01	.0000	.80	354,000
April, . . .	721,000	45	-	V. slight.	.29	1.9100	.1145	7.47	.48	.1010	.59	51,900
May, . . .	555,000	55	-	V. slight.	.27	0.3900	.0760	5.28	.78	.0150	.37	71,000
June, . . .	721,000	66	-	V. slight.	.29	0.4850	.0590	6.69	.94	.0185	.39	30,400
July, . . .	721,000	73	-	V. slight.	.18	0.2050	.0460	6.37	1.16	.0124	.26	77,500
August, . .	721,000	74	-	V. slight.	.20	0.2140	.0400	11.16	1.14	.0021	.27	53,400
September, . .	721,000	69	-	V. slight.	.29	0.5400	.0500	8.60	1.37	.0034	.39	34,600
October, . .	721,000	55	-	V. slight.	.38	1.2410	.1130	7.99	2.02	.0204	.36	36,300
November, . .	721,000	46	-	Decided.	.49	0.6250	.0740	6.40	1.90	.0044	.63	43,400
December, . .	721,000	45	-	Decided.	.44	0.2700	.0960	6.87	1.53	.0074	.74	56,600
Average, .	738,400	58	-	-	.32	0.9560	.0913	7.29	1.13	.0185	.48	80,900

Effluent of Filter No. 105.

[Parts per 100,000.]

1898.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
March, . .	1,061,000	47	-	Decided.	.45	3.2000	.3240	5.86	.01	.0000	1.78	597,000
April, . . .	721,000	45	-	Decided.	.87	3.4500	.2390	6.75	.08	.0178	1.25	301,100
May, . . .	555,000	55	-	Decided.	.65	2.3400	.1700	7.66	.55	.0085	0.78	158,200
June, . . .	721,000	66	-	Decided.	.53	1.6000	.2840	8.31	.31	.0250	2.38	169,500
July, . . .	721,000	73	-	Slight.	.37	0.7000	.1220	2.74	.98	.0150	0.83	107,900
August, . .	721,000	74	-	V. slight.	.41	1.5100	.0760	15.50	.40	.0053	0.50	46,200
September, . .	721,000	69	-	Decided.	.74	2.2000	.1010	9.82	.40	.0030	0.79	180,000
October, . .	721,000	55	-	Decided.	.70	2.1700	.1240	7.09	.94	.0094	0.64	107,400
November, . .	721,000	46	-	Decided.	.94	2.2400	.1390	6.47	.94	.0022	0.95	143,300
December, . .	721,000	45	-	Decided.	.62	1.3400	.1190	7.34	.50	.0036	0.79	108,000
Average, .	738,400	58	-	-	.63	2.0750	.1698	7.75	.51	.0090	1.07	191,900

A study of the tables show that the coke filter gave an effluent with only one-half as much color as the bead filter, less than one-half as much free ammonia, practically one-half as much albuminoid ammonia, twice as much nitrogen in the form of nitrates, less than one-half as much organic matter determined as oxygen consumed, and also less than half the number of bacteria found in the effluent of Filter No. 105. The better purification obtained by the coke filter was due undoubtedly to the rough surface of the coke, by means of which it not only holds more air than can the glass beads, but also retards the flow of sewage, so that it is a greater time passing down over the coke than over the beads, and the matters in suspension are undoubtedly held back more efficiently than by the smoother glass beads. The results from these two filters indicate that, in general, a rough material is of great advantage in filters operated as are these so-called bacterial filters.

Action of Iron in Filters.

Filters Nos. 88 and 96.

In July, 1898, a filter was put in operation containing 5 feet in depth of a mixture of sand of an effective size of 0.23 millimeter and iron filings, the proportion being one part by volume of iron to two parts of sand. During the year 1898 this filter has been operated at a rate of 115,000 gallons per acre daily, and has produced an effluent containing the smallest amount of nitrogen, determined as albuminoid ammonia, and of carbon, as shown by the determination of oxygen consumed, of any filter at the station. Even Filter No. 4, of fine river silt (see page 479), and operating at only one-sixth the rate of Filter No. 88, has not given so pure an effluent as far as these two bodies are concerned. The average analysis of the effluent is as follows: —

Effluent of Filter No. 88.

[Parts per 100,000.]

1898.	Quantity Applied. — Gallons per Acre Daily for six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	115,000	43	47	8m.	Slight.	.16	.0315	.0073	5.05	1.57	.0055	.07	2,7000
February, .	115,000	45	48	14m.	V.slight.	.16	.0319	.0077	5.16	1.96	.0050	.06	118
March, .	115,000	47	51	37m.	V.slight.	.18	.0366	.0073	6.01	2.23	.0033	.06	29
April, .	115,000	45	54	22m.	V.slight.	.15	.0380	.0086	6.18	2.35	.0030	.08	40
May, . .	115,000	55	58	9m.	None.	.17	.0831	.0095	6.20	3.26	.0034	.09	42
June, . .	115,000	66	68	5m.	V.slight.	.13	.1128	.0150	7.81	2.72	.0060	.09	55
July, . .	115,000	73	75	8m.	None.	.06	.0848	.0148	7.74	2.07	.0116	.10	67
August, .	115,000	74	76	6m.	None.	.05	.0525	.0122	9.41	1.73	.0140	.09	40
September,	115,000	69	64	7m.	None.	.02	.0152	.0066	3.26	1.23	.0041	.05	44
October, .	115,000	55	63	11m.	None.	.07	.0173	.0084	6.95	2.40	.0036	.06	25
November, .	115,000	46	56	15m.	None.	.09	.0151	.0087	7.79	2.63	.0033	.05	53
December, .	115,000	45	48	15m.	None.	.09	.0105	.0094	5.99	2.14	.0029	.07	12
Average,	115,000	55	59	-	-	.11	.0441	.0096	6.46	2.19	.0055	.07	269

An examination of this table shows that the effluent has contained more free ammonia than we should expect, considering the low albuminoid ammonia, and also more color. The color, however, was largely due to iron. The free ammonia was also undoubtedly due to the action of the iron. It is probable that in the filter the organic matter is being acted upon, not only by the oxidizing and nitrifying actions common to intermittent sand filters, but also that the iron acts directly as a carrier of oxygen to oxidize organic matter. Besides, it reduces, to some extent, the nitrates constantly forming, and changes a portion back to free ammonia. It was thought probable also that nitrogen gas was liberated by the action of the iron, and, to prove this, a weak ammonia solution of known strength was run through iron filings, with the result that, after passing quickly through 40 inches in depth of these filings, the ammonia, determined in the usual way, was reduced 33 per cent. This experiment was repeated several times.

Filter No. 96.

Filter No. 96, containing 4½ feet in depth of iron filings, was put in operation in December, 1897, and was operated at the rate of 100,000 gallons per acre daily. It was operated for five months, and produced an effluent the average analysis of which was as follows: —

Effluent of Filter No. 96.

[Parts per 100,000.]

Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
	Free.	Albuminoid.		Nitrates.	Nitrites.		
.14	2.22	.0746	6.70	.008	.0003	.50	8,270

This filter and its results further illustrate the purification methods shown by Filter No. 88, as here we obtained a good appearing effluent, with much less free ammonia than in the applied sewage, and not more than one-eighth as much albuminoid ammonia, and the effluent contained practically no nitrates. This shows that, if nitrates were formed near the surface of the filter, they were reduced before the effluent reached the outlet; and, owing to the fact that the effluent contained less free ammonia than the applied sewage, considerable free nitrogen must have passed into the air. After being in operation for five months, the iron filings in this filter were used in a large filter of the same nature, which has continued in operation up to the present time with similar results, except that, from the beginning of operation of this second filter, more iron has appeared in the effluent, owing probably to iron or steel of a somewhat different nature in this filter than in the first filter.

Purification of Wool Liquor.

Filter No. 70, containing 4½ feet in depth of sand of an effective size of 0.23 millimeter, was put in operation in June, 1896, and during the first three months of 1898 was operated at a rate of 400,000 gallons per acre daily; the sewage applied being, as in previous years, a mixture of station sewage and rinse liquor from a wool-washing establishment, the mixture being in the proportion of four parts of the wool liquor to one part sewage. The average analysis of this mixture was as follows: —

Sewage applied to Filter No. 70 during January, February and March.

[Parts per 100,000.]

Ammonia.		Chlorine.	Oxygen Consumed.
Free.	Albuminoid.		
1.95	.55	4.75	3.05

Operating at the rate stated, good results were obtained. The effluent of the filter was low in color, and contained very little unoxidized organic matter, and nitrification was active, as shown by the following average: —

Effluent of Filter No. 70 during January, February and March.

[Parts per 100,000.]

Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
Free.	Albuminoid.		Nitrates.	Nitrites.	
.0443	.0272	4.88	1.00	.0241	.40

During April the sewage applied was changed to a mixture of the strong scouring liquor, from the same wool plant, and city sewage; the proportion being one part of the wool liquor to seventeen parts sewage, and the rate of operation being 55,600 gallons per acre daily. The average analysis of the mixture during the next four months was as follows: —

Sewage applied to Filter No. 70 during April, May, June and July.

[Parts per 100,000.]

Ammonia.		Chlorine.	Oxygen Consumed.
Free.	Albuminoid.		
4.10	2.15	9.76	19.62

Operating in this way, the filter, while producing a clear and almost odorless effluent, gave one very high in unoxidized organic matter and with low nitrates, the analysis of which was as follows: —

Effluent of Filter No. 70 during April, May, June and July.

[Parts per 100,000.]

Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
Free.	Albuminoid.		Nitrates.	Nitrites.	
2.37	1.02	9.61	.57	.0550	12.50

During this second period, a sand filter, containing the same depth and grade of sand as Filter No. 70, was in operation, receiving the same mixture and at the same rate, namely, 55,600 gallons per acre daily, but before the mixture was applied to this filter it was allowed to stand in an air-tight vessel for forty-eight hours, for the same bacterial actions to take place as occur in the septic tank. Treated in this way the bacteria evidently changed the composition of the mixture, as the effluent of the filter was of a very much better character than the effluent of Filter No. 70. The average analysis of the effluent of this filter was as follows: —

Effluent of Filter No. 112.

[Parts per 100,000.]

Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
Free.	Albuminoid.		Nitrates.	Nitrites.	
.1800	.1650	10.50	3.20	.0600	2.30

Beginning in September, the wool liquor which was mixed with the sewage was obtained from the Bigelow Carpet Mills in Clinton, as this liquor will probably have to be disposed of upon the filtration area of the Clinton sewerage system. The average analysis of the samples collected from this mill during the last three months of the year being as follows: —

Analysis of Waste from Carpet Mills.

[Parts per 100,000.]

Ammonia.		Chlorine.	Oxygen Consumed.
Free.	Albuminoid.		
3.90	9.57	15.11	66.00

The two filters (Nos. 70 and 112) have been kept in operation in the same manner as during the four preceding months, and the proportion of wool liquor to sewage has been the same, the average analysis of the mixture of sewage and wool liquor for the past four months being as follows: —

Sewage applied to Filters Nos. 70 and 112 during September, October, November and December.

[Parts per 100,000.]

Ammonia.		Chlorine.	Oxygen Consumed.
Free.	Albuminoid.		
3.60	1.04	6.92	9.51

It has been found that the wool liquor from this carpet factory is more easily purified than that from the Lawrence mill as both filters during this third period have given effluents of a satisfactory quality. The one receiving the sewage which has been allowed to stand before being applied to the filter, has however given rather the better effluent. The average analyses of the effluents are as follows: —

Effluent of Filters Nos. 70 and 112 during September, October, November and December.

[Parts per 100,000.]

	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
	Free.	Albuminoid.		Nitrates.	Nitrites.	
Effluent of Filter No. 70, .	.0315	.1592	7.53	2.56	.0036	2.12
Effluent of Filter No. 112,	.0129	.1000	7.23	2.90	.0031	1.31

Tannery Sewage.

At Tannery No. 2, the sand filter containing 4 feet in depth of sand of an effective size of 0.15 millimeter, which was first put in operation during September, 1895, ceased to be operated in September, 1898. At this time the sand of the filter was in good condition, the filter was working satisfactorily, and evidently could continue to do so indefinitely. The sewage, during a portion of the year, was allowed to stand a number of hours for suspended matter to settle, and then the supernatant liquid applied to the filter. The rate of operation during 1898 was 25,000 gallons per acre daily, and the average analyses of the sewage applied to the filter and the effluent from the filter for the year are as follows: —

Tannery Sewage applied to Sand Filter.

[Parts per 100,000.]

1898.	Appearance.		Ammonia.			Chlorine.	Oxygen Consumed.	Fats.
	Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. Soluble.			
January,	Great.	Redish brown.	5.00	4.35	3.76	403.0	77.3	17.5
February,	Great.	Redish brown.	2.41	9.13	8.69	371.3	62.3	13.7
March,	Great.	Redish brown.	4.44	5.29	3.81	568.7	60.0	36.1
April,	Great.	Yellow.	4.88	4.20	3.75	309.0	23.0	8.0
May,	Great.	Brown.	3.64	1.91	1.47	450.0	31.7	9.5
June,	Great.	Brown.	5.73	4.23	2.99	398.1	40.2	11.3
July,	Great.	Brown.	10.85	2.85	2.55	408.1	38.4	13.0
August,	Great.	Brown.	8.28	2.23	1.59	409.9	44.1	18.7
September,	Great.	Brown.	6.23	1.99	1.44	548.0	64.6	2.7
Average,	-	-	5.72	4.02	3.34	429.6	49.1	14.5

Effluent of Sand Filter.

[Parts per 100,000.]

1898.	Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Fats.
	Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. Soluble.		Nitrates.	Nitrites.		
January,	Decided.	0.55	2.93	.3213	.1513	413.8	12.89	.0117	2.09	6.48
February,	Decided.	0.53	0.93	.1027	.0840	369.3	12.46	.0307	1.35	14.38
March,	Decided.	1.00	1.06	.1468	.1048	490.0	9.66	.0228	1.78	7.90
April,	Slight.	1.25	0.71	.1220	.1045	516.5	8.01	.0060	1.17	5.50
May,	Slight.	1.32	0.65	.0947	.0820	409.3	7.68	.0033	1.27	4.83
June,	Slight.	1.05	0.62	.0948	.0772	434.4	8.90	.0082	1.37	5.60
July,	Decided.	0.94	0.91	.1090	.0955	500.5	11.34	.0148	1.52	3.40
August,	Decided.	0.75	1.41	.1065	.0910	479.5	8.25	.0075	1.49	2.40
September,	Decided.	0.68	2.48	.0940	.0680	552.0	2.71	.0390	1.67	0.30
Average,	-	0.90	1.30	.1324	.0954	462.8	9.10	.0160	1.52	5.64

Coke Strainer receiving Tannery Sewage.

The coke strainer at this tannery was continued in operation during the first nine months of the year at a rate of approximately 250,000 gallons per acre daily. It was believed, when the strainer was first started, that this rate would necessitate surface scraping, and that the coke and sludge removed could be disposed of by burning. As a matter of fact, during the entire operation of this strainer, a period of nearly two years, no coke or sludge has been removed from it, a large proportion of the sludge in the sewage of this tannery being of so unstable a character that, with the access of air to the filter's surface, it dries up and decreases in bulk very largely. Owing to the situation of the strainer in a low place, a good deal of rain water collected in the tannery yard has run upon its surface, especially as the past year has been a very wet one; and this has, of course, diluted to a considerable extent the sewage actually applied, as shown by the smaller amount of chlorine in the effluent of the filter in the following tables of average analyses: —

Tannery Sewage applied to Coke Strainer.

[Parts per 100,000.]

1898.	Appearance.		Ammonia.			Chlorine.	Oxygen Consumed.	Fats.
	Turbidity.	Color.	Free.	Albuminoid. In Solution.	Albuminoid. In Suspension.			
January,	Great.	Dark brown.	0.98	4.23	2.25	333.3	125.0	30.5
February,	Great.	Reddish brown.	1.28	3.37	2.00	310.7	68.0	16.1
March,	Great.	Brown.	2.34	5.76	4.35	454.4	81.6	19.8
April,	Great.	Reddish brown.	1.95	5.52	4.28	407.8	79.5	21.2
May,	Great.	Reddish brown.	2.29	4.79	3.04	543.7	130.0	18.8
June,	Great.	Reddish brown.	2.98	4.38	1.69	469.9	128.2	36.5
July,	Great.	Greenish yellow.	9.28	3.61	1.95	278.6	45.7	16.9
August,	Great.	Yellowish brown.	8.70	3.32	1.45	292.1	69.5	20.8
September,	Great.	Yellowish brown.	6.60	5.09	1.87	666.5	129.0	23.3
Average,	-	-	4.04	4.45	2.54	417.4	95.2	22.7

Effluent of Coke Strainer.

[Parts per 100,000.]

1898.	Appearance.		Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Fats.
	Turbidity.	Color.	Free.	Albuminoid. Total.	Albuminoid. Soluble.		Nitrates.	Nitrites.		
January,	Decided.	.49	2.25	.34	.17	265.3	0.18	.0040	2.53	4.03
February,	Great.	Brown.	0.66	.49	.39	229.0	0.85	.0573	10.93	6.08
March,	Decided.	.71	2.10	.36	.24	283.6	0.29	.0068	2.98	3.80
April,	Decided.	Yellow.	2.09	.20	.16	231.0	1.31	.0175	1.53	2.95
May,	Decided.	.73	2.00	.37	.27	295.7	0.12	.0000	3.80	1.63
June,	Slight.	.87	1.90	.37	.19	247.4	0.32	.0176	3.60	2.54
July,	Decided.	.82	1.59	.52	.16	251.3	1.59	.0245	4.05	4.90
August,	Slight.	.43	2.00	.30	.13	194.1	0.38	.0065	4.05	1.50
September,	V. slight.	.59	2.53	.22	.12	268.7	0.03	.0017	2.20	0.20
Average,	-	-	1.90	.35	.20	251.8	0.56	.0151	3.96	3.07

All the sewage applied to the sand filter and the coke strainer has been highly colored, either brown, red or yellow, according to the nature of the work being carried on in the tannery, making it impossible to determine the color by our color standard. The effluent of the sand filter, however, has always been easily read, being invariably of a yellow tint, and with a color no greater than that of some of the highly colored water supplies of the State. Generally, also, the color of the effluent of the coke strainer could easily be read by our color standard.

Waste Liquor from a Paper Mill.

During the first six months of the year a cinder strainer one foot in depth was kept in operation at Paper Mill No. 1, receiving, at the rate of 400,000 gallons per acre daily, a mixture of all the waste liquors produced at this mill. This waste liquor was almost always colored black, red or otherwise, according to the work being carried on in the mill, and could not, of course, be read upon our color standards. The effluent of the strainer, however, has always been of good appearance, of rather low color and easily read upon the standard. The percentage of purification effected has been high, and especially of the carbonaceous matters, as shown by the determinations of oxygen consumed. The average analyses of the liquor applied to and the effluent from this filter are as follows: —

Paper Mill Liquor.

[Parts per 100,000.]

1898.	Appearance.		Ammonia.			Chlorine.	Oxygen Consumed.	Hardness.
				Albuminoid.				
	Turbidity.	Color.	Free.	Total.	Soluble			
January,	Great.	Black.	.0180	.0767	.0547	.63	2.29	1.7
February,	Decided.	Red.	.0135	.0655	.0425	.50	1.86	6.5
March,	Decided.	Black.	.0165	.0645	.0445	.45	1.60	1.9
April,	Decided.	Pink.	.0130	.0745	.0515	.43	1.91	—0.3
May,	Decided.	Black.	.0175	.0710	.0510	.42	2.59	1.8
June,	Great.	Black.	.0140	.0810	.0500	.67	2.28	6.9
Average,	-	-	.0154	.0722	.0490	.52	2.09	3.1

Effluent of Filter at Paper Mill.

[Parts per 100,000.]

1898.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
	Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January,	Decided.	.36	.0066	.0372	.78	.00	.00	.73	18.32
February,	Slight.	.21	.0042	.0135	.63	.00	.00	.27	11.90
March,	Slight.	.30	.0023	.0173	.57	.00	.00	.34	11.50
April,	Decided.	.31	.0032	.0191	.47	.00	.00	.47	5.70
May,	V. slight.	.41	.0026	.0231	.49	.00	.00	.44	6.75
June,	V. slight.	.22	.0031	.0231	.54	.00	.00	.58	6.40
Average,	-	.30	.0037	.0222	.58	-	-	.47	10.10

Purification of Creamery Waste.

An experiment has been made during the year upon methods of purifying the wastes from creameries, this waste consisting largely of water which has been used in washing out cans, churns and other apparatus, together with the milk washed from these cans. Owing to the composition of milk, this waste, even when containing but a very slight proportion of milk compared with the amount of water used in washing the cans, etc., shows upon analysis a very large amount of nitrogen and carbon, as determined in the form of albuminoid ammonia and the amount of oxygen consumed from permanganate. A sample of waste from a creamery at Uxbridge, supposed to be representative of the strongest waste liquor from that place, was collected upon April 8, 1898, and analyzed with the following result: —

Creamery Waste.

[Parts per 100,000.]

Solids.			Ammonia.				Oxygen Consumed.
				Albuminoid.			
Total.	Loss on Ignition.	Fixed.	Free.	Total.	In Solution.	In Suspension.	
145.00	130.70	14.30	.2120	4.62	.72	3.90	51.20

Owing to the difficulty with which samples representing the entire wastes from the creamery could be obtained, it was thought that mixtures of milk and water in different proportions could be made at the experiment station, and investigations made upon the purification of these mixtures, the results from which would be comparable with the results obtained if wastes taken directly from the creamery were used. The first experiment was as follows: —

A filter was put in operation containing 4 feet of clean sand with an effective size of 0.23 millimeter. This filter was started April 11, 1898, and at first it received a mixture containing equal proportions of skimmed milk and water, at the rate of 200,000 gallons per acre daily. The analysis of this mixture was as follows: —

Applied Liquor.

[Parts per 100,000.]

Ammonia.		Oxygen Consumed.	Bacteria per Cubic Centimeter.
Free.	Albuminoid.		
6.00	96.00	750.00	83,000,000

Owing to the strength of this mixture, as shown by the analysis, it was applied for only two days, and on the third day of operation of the filter the rate was reduced to 100,000 gallons per acre daily, and the liquor applied contained one-third skimmed milk to two-thirds water. This mixture and the rate of application clogged the filter badly, and on April 22, two inches of curd were removed from the surface of the filter, and the surface dug over to the depth of 6 inches. Following this, the liquid applied to the filter contained only one-thirty-fifth as much milk as water. The analysis of this liquid was as follows: —

Applied Liquor.

[Parts per 100,000.]

Ammonia.		Oxygen Consumed.	Bacteria per Cubic Centimeter.
Free.	Albuminoid.		
1.65	7.67	42.50	16,000,000

The amount of ammonia found in the mixtures of milk and water, and also the amount of oxygen consumed from permanganate, varied very much with different samples of milk and different age of the same sample. Up to this time, April 22, the skimmed milk used was generally, but not always, sour when applied to the filter, and the reaction of both the liquor applied to and the effluent from the filter was acid. No nitrification took place in the filter during this period, and the average analysis of the effluent for the two months of April and May was as follows: —

Effluent.

[Parts per 100,000.]

Month.	Ammonia.		Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
	Free.	Albuminoid.	Nitrates.	Nitrites.		
April, ...	5.20	18.50	.00	.0080	217.00	23,000,000
May, ...	15.23	2.72	.00	.0040	5.33	36,000,000

The greater amount of organic matter in the effluent during April was partly due to the excessive strength of the liquor applied during the first few days of operation of the filter. As stated above, up to this date the skimmed milk mixed with the water and applied to the filter was generally sour, but beginning June 1, the milk applied was sweet at the time of application to the filter on at least half the days, and when sour milk of lime was added in varying amounts of from 1 to 13 grains per gallon, enough being added each time to make this liquor slightly alkaline. The effluent of the filter did not improve, however, and continued to have a strong odor of sour milk and an acid reaction. Hence, for two weeks, from June 12 to 25 inclusive, the filter was flooded daily with water alone, the rate being the same as when the mixture of milk and water was applied. At the end of this period the filter was in good condition, and upon June 27 the regular flooding of the filter with the mixed liquor was again begun. The effluent of the filter improved slightly from this time, and during July nitrification was at times active in the filter, while at other times during the month the effluent contained practically no nitrates. The average analysis of the effluent for the month was as follows: —

Effluent.

[Parts per 100,000.]

Ammonia.		Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
Free.	Albuminoid.	Nitrates.	Nitrites.		
3.10	.31	1.00	.0550	.82	1,025,000

Nitrification was active in the filter during the first three weeks of August, but the effluent contained no nitrates during the last week of the month. During September poor results were still obtained, and on October 12 the strength of the liquid applied was still further reduced, so that it contained less than 1 per cent. of milk. The analysis of this liquid, which was applied during the remainder of this month and up to December 7, was as follows: —

Applied Liquor.

[Parts per 100,000.]

Ammonia.		Oxygen Consumed.
Free.	Albuminoid.	
.12	1.38	8.55

During the first of November nitrification again became fairly active in the filter, the average analysis of the effluent for this month and for the first week in December being as follows: —

Effluent.

[Parts per 100,000.]

Month.	Ammonia.		Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
	Free.	Albuminoid.	Nitrates.	Nitrites.		
November, . . .	.82	.1100	1.14	.0627	.52	200,000
December, . . .	.81	.0730	1.40	.0300	.38	128,000

As stated before, the odor of the effluent during the first months of operation of the filter was very strong and decidedly that of sour milk. This odor continued strong until the end of October. During November, when nitrification became fairly constant in the filter, the odor of the effluent became much less, and with the advent of colder weather in December, still less noticeable, and during the first three months of 1899 the effluent has been clear, practically colorless and without a distinguishing odor.

Upon December 7 the rate of operation of the filter was reduced to 50,000 gallons per acre daily, the proportionate mixture of milk and water being the same as from October 12. The average analysis of the liquor applied during the last three weeks of December and the first week of January, 1899, was as follows: —

Applied Liquor.

[Parts per 100,000.]

Ammonia.		Oxygen Consumed.
Free.	Albuminoid.	
.10	2.25	9.15

The average analysis of the effluent of the filter during the last three weeks of December and the first week of January was as follows: —

Effluent.

[Parts per 100,000.]

Ammonia.		Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
Free.	Albuminoid.	Nitrates.	Nitrites.		
.80	.0750	2.70	.0500	.38	77,000

Upon January 7 the strength of the applied liquor was practically doubled, but the rate of application was reduced to 25,000 gallons per acre daily, the average analysis of the applied liquor from that date up to the present time, March 31, 1899, being as follows: —

Applied Liquor.

[Parts per 100,000.]

Ammonia.		Oxygen Consumed.
Free.	Albuminoid.	
.26	4.00	35.50

The average analysis of the liquor during this period was about the same as that of the sample obtained from the Uxbridge creamery in April, 1898, and previously mentioned. The average analysis of the effluent of the filter from January 7 to March 31, 1899, is as follows: —

Effluent.

[Parts per 100,000.]

Ammonia.		Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
Free.	Albuminoid.	Nitrates.	Nitrites.		
.60	.0580	3.80	.0700	.38	26,000

During the period of operation of this filter, many bacterial analyses and determinations of the species present in the applied liquor and effluent have been made. The numbers of bacteria per cubic centimeter in the applied liquor have varied very greatly at different times. During the first period of operation, when the strongest liquor was applied, there were many million present, the first analyses showing generally from 50,000,000 to 85,000,000 bacteria per cubic centimeter at this time. With the reduction in the proportion of milk in the applied liquor, the number of bacteria decreased very greatly. Especially after the use of lime to render the applied liquor alkaline, the numbers were cut down so that at times there were only a few thousand per cubic centimeter present in the sample at the time of planting the sample and of applying the liquid to the filter. Sometimes the skimmed milk mixed with the water was sweet and sometimes sour; at the times when sweet milk was used the bacteria were very few in number as compared with the times when sour milk was used.

The range of numbers in the effluent of the filter has been nearly as great, as a rule, as in the applied liquor, and, during the last six months of operation of the filter, more bacteria have been found in the effluent than in the applied liquor. Two species have been very prominent amongst those found, both in the liquor applied to and the effluent from the filter. One of these species liquefies the gelatine plate and the other does not, but both produce lactic acid fermentation, and grow best at thirty degrees Centigrade. The applied liquor often contained the above two species, almost to the exclusion of all others. The number of species in the effluent, however, has been more varied, many kinds being found which were present in the city water applied with the milk and in the air. The two characteristic species, however, are always present. During the summer months, when the strength of the applied liquor was somewhat greater generally than that now being applied, and the rate of operation of the filter considerably higher, these two species developed in the upper portion of the filter practically to the exclusion of all other kinds, not only causing the milk to become sour shortly after its application to the filter, notwithstanding the lime used at the time of application, but also causing the sand for a considerable depth in the filter to have the characteristic odor of sour milk. The rapid growth and multiplication of these two species in the applied liquor and in the sand, and the bodies produced by them, retarded the development of the nitrifying bacteria, as shown by the results obtained. As cooler weather began, and the applied liquor and the filter itself were kept at a lower temperature, the growth of these two species became much slower, thus apparently delaying lactic acid fermentation for such a space of time that it became possible for the nitrifying bacteria to develop and establish themselves in the filter in such numbers and strength as to enable them to work over the applied liquor and produce the desired results before lactic acid fermentation could take place; and, as stated, the effluent has been for practically three months a clear, well-purified, almost colorless liquid. The rate of operation at the present time is considerably less than during the summer months, which undoubtedly has had considerable to do in obtaining more satisfactory results. Various experiments upon the use of filters of coke, iron, etc., have been tried in connection with the disposal of this waste, but without favorable results. Boracic acid in varying proportions has also been added to the waste before applying it to a sand filter, with the idea of eliminating the lactic acid bacteria and allow the greater development of the nitrifying bacteria; but this has not produced the result desired.

Cinders and Ashes as Filtering Materials.

Filter No. 80.

The use of cinders as a filtering material was begun at the experiment station during 1896, when Filter No. 80, containing 4½ feet in depth of coal ashes, was first put into operation. This filter was kept in operation until the end of September, 1898. During all this time it gave a well-purified effluent. The average rate of operation during 1898 was 84,700 gallons per acre daily. The material of the filter was almost entirely fine ashes, without any considerable portion of cinder. Owing to this, the sewage passed below the surface of the filter with considerable difficulty, as shown in the following table, and the filter was discontinued in September, as it had apparently been proved by this time that as good results qualitatively could be obtained by a filter containing less of the fine ashes, and of course the quantity applied could be greater and the degree of clogging less.

Effluent of Filter No. 80.

[Parts per 100,000.]

1898.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January,	120,000	43	42	4h. 4m.	None.	.02	0.0231	.0064	5.76	1.76	.0017	.04	114
February,	120,000	45	44	6h. 27m.	V. slight.	.04	0.0179	.0049	5.57	1.35	.0035	.05	58
March,	120,000	47	44	9h. 7m.	Slight.	.12	0.0266	.0024	5.00	1.01	.0052	.01	15
April,	93,100	45	46	8h. 5m.	Slight.	.57	0.0719	.0067	5.48	1.20	.0052	.07	13
May,	69,200	55	56	5h. 42m.	Slight.	.58	0.1521	.0087	5.61	1.97	.0072	.05	15
June,	60,000	66	67	12h.	Slight.	.50	1.0750	.0250	10.84	0.33	.0030	.06	12
July,	60,000	73	73	10h.	Slight.	.45	1.0000	.0300	9.00	0.75	.0200	.07	30
August,	60,000	74	77	50m.	None.	.08	0.0834	.0088	8.26	1.73	.0100	.06	42
September,	60,000	69	67	1h. 13m.	None.	.04	0.0376	.0056	6.90	1.45	.0006	.00	22
Average,	84,700	57	57	-	-	.27	0.2764	.0109	6.94	1.28	.0063	.05	36

Surface raked 3 inches deep each week; spaded to the depth of 6 inches April 8, 29 and July 6.

Filter No. 95.

This filter contains 4½ feet in depth of ashes from the combustion of soft coal, and was put in operation during the last part of October, 1897. The ashes in this filter were considerably coarser and of a firmer nature than those in Filter No. 80, and the rate of operation from the start up to Jan. 1, 1899, has been 100,000 gallons per acre daily. Operating at this rate the filter has produced a clear, almost colorless effluent, containing very little unoxidized organic matter, as shown by the table below. The material in the filter has been coarse enough to allow the sewage to pass readily below its surface.

Effluent of Filter No. 95.

[Parts per 100,000.]

1898.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	100,000	43	44	9m.	V. slight.	.03	.0329	.0125	5.20	1.95	.0018	.09	1,997
February, .	100,000	45	45	12m.	V. slight.	.03	.0446	.0132	6.09	2.07	.0044	.10	137
March, .	100,000	47	48	8m.	V. slight.	.07	.1013	.0231	5.99	2.16	.0023	.15	1,065
April, .	100,000	45	46	21m.	None.	.09	.0854	.0191	5.87	2.54	.0013	.15	213
May, . .	100,000	55	58	32m.	None.	.03	.0447	.0183	6.43	3.37	.0029	.15	38
June, . .	100,000	66	67	21m.	None.	.06	.0355	.0192	10.84	3.75	.0017	.15	145
July, . .	100,000	73	73	12m.	None.	.05	.0522	.0188	11.00	2.97	.0030	.12	34
August, .	100,000	74	73	13m.	None.	.02	.0248	.0131	8.50	2.07	.0004	.11	27
September,	100,000	69	63	6m.	None.	.02	.0028	.0124	8.30	2.25	.0000	.07	11
October, .	100,000	55	64	16m.	None.	.09	.0043	.0145	8.95	2.69	.0001	.13	62
November .	100,000	46	53	42m.	None.	.05	.0333	.0162	8.70	3.06	.0005	.14	39
December, .	100,000	45	46	18m.	None.	.06	.0411	.0207	7.04	2.18	.0005	.18	382
Average,	100,000	55	57	-	-	.05	.0419	.0168	7.74	2.59	.0016	.13	346

Surface raked 3 inches deep each week; spaded to a depth of 6 inches April 8.

Operation of the Large Intermittent Filters, $\frac{1}{200}$ of an Acre in Area.

The large filters, placed in the field outside the station, have accomplished their usual satisfactory work during the year. Some of these filters have now been in operation eleven years, and are without doubt in as good a physical condition as they have been since the first year or two of their operation. The following table shows the period of service to date of these filters, together with the volume of sewage applied to them and their efficiency reckoned by percentages of organic matter and bacteria removed during 1898: —

Number of Filter.	Dimensions of Filters		Date when Sewage was First Applied.	Actual Number of Gallons applied to Jan. 1, 1899.	Gallons per Acre.	Average Rate of Filtration (Gallons per Acre Daily) Six Days in a Week — 1898.	Average (1898) Per Cent Removal of		
	Depth (Inches)	Mean Diameter (Inches).					Albuminoid Ammonia.	Oxygen Consumed.	Bacteria.
1, . .	63	200	Jan. 10, 1888,	1,358,745	271,749,000	60,500	89	88	99.15
2, . .	60	200	Dec. 19, 1887,	678,268	135,653,600	38,300	96	94	99.99
4, . .	60	200	Dec. 19, 1887,	453,168	90,633,600	19,300	98	97	99.99
5A, . .	60	200	Sept. 14, 1891,	816,970	163,394,000	83,200	–*	–*	–*
5B, . .	60	200	Mar. 5, 1898,	91,600	18,320,000	70,700	93	92	98.57
6, . .	44	200	Jan. 12, 1888,	950,789	190,157,800	65,600	93	89	99.81
9A, . .	60	200	Nov. 18, 1890,	963,782	192,756,400	74,200	92	88	99.70
10, . .	60	200	July 18, 1894,	196,610	39,322,000	28,600	93	90	99.47

* In operation only two months in 1898.

Before beginning the description of these filters, it can be said that an interesting experiment was made during the year, to learn what results could be obtained by applying during the winter volumes of sewage greater than usually applied, in order to keep the filters more free from frost. It was intended, moreover, although a greater volume of sewage was applied, that this sewage should be enough weaker than the regular sewage to make the amount of organic matter reaching the filter's surface about the same as when smaller volumes of stronger sewage were used. It is the custom at the sewage disposal areas of the State to flood the beds with a very large volume of sewage on one day, and allow several days to elapse before another flooding. At these filtration areas, where the underdrains are many feet apart, this can be done with satisfactory results, the heat contained in this large volume of sewage being very efficient in removing frost from the upper portion of the sewage filters. With our relatively small experimental filters, however, each one with gravel underdrains underneath the entire area of the filter, these large volumes cannot be applied so successfully. With the increased volume applied during the cold months of 1898, however, it was evident that the upper portion of the filter was kept in a more porous condition than when smaller volumes were applied, and the effect upon the effluents obtained from the filters is shown by the following tables, in which a comparison is made of the 1897 and 1898 January and February results obtained from filters Nos. 1, 6 and 9 A: —

Average Analysis of the Effluent of Filter No. 1, January and February, 1897, and January and February, 1898.

[Parts per 100,000.]

Year.	Date of Filtration.	Temperature of Sewage.	Temperature of Effluent.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.
1897, . . .	60,000	50	40	.55	1.89	.1389	6.82	1.38	.0251	.86
1898, . . .	73,500	50	40	.45	0.98	.1210	6.19	1.66	.0770	.82

Average Analysis of the Effluent of Filter No. 6, January and February, 1897, and January and February, 1898.

[Parts per 100,000.]

Year.	Date of Filtration.	Temperature of Sewage.	Temperature of Effluent.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.
1897, . . .	60,200	50	38	.52	1.38	.1259	5.90	1.09	.1083	.77
1898, . . .	73,750	46	38	.30	0.43	.0720	4.17	1.08	.0682	.55

Average Analysis of the Effluent of Filter No. 9 A, January and February, 1897, and January and February, 1898.

[Parts per 100,000.]

Year.	Date of Filtration.	Temperature of Sewage.	Temperature of Effluent.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.
1897, . . .	57,200	46	39	.58	2.22	.1357	8.41	1.60	.0186	.88
1898, . . .	97,600	44	38	.39	0.69	.0828	4.40	1.17	.0020	.59

Studying these results in detail, we find that not only purer effluents were obtained, on account of the weaker sewage applied during these two months in 1898, but that the results were more than proportionally better, if we take into account the total nitrogen applied during each period. That is, if we multiply the total nitrogen in the average sewage applied to these filters during the first period by the rate in thousand gallons, and do the same with the total unoxidized nitrogen in the effluents, we shall find, for instance, that with Filter

No. 6 an average of 231 units of unoxidized nitrogen were applied daily during January and February, 1897, and 71 units appeared daily in the effluent, showing a removal or oxidation of 69 per cent. During January and February, 1898, an average of 194 units were applied daily, and 35 units appeared in the effluent, showing a removal or oxidation of 82 per cent. Even better comparative results, calculated in this way, were obtained with Filter No. 9 A. Tables of analyses of the sewage applied to these filters during these two periods are given on page 414 of the report for 1897 and page 437 of the present report.

Filter No. 1.

Filter No. 1 contains 60 inches in depth of coarse sand of an effective size of 0.48 millimeter, and is $\frac{1}{200}$ of an acre in area. The filter has been operated during the year at an average rate of 60,500 gallons per acre daily, and has given a satisfactory effluent. The surface of the filter has been raked 1 inch deep each week and spaded over to a depth of 6 inches on April 18 and October 1. The following table gives the averages of the analyses of the effluent for the year: —

Effluent of Filter No. 1.

[Parts per 100,000.]

1898.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January,	100,000	53	40	56m.	Great.	.48	0.9150	.1285	5.21	1.25	.0705	0.77	45,400
February,	47,000	47	40	2h. 20m.	Decided.	.41	1.0440	.1136	7.16	2.06	.0836	0.87	27,800
March,	60,000	46	43	10m.	Slight.	.32	0.3959	.0853	8.02	3.25	.0825	0.67	12,200
April,	55,400	45	46	31m.	Slight.	.27	0.0415	.0586	6.33	2.97	.0160	0.49	17,300
May,	57,700	55	51	3m.	Slight.	.21	0.0286	.0394	7.75	3.56	.0032	0.35	8,650
June,	60,000	66	64	3m.	V. slight.	.18	0.0443	.0413	7.07	3.66	.0001	0.33	27,000
July,	57,700	71	73	10m.	V. slight.	.14	0.0706	.0308	6.19	3.08	.0002	0.26	4,800
August,	60,000	72	74	8m.	Slight.	.17	0.0150	.0292	8.45	2.68	.0003	0.29	5,700
September,	60,000	68	72	6m.	V. slight.	.14	0.0119	.0225	8.35	2.35	.0001	0.26	3,000
October,	43,800	55	65	41m.	None.	.10	0.1400	.0220	6.69	2.91	.0004	0.24	5,300
November,	60,000	47	52	1h. 6m.	V. slight.	.15	0.2840	.0328	5.99	2.36	.0002	0.26	7,000
December,	64,400	45	41	2h. 38m.	Decided.	.34	1.6300	.1500	7.17	1.56	.0125	1.20	25,800
Average,	60,500	56	55	-	-	.24	0.3851	.0628	7.03	2.64	.0225	0.50	15,800

Sewage applied, 500 gallons six times a week from January 1 to February 2; 300 gallons six times a week from February 3 to December 11; 300 gallons six times a week from December 12 to 31, except when thermometer was below 15° F. at 7 A.M., when 600 gallons was applied. During January, $13\frac{1}{2}$ inches of snow and $\frac{1}{2}$ inch of ice removed; during February, $37\frac{1}{2}$ inches of snow and $\frac{1}{2}$ inch of ice removed; during March, 4 inches of snow removed; during April, 3 inches of snow removed; during November, 14 inches of snow removed; during December, $6\frac{1}{2}$ inches of snow and $1\frac{5}{8}$ inches of ice removed.

Filter No. 2.

This filter is $\frac{1}{200}$ of an acre in area and contains 60 inches in depth of fine sand of an effective size of 0.08 millimeter, with two circular trenches 1 foot wide and 2 feet deep of medium sand of an effective size of 0.19 millimeter, the surface of these trenches being below the surface of the remainder of the filter, and to these trenches the sewage is applied. The average rate of filtration for the year has been 38,300 gallons per acre daily. The surface of the trenches has been raked 1 inch deep each week and dug over to a depth of 6 inches on January 13, March 26 and October 1. The following table gives the monthly averages of the analyses of the effluent: —

Effluent of Filter No. 2.

[Parts per 100,000.]

1898.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	35,400	50	41	9h.	None.	.11	.3250	.0300	5.64	1.25	.0123	.26	256
February, .	38,300	49	39	4h. 37m.	None.	.11	.8150	.0370	4.68	1.24	.0310	.28	107
March, .	38,500	47	42	1h. 15m.	None.	.12	.7225	.0335	4.62	2.15	.0310	.24	114
April, . .	40,000	45	44	1h. 9m.	None.	.12	.0329	.0161	4.21	2.47	.0007	.18	36
May, . .	40,000	55	49	11m.	None.	.11	.0023	.0140	4.10	2.63	.0000	.16	48
June, . .	40,000	65	62	11m.	None.	.04	.0013	.0174	6.02	3.08	.0000	.17	12
July, . .	40,000	72	69	3m.	None.	.07	.0023	.0176	7.84	2.88	.0000	.20	6
August, .	40,000	73	72	8m.	None.	.06	.0015	.0172	7.80	2.67	.0000	.18	2
September,	38,500	68	72	10m.	None.	.06	.0017	.0150	7.05	2.40	.0000	.18	1
October, .	29,200	55	65	52m.	None.	.05	.0006	.0152	6.78	2.47	.0000	.17	23
November, .	40,000	47	54	1h. 24m.	None.	.05	.0028	.0154	6.56	2.73	.0000	.13	3
December, .	40,000	47	43	3h. 10m.	None.	.06	.1242	.0162	7.34	1.65	.0121	.23	3
Average,	38,300	56	54	-	-	.08	.1693	.0204	6.05	2.30	.0073	.20	51

Sewage applied, 200 gallons 6 times a week from January 1 to December 31. July 29, cut grass and weeds on surface. During January, 17 inches of snow removed from surface and $2\frac{1}{8}$ inches of ice from trenches; during February, 39 inches of snow removed from surface and 1 inch of ice from trenches; during March, 3 inches of snow removed from surface; during April, 3 inches of snow removed; during November, 14 inches of snow removed; during December, $6\frac{3}{4}$ inches of snow removed from surface and $1\frac{1}{2}$ inches of ice from trenches.

Filter No. 4.

This filter is $\frac{1}{200}$ of an acre in area and contains 60 inches in depth of fine river silt of an effective size of 0.04 millimeter, with two circular trenches, about 14 inches wide and 12 inches deep, of coarse sand of an effective size of 0.48 millimeter. The surface of these trenches is below the surface of the remainder of the filter and to them the sewage is applied. The average rate of filtration for the year has been 19,300 gallons per acre daily. The surface of the trenches has been raked 1 inch deep each week and spaded to a depth of 6 inches on March 26 and October 1. The following table gives the averages of the analyses of the effluent: —

Effluent of Filter No. 4.

[Parts per 100,000.]

1898.	Quantity Applied — Gallons per Acre Daily for Six Days in a Week.	Temperature, Deg. F. — Sewage.	Temperature, Deg. F. — Effluent.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance. — Turbidity.	Appearance. — Color.	Ammonia. — Free.	Ammonia. — Albuminoid.	Chlorine.	Nitrogen as — Nitrates.	Nitrogen as — Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January,	20,000	48	43	9h.	None.	.02	.0133	.0116	6.69	1.99	.0004	.10	9
February,	18,300	49	42	7h. 23m.	None.	.04	.0520	.0143	4.73	1.14	.0025	.15	14
March,	19,300	46	42	50m.	None.	.02	.1479	.0144	4.76	1.45	.0021	.16	8
April,	20,000	45	45	52m.	None.	.01	.1679	.0146	5.14	2.82	.0004	.11	12
May,	20,000	54	50	11m.	None.	.01	.0307	.0108	3.94	2.67	.0003	.11	4
June,	20,000	65	63	9m.	None.	.02	.0032	.0120	5.76	2.77	.0000	.10	42
July,	20,000	71	70	4m.	None.	.04	.0023	.0113	7.25	2.03	.0000	.12	2
August,	19,300	73	70	7m.	None.	.02	.0022	.0109	7.58	2.12	.0000	.11	5
September,	20,000	69	72	10m.	None.	.02	.0022	.0136	7.44	2.42	.0000	.10	8
October,	13,800	55	64	54m.	None.	.02	.0016	.0116	7.32	3.08	.0000	.09	0
November,	20,000	47	54	18m.	None.	.02	.0011	.0098	6.73	2.47	.0000	.03	3
December,	20,700	47	46	2h. 50m.	None.	.01	.0010	.0073	6.21	2.25	.0000	.07	5
Average,	19,300	56	55	-	-	.02	.0355	.0119	6.13	2.27	.0005	.10	9

Sewage applied, 200 gallons three times a week from January 1 to December 31. July 29, cut grass and weeds on surface. During January, 13 inches of snow removed from surface and 1⅛ inches of ice from trenches; during February, 38½ inches of snow removed from surface and 3½ inches of ice from trenches; during March, 3½ inches of snow removed; during April, 3 inches of snow removed; during November, 14 inches of snow removed; during December, 6 inches of snow removed from surface and ¾ inch of ice from trenches.

Filter No. 5 A.

This filter was $\frac{1}{200}$ of an acre in area and contained 60 inches in depth of fine gravel of an effective size of 1.40 millimeters. The filter was constructed in September, 1891, and sewage was first applied to it on Sept. 14, 1891. It was discontinued on March 3, 1898. It received during the period of its operation 816,970 gallons of sewage, equal to 163,394,000 upon an acre. It was operated during these years at an average rate of about 60,000 gallons per acre daily, and while, owing to the coarseness of the filtering material, its effluent was never of the degree of purity obtained with some of the other filters, still the percentage of purification was high, and the filter took the applied sewage without difficulty, and when the experiment was ended, the filtering material was in good condition and apparently capable of receiving sewage for an indefinite period of time.

Effluent of Filter No. 5 A.

[Parts per 100,000.]

1898.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	83,100	46	38	38m.	Great.	.43	1.5714	.1740	7.38	0.55	.1151	1.00	21,000
February, .	83,300	47	39	19m.	Decided.	.32	1.2100	.1275	5.64	1.38	.2845	0.76	24,900

Sewage applied, 500 gallons six times a week from January 1 to March 2. During January, 15 inches of snow and $2\frac{1}{8}$ inches of ice removed from surface; during February, 39 inches of snow and 2 inches of ice removed.

Filter No. 5 B.

This filter is $\frac{1}{200}$ of an acre in area and contains 60 inches in depth of a mixture of cinders and ashes from the combustion of soft coal. It was first put in operation on March 5, 1898, and has been operated during the year at an average rate of 73,000 gallons per acre daily. The surface has been raked 1 inch deep each week. The following table gives the averages of the analyses of the effluent of this filter : —

Effluent of Filter No. 5 B.

[Parts per 100,000.]

1898.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
March, .	100,000	48	43	4m.	V. slight.	.16	1.4133	.0400	5.95	0.24	.0383	.27	57,000
April, . .	100,000	45	44	10m.	Decided.	.26	0.9667	.0587	4.18	1.17	.0140	.37	35,000
May, . .	78,500	54	51	2m.	None.	.10	0.1071	.0159	5.94	2.31	.0074	.15	6,000
June, . .	60,000	65	63	3m.	None.	.03	0.0036	.0100	8.96	2.53	.0007	.09	386
July, . .	60,000	71	71	4m.	None.	.08	0.0090	.0161	7.95	2.11	.0002	.15	760
August, .	60,000	72	73	7m.	None.	.06	0.0459	.0126	9.04	1.89	.0019	.09	870
September,	60,000	68	72	4m.	Slight.	.20	0.3628	.0332	7.69	1.58	.0023	.23	20,070
October, .	43,800	55	65	16m.	Decided.	.25	0.3000	.0760	7.62	2.69	.0008	.43	63,800
November, .	57,700	47	53	18m.	V. slight.	.18	0.6152	.0498	7.75	2.44	.0028	.29	20,250
December, .	86,700	44	42	54m.	Slight.	.28	1.5200	.0950	7.18	1.57	.0100	.62	50,700
Average,	72,800	55	55	-	-	.20	0.6771	.0591	7.11	1.71	.0398	.37	25,100

Sewage applied, 500 gallons six times a week from March 5 to May 15; 300 gallons six times a week from May 16 to December 11; 500 gallons six times a week from December 12 to 31. During March, 4 inches of snow removed from surface; during April, 3 inches of snow removed; during November, 14 inches of snow removed; during December, 6½ inches of snow and 1¼ inches of ice removed.

Filter No. 6.

This filter is $\frac{1}{200}$ of an acre in area and contains 44 inches in depth of mixed coarse and fine sand of an effective size of 0.35 millimeter. The average rate of filtration for the year has been 65,600 gallons per acre daily. The surface of the filter has been raked to the depth of 1 inch each week and spaded to the depth of 6 inches on April 18 and October 1. The following table gives the averages of the analyses of the effluent of this filter: —

Effluent of Filter No. 6.

[Parts per 100,000.]

1898.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January, .	70,800	44	38	12h.	Decided.	.32	.4675	.0765	4.30	0.94	.0485	.56	7,100
February, .	76,700	43	38	2h. 54m.	Slight.	.29	.3920	.0676	4.05	1.22	.0880	.54	8,300
March, .	80,000	44	42	44m.	Slight.	.27	.2600	.0600	4.35	1.73	.0425	.47	5,800
April, .	70,800	46	44	31m.	V. slight.	.22	.0401	.0394	3.63	2.39	.0089	.36	3,700
May, . .	69,300	57	53	5m.	None.	.17	.0098	.0266	6.05	4.18	.0000	.30	2,150
June, . .	60,000	67	64	5m.	V. slight.	.16	.0036	.0379	8.66	4.40	.0000	.29	9,050
July, . .	55,400	74	71	5m.	None.	.13	.0353	.0288	10.37	3.99	.0001	.30	669
August, .	60,000	75	74	10m.	None.	.15	.0036	.0206	14.39	3.34	.0000	.24	235
September,	60,000	70	72	12m.	None.	.11	.0023	.0183	8.86	3.08	.0000	.22	484
October, .	43,800	56	65	23m.	None.	.11	.0122	.0198	7.80	3.07	.0006	.20	410
November, .	57,700	47	51	12m.	None.	.15	.4990	.0330	6.86	2.67	.0001	.24	623
December, .	83,000	46	40	3h.	V. slight.	.30	.9300	.0590	5.39	1.76	.0005	.49	3,144
Average,	65,600	56	54	-	-	.20	.2213	.0406	7.06	2.73	.0158	.35	3,472

Sewage applied, 400 gallons six times a week from January 1 to May 15; 300 gallons six times a week from May 16 to December 11; 500 gallons 6 times a week from December 12 to 31. During January, 16¼ inches of snow and 1⅜ inches of ice removed; during February 54 inches of snow and 4 inches of ice removed; during March, 4 inches of snow removed; during April, 3 inches of snow removed; during November, 27 inches of snow removed; during December, 3 inches of snow and 5¼ inches of ice removed.

Filter No. 9 A.

This filter is $\frac{1}{200}$ of an acre in area and contains 5 feet in depth of sand of an effective size of 0.17 millimeter. The average rate of filtration maintained during the year has been 74,200 gallons per acre daily. The surface of the filter has been raked 1 inch deep each week and spaded to a depth of 6 inches on April 18 and October 1. The following table gives the averages of the analyses of the effluent of this filter: —

Effluent of Filter No. 9 A.

[Parts per 100,000.]

1898.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	107,700	43	38	2h. 16m.	Decided.	.44	0.9283	.0880	4.31	0.84	.0023	.62	7,900
February, .	87,500	45	38	1h. 21m.	Slight.	.34	0.4460	.0776	4.49	1.50	.0016	.56	10,400
March, .	100,000	47	41	41m.	Decided.	.33	0.4471	.0660	6.17	1.85	.0013	.55	9,200
April, .	88,500	45	45	52m.	V. slight.	.25	0.1201	.0479	4.94	2.22	.0000	.39	7,500
May, . .	78,500	55	51	11m.	V. slight.	.18	0.0136	.0261	5.79	3.21	.0000	.27	2,768
June . .	60,000	66	62	10m.	V. slight.	.14	0.0067	.0274	6.43	4.00	.0000	.24	1,182
July, . .	57,700	73	70	11m.	V. slight.	.12	0.0365	.0258	8.84	3.61	.0000	.26	293
August, .	60,000	74	72	33m.	V. slight.	.12	0.0036	.0180	8.51	2.29	.0000	.28	600
September,	60,000	69	71	25m.	V. slight.	.11	0.0022	.0168	6.26	2.09	.0000	.23	333
October, .	43,800	55	63	1h. 5m.	V. slight.	.19	0.2000	.0320	5.92	1.82	.0002	.24	-
November,	60,000	46	52	57m.	V. slight.	.12	0.2780	.0282	6.54	2.67	.0001	.20	388
December,	86,700	45	41	3h. 14m.	Decided.	.51	1.4100	.0960	5.70	0.98	.0023	.87	20,000
Average,	74,200	55	54	-	-	.25	0.3243	.0458	6.16	2.26	.0007	.39	5,500

Sewage applied, 500 gallons six times a week from January 1 to May 15; 300 gallons six times a week from May 16 to December 11; 500 gallons six times a week from December 12 to 31. During January, 17½ inches of snow and 4¼ inches of ice removed from surface; during February, 45 inches of snow and 2¼ inches of ice removed; during March, 4½ inches of snow removed; during April, 3 inches of snow removed; during November, 18 inches of snow removed; during December, 6 inches of snow and ¾ inch of ice removed.

Filter No. 10.

This filter is $\frac{1}{200}$ of an acre in area and contains 5 feet in depth of mixed coarse and fine sand of an effective size of 0.35 millimeter. No underdrains are beneath the sand, except directly above and around the outlet pipe. A partition extending 3 feet below the surface separates the quarter of the surface farthest from the underdrains from the remainder of the surface. To this quarter of the surface the sewage has been applied during 1898 at a rate of 114,400 gallons per acre daily. The portion of the surface to which sewage is applied has been raked over 1 inch deep each week. The entire surface was spaded to a depth of 6 inches on March 26 and October 1: —

Effluent of Filter No. 10.

[Parts per 100,000.]

1898.	Quantity Applied. Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January, .	30,000	41	39	8h. 36m.	Decided.	.43	1.1850	.1130	4.53	1.00	.0250	.67	6,800
February, .	26,300	43	38	10h. 50m.	Slight.	.25	0.6820	.0740	3.28	1.24	.0288	.43	25,900
March, .	27,800	44	40	36m.	V. slight.	.17	0.2780	.0453	4.09	2.09	.0050	.31	6,500
April, .	30,000	46	45	15m.	None.	.16	0.0156	.0312	3.63	2.48	.0000	.26	1,240
May, . .	30,000	57	51	4m.	None.	.15	0.0194	.0229	6.09	3.05	.0000	.24	130
June, . .	30,000	67	64	4m.	None.	.13	0.0230	.0338	1.86	4.47	.0002	.27	750
July, . .	28,800	74	70	3m.	None.	.14	0.0793	.0316	10.93	3.91	.0001	.33	376
August, .	30,000	75	72	6m.	None.	.15	0.0114	.0220	14.61	2.72	.0000	.25	125
September,	30,000	70	72	9m.	None.	.11	0.0036	.0195	9.01	3.02	.0000	.20	108
October, .	21,900	56	64	9m.	None.	.11	0.1664	.0248	7.60	3.51	.0012	.22	24
November, .	30,000	46	52	6m.	None.	.12	0.1056	.0257	6.80	3.06	.0000	.21	119
December, .	28,900	44	43	4h.	Slight.	.30	0.7450	.0700	5.79	1.60	.0052	.53	9,866
Average, .	28,600	55	54	-	-	.19	0.2762	.0428	6.94	2.68	.0055	.33	4,328

Sewage applied, 150 gallons six times a week. During January, 20½ inches of snow and 5⅜ inches of ice removed from that part of surface to which sewage was applied; during February, 43 inches of snow and 2 inches of ice removed; during March, 3 inches of snow removed; during April, 3 inches of snow removed; during November, 17 inches of snow removed, during December, 4½ inches of snow and 2⅜ inches of ice removed.

FILTRATION OF WATER.

During 1898 the usual determinations of the efficiency of the experimental sand filters in operation at the station, and also of the Lawrence city filter have been made. Besides the determination of the total number of bacteria of all kinds present in the river water and in the filtered water from the various experimental filters and from the Lawrence city filter, many tests have been made to determine the presence or absence of *B. coli communis*, the characteristic bacteria of sewage. The reason for undertaking this work was to ascertain if sand filters remove the same percentage of *B. coli* that they do of the total number of bacteria present in badly polluted water. It was believed that by a continuation of this work for sufficient time, the significance of the appearance of this germ in filtered water could be determined, because of the opportunity presented of studying the results obtained in regard to its presence in the samples of the filtered city water taken from various points upon the system, together with the occurrence or non-occurrence of typhoid fever in the city. The bacterial results obtained from the city filter could also be directly compared with the results obtained from the experimental filters at the station, receiving the same polluted river water.

Different rates of filtration have also been tried with these experimental filters, in order to determine the highest rate that can be followed with natural sand filters and eliminate this germ from the water. The effect of different seasons — that is, of warm and cold weather — upon the efficiency of the filters in this respect has also been studied. It has usually been assumed that the absence of *B. coli* from filtered water is proof of the absence of the typhoid germ, and that its presence in a filtered water is suspicious, as typhoid may possibly at times accompany it, because the place of origin of the two germs is the same, namely, the human intestine. The typhoid germ is never found unaccompanied by the colon bacillus, although the reverse is, of course, far from true. We assume that for every typhoid bacillus in a polluted water there must be many thousands of the *B. coli*, since the latter are found in the dejecta from all human beings and some animals, while the typhoid bacillus comes only from persons who are ill with that particular disease. The length of life of the two germs is believed to be quite similar, experiments at the station, made several years ago, showing that the typhoid germ would live in unsterilized water in diminishing numbers for periods of even twenty days, and other experiments showing a corresponding length of life of *B. coli* under like conditions.

During the past year additional experiments have been made, and apparently somewhat shorter lengths of life, especially of the typhoid germ, have been shown than in the previous investigations. These experiments, however, differed from the former ones in that sewage-polluted water was used in these latter experiments with the bacilli present in their natural state, instead of unsterilized river water with a laboratory culture of the germ added.

Lawrence City Filter.

Determinations made throughout the year 1898 of the number of *B. coli* present in samples of Merrimack River water, collected from the river at the inlet of the Lawrence city filter, showed that it varied from an average of 20 per cubic centimeter in May and June to 92 per cubic centimeter in August and September; the average for the entire year being 47 per cubic centimeter. Up to Oct. 1, 1898, of 117 samples of the filtered water collected at the city filter and examined for this germ, 9 samples, or 8 per cent., showed its presence in a single colony. Five of these samples in which it was found were, however, taken at times of scraping the filter, or other disturbances of the sand. Of 119 samples, collected during the same period from the tap at the city hall after the filtered water had passed through the reservoir and about one mile of pipe, 4 showed the presence of *B. coli*.

The bacterial efficiency of the filter, calculated upon the total number of bacteria removed from January 1 to October 30, was 99.24 per cent. This, taken into consideration together with the *B. coli* results and the small number of cases of typhoid fever in the city during the year and the low death rate from typhoid, as shown in a table beyond, — a rate much lower than the average for the State and the lowest in Lawrence for many years, — indicates that the occasional appearance of *B. coli* in filtered water is probably not of great significance. In fact, the complete results obtained from the filter — that is, both bacterial and hygienic — indicate that, if a polluted water shows, after filtration, its presence only occasionally and generally only a single colony on a plate, and negative results in this respect generally, the water is efficiently purified. It seems reasonable to assume this because of, first, the much greater number of *B. coli* in any polluted water than of typhoid germs; second, the somewhat greater virility and longevity of *B. coli* germs when in a media unfavorable for their growth — that is, water or sand — than of typhoid germs under the same conditions; third, experimental data obtained at the Lawrence Experiment Station and elsewhere going to prove that a sand filter removes a much larger percentage of typhoid germs from water than of *B. coli*. The rate of operation of the city filter is about 1,500,000 gallons per acre daily.

Owing to a clogging by iron rust, and a growth of Crenothrix, of the gravel forming or surrounding the underdrains of the filter during the five years of its operation, it became necessary during 1898 to remove this clogging material. This was done during October, November and December, and caused many sections of sand to be dug out and the sand replaced over the renewed underdrains. The filter being all in one area of 2.5 acres, these sections had to be flooded and the water filtered through them used immediately in connection with that coming from the remainder of the filter which remained undisturbed and in good working order. Owing to this, the number of bacteria in the filtered water increased somewhat for a few days following each of the first two disturbances. With this increase in numbers, *B. coli* appeared for a day or two only, after the first two disturbances. When filling in over the underdrains at the time of the last disturbance on December 9, the sudden advent of winter weather caused some of the sand thrown out to freeze, and, although this was said to be carefully broken up and reduced to small particles before being replaced, it probably left this section of the filter more open than the remainder of the filter, and probably allowed the water to flow through this section too rapidly for good filtration, for the number of bacteria in the effluent was high for twenty days or more after this back-filling, and *B. coli* appeared in the filtered water for a still longer period. The previous work upon the filter on October 19 and 20 and November 15 to 19 inclusive had apparently little, if any, detrimental effect upon the health of the city, but from the 20th of December to the end of the year an unusual number of cases of typhoid fever occurred.

During the time of these disturbances of the filter — that is, from October 1 to December 31 — *B. coli communis* was found in 23 samples out of the 53 samples examined; that is, more than 40 per cent. of the samples collected during these three months contained *B. coli*, as compared with 8 per cent. during the first nine months of the year. The bacterial efficiency of the filter from October 19 to December 31 inclusive was 97 per cent. The results of the bacterial examinations of samples of the river water and filtered water collected at different points upon the system up to May 1, 1898, have been given in previous reports. The following tables give the bacterial results from May 1 up to Jan. 1, 1899, and tables beyond give the results of chemical analyses of the river water and filtered water: —

Average Number of Bacteria per Cubic Centimeter in River and Filtered Water.

Week ending —	Merrimack River Water.	Filtered Water from			
		City Filter.	Reservoir Outlet.	Tap at City Hall.	Tap at Experiment Station.
May 7,	1,900	35	17	11	24
14,	2,000	75	17	16	20
21,	1,600	28	23	22	39
28,	2,700	55	47	24	25
June 4,	17,600	6	53	37	21
11,	3,200	45	14	16	14
18,	2,800	118	38	48	25
25,	3,500	29	31	61	21
July 2,	1,400	16	26	16	26
9,	4,700	27	57	35	34
16,	2,900	11	75	87	40
23,	1,300	13	84	68	32
30,	3,900	22	105	45	26
Aug. 6,	3,600	4	55	42	37
13,	4,200	70	29	31	33
20,	2,500	11	32	22	17
27,	24,000	–	–	–	12
Sept. 3,	6,400	70	55	33	33
10,	7,300	–	–	–	42
17,	7,100	129	81	45	28
24,	3,600	3	43	83	25
Oct. 1,	7,300	–	42	40	17
8,	3,200	19	41	49	23
15,	2,400	37	35	46	27
22,	5,600	31	22	38	20
29,	7,100	25	31	47	20
Average,	5,150	39	44	40	26

October 19-20, cleaning underdrains of beds 13 and 19.

Number of Bacteria and B. Coli Communis in River and Filtered Water — November, 1898.

1898.	Merrimack River.		City Filter.		Reservoir.		City Hall.		Tap at Experiment Station.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
November 1,	1,700	33	17	0	74	0	68	0	70	0
2,	3,100	4	23	0	73	0	50	0	252	0
3,	2,800	-	15	1	-	-	98	0	486	1
4,	700	54	13	0	218	0	304	0	191	0
5,	5,600	12	10	0	251	0	189	0	98	1
6,	-	-	-	-	-	-	-	-	-	-
7,	3,400	50	8	0	298	0	179	1	87	0
8,	2,600	5	2	0	88	0	138	0	52	0
9,	2,400	74	7	0	145	0	89	0	40	0
10,	4,600	43	8	0	127	0	77	0	-	-
11,	19,700	24	24	0	120	0	-	-	49	0
12,	-	-	25	0	97	0	106	0	25	0
13,	-	-	-	-	-	-	-	-	-	-
14,	6,800	8	87	0	92	0	66	0	60	0
15,	3,400	9	-	-	97	0	133	0	47	0
16,	200	0	-	-	112	0	75	0	78	0
17,	3,400	10	-	-	67	0	22	0	-	-
18,	4,700	4	306*	0	111	0	340	0	66	0
19,	8,400	11	630†	1	141	0	113	0	58	0
20,	-	-	468‡	1	274	0	-	-	-	-
21,	8,100	38	325	1	250	0	231	1	101	0
22,	3,800	28	123	0	141	1	119	1	96	1
23,	6,200	8	211	0	272	1	192	0	113	1
24,	-	-	-	-	-	-	-	-	-	-
25,	3,400	16	124	0	228	0	201	0	74	0
26,	4,300	30	107	1	220	1	148	0	97	0
27,	-	-	-	-	-	-	-	-	-	-
28,	-	-	-	-	-	-	-	-	139	0
29,	2,800	38	119	1	112	0	114	1	72	0
30,	1,400	30	40	0	115	0	65	0	38	0
Average,	4,310	-	122	-	155	-	136	-	104	-

* Average of 2 samples. † Average of 9 samples, *B. coli* in only one. ‡ Average of 2 samples.

November 13, water shut off filter at 6 P.M. November 15–19, filter drained; all beds scraped; beds 14, 15, 18, 19 dug out; underdrains rebuilt, refilled to grade with mixture of old and washed sand.

Number of Bacteria and B. Coli Communis in River and Filtered Water, December, 1898.

1898.	Merrimack River. Bacteria.	Merrimack River. B. Coli.	City Filter. Bacteria.	City Filter. B. Coli.	Reservoir. Bacteria.	Reservoir. B. Coli.	City Hall. Bacteria.	City Hall. B. Coli.	Tap at Experiment Station. Bacteria.	Tap at Experiment Station. B. Coli.
December 1,	3,300	12	65	1	96	0	60	0	284	0
2,	15,800	16	74	0	84	1	77	0	35	0
3,	3,000	5	116	0	102	0	52	0	54	0
4,	-	-	-	-	-	-	-	-	-	-
5,	11,100	18	98	0	72	0	96	0	70	0
6,	8,000	0	63*	1*	63	0	51	0	34	0
7,	3,500	13	-	-	67	0	37	0	31	0
8,	5,200	13	-	-	57	0	27	0	43	0
9,	5,200	12	-	-	68	0	44	0	32	0
10,	4,700	5	486†	1	64	0	-	-	37	0
11,	-	-	455‡	1	144	0	-	-	-	-
12,	2,900	16	473	1	175	1	132	1	111	1
13,	2,800	28	610	1	317	0	300	1	174	1
14,	1,700	15	607	1	321	0	263	0	250	0
15,	3,300	45	632	1	262	1	366	1	282	0
16,	1,700	65	377	1	426	1	476	1	264	1
17,	-	-	217	0	248	0	333	0	329	1
18,	-	-	-	-	-	-	-	-	-	-
19,	3,300	10	284	1	437	1	365	1	333	0
20,	4,600	13	191	1	332	1	353	1	207	1
21,	2,100	146	198	1	272	1	208	1	215	1
22,	6,800	17	-	-	327	1	344	1	350	1
23,	7,500	19	226	0	232	1	260	1	252	0
24,	8,100	6	378	1	496	1	488	1	125	0
25,	-	-	-	-	-	-	-	-	-	-
26,	-	-	-	-	-	-	-	-	-	-
27,	1,200	33	300	1	574	1	-	-	257	0
28,	7,300	32	100	0	577	0	386	0	131	0
29,	3,200	6	159	1	260	0	256	0	195	1
30,	5,500	7	131	0	-	-	284	1	102	0
31,	8,300	13	217	0	400	0	262	1	192	0
Averages,	5,200	-	280	-	249	-	230	-	169	-

* Water standing in force main. † Average of 9 samples.
‡ Average of 2 samples, *B. coli* in both.

December 5, water shut off filter at 1.40 P.M. December 6-9, filter drained, scraped; beds 16, 17, 21, 22 dug out; underdrains rebuilt, and beds refilled with a mixture of old and washed sand. December 8-9, very cold.

Merrimack River Water as it flows upon the Lawrence City Filter.

[Parts per 100,000.]

1898.	Temperature. Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Soluble.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
January,	32	.41	.0054	.0177	.0139	.21	.020	.0000	.41	1.1
February,	34	.37	.0051	.0130	.0113	.25	.017	.0000	.35	1.2
March,	39	.41	.0026	.0140	.0110	.17	.011	.0000	.45	1.1
April,	47	.43	.0035	.0163	.0136	.18	.013	.0000	.39	0.9
May,	54	.41	.0039	.0154	.0134	.16	.010	.0000	.40	1.2
June,	66	.49	.0070	.0192	.0163	.15	.010	.0000	.49	1.3
July,	76	.43	.0114	.0239	.0176	.25	.012	.0003	.41	1.4
August,	80	.41	.0140	.0274	.0170	.25	.010	.0004	.39	1.4
September,	68	.42	.0085	.0226	.0183	.27	.015	.0003	.35	1.5
October,	56	.64	.0078	.0231	.0209	.26	.012	.0001	.66	1.1
November,	42	.57	.0026	.0228	.0186	.23	.010	.0000	.61	0.7
December,	33	.44	.0065	.0165	.0144	.17	.016	.0001	.42	0.9
Average,	52	.45	.0065	.0193	.0155	.21	.013	.0001	.44	1.2

Effluent from the City Filter.

[Parts per 100,000.]

1898.	Temperature. Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Soluble.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
January,	34	.45	.0085	.0092	.0083	.22	.037	.0000	.31	1.5
February,	36	.49	.0143	.0088	.0083	.27	.044	.0000	.30	1.7
March,	42	.46	.0117	.0076	.0074	.21	.040	.0000	.28	1.6
April,	47	.36	.0074	.0093	.0081	.19	.032	.0000	.27	1.3
May,	58	.38	.0068	.0091	.0088	.16	.044	.0000	.26	1.4
June,	64	.33	.0076	.0094	.0092	.16	.043	.0000	.25	1.8
July,	76	.24	.0063	.0083	.0078	.28	.037	.0000	.18	1.7
August,	71	.27	.0134	.0086	.0074	.33	.057	.0002	.23	2.2
September,	66	.33	.0074	.0102	.0098	.29	.039	.0000	.25	1.8
October,	58	.53	.0070	.0137	.0131	.27	.032	.0000	.46	1.5
November,	44	.55	.0110	.0122	.0114	.23	.064	.0000	.41	1.7
December,	38	.47	.0169	.0100	.0098	.20	.065	.0001	.33	1.9
Average,	53	.41	.0099	.0097	.0091	.23	.045	.0000	.29	1.7

Water from the Outlet of the Distributing Reservoir.

[Parts per 100,000.]

1898.	Temperature. Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Soluble.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
January,	35	.41	.0080	.0090	.0088	.22	.042	.0000	.30	1.5
February,	36	.44	.0092	.0087	.0084	.26	.047	.0000	.26	1.8
March,	42	.44	.0092	.0084	.0082	.21	.040	.0000	.26	1.7
April,	45	.38	.0047	.0086	.0081	.19	.034	.0000	.24	1.2
May,	55	.33	.0030	.0091	.0087	.16	.044	.0000	.24	1.4
June,	64	.29	.0029	.0093	.0088	.16	.043	.0000	.23	1.4
July,	75	.24	.0032	.0098	.0095	.25	.042	.0000	.20	1.7
August,	75	.29	.0028	.0118	.0112	.25	.035	.0000	.28	1.7
September,	68	.27	.0035	.0111	.0104	.28	.035	.0000	.23	1.8
October,	58	.39	.0027	.0155	.0115	.28	.036	.0000	.33	1.5
November,	46	.49	.0038	.0118	.0116	.23	.035	.0000	.44	1.3
December,	36	.45	.0072	.0106	.0100	.18	.038	.0001	.35	1.3
Average,	53	.37	.0050	.0103	.0096	.22	.039	.0000	.28	1.5

Water from a Tap at the Lawrence City Hall.

[Parts per 100,000.]

1898.	Temperature. Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
January,	37	.43	.0057	.0087	.22	.041	.0000	.28	1.6
February,	38	.43	.0068	.0085	.26	.046	.0000	.25	1.8
March,	41	.44	.0060	.0071	.21	.040	.0000	.25	1.6
April,	45	.35	.0042	.0086	.19	.038	.0000	.28	1.2
May,	55	.36	.0018	.0083	.17	.046	.0000	.23	1.3
June,	68	.26	.0014	.0086	.16	.046	.0000	.21	1.4
July,	72	.22	.0020	.0086	.27	.043	.0000	.18	1.6
August,	72	.15	.0016	.0066	.28	.048	.0000	.17	1.5
September,	68	.24	.0019	.0091	.27	.035	.0000	.22	1.9
October,	59	.34	.0021	.0109	.28	.036	.0000	.29	1.6
November,	53	.45	.0020	.0120	.23	.039	.0000	.42	1.3
December,	51	.45	.0055	.0103	.17	.042	.0001	.35	1.3
Average,	55	.34	.0034	.0089	.23	.042	.0000	.26	1.5

Water from a Tap at the Lawrence Experiment Station.

[Parts per 100,000.]

1898.	Temperature. Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
January,	41	.40	.0037	.0084	.22	.040	.0000	.27	1.5
February,	41	.41	.0042	.0078	.26	.045	.0000	.23	1.8
March,	43	.41	.0035	.0071	.21	.040	.0000	.26	1.5
April,	50	.32	.0011	.0080	.18	.039	.0000	.24	1.2
May,	52	.29	.0017	.0081	.17	.046	.0000	.21	1.3
June,	64	.24	.0009	.0086	.16	.045	.0000	.20	1.4
July,	65	.18	.0011	.0078	.27	.045	.0000	.18	1.6
August,	69	.16	.0013	.0070	.30	.043	.0000	.16	1.7
September,	67	.20	.0064	.0089	.27	.039	.0000	.19	1.7
October,	62	.28	.0007	.0108	.28	.039	.0000	.28	1.6
November,	52	.41	.0004	.0120	.25	.037	.0000	.39	1.3
December,	47	.41	.0026	.0104	.18	.042	.0000	.33	1.3
Average,	54	.31	.0023	.0087	.23	.042	.0000	.25	1.5

Deaths from Typhoid Fever in Lawrence, 1887–98.

Years.	Total Number of Deaths.	Deaths per 10,000 of Population.	Persons who may have been exposed to Infection — By drinking Canal Water.	Persons who may have been exposed to Infection — While living out of Town just before falling sick in Lawrence.
1887,	47	11.44	-	-
1888,	48	11.36	-	-
1889,	55	12.66	-	-
1890,	60	13.44	-	-
1891,	55	11.94	-	-
1892,	50	10.52	-	-
1893,	39	7.96	-	-
1894,	24	4.75	12	4
1895,	16	3.07	9	2
1896,	10	1.86	2	4
1897,	9	1.62	-	-
1898,	8	1.39	1	-

RESULTS FROM FILTERS NOS. 3, 7 AND 8.

From Dec. 1, 1897, to Jan. 7, 1898, these three filters were operated at an approximate rate of 4,000,000 gallons per acre daily. Filters Nos. 3 and 8 each contained about 4 feet in depth of sand of an effective size of 0.23 millimeter; Filter No. 3 being an intermittent filter and Filter No. 8 a continuous filter. Filter No. 7 contained 18 inches in depth of sand of an effective size of 0.26 millimeter, and is a continuous filter. Each of these filters is one two-hundredths of an acre in area, and covered so that no ice is formed upon its surface even in the coldest weather. Operating at the rate given, 61 per cent. of the samples from filters Nos. 3 and 7 which were collected and examined contained *B. coli*, and 39 per cent. of the samples from Filter No. 8. Deducting the number of samples taken at or soon after times of scraping or other disturbances of the sand of the filter, 13 per cent. of the samples from filters Nos. 3 and 8 showed the presence of *B. coli* and 22 per cent. of the samples from Filter No. 7. During this period the bacterial efficiency of Filter No. 3 was 98.00 per cent. and of Filter No. 8 99.25 per cent.; this percentage being based upon the total number of the bacteria present in the unfiltered water that was removed by the filters.

Upon Jan. 7, 1898, the rate of the filters was reduced to 2,500,000 gallons per acre daily, and this rate continued until August 8 of the same year. During this period only 9 per cent. of the samples from filters Nos. 3 and 8 contained *B. coli* and 11 per cent. of the samples from Filter No. 7. Deducting the samples taken soon after times of scraping or other disturbances of the filter, only 3½ per cent. of the samples from Filter No. 3 contained *B. coli* and 6 per cent. of those from filters Nos. 7 and 8. During this period the bacterial efficiency of Filter No. 3 was 99.50 per cent. and of Filter No. 8, 99.63 per cent.

Upon August 8 the rate of filtration of all the filters was again placed at 4,000,000 gallons per acre daily, and so continued until November 14. Much better results, however, were obtained operating at this rate during this period of warm weather than during the period of cold weather from Dec. 1, 1897, to Jan. 7, 1898, when the filters were operated at an equal rate as noted above. During this period, from August 8 to November 14, only 5 per cent. of the samples from Filter No. 3, collected at periods of normal operation of the filter, contained *B. coli*, 7 per cent. of the samples from Filter No. 8, and 10 per cent. of the samples from Filter No. 7. During this third period the bacterial efficiency of Filter No. 3 was 99.70 per cent. and of Filter No. 8, 99.68 per cent. Every sample of canal water collected contained *B. coli*, the average number being 54 per cubic centimeter.

Summarizing these results in another way, showing the different action of intermittent and continuous filters at different seasons of the year, and also showing the general effect of cold and warm weather, we find the following facts: —

Filters Nos. 3 and 8, as stated, were operated at approximately equal rates during the year, although the rate of intermittent Filter No. 3 was always somewhat less than that of continuous Filter No. 8. Of the 52 samples of the effluent of Filter No. 3 which contained *B. coli*, 45 were collected during the colder six months of the year and 7 during the warmer six months. Of the 34 samples collected from Filter No. 8 which contained *B. coli*, 18 were collected during the colder and 16 during the warmer months of the year. Studying these results and comparing the bacterial efficiency of the filters with the number of samples of effluent that contained *B. coli*, we must conclude that, even though we can obtain a bacterial efficiency of 99.44 per cent. when filtering water as polluted as that of the Merrimack River through four feet of sand at a rate of 4,000,000 gallons per acre daily, yet the rate is perhaps too great if 13 per cent. of the samples collected at times of normal operation contain *B. coli*.

With Filter No. 3, operating intermittently but at a rate approximating 4,000,000 gallons per acre daily, even poorer results were obtained in the winter, on account of the daily exposure of the surface of the filter to the low temperature of these months. Better results at similar rates were obtained during the warmer period of the year, as noted above; but, as a filtration area must be constructed to furnish a safe and sufficient supply of water when operating at its lowest rate, the winter results are the ones of more interest.

These results are summarized in a following table. Tables beyond give the bacterial and chemical results of analyses of the effluents of these three filters and of the water applied to them; this applied water being Merrimack River water drawn from the Essex Company's canal.

Summary of B. Coli Communis Results from Filters Nos. 3, 7 and 8.

Filter Number.		Rate, Million Gallons per Acre Daily.	Number of Samples examined for B. Coli.	Number of Times B. Coli found.	Total Per Cent. Samples containing B. Coli.	Times Filter was scraped.	Times Filter stood closed or drained.	Number of times B. Coli probably due to Scraping.	Number of times B. Coli probably due to Closing or Draining.	B. Coli not due to Disturbance.	Per Cent. of Normal Samples containing B. Coli.
3	Dec. 1, 1897, to Jan. 7, 1898,	4	23	14	60.9	1	1	9	2	3	13.0
7	Dec. 1, 1897, to Jan. 7, 1898,	4	23	14	60.9	1	2	0	9	5	21.7
8	Dec. 1, 1897, to Jan. 7, 1898,	4	23	9	39.1	2	3	2	4	3	13.0
3	January 7 to August 8, .	2½	144	14	9.0	7	14	7	2	5	3.5
7	January 7 to August 8, .	2½	146	16	10.9	3	12	3	4	9	6.2
8	January 7 to August 8, .	2½	149	13	8.7	4	14	2	2	9	6.0
3	August 8 to November 14, .	4	83	6	7.1	4*	6	1	1	4	4.8
7	August 8 to November 14, .	4	81	15	18.5	5*	5	4	3	8	9.9
8	August 8 to November 14, .	4	75	12	16.0	4*	5	6*	1	5	6.7

* Dug over once, 6 inches deep.

The following tables give the results of the daily bacterial examination of the water applied to and the effluents from these three filters, and tables beyond show the results of the chemical analyses of applied water and effluents.

Notes in regard to the operation of the filters are given with the tables. At times of scraping the surface of the filters approximately ½ inch of sand was removed.

Number of Bacteria and B. Coli Communis in Applied Water and Effluents of Filters Nos. 3, 7 and 8.

Date — 1897.	Canal Water.		Filter No. 3.		Filter No. 7.		Filter No. 8.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
December 1, .	2,700	-	45	-	19	-	6	-
2, .	6,600	2	66	0	32	1	10	0
3, .	5,300	-	112	-	126	-	7	-
4, .	2,900	-	74	0	69	0	14	0
5, .	-	-	-	-	-	-	-	-
6, .	5,500	-	103	-	96	-	66	-
7, .	3,400	-	71	1	65	1	20	0
8, .	7,500	-	54	0	72	0	17	0
9, .	900	-	62	0	107	0	41	0
10, .	4,300	-	56	1	60	0	31	0
11, .	5,400	5	45	0	39	0	16	0
12, .	-	-	-	-	-	-	-	-
13, .	7,500	3	100	0	154	0	11	0
14, .	6,200	3	72	0	171	0	28	0
15, .	6,500	12	16	1	24	0	-	-
16, .	2,100	4	-	-	-	-	-	-
17, .	6,200	0	-	-	-	-	-	-
18, .	5,500	28	-	-	-	-	-	-
19, .	-	-	-	-	-	-	-	-
20, .	6,900	11	73	1	187	1	40	1
21, .	3,500	5	55	1	73	1	95	1
22, .	2,700	4	19	0	75	1	33	-
23, .	900	11	-	-	110	1	29	1
24, .	5,200	16	-	-	87	1	26	1
25, .	-	-	-	-	-	-	-	-
26, .	-	-	-	-	-	-	-	-
27, .	2,800	9	253	1	165	1	22	0
28, .	3,700	3	248	1	90	1	20	0
29, .	7,600	28	338	1	86	1	43	0
30, .	9,400	12	140	0	38	0	24	0
31, .	7,600	24	237	1	36	0	10	0
Average, .	4,954	10	107	-	86	-	29	-

December 16-19 inclusive, filters closed, due to high water in river. December 5, filters closed, canal drawn off. December 11, Filter No. 7 scraped. December 22, Filter No. 8 scraped. December 23, Filter No. 3 scraped. December 2, depth of water over surface of Filter No. 7 increased permanently from 10 to 26 inches.

Number of Bacteria and B. Coli Communis in Applied Water and Effluents of Filters Nos. 3, 7 and 8.

Date — 1898.	Canal Water.		Filter No. 3.		Filter No. 7.		Filter No. 8.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
January 1, . .	9,100	22	157	1	81	1	98	1
2, . .	-	-	-	-	-	-	-	-
3, . .	6,000	53	170	1	29	1	127	1
4, . .	12,200	114	181	1	28	1	140	1
5, . .	10,500	122	108	1	44	0	99	1
6, . .	6,500	15	92	1	57	1	10	1
7, . .	2,900	17	40	0	266	1	32	0
8, . .	8,000	37	27	1	49	1	43	0
9, . .	-	-	-	-	-	-	-	-
10, . .	2,200	2	23	0	35	1	15	0
11, . .	2,500	10	25	0	19	0	10	0
12, . .	2,700	72	19	0	26	1	13	1
13, . .	2,200	10	14	0	11	0	10	0
14, . .	4,500	14	15	0	19	0	10	0
15, . .	2,600	4	15	0	19	0	13	0
16, . .	-	-	-	-	-	-	-	-
17, . .	2,100	16	23	0	9	0	11	0
18, . .	2,000	35	18	1	9	1	10	0
19, . .	1,200	30	19	0	35	0	8	0
20, . .	4,200	47	9	1	50	0	12	0
21, . .	1,800	34	5	0	12	0	28	0
22, . .	5,100	17	80	0	8	0	12	1
23. . .	-	-	-	-	-	-	-	-
24, . .	800	9	41	0	16	0	14	1
25, . .	1,400	68	-	-	12	1	6	0
26, . .	6,500	43	370	1	27	0	14	0
27, . .	4,500	13	41	0	16	0	13	0
28, . .	4,000	65	35	1	13	0	22	0
29, . .	4,000	25	55	1	12	1	18	0
30, . .	-	-	-	-	-	-	-	-
31, . .	6,000	27	31	0	14	0	6	0
Average, .	4,442	35	65	-	35	-	31	-

January 6, Filter No. 7 scraped. January 7, rates of filters Nos. 3, 7 and 8 reduced to 2½ million gallons per acre daily. January 20, Filter No. 8 scraped. January 25, Filter No. 3 scraped.

Number of Bacteria and B. Coli Communis in Water applied to and Effluents from Filters Nos. 3, 7 and 8.

Date—1898.	Canal Water.		Filter No. 3.		Filter No. 7.		Filter No. 8.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
February 1, .	7,500	27	7	0	18	0	22	0
2, .	2,800	55	63	1	15	1	25	0
3, .	2,200	64	46	0	14	0	18	0
4, .	2,900	33	22	0	13	0	9	0
5, .	6,600	16	37	0	23	0	8	0
6, .	-	-	-	-	-	-	-	-
7, .	6,900	43	33	0	18	0	10	0
8, .	8,300	64	92	0	15	0	7	0
9, .	5,000	44	35	0	18	1	9	0
10, .	7,000	14	28	-	31	0	40	0
11, .	10,800	10	33	1	15	1	55	0
12, .	5,400	2	27	0	15	0	10	0
13, .	-	-	-	-	-	-	-	-
14, .	5,400	32	36	0	15	0	18	0
15, .	5,200	43	16	0	22	0	18	0
16, .	2,700	40	3	0	26	0	20	1
17, .	4,600	26	13	0	55	1	15	0
18, .	3,700	8	-	-	47	0	19	1
19, .	3,300	-	14	0	94	0	20	0
20, .	-	-	-	-	-	-	-	-
21, .	2,800	-	22	0	69	0	21	0
22, .	-	-	-	-	-	-	-	-
23, .	8,500	41	35	0	47	0	25	0
24, .	8,800	27	11	0	47	0	29	0
25, .	8,000	30	27	0	43	0	10	0
26, .	2,800	35	31	0	26	0	12	0
27, .	-	-	-	-	-	-	-	-
28, .	2,700	20	37	0	23	1	46	1
Average, .	5,387	32	30	-	31	-	20	-

February 10, Filter No. 8 scraped. February 26, Filter No. 3 scraped.

Number of Bacteria and B. Coli Communis in Water applied to and Effluents from Filters Nos. 3, 7 and 8.

Date—1898.	Canal Water.		Filter No. 3.		Filter No. 7.		Filter No. 8.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
March 1, . .	1,300	22	16	1	67	0	20	0
2, . .	1,900	29	8	0	27	0	13	0
3, . .	2,800	16	24	0	19	0	9	0
4, . .	2,000	23	16	0	27	0	31	0
5, . .	2,200	7	25	0	11	0	15	0
6, . .	-	-	-	-	-	-	-	-
7, . .	3,700	7	12	0	8	0	18	0
8, . .	4,800	6	22	0	18	0	7	0
9, . .	3,300	7	13	0	23	0	17	0
10, . .	8,100	3	18	0	23	0	13	0
11, . .	2,900	3	7	0	11	0	10	1
12, . .	4,400	3	16	0	8	0	14	0
13, . .	-	-	-	-	-	-	-	-
14, . .	3,200	-	-	-	-	-	-	-
15, . .	5,600	27	-	-	-	-	-	-
16, . .	2,600	4	-	-	-	-	-	-
17, . .	4,200	5	-	-	-	-	-	-
18, . .	2,000	17	-	-	-	-	-	-
19, . .	3,700	14	-	-	-	-	-	-
20, . .	-	-	-	-	-	-	-	-
21, . .	4,700	5	-	-	-	-	-	-
22, . .	2,700	16	-	-	-	-	-	-
23, . .	2,500	3	-	-	-	-	-	-
24, . .	3,600	0	-	-	-	-	-	-
25, . .	1,100	10	-	-	-	-	-	-
26, . .	1,200	14	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	-
28, . .	2,800	17	-	-	-	-	-	-
29, . .	1,000	13	-	-	-	-	-	-
30, . .	3,100	38	-	-	-	-	-	-
31, . .	2,500	49	-	-	-	-	-	-
Average, .	3,108	14	16	-	22	-	15	-

March 13-18, filters closed, high water. March 18, filters opened and allowed to drain. March 18-31, filters remained drained.

Number of Bacteria and B. Coli Communis in Water applied to and Effluents from Filters Nos. 3, 7 and 8.

Date—1898.	Canal Water.		Filter No. 3.		Filter No. 7.		Filter No. 8.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
April 1, . .	1,500	60	26	1	46	1	7	0
2, . .	1,500	48	41	1	42	0	10	1
3, . .	-	-	-	-	-	-	-	-
4, . .	1,400	10	16	-	26	-	10	0
5, . .	2,400	45	15	-	20	-	7	0
6, . .	2,800	87	7	0	15	0	6	0
7, . .	2,200	30	-	-	20	0	19	0
8, . .	800	2	24	0	26	0	14	0
9, . .	1,100	1	27	1	18	0	24	0
10, . .	-	-	-	-	-	-	-	-
11, . .	1,500	6	8	1	10	1	11	0
12, . .	1,400	32	11	0	11	0	5	0
13, . .	4,600	16	33	0	27	0	12	0
14, . .	2,800	66	40	0	16	0	18	0
15, . .	3,000	-	35	0	47	0	20	0
16, . .	2,500	5	12	0	31	0	15	0
17, . .	-	-	-	-	-	-	-	-
18, . .	1,200	4	14	0	60	0	14	0
19, . .	-	-	-	-	-	-	-	-
20, . .	1,200	3	3	0	23	0	44	0
21, . .	1,300	-	45	0	21	0	9	0
22, . .	900	7	15	0	39	0	12	1
23, . .	700	-	18	0	26	0	12	0
24, . .	-	-	-	-	-	-	-	-
25, . .	5,100	26	-	-	-	-	-	-
26, . .	2,700	11	-	-	-	-	-	-
27, . .	2,500	31	-	-	-	-	-	-
28, . .	1,700	1	-	-	-	-	-	-
29, . .	1,300	15	-	-	-	-	-	-
30, . .	1,000	-	-	-	-	-	-	-
Average, .	1,964	24	22	-	28	-	14	-

April 7, Filter No. 3 scraped. April 23, Filter No. 3 scraped. April 24-30, filters drained. High water in the river.

Number of Bacteria and B. Coli Communis in Water applied to and Effluents from Filters Nos. 3, 7 and 8.

Date — 1898.	Canal Water.		Filter No. 3.		Filter No. 7.		Filter No. 8.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
May 1,	-	-	-	-	-	-	-	-
2,	2,400	5	14	0	67	0	20	0
3,	2,100	-	14	-	40	-	15	-
4,	1,800	-	6	-	25	-	11	-
5,	1,900	-	20	-	19	-	15	-
6,	1,400	9	54	0	11	0	15	0
7,	2,000	9	22	0	18	0	47	0
8,	-	-	-	-	-	-	-	-
9,	1,800	16	25	0	16	0	43	1
10,	2,600	12	11	0	21	0	14	0
11,	2,100	11	5	0	32	0	15	0
12,	2,700	39	13	0	22	0	38	0
13,	2,400	29	11	0	11	1	11	0
14,	2,300	8	10	0	11	1	25	0
15,	-	-	-	-	-	-	-	-
16,	2,900	3	14	0	19	0	28	0
17,	3,800	72	23	0	44	0	40	0
18,	2,700	13	36	0	25	0	12	0
19,	4,000	16	15	0	25	1	16	0
20,	1,500	16	11	0	12	0	17	1
21,	2,200	37	19	0	6	0	7	0
22,	-	-	-	-	-	-	-	-
23,	800	19	7	0	17	0	12	0
24,	8,600	50	14	0	15	0	7	0
25,	10,400	70	15	0	14	0	7	0
26,	5,700	27	3	0	16	0	6	0
27,	6,500	44	4	-	12	-	5	-
28,	5,000	-	-	-	-	-	-	-
29,	-	-	-	-	-	-	-	-
30,	-	-	-	-	-	-	-	-
31,	2,900	42	9	0	13	0	10	0
Average,	3,300	26	16	-	21	-	18	-

May 2, filters started after standing out of operation for 5 days. May 8, filters drained; canal drawn off. May 15, filters drained; canal drawn off. May 16, Filter No. 8 scraped. May 28-29, filters drained; high water in the river.

Number of Bacteria and B. Coli Communis in Water applied to and Effluents from Filters Nos. 3, 7 and 8.

Date—1898.	Canal Water.		Filter No. 3.		Filter No. 7.		Filter No. 8.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
June 1, . .	3,200	-	-	-	90	0	11	0
2, . .	4,400	19	29	0	16	0	7	0
3, . .	3,100	47	52	0	33	0	30	0
4, . .	6,400	5	12	0	38	0	144	0
5, . .	-	-	-	-	-	-	-	-
6, . .	2,100	5	10	0	13	0	14	0
7, . .	5,000	17	43	0	9	0	10	0
8, . .	8,300	27	10	0	60	0	4	0
9, . .	5,600	14	12	0	45	0	7	0
10, . .	6,700	14	21	0	24	0	70	0
11, . .	14,100	3	27	0	22	0	8	0
12, . .	-	-	-	-	-	-	-	-
13, . .	6,300	18	16	0	24	0	17	0
14, . .	14,000	39	15	0	22	0	10	0
15, . .	11,800	213	23	0	26	0	67	0
16, . .	11,800	-	30	0	20	0	14	0
17, . .	-	-	-	-	-	-	-	-
18, . .	12,200	28	21	0	19	0	21	0
19, . .	-	-	-	-	-	-	-	-
20, . .	3,100	72	11	0	29	0	19	0
21, . .	4,800	110	22	0	38	0	23	0
22, . .	7,400	79	24	0	44	0	57	0
23, . .	10,100	52	44	0	22	0	20	0
24, . .	11,500	28	27	0	23	0	12	0
25, . .	16,900	-	18	0	32	0	20	0
26, . .	-	-	-	-	-	-	-	-
27, . .	1,800	5	20	0	78	0	15	0
28, . .	4,000	-	13	0	33	0	8	0
29, . .	9,700	80	30	0	22	0	10	0
30, . .	2,800	14	12	0	42	0	12	0
Average, .	7,484	42	23	-	33	-	23	-

June 1, Filter No. 3 scraped. June 12, filters drained, canal drawn off. June 19, filters drained, canal drawn off. June 25, filters drained, canal drawn off.

Number of Bacteria and B. Coli Communis in Water applied to and Effluents from Filters Nos. 3, 7 and 8.

Date — 1898.	Canal Water.		Filter No. 3.		Filter No. 7.		Filter No. 8.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
July 1, . .	5,300	28	23	0	70	0	11	0
2, . .	3,900	8	16	0	25	0	21	0
3, . .	-	-	-	-	-	-	-	-
4, . .	-	-	-	-	-	-	-	-
5, . .	2,200	9	17	0	47	1	13	0
6, . .	1,700	18	16	0	47	0	15	0
7, . .	5,900	55	-	-	32	0	15	0
8, . .	5,400	9	37	0	28	1	9	0
9, . .	11,000	164	60	1	88	0	30	0
10, . .	-	-	-	-	-	-	-	-
11, . .	2,200	78	69	0	34	0	44	0
12, . .	7,000	24	23	0	34	0	10	0
13, . .	92,200	15	33	0	42	0	17	0
14, . .	4,800	195	21	1	20	0	18	0
15, . .	11,200	422	34	0	20	-	28	0
16, . .	8,400	174	24	0	19	0	20	0
17, . .	-	-	-	-	-	-	-	-
18, . .	3,600	41	36	0	-	-	-	-
19, . .	4,300	55	14	0	27	0	9	0
20, . .	6,500	48	9	0	25	0	8	0
21, . .	4,300	120	8	0	19	0	9	0
22, . .	4,400	-	8	0	16	0	8	0
23, . .	5,000	454	12	0	15	0	15	0
24, . .	-	-	-	-	-	-	-	-
25, . .	2,300	12	-	-	27	0	9	0
26, . .	1,000	32	27	0	22	0	10	0
27, . .	4,600	88	27	0	17	0	18	0
28, . .	3,200	72	33	0	8	0	8	0
29, . .	2,000	12	22	0	11	0	5	0
30, . .	4,700	-	15	0	22	0	19	0
31, . .	-	-	-	-	-	-	-	-
Average, .	8,284	93	25	-	30	-	15	-

July 7 and 25, Filter No. 3 scraped. July 18, filters Nos. 7 and 8 scraped. July 3, 4, 10, 17, 24, 31, canal drawn off and filters drained.

Number of Bacteria and B. Coli Communis in Water applied to and Effluents from Filters Nos. 3, 7 and 8.

Date — 1898.	Canal Water.		Filter No. 3.		Filter No. 7.		Filter No. 8.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
August 1, .	2,600	-	10	0	13	0	36	0
2, .	2,000	-	9	0	17	0	19	0
3, .	3,100	73	16	0	15	0	8	0
4, .	5,600	42	7	0	8	0	3	0
5, .	3,700	280	12	0	8	0	41	0
6, .	3,700	138	11	0	9	0	19	0
7, .	-	-	-	-	-	-	-	-
8, .	2,200	103	8	0	-	-	-	-
9, .	1,900	86	40	0	21	0	20	1
10, .	5,300	67	6	0	28	0	26	0
11, .	4,600	430	17	0	22	0	30	1
12, .	13,300	211	7	0	25	1	8	1
13, .	8,500	43	10	0	33	0	12	0
14, .	-	-	-	-	-	-	-	-
15, .	1,800	22	13	0	17	0	8	0
16, .	11,600	97	7	0	16	0	8	0
17, .	9,000	154	4	0	26	0	10	0
18, .	13,500	135	9	0	12	0	5	0
19, .	8,800	489	3	0	15	0	9	0
20, .	6,800	113	5	0	15	0	8	0
21, .	-	-	-	-	-	-	-	-
22, .	2,400	46	4	0	16	0	9	0
23, .	2,200	84	4	0	16	0	3	0
24, .	13,500	44	14	0	38	0	6	0
25, .	18,500	14	24	0	21	0	13	0
26, .	5,800	330	29	0	21	0	23	0
27, .	2,000	21	7	0	15	0	11	0
28, .	-	-	-	-	-	-	-	-
29, .	1,400	28	36	0	21	0	5	0
30, .	700	16	5	0	10	0	8	0
31, .	2,900	10	12	0	13	0	5	0
Average, .	5,829	123	12	-	18	-	14	-

August 8 and 23, filters Nos. 7 and 8 scraped. August 23, Filter No. 3 scraped. August 7, canal drawn off and filters drained.

Number of Bacteria and B. Coli Communis in Water applied to and Effluents from Filters Nos. 3, 7 and 8.

Date — 1898.	Canal Water.		Filter No. 3.		Filter No. 7.		Filter No. 8.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
September 1, .	7,800	352	41	0	13	0	17	0
2, .	13,400	217	41	1	12	0	5	0
3, .	7,900	38	70	0	29	1	15	0
4, .	-	-	-	-	-	-	-	-
5, .	-	-	-	-	-	-	-	-
6, .	3,300	49	10	0	44	0	-	-
7, .	3,900	200	5	0	-	-	3	0
8, .	8,700	108	25	0	150	1	14	1
9, .	9,100	54	4	0	113	1	10	0
10, .	11,600	-	6	0	95	0	13	0
11, .	-	-	-	-	-	-	-	-
12, .	1,900	156	3	0	32	0	8	0
13, .	6,600	195	59	1	22	1	7	1
14, .	23,700	1,065	122	0	14	0	20	0
15, .	22,700	217	102	0	133	0	26	0
16, .	15,800	141	43	0	12	0	22	0
17, .	16,900	344	27	0	11	0	15	0
18, .	-	-	-	-	-	-	-	-
19, .	2,600	35	20	0	33	1	14	0
20, .	1,800	27	30	0	25	1	24	0
21, .	7,800	75	20	0	26	0	31	0
22, .	14,600	123	15	0	52	0	29	0
23, .	14,700	211	25	0	16	0	55	0
24, .	12,600	350	13	0	27	0	52	0
25, .	-	-	-	-	-	-	-	-
26, .	11,900	40	75	0	7	0	20	0
27, .	4,200	29	10	0	14	0	13	0
28, .	5,200	26	25	-	15	0	15	0
29, .	8,600	14	-	-	15	0	-	-
30, .	8,600	70	-	-	6	0	-	-
Average, .	9,836	172	34	-	38	-	19	-

September 12, Filter No. 3 scraped and September 30 spaded to depth of 6 inches. September 7, Filter No. 7 scraped; September 6, Filter No. 8 scraped. September 4, 5, 18, 25, canal drawn off and filters drained.

Number of Bacteria and B. Coli Communis in Water applied to and Effluents from Filters Nos. 3, 7 and 8.

Date—1898.	Canal Water.		Filter No. 3.		Filter No. 7.		Filter No. 8.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
October 1, . .	6,300	20	29	0	6	0	-	-
2, . .	-	-	-	-	-	-	-	-
3, . .	4,000	5	25	0	10	0	-	-
4, . .	1,900	3	23	0	8	0	-	-
5, . .	15,500	240	27	0	10	0	-	-
6, . .	13,500	135	44	0	18	0	107	1
7, . .	19,700	530	44	0	12	0	364	1
8, . .	12,900	-	32	0	13	0	154	0
9, . .	-	-	-	-	-	-	-	-
10, . .	16,700	5	43	0	14	0	70	0
11, . .	36,400	18	23	1	51	0	54	1
12, . .	3,400	35	8	0	16	-	23	0
13, . .	15,800	66	6	0	109	0	40	0
14, . .	6,600	14	9	0	161	0	26	0
15, . .	10,800	41	11	1	194	0	21	0
16, . .	-	-	-	-	-	-	-	-
17, . .	5,400	8	18	0	51	0	12	0
18, . .	8,600	0	13	0	41	1	12	0
19, . .	6,200	0	6	0	26	0	15	0
20, . .	8,500	23	3	0	43	1	8	0
21, . .	7,100	8	49	0	14	0	9	0
22, . .	6,500	15	66	0	14	0	10	0
23, . .	-	-	-	-	-	-	-	-
24, . .	5,300	2	22	0	20	0	17	0
25, . .	6,400	24	31	0	9	0	17	1
26, . .	2,900	22	18	0	10	0	12	0
27, . .	6,000	12	22	0	11	1	6	0
28, . .	3,800	7	14	0	15	0	26	0
29, . .	5,200	0	15	1	16	1	56	0
30, . .	-	-	-	-	-	-	-	-
31, . .	3,700	-	8	1	30	0	10	0
Average, .	9,196	51	23	-	35	-	49	-

October 20, Filter No. 3 scraped. October 12, Filter No. 7 spaded to depth of 6 inches. October 5, Filter No. 8 scraped and spaded to depth of 6 inches. October 30, canal drawn off and filters drained.

Number of Bacteria and B. Coli Communis in Water applied to and Effluents from Filters Nos. 3, 7 and 8.

Date — 1898.	Canal Water.		Filter No. 3.		Filter No. 7.		Filter No. 8.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
November 1,	5,800	20	12	0	26	0	15	1
2,	4,400	8	11	0	23	0	27	1
3,	4,400	21	11	0	16	0	34	0
4,	6,100	133	12	0	20	0	22	0
5,	2,200	216	23	0	110	1	39	1
6,	-	-	-	-	-	-	-	-
7,	2,000	57	10	0	19	0	8	0
8,	4,500	74	16	0	24	1	13	0
9,	1,800	70	6	0	22	0	10	0
10,	1,100	39	6	0	16	1	13	0
11,	5,100	45	5	0	31	0	21	0
12,	8,100	10	67	0	35	0	28	0
13,	-	-	-	-	-	-	-	-
14,	5,400	14	95	0	48	0	42	0
15,	3,000	10	35	0	12	0	31	0
16,	2,800	60	59	1	22	1	44	0
17,	5,900	16	57	1	15	0	21	0
18,	4,300	20	34	0	18	0	9	0
19,	5,500	24	22	0	9	0	17	0
20,	-	-	-	-	-	-	-	-
21,	5,000	26	-	-	-	-	-	-
22,	6,100	9	35	0	40	0	6	0
23,	4,300	12	11	0	26	0	18	0
24,	-	-	-	-	-	-	-	-
25,	4,800	33	27	0	21	0	22	0
26,	2,100	36	11	1	16	0	15	0
27,	-	-	-	-	-	-	-	-
28,	3,400	33	32	1	22	0	23	0
29,	3,100	83	34	0	18	0	27	0
30,	2,100	30	11	1	20	0	21	0
Average,	4,132	44	27	-	26	-	22	-

November 4, Filter No. 7 scraped. November 21, Filter No. 8 scraped. November 6 and 20, canal drawn off and filters drained.

Number of Bacteria and B. Coli Communis in Water applied to and Effluents from Filters Nos. 3, 7 and 8.

Date—1898.	Canal Water.		Filter No. 3.		Filter No. 7.		Filter No. 8.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
December 1, .	3,400	22	14	0	29	0	30	0
2, .	4,400	22	16	0	-	1	55	0
3, .	5,000	7	20	0	120	0	20	0
4, .	-	-	-	-	-	-	-	-
5, .	8,900	18	11	0	69	0	24	0
6, .	11,600	12	8	0	90	1	14	0
7, .	4,800	33	16	-	122	1	15	0
8, .	5,000	30	132	1	115	1	20	0
9, .	2,800	10	181	1	102	1	22	0
10, .	3,100	12	85	1	86	1	30	0
11, .	-	-	-	-	-	-	-	-
12, .	2,200	23	39	1	72	0	18	1
13, .	4,800	31	66	0	45	0	12	0
14, .	1,600	35	83	1	40	0	18	0
15, .	2,800	42	90	1	47	0	16	1
16, .	3,200	73	105	1	30	0	27	0
17, .	4,800	62	105	1	50	0	30	0
18, .	-	-	-	-	-	-	-	-
19, .	1,900	35	99	1	51	0	30	0
20, .	3,400	37	80	1	49	1	28	1
21, .	2,500	48	101	1	34	0	19	0
22, .	3,700	46	115	1	46	1	28	0
23, .	5,200	47	82	1	90	0	35	0
24, .	8,800	5	84	1	64	1	35	0
25, .	-	-	-	-	-	-	-	-
26, .	-	-	-	-	-	-	-	-
27, .	2,900	33	64	1	116	1	22	0
28, .	6,300	17	23	0	50	0	15	0
29, .	6,700	7	16	1	157	1	12	1
30, .	2,500	34	70	0	50	0	7	0
31, .	6 100	26	58	1	55	0	24	0
Average, .	4,554	30	68	-	71	-	23	-

December 7, Filter No. 3 scraped. December 2, Filter No. 7 scraped. December 11, canal drawn off and filters drained.

Monthly Averages of Analyses of Canal Water (Merrimack River).

[Parts per 100,000.]

1898.	Temperature. — Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Soluble.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
January, ...	40	.38	.0046	.0134	.0116	.21	.021	.0002	.38	103.7	4,442
February, ...	34	.39	.0061	.0153	.0131	.23	.020	.0001	.38	97.6	5,367
March, ...	34	.36	.0046	.0128	.0120	.25	.019	.0000	.33	99.3	3,108
April, ...	44	.41	.0038	.0149	.0125	.19	.015	.0000	.40	97.1	1,964
May, ...	56	.45	.0042	.0155	.0140	.16	.012	.0000	.42	79.0	3,300
June, ...	70	.46	.0061	.0201	.0169	.16	.014	.0002	.46	82.4	7,484
July, ...	74	.37	.0087	.0203	.0161	.26	.015	.0002	.32	59.6	8,284
August, ...	75	.51	.0068	.0193	.0165	.25	.013	.0002	.30	62.6	5,829
September, . . .	67	.39	.0072	.0227	.0174	.26	.015	.0002	.28	64.2	9,836
October, ...	55	.64	.0067	.0264	.0229	.26	.012	.0001	.67	76.6	9,196
November, . . .	45	.61	.0041	.0210	.0179	.23	.015	.0001	.62	87.7	4,132
December, . . .	34	.43	.0055	.0160	.0143	.17	.017	.0000	.46	93.9	4,554
Average, . . .	52	.45	.0057	.0181	.0154	.22	.016	.0001	.42	83.6	4,771

Effluent of Filter No. 3 B.

[Parts per 100,000.]

1898.	Quantity of Effluent.* — Gallons per Acre Daily.	Temperature. Deg. F. Applied Water.	Temperature. Deg. F. Effluent.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
January, . .	2,156,000	40	34	.31	.0010	.0090	.21	.032	.0000	.32	94.1	65
February, .	1,939,000	34	34	.32	.0003	.0080	.23	.035	.0000	.30	93.2	30
March, . .	1,845,000	34	34	.30	.0006	.0082	.25	.030	.0000	.27	93.6	16
April, . .	2,143,000	44	45	.28	.0014	.0084	.19	.030	.0000	.31	89.4	22
May, . .	2,334,000	56	56	.27	.0011	.0068	.16	.050	.0000	.24	80.6	16
June, . .	2,127,000	70	69	.25	.0013	.0084	.16	.065	.0000	.30	71.0	23
July, . .	1,972,000	74	73	.14	.0018	.0082	.27	.046	.0000	.16	62.6	25
August, . .	2,239,000	75	75	.24	.0013	.0084	.25	.053	.0000	.27	67.4	12
September, .	2,555,000	67	70	.21	.0010	.0092	.25	.032	.0000	.25	68.0	34
October, . .	3,025,000	55	56	.41	.0012	.0137	.27	.034	.0001	.46	77.8	23
November, .	2,831,000	45	46	.42	.0015	.0120	.22	.026	.0000	.40	91.6	27
December, .	2,632,000	34	36	.31	.0010	.0093	.17	.029	.0000	.36	92.3	68
Average, .	2,317,000	52	52	.29	.0011	.0091	.22	.039	.0000	.30	81.8	30

* The rates given under this heading are based upon the total volume of water filtered during each month; that is, in calculating this rate the volume passed is divided by the number of days the filters were in actual operation, including days just before, during or just after scraping, when the rate was lower than the prescribed rate.

Effluent of Filter No. 8 A.

[Parts per 100,000.]

1898.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			
January, . .	2,544,000	40	34	.31	.0008	.0082	.21	.038	.0002	.30	78.2	31
February, .	2,366,000	34	34	.33	.0007	.0086	.22	.028	.0000	.31	77.9	20
March, . .	2,677,000	34	34	.31	.0006	.0086	.25	.031	.0000	.26	81.1	15
April, . .	2,575,000	44	44	.30	.0023	.0090	.20	.027	.0000	.30	68.8	14
May, . .	1,970,000	56	55	.28	.0013	.0072	.16	.043	.0000	.27	55.4	18
June, . .	2,519,000	70	70	.27	.0015	.0086	.15	.036	.0000	.32	28.2	25
July, . .	2,230,000	74	74	.15	.0013	.0079	.27	.032	.0000	.19	3.1	15
August, . .	2,817,000	75	75	.28	.0014	.0085	.24	.026	.0000	.32	14.6	14
September, .	2,478,000	67	70	.20	.0008	.0088	.24	.030	.0000	.26	15.5	19
October, . .	3,872,000	55	54	.50	.0014	.0149	.27	.021	.0000	.55	60.3	49
November, .	3,218,000	45	45	.46	.0012	.0122	.22	.022	.0000	.45	75.3	22
December, .	2,680,000	34	35	.34	.0014	.0098	.17	.024	.0000	.37	85.6	23
Average, .	2,662,000	52	52	.31	.0012	.0094	.22	.030	.0000	.33	53.7	22

Effluent of Filter No. 7 A.

[Parts per 100,000.]

1898.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			
January, . .	2,719,000	40	33	.32	.0010	.0082	.21	.030	.0002	.31	79.9	35
February, .	2,423,000	34	35	.32	.0008	.0088	.23	.041	.0000	.29	81.3	31
March, . .	1,496,000	34	34	.31	.0006	.0082	.25	.029	.0000	.26	79.5	22
April, . .	2,636,000	44	44	.30	.0013	.0088	.20	.026	.0000	.31	70.1	28
May, . .	2,398,000	56	56	.29	.0017	.0084	.16	.034	.0000	.32	56.5	21
June, . .	2,579,000	70	70	.29	.0012	.0092	.16	.036	.0000	.34	19.0	33
July, . .	2,375,000	74	74	.16	.0022	.0076	.27	.029	.0010	.20	3.3	30
August, . .	2,250,000	75	76	.29	.0017	.0095	.25	.026	.0000	.33	12.8	18
September, .	3,422,000	67	70	.22	.0014	.0098	.25	.031	.0000	.27	19.0	38
October, . .	3,737,000	55	53	.51	.0013	.0157	.27	.020	.0000	.61	51.3	35
November, .	2,445,000	45	45	.46	.0013	.0121	.22	.022	.0000	.45	77.2	26
December, .	2,384,000	34	35	.35	.0016	.0098	.17	.023	.0000	.37	85.1	71
Average, .	2,572,000	52	52	.32	.0013	.0097	.22	.029	.0001	.34	52.9	32

Filters Nos. 68 and 69.

These two filters have each contained during 1898 approximately 40 inches in depth of sand of an effective size of 0.23 millimeter. To each of the filters has been applied a polluted water, containing more organic matter than the river water and many more bacteria; this water being filtered river water to which a certain volume of sewage has been added. During the year, this applied water has contained an average of 43,842 bacteria of all kinds per cubic centimeter and 595 *B. coli* per cubic centimeter. This water, although containing more organic matter than the river water applied to the Lawrence city filter and to the remainder of the experimental filters at the station, having passed through one filter, has been freed to a great extent of the silt, or clay and sand, which is largely the material which clogs the surface of water filters. Owing to this, both of these filters have been operated throughout the year without the removal of any material from their surfaces, an occasional raking being all that was necessary, when the surfaces were clogged, to put them again into a condition to allow water to pass through freely. Owing also to the removal of this silt from the water before its application to these two filters, the bacterial results obtained from them have been less favorable than they would have been if water containing silt had been applied.

From January 1 to April 14 the rate of operation of each filter was 2,000,000 gallons per acre daily. Filter No. 68 was operated continuously during this period and Filter No. 69 intermittently. During this time *B. coli* were found, in varying numbers, in the effluent of Filter No. 68 in 38 of the 108 samples examined for this bacillus; and in the effluent of Filter No. 69 in 50 of the 108 samples examined. The bacterial efficiency, calculated upon the removal of bacteria of all kinds, was, during this period, 99.79 per cent. for Filter No. 68 and 99.65 per cent. for Filter No. 69.

From July 18 to December 31, inclusive, Filter No. 68 was operated intermittently at an average rate of about 1,500,000 gallons per acre daily. During this period *B. coli* were found in the effluent in 42 of the 132 samples examined for this germ. From April 15 to December 31, inclusive, Filter No. 69 was operated continuously at a rate approximating 2,300,000 gallons per acre daily. During this time *B. coli* were found in 90 of the 184 samples examined. During the entire year 30 per cent. of the samples from

Filter No. 68 contained *B. coli* and 44 per cent. of the samples from Filter No. 69.

During the first five months of the year the effluents from these two filters were applied to Filter No. 90, containing 4 feet in depth of sand of an effective size of 0.23 millimeter. Owing to the fact that all the organic matter in suspension as well as the silt had been removed from the water before reaching the surface of Filter No. 90, containing sand of the same degree of fineness as filters Nos. 68 and 69, the effluent of this secondary filter was but little better, from a bacterial point of view, than the effluents applied to it; the bacterial efficiency, reckoned upon total numbers of bacteria removed, being somewhat greater when calculated against the bacteria in the water applied to filters Nos. 68 and 69, but, nevertheless, 42 per cent. of the samples of effluent examined contained *B. coli*. The surface of this filter did not become clogged during its period of operation in 1898 and was neither scraped nor raked. The average rate of operation of the filter was 3,528,000 gallons per acre daily, and it was discontinued May 14.

Upon April 23, Filter No. 109 was put in operation. This filter contains the same depth of sand as Filter No. 90, but the sand is of a much finer grade, having an effective size of 0.14 millimeter. To this filter, canal water was applied from April 23 to May 15, inclusive, and from May 16 to July 17 the same water as applied to filters Nos. 68 and 69. This was done in order to cause a deposit of organic matter upon the sand grains in the upper portion of this filter. From July 18 to December 31, inclusive, the filter received the effluents of filters Nos. 68 and 69. From August 1 to December 31, inclusive, only 9 of the 102 samples examined for *B. coli* contained this germ, and the bacterial efficiency, calculated upon the bacteria present in the water applied to filters Nos. 68 and 69, was 99.90 per cent. The average rate of filtration maintained was 2,769,000 gallons per acre daily, and its surface did not become clogged and hence was not scraped or raked during the period from August 1 to December 31.

Determinations of the percentage of oxygen dissolved, in the polluted water applied to filters Nos. 68 and 69 and in the effluents of these two filters, have been made on many of the days of the year. Tables giving the results of these examinations are given on pages 528 and 529. It will be seen from an examination of these tables that the amount present in the applied water was not decreased during the passage of the water through the filters when they were operated intermittently, owing to the additional volume of air introduced into the body of the filter each day, by the daily freeing of the surface of the filter from water. With continuous operation of the filters, moreover, the oxygen was not perceptibly reduced during cold weather. During warm weather the amount present in the effluent of Filter No. 69, then being operated continuously, was very small; but its entire absence was noted on only one occasion, and the "total" bacterial results were equal to those obtained from the intermittent filter, but *B. coli* appeared in the effluent more frequently and in greater numbers than in the effluent of the intermittent filters. The difference in the *B. coli* results would probably have been much more pronounced also than the tables show, if Filter No. 68 had been in operation during the period from May 15 to July 18, as it took this filter some days to get into good working condition after being put in operation again on July 18.

Number of Bacteria and B. Coli Communis in applied Water and Effluents of Filters Nos. 68, 69 and 90.

Date — 1898.	Canal Water for Filters Nos. 68 and 69.		Filter No. 68.		Filter No. 69.		Filter No. 90.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
January 1,	102,500	510	213	4	182	4	58	1
2,	-	-	-	-	-	-	-	-
3,	59,500	616	122	2	318	5	79	1
4,	44,800	350	99	0	153	1	76	0
5,	108,700	704	228	2	1,657	44	59	0
6,	69,700	728	99	0	262	4	79	1
7,	38,000	370	13	0	186	2	50	0
8,	165,000	225	103	0	113	4	46	0
9,	-	-	-	-	-	-	-	-
10,	135,200	270	53	0	150	-	61	0
11,	152,500	190	185	3	156	5	57	1
12,	52,700	676	66	0	159	-	72	1
13,	27,700	945	130	1	87	2	73	1
14,	55,000	560	96	0	80	0	48	1
15,	17,000	420	118	0	125	3	59	0
16,	-	-	-	-	-	-	-	-
17,	-	-	186	4	162	6	81	1
18,	140,400	280	96	0	126	5	117	1
19,	49,900	100	102	0	71	0	63	0
20,	80,400	534	112	0	100	4	61	1
21,	109,000	396	135	0	108	7	45	0
22,	130,200	104	112	0	52	0	41	0
23,	-	-	-	-	-	-	-	-
24,	64,600	62	101	0	378	3	81	1
25,	77,500	175	111	0	50	0	53	0
26,	99,600	330	109	0	88	0	48	0
27,	119,600	1,225	196	1	114	0	47	0
28,	173,400	1,015	124	0	125	2	67	0
29,	157,500	290	85	0	118	3	40	0
30,	-	-	-	-	-	-	-	-
31,	79,600	370	195	2	182	0	58	1
Average,	92,760	458	123	-	204	-	63	-

January 5, Filter No. 69 raked 1 inch. January 12, Filter No. 68 raked 1 inch.

Number of Bacteria and B. Coli Communis in applied Water and Effluents of Filters Nos. 68, 69 and 90.

Date—1898.	Canal Water for Filters Nos. 68 and 69.		Filter No. 68.		Filter No. 69.		Filter No. 90.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
February 1, . .	99,000	780	112	0	87	0	83	0
2, . .	78,400	424	370	0	57	0	85	0
3, . .	65,500	400	109	0	199	0	54	
4, . .	43,300	140	192	2	90	0	65	1
5, . .	44,500	1,211	267	0	123	0	42	0
6, . .	-	-	-	-	-	-	-	-
7, . .	66,500	324	109	0	70	0	47	0
8, . .	154,700	270	107	0	70	0	48	0
9, . .	129,300	455	414	0	84	0	53	0
10, . .	152,500	128	464	24	75	0	65	1
11, . .	154,800	556	660	1	104	1	80	1
12, . .	103,700	450	430	0	29	0	63	0
13, . .	-	-	-	-	-	-	-	-
14, . .	109,400	233	170	0	212	0	90	1
15, . .	24,000	5	112	0	86	0	58	0
16, . .	57,200	392	154	0	124	1	55	1
17, . .	54,600	452	340	0	4,030	1	686	1
18, . .	102,800	596	105	0	840	0	116	0
19, . .	126,500	-	106	-	470	-	141	1
20, . .	-	-	-	-	-	-	-	-
21, . .	56,200	-	185	-	199	-	109	0
22, . .	-	-	-	-	-	-	-	-
23, . .	63,000	588	166	0	193	0	102	0
24, . .	57,200	430	229	0	152	0	77	0
25, . .	74,400	308	142	0	172	0	82	0
26, . .	56,700	190	340	0	60	0	55	0
27, . .	-	-	-	-	-	-	-	-
28, . .	49,500	416	92	0	106	0	80	1
Average, . .	83,639	417	234	-	332	-	102	-

Number of Bacteria and B. Coli Communis in applied Water and Effluents of Filters Nos. 68, 69 and 90.

Date — 1898.	Canal Water for Filters Nos. 68 and 69.		Filter No. 68.		Filter No. 69.		Filter No. 90.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
March 1, . .	32,000	430	38	0	96	0	54	0
2, . .	41,200	572	74	0	82	0	59	0
3, . .	104,300	888	59	0	64	0	83	0
4, . .	134,500	676	51	0	137	0	51	0
5, . .	720,000	639	53	0	80	0	37	0
6, . .	-	-	-	-	-	-	-	-
7, . .	33,200	496	62	0	64	0	71	0
8, . .	41,000	4,183	52	0	74	0	55	1
9, . .	15,000	-	228	6	85	0	68	1
10, . .	36,400	577	135	1	38	0	53	0
11, . .	92,000	27	238	0	71	0	70	1
12, . .	184,800	481	124	0	193	0	141	1
13, . .	-	-	-	-	-	-	-	-
14, . .	95,700	173	93	0	362	3	95	0
15, . .	56,600	370	218	4	200	7	121	0
16, . .	39,000	668	130	2	143	3	95	0
17, . .	36,900	1,164	208	5	304	14	313	1
18, . .	59,400	838	100	2	162	2	70	1
19, . .	93,000	781	93	0	69	1	49	1
20, . .	-	-	-	-	-	-	-	-
21, . .	39,700	476	116	0	111	3	81	0
22, . .	65,900	474	51	1	126	1	56	1
23, . .	36,900	636	63	2	54	2	37	0
24, . .	39,200	504	55	1	66	3	47	0
25, . .	36,400	592	61	2	57	2	94	1
26, . .	37,500	618	88	0	48	0	46	1
27, . .	-	-	-	-	-	-	-	-
28, . .	20,800	430	35	4	73	1	72	1
29, . .	114,700	424	134	1	80	0	91	1
30, . .	18,500	440	642	22	21	1	132	1
31, . .	32,800	640	195	0	19	1	92	1
Average, . .	83,607	700	126	-	107	-	83	-

Number of Bacteria and B. Coli Communis in applied Water and Effluents of Filters Nos. 68, 69 and 90.

Date—1898.	Canal Water for Filters Nos. 68 and 69.		Filter No. 68.		Filter No. 69.		Filter No. 90.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
April 1, . . .	29,200	1,050	222	4	135	1	130	1
2, . . .	28,500	653	321	12	312	32	139	1
3, . . .	-	-	-	-	-	-	-	-
4, . . .	21,100	724	760	32	206	8	139	1
5, . . .	15,700	747	194	16	122	6	95	1
6, . . .	25,600	639	98	0	55	8	185	1
7, . . .	10,500	700	138	26	84	8	72	1
8, . . .	22,200	406	110	3	75	1	89	1
9, . . .	20,000	35	65	0	66	0	32	0
10, . . .	-	-	-	-	-	-	-	-
11, . . .	28,600	200	50	1	48	2	31	1
12, . . .	13,600	130	29	1	-	0	24	1
13, . . .	24,200	316	47	0	135	0	58	1
14, . . .	20,900	216	50	0	78	0	34	0
15, . . .	25,700	-	48	0	322	67	15	0
16, . . .	31,000	327	45	12	366	5	140	0
17, . . .	-	-	-	-	-	-	-	-
18, . . .	18,500	-	179	5	115	0	43	0
19, . . .	-	-	-	-	-	-	-	-
20, . . .	26,400	298	157	0	36	0	60	1
21, . . .	25,700	-	186	-	55	-	44	0
22, . . .	17,800	-	205	-	84	-	44	0
23, . . .	18,600	655	84	0	86	0	31	0
24, . . .	-	-	-	-	-	-	-	-
25, . . .	11,900	140	51	0	50	0	39	0
26, . . .	11,900	640	124	1	74	0	48	2
27, . . .	13,600	500	83	0	135	0	74	1
28, . . .	48,700	596	102	0	160	0	67	0
29, . . .	14,300	840	95	4	49	0	56	0
30, . . .	13,300	799	236	3	75	0	77	0
Average, . .	21,500	505	147	-	122	-	71	-

April 6, Filter No. 68 raked. April 14, Filter No. 69 raked. April 15, rates of filters Nos. 68 and 69 increased to 3,000,000; 69 to run continuously.

Number of Bacteria and B. Coli Communis in applied Water and Effluents of Filters Nos. 68, 69, 90 and 109.

Date. 1898.	Canal Water for Filters Nos. 68, 69, and 109.		Filter No. 68.		Filter No. 69.		Filter No. 90.		Filter No. 109.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
May 1, .	21,000	212	-	-	-	-	-	-	-	-
2, .	21,000	212	84	0	22	0	126	0	-	-
3, .	17,300	-	63	-	90	-	48	-	-	-
4, .	27,100	-	52	-	265	-	21	-	-	-
5, .	16,600	-	58	-	87	-	49	-	-	-
6, .	10,100	285	18	0	124	0	104	0	-	-
7, .	15,000	211	78	0	99	1	136	0	-	-
8, .	-	-	-	-	-	-	-	-	-	-
9, .	5,500	124	68	0	34	0	130	0	-	-
10, .	10,600	43	16	0	740	0	123	0	-	-
11, .	9,500	130	44	0	19	0	25	0	-	-
12, .	21,000	346	87	0	956	0	182	0	-	-
13, .	22,000	601	13	0	44	4	32	0	-	-
14, .	26,600	660	75	0	20	0	38	0	-	-
15, .	-	-	-	-	-	-	-	-	-	-
16, .	20,800	5	-	-	78	0	-	-	107	0
17, .	15,200	611	-	-	240	0	-	-	163	12
18, .	15,400	285	-	-	297	34	-	-	115	5
19, .	22,500	780	-	-	96	4	-	-	35	0
20, .	30,100	124	-	-	86	6	-	-	92	0
21, .	76,000	568	-	-	151	9	-	-	70	2
22, .	-	-	-	-	-	-	-	-	-	-
23, .	62,100	410	-	-	128	-	-	-	351	3
24, .	86,000	225	-	-	585	11	-	-	56	0
25, .	30,600	240	-	-	514	24	-	-	106	3
26, .	11,600	390	-	-	675	14	-	-	31	0
27, .	8,800	240	-	-	338	9	-	-	17	0
28, .	8,800	-	-	-	202	1	-	-	24	0
29, .	-	-	-	-	-	-	-	-	-	-
30, .	-	-	-	-	-	-	-	-	-	-
31, .	13,900	408	-	-	129	3	-	-	23	0
Average,	24,042	323	55	-	241	-	84	-	92	-

April 25 to May 15, Filter No. 109 run with canal water; rate, 2,500,000. May 15, Filter No. 90 discontinued; Filter No. 109 started. May 20, Filter No. 69 raked. May 30, Filter No. 109 scraped.

Number of Bacteria and B. Coli Communis in applied Water and Effluents of Filters Nos. 69 and 109.

Date — 1898.	Canal Water for Filters Nos. 69 and 109.		Filter No. 69.		Filter No. 109.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
June 1,	17,900	-	137	-	51	-
2,	17,700	-	166	8	32	0
3,	10,400	518	592	12	25	1
4,	8,700	324	119	3	26	0
5,	-	-	-	-	-	-
6,	19,800	246	51	0	34	0
7,	14,900	410	22	0	30	0
8,	19,000	596	19	0	13	0
9,	18,100	212	51	2	18	0
10,	11,500	442	46	1	18	0
11,	11,900	286	17	3	21	0
12,	-	-	-	-	-	-
13,	6,300	270	57	3	26	0
14,	7,700	168	59	5	16	0
15,	4,600	324	59	1	29	0
16,	41,000	638	187	0	25	0
17,	-	-	-	-	-	-
18,	140,000	1,628	159	5	13	0
19,	-	-	-	-	-	-
20,	22,100	-	205	0	49	2
21,	65,500	5	262	4	38	1
22,	30,700	163	246	0	64	1
23,	21,900	355	314	21	58	4
24,	22,300	716	202	14	48	2
25,	20,500	600	418	0	73	2
26,	-	-	-	-	-	-
27,	30,800	170	356	4	113	0
28,	25,100	-	299	-	47	-
29,	12,900	23	203	0	30	0
30,	18,300	696	78	4	40	-
Average,	24,784	419	173	-	37	-

June 9, Filter No. 109 scraped. June 10, rate of Filter No. 109 increased to 3,000,000 gallons per acre daily. June 13, Filter No. 69 raked. June 18, rates of filters Nos. 109 and 69 reduced to 2,000,000 gallons per acre daily. June 27, Crenothrix growing on Filter No. 109.

Number of Bacteria and B. Coli Communis in applied Water and Effluents of Filters Nos. 68, 69 and 109.

Date — 1898.	Canal Water for Filters Nos. 68 and 69.		Filter No. 68.		Filter No. 69.		Filter No. 109.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
July 1, . . .	24,500	718	-	-	109	1	33	2
2, . . .	47,300	137	-	-	63	0	27	0
3, . . .	-	-	-	-	-	-	-	-
4, . . .	-	-	-	-	-	-	-	-
5, . . .	27,500	150	-	-	79	0	73	0
6, . . .	51,500	103	-	-	137	2	50	1
7, . . .	9,900	470	-	-	68	2	21	3
8, . . .	16,700	777	-	-	23	2	58	2
9, . . .	32,800	454	-	-	38	-	108	-
10, . . .	-	-	-	-	-	-	-	-
11, . . .	12,900	925	-	-	30	2	27	0
12, . . .	19,400	577	-	-	12	1	47	0
13, . . .	65,000	1,620	-	-	59	12	46	40
14, . . .	35,900	1,280	-	-	118	4	28	0
15, . . .	21,200	828	-	-	151	24	58	12
16, . . .	23,000	1,678	-	-	100	10	45	5
17, . . .	-	-	-	-	-	-	-	-
18, . . .	43,500	930	4,373	-	88	10	39	1
19, . . .	40,200	286	2,985	56	33	1	56	2
20, . . .	15,306	735	344	7	22	0	13	0
21, . . .	37,900	185	189	2	48	36	72	28
22, . . .	20,800	-	192	-	193	-	12	-
23, . . .	19,800	2,496	175	12	86	20	6	0
24, . . .	-	-	-	-	-	-	-	-
25, . . .	18,900	1,362	94	2	34	2	10	0
26, . . .	20,700	366	106	2	43	1	8	0
27, . . .	10,000	288	74	0	13	0	9	0
28, . . .	17,000	1,686	77	-	19	5	7	0
29, . . .	23,200	540	80	0	46	0	12	0
30, . . .	12,900	-	85	-	94	-	9	-
31, . . .	-	-	-	-	-	-	-	-
Average, . .	26,712	808	731	-	68	-	35	-

July 2, Filter No. 109 scraped. July 18, Filter No. 68 started; intermittent. Filter No. 109 receives effluents of filters Nos. 68 and 69. July 22, Filter No. 69 raked.

Number of Bacteria and B. Coli Communis in applied Water and Effluents of Filters Nos. 68, 69 and 109.

Date—1898.	Canal Water for Filters Nos. 68 and 69.		Filter No. 68.		Filter No. 69.		Filter No. 109.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
August 1, . .	20,800	-	37	-	21	-	4	-
2, . .	15,400	-	24	-	9	-	3	-
3, . .	15,300	810	36	1	21	0	27	0
4, . .	16,700	638	62	0	26	2	4	0
5, . .	17,100	644	12	0	25	1	4	0
6, . .	12,300	130	61	0	21	1	1	0
7, . .	-	-	-	-	-	-	-	-
8, . .	13,200	93	92	0	73	0	0	0
9, . .	15,500	623	21	0	33	0	2	0
10, . .	16,700	663	53	0	18	0	2	0
11, . .	13,400	390	41	1	26	0	6	0
12, . .	6,000	330	42	0	44	0	2	0
13, . .	5,800	318	26	0	3	0	6	0
14, . .	-	-	-	-	-	-	-	-
15, . .	9,600	193	38	0	15	0	11	0
16, . .	11,200	211	22	0	13	0	7	0
17, . .	34,400	228	98	0	35	0	2	0
18, . .	18,500	212	48	0	12	0	0	0
19, . .	6,000	110	22	0	34	0	10	0
20, . .	11,800	327	16	0	21	0	2	0
21, . .	-	-	-	-	-	-	-	-
22, . .	4,500	23	46	0	65	0	2	0
23, . .	2,900	-	28	0	30	0	4	0
24, . .	4,900	186	31	0	29	0	0	0
25, . .	18,100	125	58	0	61	0	4	0
26, . .	53,400	647	46	0	50	0	6	0
27, . .	26,600	129	68	0	24	0	14	0
28, . .	-	-	-	-	-	-	-	-
29, . .	7,300	75	23	0	18	0	4	0
30, . .	15,800	38	21	0	23	0	7	0
31, . .	31,300	310	59	0	17	0	4	0
Average, . .	15,722	311	42	-	28	-	5	-

Number of Bacteria and B. Coli Communis in applied Water and Effluents of Filters Nos. 68, 69 and 109.

Date — 1898.	Canal Water for Filters Nos. 68 and 69.		Filter No. 68.		Filter No. 69.		Filter No. 109.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
September 1, . .	25,700	417	73	0	18	0	8	0
2, . .	32,400	626	95	1	88	1	11	0
3, . .	26,500	885	57	0	24	1	5	0
4, . .	-	-	-	-	-	-	-	-
5, . .	-	-	-	-	-	-	-	-
6, . .	4,100	87	103	4	55	3	13	0
7, . .	5,500	105	42	0	31	1	2	0
8, . .	35,200	1,887	34	0	5	1	1	0
9, . .	38,700	947	73	5	30	2	9	0
10, . .	111,000	-	440	0	20	0	9	0
11, . .	-	-	-	-	-	-	-	-
12, . .	53,100	344	109	0	169	4	8	0
13, . .	40,500	150	99	0	90	8	25	0
14, . .	32,600	310	68	0	48	0	12	0
15, . .	16,900	222	61	0	63	0	9	0
16, . .	20,000	218	55	0	38	0	8	0
17, . .	21,800	502	76	2	35	0	11	1
18, . .	-	-	-	-	-	-	-	-
19, . .	24,800	1,432	45	0	105	1	17	0
20, . .	22,600	1,625	163	0	269	1	33	0
21, . .	20,900	1,194	82	1	217	2	28	0
22, . .	18,200	1,679	69	0	143	0	92	1
23, . .	15,600	626	38	0	69	1	15	1
24, . .	20,000	2,034	17	0	36	0	12	0
25, . .	-	-	-	-	-	-	-	-
26, . .	23,100	1,409	21	0	36	1	125	0
27, . .	52,700	282	52	0	153	1	22	0
28, . .	25,200	1,245	87	1	320	0	45	0
29, . .	46,400	1,147	51	0	178	1	15	0
30, . .	71,400	548	43	0	25	1	18	0
Average, . .	32,196	830	82	-	91	-	22	-

Number of Bacteria and B. Coli Communis in Applied Water and Effluents of Filters Nos. 68, 69 and 109.

Date—1898.	Canal Water for Filters Nos. 68 and 69.		Filter No. 68.		Filter No. 69.		Filter No. 109.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
October 1, . .	39,700	386	32	0	25	6	3	0
2, . .	-	-	-	-	-	-	-	-
3, . .	20,300	-	27	0	112	0	47	0
4, . .	13,000	444	21	1	229	3	53	0
5, . .	36,500	424	33	0	80	0	4	0
6, . .	23,600	658	68	0	195	0	5	0
7, . .	23,800	1,071	39	0	21	0	3	0
8, . .	24,100	306	72	1	109	0	24	0
9, . .	-	-	-	-	-	-	-	-
10, . .	27,200	818	99	1	44	0	-	0
11, . .	52,000	3,982	143	4	740	0	16	0
12, . .	56,900	2,640	1,155	44	1,840	18	67	0
13, . .	200,000	4,381	657	10	2,072	0	69	0
14, . .	94,600	840	568	0	1,351	0	36	0
15, . .	114,700	420	110	0	540	4	32	0
16, . .	-	-	-	-	-	-	-	-
17, . .	73,200	290	91	0	211	1	28	0
18, . .	45,500	910	38	0	175	1	22	0
19, . .	24,800	1,478	49	0	123	3	12	0
20, . .	25,700	629	94	2	126	3	30	0
21, . .	29,000	629	108	0	35	0	19	0
22, . .	39,200	530	17	0	31	0	38	0
23, . .	-	-	-	-	-	-	-	-
24, . .	52,300	146	42	0	73	3	9	0
25, . .	57,700	725	33	0	181	2	21	0
26, . .	38,300	715	61	0	105	0	28	0
27, . .	49,900	759	74	0	81	0	40	1
28, . .	17,700	687	80	0	131	3	25	1
29, . .	39,400	1,350	51	0	89	0	-	1
30, . .	-	-	-	-	-	-	-	-
31, . .	55,200	971	58	0	66	1	56	0
Average, . .	49,012	1,048	147	-	338	-	29	-

October 11, filters Nos. 68 and 69 raked.

Number of Bacteria and B. Coli Communis in applied Water and Effluents of Filters Nos. 68, 69 and 109.

Date — 1898.	Canal Water for Filters Nos. 68 and 69.		Filter No. 68.		Filter No. 69.		Filter No. 109.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
November 1, .	48,900	1,206	247	0	212	4	16	0
2, .	21,900	952	35	6	163	4	43	0
3, .	15,200	688	193	6	215	0	57	0
4, .	22,400	280	37	2	80	0	44	0
5, .	46,200	607	88	1	310	0	42	1
6, .	-	-	-	-	-	-	-	-
7, .	26,100	570	214	6	14	0	34	0
8, .	29,900	1,446	282	0	396	0	6	0
9, .	28,000	1,178	246	8	17	4	23	1
10, .	33,000	959	-	-	118	4	26	0
11, .	35,500	1,480	222	4	435	3	44	0
12, .	39,800	1,260	236	0	127	0	84	0
13, .	-	-	-	-	-	-	-	-
14, .	14,400	225	155	3	147	1	78	0
15, .	22,300	1,260	124	0	506	0	-	-
16, .	17,600	568	112	0	20	0	33	0
17, .	20,200	1,110	84	0	-	0	123	1
18, .	40,100	540	100	1	42	0	62	0
19, .	33,800	672	525	0	354	2	141	0
20, .	-	-	-	-	-	-	-	-
21, .	27,700	560	106	-	364	2	15	0
22, .	21,300	732	172	2	720	3	67	0
23, .	35,100	540	157	0	276	3	71	0
24, .	-	-	-	-	-	-	-	-
25, .	21,600	863	179	0	347	0	25	0
26, .	21,400	848	242	6	788	0	39	0
27, .	-	-	-	-	-	-	-	-
28, .	26,000	860	299	10	451	0	77	1
29, .	33,800	725	83	4	356	0	95	0
30, .	65,200	1,448	330	2	230	6	40	0
Average, . .	29,896	863	186	-	279	-	54	-

November 5, rates of filters Nos. 68 and 69 reduced to 1½ million. November 30, Filter No. 69 raked.

Number of Bacteria and B. Coli Communis in applied Water and Effluents of Filters Nos. 68, 69 and 109.

Date — 1898.	Canal Water for Filters Nos. 68 and 69.		Filter No. 68.		Filter No. 69.		Filter No. 109.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
December 1, . .	61,400	863	145	0	176	4	38	0
2, . .	55,800	1,221	70	0	107	1	215	0
3, . .	49,300	227	197	1	219	0	52	0
4, . .	-	-	-	-	-	-	-	-
5, . .	47,900	938	4,271	55	618	0	20	0
6, . .	72,000	750	976	6	147	0	41	0
7, . .	23,100	436	156	1	82	0	29	0
8, . .	26,600	713	135	3	35	1	90	0
9, . .	55,300	900	115	0	389	0	27	0
10, . .	102,800	1,013	70	0	103	0	74	0
11, . .	-	-	-	-	-	-	-	-
12, . .	26,700	825	58	0	654	0	14	0
13, . .	18,000	400	220	0	207	0	64	0
14, . .	42,100	350	230	0	571	0	14	0
15, . .	35,700	465	125	0	888	0	58	0
16, . .	40,000	206	281	0	702	0	33	0
17, . .	30,400	157	494	0	177	0	38	0
18, . .	-	-	-	-	-	-	-	-
19, . .	32,700	788	424	0	508	0	58	0
20, . .	27,500	188	409	1	201	0	19	0
21, . .	20,400	158	715	0	125	0	12	0
22, . .	13,900	-	525	0	686	0	75	1
23, . .	35,000	46	292	0	391	0	54	0
24, . .	70,500	185	448	0	215	0	32	0
25, . .	-	-	-	-	-	-	-	-
26, . .	-	-	-	-	-	-	-	-
27, . .	33,100	123	277	0	181	0	50	0
28, . .	34,600	188	305	0	58	0	133	0
29, . .	28,900	174	154	0	113	0	15	0
30, . .	28,800	45	134	0	266	0	5	0
31, . .	85,500	356	65	0	110	0	24	0
Average, . .	42,231	469	434	-	305	-	49	-

December 5, Filter No. 68 raked.

Average Analyses of Water applied to Filters Nos. 68 and 69.

[Parts per 100,000.]

1898.	Temperature. Deg. F.	Color.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Soluble.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
January, ...	48	.43	.0661	.0234	.0155	.39	.045	.0008	.36	88.7	92,760
February, . . .	48	.40	.0618	.0198	.0141	.34	.046	.0010	.35	83.5	83,639
March, ...	47	.44	.0755	.0183	.0149	.37	.055	.0007	.31	84.7	83,607
April, ...	46	.37	.0155	.0753	.0191	.32	.043	.0002	.29	78.1	21,500
May, ...	53	.31	.0931	.0206	.0144	.36	.048	.0003	.29	67.8	24,042
June, ...	62	.27	.0907	.0223	.0153	.46	.038	.0003	.27	50.6	24,784
July, ...	69	.22	.0567	.0176	.0132	.49	.051	.0009	.22	41.6	26,712
August, ...	72	.23	.0671	.0175	.0123	.52	.041	.0005	.23	36.4	15,722
September, . . .	70	.24	.0386	.0162	.0135	.45	.057	.0006	.23	42.9	32,196
October, ...	62	.32	.0753	.0255	.0203	.51	.049	.0004	.35	52.4	49,012
November, . . .	50	.46	.0918	.0286	.0201	.50	.059	.0003	.45	62.2	29,896
December, . . .	54	.43	.0606	.0219	.0160	.40	.050	.0002	.35	76.3	42,231
Average, . . .	56	.34	.0661	.0256	.0158	.43	.049	.0005	.31	63.8	43,842

Effluent of Filter No. 68.

[Parts per 100,000.]

1898.	Quantity of Effluent. Gallons per Acre Daily.	Temperature. Deg. F. Applied Water.	Temperature. Deg. F. Effluent.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen	Bacteria per Cubic Centimeter.
January, . .	1,762,000	48	55	.27	.0010	.0083	.49	.101	.0000	.25	77.1	123
February, .	1,834,000	48	52	.28	.0007	.0075	.36	.102	.0001	.30	72.2	234
March, . .	1,695,000	47	54	.21	.0007	.0064	.37	.106	.0000	.20	72.9	126
April, . .	2,155,000	46	43	.21	.0020	.0077	.31	.103	.0001	.19	75.5	147
May, . .	2,319,000	53	45	.19	.0016	.0088	.33	.157	.0000	.20	70.1	55
June, . .	-	-	-	-	-	-	-	-	-	-	-	-
July, . .	1,104,000	69	73	.15	.0022	.0098	.50	.115	.0002	.19	30.4	731
August, . .	1,319,000	72	72	.13	.0017	.0074	.51	.089	.0000	.20	39.2	42
September, .	1,241,000	70	66	.16	.0019	.0080	.44	.098	.0000	.20	51.7	82
October, . .	1,313,000	62	56	.19	.0017	.0106	.52	.111	.0000	.25	44.9	147
November, .	1,856,000	50	49	.29	.0018	.0106	.50	.058	.0000	.30	61.0	186
December, .	2,050,000	54	55	.29	.0019	.0094	.48	.105	.0000	.25	66.4	434
Average, .	1,695,000	56	56	.22	.0016	.0086	.44	.104	.0000	.23	60.1	210

Effluent of Filter No. 69.

[Parts per 100,000.]

1898.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			
January, . .	1,906,000	48	53	.24	.0007	.0067	.51	.099	.0000	.21	56.9	204
February, .	1,834,000	48	51	.27	.0043	.0073	.35	.097	.0000	.23	58.1	332
March, . .	1,841,000	47	50	.21	.0005	.0060	.37	.106	.0000	.18	62.8	107
April, . .	2,547,000	47	42	.20	.0022	.0077	.30	.093	.0000	.18	52.1	122
May, . .	2,859,000	53	52	.20	.0046	.0074	.36	.105	.0029	.19	20.4	84
June, . .	2,613,000	62	69	.22	.0271	.0087	.46	.060	.0051	.22	15.2	173
July, . .	2,240,000	69	71	.17	.0219	.0101	.49	.059	.0046	.18	14.6	68
August, . .	2,263,000	71	71	.13	.0063	.0066	.51	.058	.0064	.18	4.7	28
September, .	2,114,000	70	65	.15	.0033	.0089	.44	.094	.0013	.19	10.8	91
October, . .	2,132,000	62	54	.20	.0028	.0111	.51	.111	.0022	.23	10.2	338
November, .	2,016,000	50	50	.28	.0028	.0108	.50	.098	.0030	.31	27.8	279
December, .	1,934,000	54	53	.26	.0013	.0088	.45	.098	.0004	.21	15.4	305
Average, .	2,192,000	57	57	.21	.0065	.0083	.44	.090	.0022	.21	29.1	178

Effluent of Filter No. 90.

[Parts per 100,000.]

1898.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			
January, . .	3,331,000	53	54	.24	.0007	.0075	.48	.101	.0000	.21	77.7	63
February, .	3,270,000	52	49	.27	.0005	.0075	.34	.095	.0001	.21	81.2	102
March, . .	3,008,000	53	50	.20	.0009	.0062	.37	.100	.0000	.16	83.9	83
April, . .	3,844,000	45	42	.20	.0017	.0079	.31	.104	.0000	.19	77.5	71
May, . .	4,189,000	52	45	.20	.0022	.0078	.33	.125	.0000	.19	69.4	92
Average, .	3,528,000	51	48	.22	.0012	.0074	.37	.105	.0000	.19	77.9	82

Effluent of Filter No. 109.

[Parts per 100,000.]

1898.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.		
May, ...	2,308,000	49	55	.16	.0215	.0075	.32	.085	.0010	.16	92
June, ...	2,738,000	69	67	.13	.0253	.0078	.46	.059	.0087	.16	37
July, ...	2,317,000	72	71	.11	.0065	.0087	.49	.085	.0020	.16	35
August, ...	3,034,000	72	71	.11	.0017	.0063	.50	.081	.0000	.16	5
September, ...	2,789,000	66	64	.14	.0012	.0079	.44	.093	.0000	.20	22
October, ...	2,993,000	55	54	.15	.0016	.0099	.52	.126	.0000	.20	29
November, ...	3,108,000	50	49	.22	.0008	.0101	.50	.103	.0000	.25	54
December, ...	2,865,000	54	52	.20	.0012	.0082	.48	.117	.0000	.18	49
Average, ...	2,769,000	61	60	.15	.0075	.0083	.46	.094	.0015	.18	40

Per Cent. of Dissolved Oxygen in Water applied to Filters Nos. 68 and 69.

Day of Month.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1, ...	84.0	-	-	86.2	-	52.8	-	-	36.0	-	51.8	66.8
2, ...	-	80.5	-	78.6	-	-	-	37.1	37.8	-	67.4	68.7
3, ...	-	85.3	90.0	-	-	-	-	38.8	25.1	-	84.2	68.6
4, ...	93.2	83.7	79.3	82.3	77.6	54.2	-	-	-	57.5	58.6	-
5, ...	87.0	82.1	71.7	78.5	80.5	-	-	37.3	52.7	38.6	-	60.6
6, ...	90.9	-	-	77.7	72.2	61.3	-	-	-	43.8	-	60.6
7, ...	86.6	84.5	-	81.0	-	57.2	48.9	-	41.0	42.4	64.6	68.4
8, ...	89.6	77.0	-	89.3	-	-	-	36.3	39.4	-	58.6	65.9
9, ...	-	-	-	74.6	76.1	73.4	46.2	-	35.3	-	41.5	72.8
10, ...	92.7	-	87.8	-	76.1	-	-	31.6	33.2	44.4	55.8	60.4
11, ...	94.0	87.3	85.8	86.1	74.3	-	48.4	37.5	-	48.0	46.7	-
12, ...	-	80.2	82.9	-	72.2	-	-	44.1	46.4	34.6	-	69.8
13, ...	90.7	-	-	88.9	70.5	-	42.7	47.3	44.0	35.0	-	77.0
14, ...	87.0	77.2	-	73.0	-	-	-	-	32.0	44.6	-	80.2
15, ...	89.4	78.9	89.0	74.8	-	-	47.3	33.3	43.0	-	-	83.3
16, ...	-	84.9	-	71.5	64.6	52.3	43.0	34.3	51.5	-	55.1	83.0
17, ...	83.7	83.9	88.1	-	72.7	-	-	32.1	40.7	57.7	57.2	88.8
18, ...	92.7	87.6	-	78.7	-	-	50.5	33.6	-	-	56.9	-
19, ...	90.0	81.5	-	-	-	-	47.5	37.3	40.7	61.6	59.0	-
20, ...	-	-	-	70.6	-	-	35.9	31.7	48.4	66.7	-	91.6
21, ...	95.8	79.8	85.4	74.0	-	-	19.2	-	45.7	46.3	58.2	87.4
22, ...	83.5	-	89.1	73.9	-	-	45.2	44.8	49.9	55.8	57.0	87.5
23, ...	-	86.0	78.4	68.5	50.0	-	-	-	39.9	-	63.3	84.3
24, ...	85.1	87.9	-	-	55.3	-	-	-	53.7	64.7	-	-
25, ...	86.2	89.1	-	74.8	53.1	30.7	-	-	-	59.2	64.1	-
26, ...	88.5	-	-	-	54.1	-	-	24.4	57.9	60.4	57.3	-
27, ...	87.4	-	-	-	-	-	-	39.2	41.1	50.8	-	82.2
28, ...	-	89.4	80.7	-	-	-	-	-	56.2	69.7	68.6	84.0
29, ...	85.7	-	89.9	-	-	34.8	24.1	42.3	45.0	53.7	78.9	81.9
30, ...	-	-	87.9	-	-	39.0	-	23.0	34.7	-	70.4	78.4
31, ...	87.6	-	84.1	-	-	-	-	41.9	-	47.5	-	78.8

Per Cent. of Dissolved Oxygen in Effluent of Filter No. 68.

Day of Month.	January.	February.	March.	April.	May.	July.	August.	September.	October.	November.	December.
1,	82.7	–	–	77.8	–	–	–	41.9	–	31.6	56.7
2,	–	77.1	–	69.0	–	–	21.8	32.1	–	39.0	55.1
3,	–	83.2	66.7	–	–	–	21.4	45.2	–	34.4	50.2
4,	88.7	80.9	61.8	80.2	75.6	–	–	–	57.0	44.9	–
5,	84.4	68.8	58.0	75.4	71.4	–	37.2	104.7	46.8	–	48.7
6,	74.5	–	–	82.3	66.1	–	–	–	54.6	–	65.3
7,	66.7	73.1	–	64.8	–	–	–	100.0	53.9	69.8	65.9
8,	67.9	60.6	–	76.0	–	–	36.1	79.5	–	67.3	57.7
9,	–	–	–	74.8	73.5	–	–	59.3	–	35.7	65.2
10,	57.4	–	66.7	–	68.1	–	43.2	–	49.0	32.0	65.7
11,	66.7	82.6	64.1	80.9	70.0	–	43.5	–	32.9	38.3	–
12,	–	82.7	66.1	–	71.3	–	51.1	37.9	30.4	–	65.9
13,	–	–	–	70.5	65.0	–	43.8	37.5	29.8	–	69.7
14,	70.5	75.2	–	65.2	–	–	–	45.1	16.2	–	71.1
15,	74.1	69.4	73.1	62.6	–	–	35.2	43.0	–	–	66.3
16,	–	61.6	–	87.0	–	–	43.0	41.8	–	84.1	69.9
17,	93.9	72.6	–	–	–	–	54.7	38.5	37.1	83.7	81.1
18,	75.9	75.2	–	84.5	–	–	44.2	–	–	70.3	–
19,	91.7	72.6	–	–	–	75.6	46.6	52.7	40.5	70.6	–
20,	–	–	–	86.6	–	26.2	39.6	65.4	50.6	–	69.5
21,	73.6	71.7	81.4	82.9	–	18.1	–	53.9	55.9	69.1	72.5
22,	72.5	–	85.5	76.5	–	9.3	27.4	42.6	54.6	64.6	72.5
23,	–	65.1	74.1	77.3	–	–	–	41.8	–	66.5	70.5
24,	89.6	65.7	–	–	–	–	–	36.2	35.7	–	–
25,	82.4	62.9	–	83.2	–	–	–	–	39.9	62.3	–
26,	80.2	–	–	–	–	–	27.1	57.9	54.5	68.7	–
27,	77.1	–	–	–	–	–	48.3	49.1	50.2	–	75.6
28,	–	68.5	85.8	–	–	–	–	53.3	55.7	71.6	69.9
29,	72.7	–	79.8	–	–	22.7	39.1	62.7	50.6	63.9	73.2
30,	–	–	80.9	–	–	–	35.6	38.0	–	58.8	69.2
31,	76.3	–	76.0	–	–	–	44.8	–	36.3	–	65.6

Filter operated continuously from January 1 to May 14, inclusive, and intermittently from July 18 to December 31, inclusive.

Per Cent. of Dissolved Oxygen in Effluent of Filter No. 69.

Day of Month.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1,	–	–	–	70.6	–	1.0	–	–	0.8	–	0.6	42.2
2,	–	53.4	–	68.0	–	–	–	1.9	1.7	–	0.3	26.5
3,	–	57.1	61.2	–	–	–	–	3.3	–	–	1.0	15.6
4,	67.3	62.9	56.4	74.2	6.7	0.9	–	–	–	2.0	16.7	–
5,	59.6	71.4	57.1	63.1	13.4	–	–	6.1	–	0.7	–	1.6
6,	53.8	–	–	71.5	5.4	55.2	–	–	72.8	12.8	–	0.9
7,	73.1	67.3	–	68.5	–	53.0	0.8	–	76.2	2.1	6.1	3.5
8,	47.2	58.3	–	70.6	–	–	–	9.8	36.7	–	17.3	0.6
9,	–	–	–	72.4	15.0	–	2.0	–	19.6	–	1.0	2.1
10,	60.2	–	53.7	–	24.8	–	–	11.5	5.6	17.7	4.2	4.8
11,	59.3	57.7	49.5	61.8	21.8	–	0.8	2.2	–	81.3	1.5	–
12,	–	57.3	50.9	–	11.1	–	–	7.8	0.7	24.7	–	5.3
13,	67.6	–	–	–	1.0	–	0.7	4.1	0.7	0.3	–	8.1
14,	54.7	52.7	–	60.0	–	–	–	–	0.7	0.8	–	12.5
15,	54.6	51.4	64.8	63.4	–	–	46.0	1.2	0.9	–	–	13.4
16,	–	50.9	–	45.5	8.9	7.2	5.8	34.0	0.7	–	6.2	13.2
17,	59.8	59.3	83.6	–	86.2	–	–	1.2	1.1	17.4	6.2	15.4
18,	68.1	61.8	–	22.2	–	–	1.5	1.2	–	–	5.2	–
19,	61.1	62.5	–	–	–	–	4.5	1.2	1.2	24.4	3.5	–
20,	–	–	–	39.5	–	–	1.6	0.7	1.4	14.0	–	16.8
21,	63.2	56.6	72.6	19.0	–	–	29.2	–	0.7	0.7	2.7	21.1
22,	53.7	–	73.6	18.5	–	–	77.0	2.0	4.6	2.7	3.5	22.1
23,	–	55.5	61.5	19.3	69.0	–	–	–	1.1	–	16.3	23.4
24,	50.0	–	–	–	21.3	–	–	–	0.7	15.6	–	–
25,	54.5	48.6	–	13.4	0.6	2.7	–	–	–	1.4	11.7	–
26,	47.2	–	–	–	0.6	–	–	1.2	8.8	1.0	10.5	–
27,	42.9	–	–	–	–	–	–	0.8	6.1	1.0	–	27.0
28,	–	60.2	67.9	–	–	–	–	–	12.0	0.5	76.5	23.5
29,	50.0	–	63.3	–	–	0.0	5.8	1.1	3.2	0.6	80.1	25.7
30,	–	–	59.1	–	–	1.2	–	0.8	1.1	–	70.2	24.3
31,	46.6	–	66.1	–	–	–	–	1.2	–	1.2	–	20.9

Filter operated intermittently from January 1 to April 14, inclusive, and continuously from April 15 to December 31, inclusive.

Filtration through Ashes.

Filter No. 86.

Filter No. 86 was first put in operation on May 28, 1897, and contains 48 inches in depth of coal ashes. Merrimack River water was applied to it at an average rate of 4,206,000 gallons per acre daily during the three months of 1897 that it was operated, and the effluent of the filter was clear and odorless, and the removal of organic matter from the applied water was equal to the removal obtained by the best of our sand filters. The effluent was slightly harder than the river water, and the bacterial efficiency very much poorer than that of our best sand filters. The filter was again put into operation on May 1, 1898, and continued until October 31 of the same year. During this period the rate of filtration was approximately 3,000,000 gallons per acre daily, and the effluent was well purified from a chemical point of view. During this year the hardness of the effluent was somewhat less than during 1897, and the bacterial results obtained were very much better. It was noticed, however, that *B. coli* came through in large numbers on several of the days during its period of operation in 1898, even on days when the total number of bacteria present in the effluent was low. The surface of the filter has not clogged during its period of operation in 1897 and 1898, and hence has been neither raked or scraped. The following tables show the bacterial and chemical analyses of the effluent: —

Average Daily Number of Bacteria per Cubic Centimeter in Effluent from Filter No. 86.

Day.	May.		June.		July.		August.		September		October.	
	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.	Bacteria.	B. Coli.
1, ...	-	-	111	-	51	0	123	-	30	4	112	0
2, ...	400	-	62	0	63	0	46	-	38	0	-	-
3, ...	600	-	11	1	-	-	75	1	19	0	73	0
4, ...	800	-	85	0	-	-	106	6	-	-	34	0
5, ...	93	-	-	-	172	0	60	5	-	-	136	0
6, ...	83	-	27	0	52	0	80	20	372	0	110	0
7, ...	23	-	70	0	193	0	-	-	266	0	175	0
8, ...	-	-	52	1	94	2	53	4	165	0	137	0
9, ...	80	-	26	0	340	12	44	0	118	10	-	-
10, ...	85	-	95	0	-	-	98	4	349	15	30	0
11, ...	58	-	37	0	72	4	55	-	-	-	21	0
12, ...	44	-	-	-	38	0	85	6	35	0	19	0
13, ...	60	-	223	0	127	-	105	4	13	0	42	0
14, ...	71	-	17	0	95	12	-	-	166	3	53	0
15, ...	-	-	70	1	188	28	83	0	86	2	41	0
16, ...	73	0	103	0	61	20	28	0	39	0	-	-
17, ...	85	5	-	-	-	-	35	0	66	0	109	0
18, ...	39	3	41	0	83	5	48	0	-	-	18	0
19, ...	21	2	-	-	41	0	18	2	232	0	54	0
20, ...	3	0	32	1	103	2	88	3	100	0	99	0
21, ...	41	0	71	0	124	2	-	-	142	0	103	0
22, ...	-	-	101	0	95	-	30	3	358	2	28	0
23, ...	85	3	112	2	122	0	30	0	188	0	-	-
24, ...	73	0	33	1	-	-	43	0	204	0	18	0
25, ...	55	0	33	0	125	12	22	0	-	-	31	0
26, ...	41	1	-	-	43	0	35	0	284	0	75	0
27, ...	34	1	253	0	90	0	17	0	110	0	84	0
28, ...	102	0	60	-	72	0	-	-	34	0	22	0
29, ...	-	-	122	0	75	0	9	0	48	0	85	4
30, ...	-	-	57	0	20	0	10	0	103	0	-	-
31, ...	86	-	-	-	-	-	33	0	-	-	95	0
Average, . .	56	-	68	-	104	-	53	-	143	-	69	-

Effluent of Filter No. 86.

[Parts per 100,000.]

1898.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			
May, . .	2,496,000	–	60	.28	.0013	.0082	.17	.019	.0000	.29	69.6	56
June, . .	2,621,000	–	68	.28	.0012	.0104	.15	.025	.0000	.30	30.5	68
July, . .	2,518,000	–	70	.20	.0010	.0068	.25	.026	.0000	.18	2.3	104
August, . .	2,660,000	–	74	.24	.0017	.0096	.25	.023	.0003	.29	2.3	53
September, .	2,622,000	–	69	.20	.0006	.0086	.24	.031	.0000	.42	8.6	143
October, . .	2,612,000	–	52	.44	.0016	.0147	.27	.024	.0000	.49	9.2	69
Average, .	2,586,000	–	66	.27	.0012	.0097	.22	.025	.0001	.33	20.4	82

Method of Differentiation of Bacillus Coli Communis, employed at the Lawrence Experiment Station, used as a Test to determine the Presence of Sewage Bacteria in Water.

The bacillus *coli communis* is the characteristic organism of human fæces, occurring in large numbers in sewage and in greater or less numbers in all sewage-polluted waters.

The method used in testing for *B. coli* is a combination of the tests generally employed in species determinations, modified and adapted to the routine handling of a number of samples daily. The details have all been determined by experiment to be those most favorable for rapid and accurate differentiation.

Cultural Characteristics.

The cultural characteristics of the colon bacillus are as follows: —

Agar. — On the surface of glycerine agar it produces a luxuriant, smooth, moist, white growth, which is never stringy to the needle.

Gelatine. — It grows well in nutrient gelatine, without liquefying that medium.

Lactose-Litmus-Agar. — In neutral agar, containing milk sugar and blue litmus, it grows rapidly, producing acid and turning the litmus red around the colonies.

Milk. — Grown in milk, acid is produced and the milk is quickly coagulated.

Smith's Solution. — In bouillon containing glucose, fermentation at once takes place; contained in a bent tube with one arm closed, the gas is collected in the closed arm of the tube.

Nitrate Solution. — In nutrient solution, containing small amounts of potassium nitrate, the nitrate is quickly and completely reduced to nitrite.

Indol. — In solutions containing small amounts of peptone and salt, or in bouillon free from carbohydrates and containing peptone and salt, indol is produced.

Method.

The method employed in testing waters for *B. coli communis* varies slightly with the character of the water under examination. For waters in which *B. coli* is very rarely found, a qualitative test is used; while, for waters generally containing that organism in some numbers, a quantitative method is used.

The qualitative test consists in inoculating a Smith tube, containing glucose-bouillon, with one cubic centimeter of the water. This tube is set away in an incubator, automatically kept at a temperature of 38° C. If, after twelve hours' growth, gas has collected in the closed arm, the tube is taken out and complete species tests made. The absence of gas is final, there being no *B. coli* in the water.

Some of the bouillon from the fermented tube is now diluted with sterile water, and a portion plated on lactose-litmus-agar. This plate is grown for twelve hours in the incubator at 38° C. If at the end of this time any red colonies are found on the plate, a few of these are fished to agar slants and grown twelve hours, as before. If this culture resembles *B. coli*, tubes of Smith's solution, milk, nitrate solution and Dunham's solution are inoculated with it, and a gelatine stab is made. The Smith tubes, nitrate solution and milk are grown twelve hours at 38° C. The Dunham's solution is grown at the same temperature for three days. The gelatine must be grown at 20° C. for at least seven days. Some species of bacteria, resembling *B. coli* closely, will liquefy the gelatine very slowly. A culture which gives characteristic reactions with all of the above media belongs to the colon group undoubtedly.

In quantitative work, when dealing with waters in which *B. coli* is known to be present, the preliminary test on Smith's solution is omitted. One cubic centimeter of the water is plated direct on lactose-litmus-agar, and the plates grown twelve hours at 38° C. At the end of this time the plates are taken out and the number of red colonies counted. If the number is small, all of the colonies are fished to agar slants; if, however, the number is large, a few representative colonies are chosen as an average of the whole number, and are fished as before. The agar slants are grown over night at 38° C., and the cultures so obtained are examined and tested exactly as those obtained in the qualitative method.

The reason for employing the qualitative method, instead of using the plate method, is that the test is more delicate. We have frequently found that duplicate determinations gave *B. coli* present by the gas test and absent by the plate method. This is probably due to the influence of the slightly alkaline media, and to the fact that better development is always obtained in fluid than in solid media. The test also requires less time in manipulation and less room in the incubator.

The accuracy of these tests depends largely on attention to the seemingly minor details of time of growth, temperature, reaction and composition of media. *B. coli* will develop well at a temperature of 38° to 40° C. in from eight to twelve hours. The thermal death point of most species of water bacteria lies below that temperature, and some species, which would grow, require more time, usually thirty-six to forty-eight hours, for development.

Preparation of Media.

Glycerine Agar. — Meat bouillon is first prepared by soaking 500 grams of finely chopped lean beef in 1 liter of water over night. The juice is then pressed out, boiled fifteen minutes, and the coagulated matter filtered out. To this is added 1 per cent. peptone and 1 per cent. chopped agar-agar. It is usual to soak the agar in a known volume of water, and make allowance for the extra water in boiling down. This mixture is boiled thirty minutes, the evaporated water replaced, the solution titrated, and normal sodium hydrate solution added in sufficient amount to make the solution neutral to phenolphthalein. We now boil for one hour, replace water and titrate again, and add normal hydrochloric acid to make the acidity of the media about 15°, Fuller's scale (see annual report of Board for 1895, page 591). The solution is now filtered through cloth and wet cotton until clear, 3 per cent. glycerine is added, and the media tubed and sterilized. Slants are made by allowing the melted media to harden with the tubes laid on one side in a sloping position.

Lactose Agar. — Lactose agar is prepared from the neutral agar by adding 2 per cent. powdered lactose, cooking ten minutes and adding caustic soda solution to make the reaction of the media about minus five, Fuller's scale. Some change in reaction takes place in sterilizing, and the media, as used, is nearly neutral. The media is tubed and sterilized, and enough strong aqueous solution of litmus is added, just before using, to turn it a dark blue.

Smith's Solution. — Smith's solution or glucose bouillon is prepared from the meat bouillon by adding 1 per cent. peptone and 2 per cent. glucose, cooking fifteen minutes and neutralizing with caustic soda solution. It is then filtered through wet paper, run into Smith tubes and sterilized.

Milk. — Fresh milk is heated for fifteen minutes, cooled and set in ice chest over night. In the morning the clear milk is separated from the cream, tubed and sterilized.

Nitrate Solution. — One-tenth of one per cent. peptone and two-hundredths of one per cent. potassium nitrate are dissolved in distilled water, heated ten minutes, filtered through paper, tubed and sterilized. To test for presence of nitrite, add a few drops of a mixture of equal parts of the following: A = 10 grains naphthalamine dissolved in 10 cubic centimeters of strong hydrochloric acid, and made up to one liter with distilled water; B = 10 grams sulphanilic acid, dissolved in 10 cubic centimeters concentrated sulphuric acid, and made up to one liter with distilled water.

Dunham's Solution. — Dissolve 1 per cent. Witte's peptone and half of 1 per cent. of common salt in water, heat ten minutes, filter, tube and sterilize. To test for indol add 1 cubic centimeter of sodium nitrite solution and 1 cubic centimeter of sulphuric acid, and a pink color will appear if indol is present.

Precautions and Hints on Manipulation.

All media containing sugar, glucose or lactose should be sterilized in the Arnold for thirty minutes, three successive days. Other media are more conveniently sterilized in the Autoclave at a pressure of fifteen to twenty pounds. Fifteen minutes is sufficient. Care should be observed to remove gas from closed arm of Smith tubes immediately after sterilizing, as it is reabsorbed on cooling, and will give false tests when placed in the incubator.

In making plates with lactose-litmus-agar it is better to turn the plates upside down before placing in the incubator. Spreaders are thus avoided, and pure cultures are more easily obtained.

In testing for indol it is well to keep the tubes cold. The reaction in warm solution is apt to go too far, and the characteristic color to be destroyed.

AN INVESTIGATION

OF THE

ACTION OF WATER UPON LEAD, TIN AND ZINC,

WITH ESPECIAL REFERENCE TO THE USE OF LEAD PIPES WITH MASSACHUSETTS WATER SUPPLIES.

By H. W. CLARK, *Chemist of the Board.*

AN INVESTIGATION OF THE ACTION OF WATER UPON LEAD, TIN AND ZINC, WITH ESPECIAL REFERENCE TO THE USE OF LEAD PIPES WITH MASSACHUSETTS WATER SUPPLIES.

By H. W. Clark, Chemist of the Board.

During the past two years an investigation has been carried on by the State Board of Health, in order to learn the nature and degree of the action of the waters of the various public water supplies of the State upon lead, in such towns as use lead or lead-lined service pipes, and to ascertain facts in regard to the occurrence of lead-poisoning in these towns. This investigation was undertaken on account of a large number of cases of lead poisoning in several of the towns of the State, which were upon investigation found to be due to the fact that the water supplied publicly to these towns was of such a character as to actively attack lead, and cause an appreciable amount of lead to be taken constantly into their systems by persons who habitually used these waters drawn through lead pipes.

When the investigation was begun, communications had been received from the water department officials of 136 of the cities and towns of the State in regard to the use or non-use of lead service pipes by them. Sixty-five of these municipalities reported that no lead service pipes were in use, and 71 reported the use of lead or lead-lined service pipes. Of the 71 towns reporting the use of lead or lead-lined service pipes, 7, namely, Ashburnham, Everett, Fall River, Lexington, Milford, South Hadley and Warren, reported that all the service pipes in use were lead; 2, namely, Easton and Millbury, reported that all the service pipes in use were lead-lined; and 1, namely Stoughton, reported that all the service pipes in use were either lead or lead-lined; 14 other municipalities reported that more than 50 per cent. of the service pipes in use were lead or lead-lined; while the remaining towns furnished reports showing the use of lead pipes in very different proportions, varying from 1 service pipe up to 50 per cent. of the service pipes; but in most of these towns only a very few lead service pipes were in use. It is probable, however, that in all of these places many houses are piped with lead beyond the service pipe.

During the past two years we have examined in this laboratory, for lead, about 800 samples of water, from 63 different towns and cities. Many of the samples taken have really required two analyses, in order to determine both the lead in solution and that in suspension. From 30 of the municipalities one or more series of samples have been taken; the cities and towns from which these series were taken being selected partly because of the large amount of lead pipe in use, and partly because of real or supposed cases of lead poisoning in these towns.

When the work of determining the amount of lead in the various water supplies was begun in this laboratory, the method of analysis previously used by Dr. Worcester, of the food and drug laboratory of the Board, was employed. This was a colorimetric method, by which, after preliminary treatment of the sample, small amounts of lead could be determined in solution, by noting the color obtained when the lead was precipitated as sulphide by hydrogen sulphide. This method as first used was not entirely satisfactory to us, as the colors obtained were at times difficult to read. Experiments were therefore made, as the work progressed, to improve it, if possible; and, with Dr. Worcester's method as a basis, a fairly satisfactory method of analysis has been worked out, by which very minute quantities of lead can be determined with considerable accuracy, — an accuracy much greater, we believe, than would result if any gravimetric method were used in dealing with the small quantities of lead found in one gallon of most of the samples of water examined. An appended paper describes the first method employed, together with the various steps by which it was improved, and a description of the method now in use, together with certain experiments to indicate the accuracy of the method.

Sheets showing the analyses of all samples examined during this investigation, together with the data in regard to age, size and length of pipes, and length of time that the sample of water examined remained in the pipe, are on file in the office of the engineer of the Board.

There is given below a list of the cities and towns from which samples of water have been collected for the determination of lead. Opposite the name of each place is given the greatest amount of lead found in any sample of water from this town which has been examamined. The asterisk, placed after the figures giving the amount of lead present, indicates that the amount of lead found in this sample was very much greater than the average amount in the samples from this city or town.

List of Cities and Towns.

	Lead (Parts per 100,000).†		Lead (Parts per 100,000).
Acton,	.1880	Millbury,	.1320*
Andover,	.0616	Nantucket,	.0496
Ashburnham,	.3796	Needham,	.0633
Attleborough,	.3390	New Bedford,	.4497*
Berlin,	.1778	Newton,	.0610
Boston,	.6424*	North Andover,	.1898
Bridgewater,	.0513	North Attleborough,	.0103
Chicopee, two systems,	.1402	Northfield,	.0131
	.7154*	Norwood,	.1051
Cohasset,	.0023	Palmer,	.1727
Concord,	.1868*	Pittsfield,	.0085
Easton,	.5256*	Plymouth,	.0082
Everett,	.0205	Quincy,	.0838
Fairhaven,	.5865	Reading,	.0292
Fall River,	.0924*	Revere,	.0342
Framingham,	.0584	Rockland,	.1664
Haverhill,	.0584	Rutland,	.0410
Holyoke,	.0171	Sharon,	.0467
Hudson,	.0068	Shelburne Falls,	.0058
Ipswich,	.0874*	Southborough,	.0085
Kingston,	.5574	Southbridge,	.1915
Lancaster,	.0188	South Hadley,	.3504
Lawrence,	.3450*	South Hanover,	.0237
Lexington,	.0171	Springfield,	.1343
Lowell,	2.0440*	Stoughton,	.4380
Malden,	.2803	Walpole,	.0340
Marlborough,	.0085	Warren,	.0862
Medway,	.2914	Wellesley,	.0180
Melrose,	.0088	Wellesley Farms,	.0085
Methuen,	.0142	West Brookfield,	8.5460
Middleborough,	.1727	Weymouth,	.1676
Milford,	.4700	Williamstown,	.0142

† Parts per 100,000 × .583 = grains per United States gallon.

A number of the analyses given here are of samples from wells in certain towns which have no public water supply, and the samples were forwarded to this laboratory for analysis because the water was suspected of being the cause of cases of lead poisoning.

One or more series of samples have been taken from Ashburnham, Boston, Chicopee, Concord, Easton, Fairhaven, Fall River, Framingham, Haverhill, Ipswich, Kingston, Lawrence, Lexington, Lowell, Malden, Methuen, Milford, Millbury, New Bedford, Norwood, Palmer, Reading, Revere, Rockland, Sharon, South Hadley, Springfield, Stoughton, Warren and West Brookfield, and the work is still in progress.

The four following tables summarize the results in regard to the lead found in the series of samples taken from the towns just named; the first table being an arrangement of ground-water supplies according to the maximum amount of lead found in the samples taken after the water had stood in the pipes for a number of hours, and the second being an arrangement of ground-water supplies according to the average amount found in the samples when the water was in ordinary daytime use. The third and fourth tables are similar arrangements of samples from surface-water supplies. The tables also show the minimum amounts of lead found both in samples taken when the water was in ordinary daytime use, and in samples taken after the water had stood in the pipes for a number of hours; also the average of the sets of samples.

Table No. 1.

Lead in Samples of Water.— Ground Waters, arranged according to Maximum Amount of Lead found after Water has stood in Pipes.

[Parts per 100,000.]

	Maximum Amount.	Minimum Amount.	Average.	Locality.
In ordinary use,	.0966	.0069	.0518	West Brookfield, Quaboag Aqueduct Company.
After standing in pipe,	.0207 *8.5460	.0207 8.2110	.0207 8.3785	
In ordinary use,	.0138	.0069	.0092	West Brookfield, Aqueduct Company.
After standing in pipe,	.0414 *1.0660	.0069 .0621	.0233 .5774	
In ordinary use,	2.0440†	.0034	.1899	Lowell.
After standing in pipe,	1.0454	.0204	.1933	
In ordinary use,	.3762	.0068	.0959	Fairhaven.
After standing in pipe,	.5865	.0445	.2461	
In ordinary use,	.4189	.0154	.0944	Kingston.
After standing in pipe,	.5574	.0547	.1962	
In ordinary use,	.0555	.0234	.0414	North Easton.
After standing in pipe,	.5256	.0409	.1667	
In ordinary use,	.3870	.0290	.1258	Milford.
After standing in pipe,	.4700	.0320	.1991	
In ordinary use,	.0555	.0204	.0307	Ashburnham.
After standing in pipe,	.3796	.0292	.1210	
In ordinary use,	.0496	.0234	.0385	South Hadley.
After standing in pipe,	.3504	.0350	.1194	
In ordinary use,	.0450	.0000	.0170	Millbury.
After standing in pipe,	.1320	.0000	.0340	
In ordinary use,	.0513	.0285	.0437	West Brookfield, Cement Aqueduct Company.
After standing in pipe,	.0969	.0627	.0779	
In ordinary use,	.0350	.0058	.0189	Framingham.
After standing in pipe,	.0584	.0117	.0340	
In ordinary use,	.0229	.0000	.0057	Malden.
After standing in pipe,	.0486	.0058	.0200	
In ordinary use,	.0234	.0058	.0140	Sharon.
After standing in pipe,	.0467	.0117	.0274	
In ordinary use,	.0171	.0057	.0101	Revere.
After standing in pipe,	.0342	.0114	.0185	
In ordinary use,	.0146	.0000	.0055	Reading.
After standing in pipe,	.0292	.0029	.0142	
In ordinary use,	.0103	.0041	.0073	Lexington.
After standing in pipe,	.0172	.0064	.0108	
In ordinary use,	–	–	–	Methuen.
After standing in pipe,	.0142	.0000	.0056	

* With the West Brookfield waters, the lower figures give lead in suspension, and the figures above, lead in solution.

† At the place where this sample was taken there was about 300 feet of lead and lead-lined pipe. No sample of the water in the pipe a number of hours taken.

Table No. 2.

Lead in Samples of Water.— Ground Waters, arranged according to Average Amount of Lead found when Water is in Ordinary Use.

[Parts per 100,000.]

	Average.	Maximum Amount.	Minimum Amount.	Locality.
In ordinary use,	.1899	2.0440	.0034	Lowell.
After standing in pipe,	.1933	1.0454	.0204	
In ordinary use,	.1258	.3870	.0154	Milford.
After standing in pipe,	.1991	.4700	.0188	
In ordinary use,	.0959	.3762	.0068	Fairhaven.
After standing in pipe,	.2461	.5865	.0445	
In ordinary use,	.0944	.4189	.0154	Kingston.
After standing in pipe,	.1962	.5574	.0380	
In ordinary use,	.0518	.0966	.0069	West Brookfield, Quaboag Aqueduct Company.
After standing in pipe,	.0207 *8.3785	.0207 8.5460	.0207 8.2110	
In ordinary use,	.0437	.0513	.0285	West Brookfield, Cement Aqueduct Company.
After standing in pipe,	.0779	.0969	.0627	
In ordinary use,	.0414	.0555	.0234	Easton.
After standing in pipe,	.1667	.5256	.0409	
In ordinary use,	.0385	.0496	.0234	South Hadley.
After standing in pipe,	.1194	.3504	.0350	
In ordinary use,	.0307	.0555	.0204	Ashburnham.
After standing in pipe,	.1210	.3796	.0292	
In ordinary use,	.0189	.0350	.0058	Framingham.
After standing in pipe,	.0340	.0584	.0117	
In ordinary use,	.0170	.0450	.0000	Millbury.
After standing in pipe,	.0340	.1320	.0000	
In ordinary use,	.0140	.0234	.0058	Sharon.
After standing in pipe,	.0274	.0467	.0117	
In ordinary use,	.0101	.0171	.0057	Revere.
After standing in pipe,	.0185	.0342	.0114	
In ordinary use,	.0092	.0138	.0069	West Brookfield, Aqueduct Company.
After standing in pipe,	.0233 *.5774	.0414 1.0660	.0069 .0621	
In ordinary use,	.0073	.0103	.0041	Lexington.
After standing in pipe,	.0108	.0171	.0064	
In ordinary use,	.0057	.0229	.0000	Malden.
After standing in pipe,	.0200	.0486	.0058	
In ordinary use,	.0055	.0146	.0000	Reading.
After standing in pipe,	.0142	.0292	.0029	
In ordinary use,	–	–	–	Methuen.
After standing in pipe,	.0056	.0142	.0000	

* With the West Brookfield waters, the lower figures give lead in suspension, and the figures above, lead in solution.

West Brookfield is supplied with water by several small companies. The water comes from springs on the hills, and flows by gravity through small lead mains to cisterns in the cellars of the houses of the takers. From these cisterns it is pumped, and most of the lead taken from the pipes between the springs and the houses settles to the bottom of the cisterns, and is not pumped with the water used.

TABLE No. 3.

Lead in Samples of Water.— Surface Waters, arranged according to Maximum Amount of Lead found after Water has stood in Pipes.

[Parts per 100,000.]

	Maximum Amount.	Minimum Amount.	Average.	Locality.
In ordinary use,	.1343	.0467	.0788	Chicopee, Abbe system.
After standing in pipe,	.7154	.1577	.3921	
In ordinary use,	.0359	.0051	.0177	New Bedford.
After standing in pipe,	.4497	.0445	.1466	
In ordinary use,	.1095	.0438	.0774	Stoughton.
After standing in pipe,	.4380	.0504	.2178	
In ordinary use,	.1110	.0062	.0276	Lawrence.
After standing in pipe,	.3450	.0263	.1094	
In ordinary use,	.0171	.0068	.0099	Boston.
After standing in pipe,	.3061	.0496	.1778	
In ordinary use,	.0642	.0117	.0309	Malden.
After standing in pipe,	.2803	.0467	.1056	
In ordinary use,	.0190	.0000	.0060	Concord.
After standing in pipe,	.1868	.0161	.0663	
In ordinary use,	.1440	.0050	.0511	Palmer.
After standing in pipe,	.1727	.0220	.0829	
In ordinary use,	.0788	.0117	.0283	Rockland.
After standing in pipe,	.1664	.0088	.1057	
In ordinary use,	.0494	.0000	.0195	Springfield.
After standing in pipe,	.1343	.0204	.0687	
In ordinary use,	.0526	.0292	.0409	Chicopee, Cooley system.
After standing in pipe,	.1052	.1022	.1037	
In ordinary use,	.0496	.0146	.0310	Norwood.
After standing in pipe,	.1051	.0248	.0581	
In ordinary use,	.0231	.0000	.0080	Fall River.
After standing in pipe,	.0924	.0000	.0256	
In ordinary use,	.0154	.0000	.0031	Ipswich.
After standing in pipe,	.0874	.0000	.0099	
In ordinary use,	.0234	.0051	.0095	Haverhill.
After standing in pipe,	.0584	.0088	.0281	

TABLE NO. 4.

Lead in Samples of Water.— Surface Waters, arranged according to Average Amount of Lead found when Water is in Ordinary Use.

[Parts per 100,000.]

	Average.	Maximum Amount.	Minimum Amount.	Locality.
In ordinary use, ...	.0788	.1343	.0467	Chicopee, Abbe system.
After standing in pipe, , ...	.3921	.7154	.1577	
In ordinary use, ...	.0774	.1095	.0438	Stoughton.
After standing in pipe, ...	.2178	.4380	.0584	
In ordinary use, ...	.0511	.1440	.0050	Palmer.
After standing in pipe, ...	.0829	.1727	.0220	
In ordinary use, ...	.0409	.0526	.0292	Chicopee, Cooley system.
After standing in pipe, ...	.1037	.1052	.1022	
In ordinary use, ...	.0310	.0496	.0146	Norwood.
After standing in pipe, ...	.0581	.1051	.0248	
In ordinary use, ...	.0309	.0642	.0117	Malden.
After standing in pipe, ...	.1056	.2803	.0467	
In ordinary use, ...	.0283	.0788	.0117	Rockland.
After standing in pipe, ...	.1057	.1664	.0088	
In ordinary use, ...	.0276	.1110	.0062	Lawrence.
After standing in pipe, ...	.1094	.3450	.0263	
In ordinary use, ...	.0195	.0494	.0000	Springfield.
After standing in pipe, ...	.0687	.1343	.0204	
In ordinary use, ...	.0177	.0359	.0051	New Bedford.
After standing in pipe, ...	.1466	.4497	.0445	
In ordinary use, ...	.0099	.0171	.0068	Boston.
After standing in pipe, ...	.1778	.3061	.0496	
In ordinary use, ...	.0095	.0234	.0051	Haverhill.
After standing in pipe, ...	.0281	.0584	.0088	
In ordinary use, ...	.0080	.0231	.0000	Fall River.
After standing in pipe, ...	.0256	.0924	.0000	
In ordinary use, ...	.0060	.0190	.0000	Concord.
After standing in pipe, ...	.0663	.1868	.0161	
In ordinary use, ...	.0031	.0154	.0000	Ipswich.
After standing in pipe, ...	.0099	.0874	.0000	

Stoughton water is hard to classify, being generally, up to a few months before the collection of the samples, largely ground water; when the samples were collected, however, surface water was in use almost entirely. This change may have affected and loosened or corroded the coating on the pipes, and a larger amount of lead found in the samples examined than had generally been in the water as used.

In order to make comparisons between the amount of lead found in the waters from the various places during daytime use, and the sanitary analyses of these waters, the following sets of tables are presented, the first set being of the ground waters. The sanitary analyses used are of the waters at or near the date of collection of the samples for the determination of lead.

Table showing Comparison between Color and Lead.—Arranged in Order of Degree of Color.

[Parts per 100,000.]

	Color.	Lead.		Color.	Lead.
Lexington,	.37	.0073	Kingston,	.07	.0944
Reading,	.30	.0055	South Hadley,	.05	.0385
Ashburnham,	.24	.0307	Revere,	.05	.0101
Lowell,	.13	.1899	Malden,	.02	.0057
Milford,	.12	.1258	Easton,	.01	.0414
Framingham,	.09	.0189	Millbury,	.00	.0170
Methuen,	.08	.0056	Sharon,	.00	.0140
Fairhaven,	.08	.0959			

Table showing Comparison between Total Solids and Lead.—Arranged in Order of Amount of Total Solids.

[Parts per 100,000.]

	Total Solids.	Lead.		Total Solids.	Lead.
Malden,	28.50	.0057	Kingston,	5.60	.0944
Reading,	16.70	.0055	Easton,	4.60	.0414
Revere,	14.30	.0101	Millbury,	4.40	.0170
Sharon,	8.60	.0140	Lexington,	4.05	.0073
Framingham,	7.15	.0189	Ashburnham,	3.80	.0307
Methuen,	7.00	.0056	Milford,	2.80	.1258
Lowell,	6.65	.1899	South Hadley,	2.25	.0385
Fairhaven,	6.00	.0959			

Table showing Comparison between Free Ammonia and Lead.—Arranged in Order of Amount of Free Ammonia.

[Parts per 100,000.]

	Free Ammonia.	Lead.		Free Ammonia.	Lead.
Kingston,	.0074	.0944	Milford,	.0007	.1258
Lowell,	.0074	.1899	Ashburnham,	.0006	.0307
Lexington,	.0038	.0073	Fairhaven,	.0002	.1085
Reading,	.0028	.0055	Methuen,	.0002	.0056
Revere,	.0014	.0101	Easton,	.0000	.0414
Millbury,	.0010	.0170	South Hadley,	.0000	.0385
Framingham,	.0008	.0189	Sharon,	.0000	.0140
Malden,	.0008	.0057			

Table showing Comparison between Oxygen consumed and Lead.—Arranged in Order of Amount of Oxygen consumed.

[Parts per 100,000.]

	Oxygen Consumed.	Lead.		Oxygen Consumed.	Lead.
Lexington,	.3600	.0073	Framingham,	.0720	.0189
Reading,	.3200	.0055	Millbury,	.0533	.0170
Ashburnham,	.2700	.0307	Kingston,	.0320	.0944
Milford,	.2000	.1258	Malden,	.0320	.0057
Methuen,	.1520	.0056	Easton,	.0200	.0414
Fairhaven,	.1130	.0959	Sharon,	.0200	.0140
Lowell,	.1020	.1899	Revere,	.0160	.0101
South Hadley,	.1000	.0385			

Table showing Comparison between Chlorine and Lead.—Arranged in Order of Amount of Chlorine.

[Parts per 100,000.]

	Chlorine.	Lead.		Chlorine.	Lead.
Malden,	3.04	.0057	Reading,	0.41	.0055
Revere,	1.42	.0101	Lexington,	0.37	.0073
Sharon,	1.08	.0140	Methuen,	0.28	.0056
Fairhaven,	0.99	.0959	Milford,	0.22	.1258
Framingham,	0.93	.0189	Millbury,	0.19	.0170
Kingston,	0.83	.0944	South Hadley,	0.13	.0385
Easton,	0.44	.0414	Ashburnham,	0.12	.0307
Lowell,	0.42	.1899			

Table showing Comparison between Nitrates and Lead.—Arranged in Order of Amount of Nitrates.

[Parts per 100,000.]

	Nitrates.	Lead.		Nitrates.	Lead.
Malden,	.8800	.0057	Milford,	.0170	.1258
Sharon,	.2520	.0140	Framingham,	.0160	.0189
Revere,	.1900	.0101	Lexington,	.0150	.0073
Easton,	.0500	.0414	Reading,	.0070	.0055
Fairhaven,	.0400	.0959	Methuen,	.0030	.0056
Kingston,	.0300	.0944	South Hadley,	.0020	.0385
Lowell,	.0300	.1899	Ashburnham,	.0000	.0307
Millbury,	.0230	.0170			

Table showing Comparison between Hardness and Lead.—Arranged in Order of Degree of Hardness.

[Parts per 100,000.]

	Hardness.	Lead.		Hardness.	Lead.
Malden,	14.5	.0057	Lexington,	1.8	.0073
Reading,	9.1	.0055	Fairhaven,	1.7	.0959
Revere,	7.7	.0101	Kingston,	1.6	.0944
Methuen,	3.1	.0056	Easton,	1.3	.0414
Framingham,	3.0	.0189	Ashburnham,	1.1	.0307
Sharon,	2.9	.0140	Milford,	0.9	.1258
Lowell,	2.8	.1899	South Hadley,	0.2	.0385
Millbury,	1.9	.0170			

The following tables are of a similar series, to make the same comparisons as in the previous tables, but of the surface waters examined: —

Table showing Comparison between Color and Lead.—Arranged in Order of Degree of Color.

[Parts per 100,000.]

	Color.	Lead.		Color.	Lead.
New Bedford,	.85	.0177	Fall River,	.29	.0080
Boston,	.55	.0099	Stoughton,	.15	.0774
Palmer,	.50	.0511	Rockland,	.14	.0283
Lawrence,	.49	.0276	Concord,	.13	.0060
Malden,	.40	.0309	Norwood,	.10	.0310
Springfield,	.34	.0195	Chicopee,	.07	.0788
Ipswich,	.32	.0031			

Table showing Comparison between Total Solids and Lead.—Arranged in Order of Amount of Total Solids.

[Parts per 100,000.]

	Total Solids.	Lead.		Total Solids.	Lead.
Boston,	5.85	.0099	Chicopee,	3.35	.0788
Ipswich,	5.20	.0031	Rockland,	3.35	.0283
Malden,	5.15	.0309	Springfield,	3.20	.0195
Fall River,	4.62	.0080	Stoughton,	3.00	.0774
Lawrence,	4.40	.0276	Concord,	2.60	.0060
Palmer,	4.00	.0511	Norwood,	2.45	.0310
New Bedford,	3.75	.0177			

Table showing Comparison between Free Ammonia and Lead.— Arranged in Order of Amount of Free Ammonia.

[Parts per 100,000.]

	Free Ammonia.	Lead.		Free Ammonia.	Lead.
Lawrence, . . .	.0078	.0276	Chicopee, ...	.0006	.0788
Ipswich, ...	.0030	.0031	Palmer, ...	.0006	.0511
New Bedford, . . .	.0020	.0177	Malden, ...	.0004	.0309
Norwood, ...	.0012	.0310	Concord, ...	.0004	.0060
Springfield, . . .	.0012	.0195	Stoughton, . . .	.0000	.0774
Boston, ...	.0008	.0099	Rockland, . . .	.0000	.0283
Fall River, . . .	.0007	.0080			

Table showing Comparison between Oxygen consumed and Lead.— Arranged in Order of Amount of Oxygen consumed.

[Parts per 100,000.]

	Oxygen Consumed.	Lead.		Oxygen Consumed.	Lead.
Boston, ...	.8100	.0099	Norwood, ...	.3040	.0310
New Bedford, . . .	.6960	.0177	Springfield, . . .	.3040	.0195
Malden, ...	.6160	.0309	Rockland, ...	.2880	.0283
Palmer, ...	.5224	.0511	Concord, ...	.2160	.0060
Fall River, . . .	.4080	.0080	Stoughton, . . .	.1600	.0774
Lawrence, . . .	.4000	.0276	Chicopee, ...	.1360	.0788
Ipswich, ...	.3200	.0031			

Table showing Comparison between Chlorine and Lead.— Arranged in Order of Amount of Chlorine.

[Parts per 100,000.]

	Chlorine.	Lead.		Chlorine.	Lead.
Fall River, . . .	0.77	.0080	Stoughton, . . .	0.32	.0774
Ipswich, ...	0.68	.0031	Concord, ...	0.30	.0060
Rockland, . . .	0.64	.0283	Lawrence, . . .	0.23	.0276
New Bedford, . . .	0.58	.0177	Springfield, . . .	0.18	.0195
Boston, ...	0.46	.0099	Chicopee, ...	0.15	.0788
Malden, ...	0.41	.0309	Palmer, ...	0.15	.0511
Norwood, . . .	0.35	.0310			

Table showing Comparison between Nitrates and Lead.— Arranged in Order of Amount of Nitrates.

[Parts per 100,000.]

	Nitrates.	Lead.		Nitrates.	Lead.
Boston, ...	.0230	.0099	New Bedford, . . .	.0050	.0177
Lawrence, . . .	.0220	.0276	Stoughton, . . .	.0030	.0774
Ipswich, ...	.0130	.0031	Malden, ...	.0030	.0309
Fall River, . . .	.0110	.0080	Rockland, . . .	.0020	.0283
Chicopee, ...	.0080	.0788	Norwood, . . .	.0010	.0310
Springfield, . . .	.0080	.0195	Concord, ...	.0010	.0060
Palmer, ...	.0050	.0511			

Table showing Comparison between Hardness and Lead.— Arranged in Order of Degree of Hardness.

[Parts per 100,000.]

	Hardness.	Lead.		Hardness.	Lead.
Lawrence, . . .	2.2	.0276	Chicopee, ...	0.8	.0788
Ipswich, ...	2.2	.0031	Concord, ...	0.8	.0060
Malden, ...	2.0	.0309	Rockland, . . .	0.6	.0283
Boston, ...	1.8	.0099	New Bedford, . . .	0.6	.0177
Fall River, . . .	1.4	.0080	Stoughton, . . .	0.5	.0774
Palmer, ...	1.1	.0511	Norwood, . . .	0.5	.0310
Springfield, . . .	1.0	.0195			

These tables, making a comparison of the sanitary analyses of some of the waters examined for lead with the amount of lead found in these waters, do not show very clearly the reasons why some waters attack lead and others do not. They apparently indicate, however, that the surface waters having the greatest amount of solids and chlorine and the greatest degree of hardness take the least lead from the pipes; while, with the ground waters, those with the greatest solids and hardness take generally the least amount of lead.

A series of experiments was begun early in the investigation, to learn, if possible, more upon this subject than our regular analytical work showed; that is to say, the experiments were made to study the effect upon lead of water to which known amounts of the substances found in natural waters were added in different proportions. In all of these experiments the water was in contact with the lead for several days, or in some cases even weeks, instead of for a few hours, as in service and house pipes. The first water used in this connection was that from Naukeag Pond, Ashburnham. The analysis of the water was at that time as follows: —

[Parts per 100,000.]

Color,	.15	Chlorine,	.15
Total solids,	1.56	Nitrates,	.0040
Free ammonia,	.0036	Hardness,	.3

Half-gallon bottles, each containing a piece of clean lead pipe one-half inch in diameter and eight inches long, were completely filled with water, and to each was added a definite amount of a different substance. The bottles were allowed to stand undisturbed in a dark closet for one week, when the pipe was withdrawn, and the amount of lead taken from the lead pipe by the water was determined. The experiments and the results obtained are given in the following table: —

SERIES NO. 1.

No.	SUBSTANCE ADDED (Parts per 100,000).	Lead Found (Parts per 100,000).
1	Nothing,	.1226
2	200 c.c. of highly colored swamp water, increasing color to 0.50 parts,	.1686
3	Sodium chloride, increasing chlorine to 5.00 parts,	.0920
4	Calcium carbonate, increasing hardness to 1.6 parts (excess of $CaCo_3$ being filtered off)	.0409
5	Sodium silicate, increasing fixed solids to 5.80 parts,	.0715
6	Ammonia, increasing free ammonia to .0250 parts,	.0588
7	Potassium nitrate, increasing nitrogen as nitrates to 2.30 parts,	.0128
8	Magnesium carbonate plus carbonic acid, increasing hardness to 58.0 parts,	.0818
9	Carbonic acid, increasing hardness to 13.3 parts; then magnesium carbonate, increasing it further to 71.0 parts.	.0084

During the time that the lead remained in the bottles, the water was kept at an approximately constant temperature of 75° F. It will be seen from a study of the table that the addition of every substance decreased the action of the original water upon the lead pipe, with the exception of the addition of the highly colored swamp water, which increased to some extent the amount of lead taken from the pipe; but in regard to this it must be noted that, in order to add the color, it was necessary to add, as stated, 200 cubic centimeters of a different water.

A second series of similar experiments, with the same water and with the lead in contact with the water for the same length of time, resulted as follows: —

SERIES NO. 2.

No.	SUBSTANCE ADDED (Parts per 100,000).	Lead Found (Parts per 100,000).
1	Nothing, ...	.8301
2	200 c.c. of highly colored swamp water, increasing color to 0.50 parts, . . .	.3642
3	Sodium chloride, increasing chlorine to 5.00 parts, ...	.1319
4	Calcium carbonate, increasing hardness to 1.6 parts (excess of $CaCo_3$ being filtered off).	.1090
5	Sodium silicate, increasing fixed solids to 6.60 parts, ...	.0914
6	Ammonia, increasing free ammonia to .0250 parts, ...	2.1860
7	Potassium nitrate, increasing nitrogen as nitrates to 1.72 parts,.	11.8800
8	Carbonic acid, increasing hardness to 6.5, then magnesium carbonate, increasing it further to 14.0 parts.	.3695

The temperature of the water during the time the lead remained in the bottles during this series of experiments was approximately 80° F. The bottles were filled in this instance with water sufficient to cover the lead pipe, which stood upright in the bottle; but the tops of the bottles contained some air. It will be seen from a study of the results that in every instance more lead was taken into solution than during the previous set of experiments, partly due to the higher temperature, but largely, as further experiments will demonstrate, to the fact that the air was allowed to reach the surface of the water. The increased amount was particularly noticeable in experiments Nos. 6 and 7, in which ammonia and potassium nitrate were added. It will also be noticed that the experiment of adding carbonic acid and magnesium carbonate in the second series did not decrease the action of the water to the same extent as in the first series; but the substances were added in amounts only sufficient to make the hardness one-fifth what it was in the similar experiment in the first set. The total solids were, of course, less also.

Another set of experiments similar to the foregoing was made with redistilled water. These experiments were as follows: —

SERIES NO. 3.

No.	SUBSTANCE ADDED (Parts per 100,000).	Amount of Substance added, found at End of Experiment (Parts per 100,000).	Lead Found (Parts per 100,000).
1	Nothing,	- -	10.5800
2	200 c.c. of swamp water, making color 0.50 parts,	Color, 0.50,	1.0220
3	Sodium chloride, making chlorine 5.20 parts,	Chlorine,	.6390
4	Calcium carbonate, making hardness 1.30 parts,	Hardness, 1.00,	1.1960
5	Sodium silicate, making fixed solids 6.90 parts,	Fixed solids, 5.70,	.1895
6	Ammonia, making free ammonia .0250 parts,	Free ammonia, .0250,	11.6280
7	Potassium nitrate, making nitrogen as nitrates 2.60 parts,	Nitrates, 0.56,	16.5460
8	Carbonic acid, making hardness 9.70, then magnesium carbonate, making total hardness 46.00 parts.	Total hardness, 22.0,	.0648

During the week that the water was kept in contact with the lead in this set of experiments the temperature of the water averaged 81° F., and there was a small volume of air in the top of each bottle. It will be seen that in every instance the addition of a substance to the distilled water caused a less violent action of the water upon lead, excepting of ammonia and potassium nitrate. It will also be seen that the hardness was reduced during Experiment No. 4, the fixed solids during Experiment No. 5, the nitrates during Experiment No. 7 and the total hardness during Experiment No. 8.

Another series of experiments was made as given below. As in the previous series, the water in each case was in a half-gallon bottle containing a piece of lead pipe one-half inch in diameter and eight inches long. The bottles were kept in a dark closet, were not disturbed during the week, the temperature remained approximately constant at 84° F., and there was a small amount of air in the top of each bottle.

SERIES NO. 4.

	No.	SUBSTANCE ADDED (Parts per 100,000).	Lead Found (Parts per 100,000).
Tap water,	1	Potassium nitrate, increasing nitrates to .51 parts,	0.3773
Redistilled water,	2	Potassium nitrate, increasing nitrates to .51 parts,	14.1630
Redistilled water,	3	Ammonia, increasing free ammonia to .0260 parts,	15.3290
Redistilled water,	4	Potassium nitrate, increasing nitrates to .54 parts, and 0.5 gram peptone.	0.6594
Redistilled water,	5	Ammonia, increasing free ammonia to .0280 parts, and 0.5 gram peptone.	0.3614

A study of the table will show that the addition of potassium nitrate to tap water (Boston city water) did not cause a violent action upon lead pipe, such as ensued when the same amount of potassium nitrate was added to distilled water. It will also be noticed that, when organic matter, namely, peptone, was added to the redistilled water in experiments 4 and 5 of this series, the action of the nitrate and ammonia was very much decreased when compared with the action in experiments 2 and 3, containing the same amounts of ammonia and nitrate, but no organic matter.

Another similar series of experiments was made, but with the use of tap water (Boston city water). The bottles contained, as usual, pieces of lead pipe one-half inch in diameter and eight inches long, and were allowed to stand undisturbed for eight days in a dark closet. Their temperature during the experiment was approximately constant at 82° F. The bottles were completely filled with the water, excluding all air; the stoppers, however, were not sealed. The amount of each substance added and the amount of lead taken up by the water is shown in the following table: —

SERIES No. 5.

No.	Substance Added (Parts per 100,000).	Lead Found (Parts per 100,000).
1	Nothing,	.1635
2	200 c c. of swamp water, increasing color to 0.55 parts,	.2336
3	Sodium chloride, increasing chlorine to 2.50 parts,	.1635
4	Calcium carbonate, increasing hardness to 2.3 parts (excess of $CaCo_3$ filtered off),	.0584
5	Sodium silicate, increasing fixed solids to 5.50 parts,	.1343
6	Ammonia, increasing free ammonia to .0330 parts,	.7709
7	Potassium nitrate, increasing nitrogen as nitrates to .5900 parts,	.2278

From a study of this table it will be noticed that the action of the water was increased by the addition of the swamp water, ammonia and potassium nitrate, although the action was inconsiderable when compared with that induced by these bodies in distilled water.

In all previous experiments, either with natural waters or with distilled water, there was always a considerable percentage of dissolved oxygen present in the water and sometimes a small volume of air in the neck of the bottles, and also in many cases a small amount of carbonic acid present. In order to note, however, the effect upon lead of distilled water which contained neither oxygen nor carbonic acid, a half-gallon bottle, containing a piece of lead pipe of the usual size and length, was filled with redistilled water, freed from carbonic acid by treatment with barium hydrate, and from dissolved oxygen by boiling. The water, after boiling, was cooled in the bottle in an atmosphere of hydrogen, the lead pipe introduced and the bottle sealed. It was then allowed to stand undisturbed in a dark place at an approximately constant temperature of 82° F. At the end of one week the lead was as bright as when first put in, although in all other experiments the appearance of the lead changed materially. At the end of two weeks the lead appeared to have been acted upon slightly in spots, while the water was very slightly turbid. A determination was then made of the amount of lead in the water, and it was found to contain only .0774 parts per 100,000, or .0451 grains per gallon. Upon referring to Series No. 3, it will be noted that Experiment No. 1, an experiment exactly similar to this, with the exception that the distilled water was not made free from carbonic acid and oxygen, resulted in the water's taking from the lead pipe in the course of a week 10.58 parts per 100,000 of lead or 6.17 grains per gallon. This experiment, in regard to the effect of distilled water after the removal from it of oxygen and carbonic acid, was repeated with a similar result. It was made also with tap water (Boston city water), and found to reduce quite materially the amount of lead that would be taken into solution by this tap water in a given length of time.

Summarizing the experiments so far given, it can be said that the action upon lead taking place in *distilled water* containing oxygen is more violent than the action taking place in any natural water which we have examined or with which we have experimented; that this action of distilled water is increased by the addition of ammonia or potassium nitrate; that it is decreased very greatly by the addition of sodium chloride, calcium carbonate, sodium silicate, or by an increase in the hardness or total solids of the water, or by the addition of organic matter. Still more worthy of note is the fact that, when the oxygen and carbonic acid are removed from distilled water, the action of this water upon lead is reduced almost to a minimum. There would probably be no action whatever if we could completely remove both the carbonic acid and the oxygen, and prevent any from reaching the water and being absorbed by it during our experiments.

The addition of the various substances to *natural waters* shows that an increase of coloring matter generally increases the action of the water upon lead slightly, and that an increase of ammonia or potassium nitrate also increases the action but slightly, if air is practically excluded. The addition of all other substances experimented with decreases the action. Free access of air increases the action above that taking place when air is excluded and only the air dissolved in the water comes into play. Ammonia or potassium nitrate increase the action very slightly in natural waters, while in distilled waters they increase it quite materially, especially the addition of potassium nitrate. It is doubtful, however, if it is these two bodies themselves which act upon the lead pipe. They are unstable bodies and carriers of oxygen, and it is probably this oxygen which has the marked effect upon the pipe. To prove this point, two experiments were made, as follows: —

Two half-gallon bottles were filled completely with redistilled water, freed from carbonic acid and dissolved oxygen by boiling the water and then cooling it in an atmosphere of hydrogen. To the water in one of these bottles was added a definite amount of potassium nitrate and to the other a definite amount of free ammonia, and the bottles were sealed and allowed to stand for one week at an approximately constant temperature of 68° F. The results were as follows: —

SERIES No. 6.

No.	Substance Added and Amount.	Appearance of Pipe at End of Experiment.	Lead Found (Parts per 100,000).
1	Potassium nitrate to equal 2.5 parts N per 100,000.	Slight white coating at one end, both inside and outside.	.3430
2	Free ammonia to equal .0300 parts per 100,000.	- -	.0292

Comparing these results with the results of experiments 6 and 7 of Series No. 3, the great difference, due to the presence of oxygen and perhaps of carbonic acid in the water in the Series 3 experiments, will be noted. The experiments, in which a small amount of peptone was added with the ammonia and nitrate (see Series No. 4), are fairly convincing, however, as the amount of lead taken from the pipes was very much less than in similar experiments where peptone was not added; that is to say, the oxygen primarily in the water, and that absorbed by it during the experiment, was probably largely employed in oxidizing the organic matter, instead of being left free to attack the lead pipe.

In regard to the coloring matter, I have considered it doubtful if the organic matter giving the color to the water has in itself any effect upon lead, but that, undergoing change, carbonic acid is set free, which is the active agent in attacking the lead, this carbonic acid probably being especially active in its nascent state. A series of experiments, making this fact somewhat clear, is as follows: —

Four gallon bottles were filled with different waters: No. 1 with Merrimack River water, No. 2 with a mixture of two-thirds river water and one-third hay infusion, No. 3 with a mixture of one-third river water and two-thirds hay infusion, and No. 4 with hay infusion only, this hay infusion being prepared by soaking a given quantity of hay in a tank filled with Merrimack River water. The infusion was drawn from the bottom of the tank through a cloth strainer, and was an ill-smelling, highly colored liquid, containing considerable nitrogenous and a large amount of carbonaceous matter in solution. It was free from dissolved oxygen, and the portion drawn from the bottom of the tank contained little, if any, carbonic acid in solution. Each of the bottles in which this water was placed contained a piece of clean lead pipe, three-quarters of an inch in diameter and eight inches long. The bottles stood in the laboratory for eighty-five days, when half of the water was withdrawn from each, and the amount of lead determined in each sample. The remainder of the water was allowed to stand undisturbed in the bottle for an additional period of one hundred and twenty-nine days, making the total length of time two hundred and fourteen days. During this last period the bottles remained only half full of water, and there was a free access of air. The analyses resulted as follows: —

Series No. 7 (without Air).

First Portion.

Number of Bottle.	Total Lead Found (Parts per 100,000).	Number of Bottle.	Total Lead Found (Parts per 100,000).
1, ...	.2156	3, ...	.4312
2, ...	.2156	4, ...	.0270

SERIES NO. 8 (WITH AIR).

Second Portion.

Number of Bottle.	Lead. (Parts per 100,000.)			Number of Bottle.	Lead. (Parts per 100,000.)		
	In Solution.	In Suspension.	Total.		In Solution.	In Suspension.	Total.
1, .	.1051	.2102	.3153	3, .	.8468	1.9710	2.8178
2, .	.7300	.3650	1.0950	4, .	2.0440	1.6425	3.6865

Studying the analyses first made, we find that there was no difference in the action of the river water only and of the solution containing two-thirds river water and one-third hay infusion. The solution containing one-third river water and two-thirds hay infusion had a more violent action upon the lead, while the hay infusion alone acted during this first period very weakly upon the lead. During the second and longer period the lead in the first sample increased; the second sample contained five times as much lead as at the end of eighty-five days; the third sample nearly seven times as much lead: while the fourth sample, which contained hardly any lead at the end of the period of eighty-five days, contained by far the most at the end of this second period. As stated before this hay infusion, drawn from the bottom of the tank, contained little carbonic acid and no oxygen, apparently not enough of either to act upon the lead during the first period of eighty-five days; neither did the coloring matter act upon the lead. The reason of the different action during the two periods is as follows: —

Carbonic acid was not formed in this bottle during the first period, owing to the exclusion of air. During the second period, however, air was freely admitted to the surface of the liquid, and resulted in the fermentation of this strong hay infusion and the formation of much carbonic acid, which, together with the air itself, acted violently upon the lead. This same action took place in samples Nos. 2 and 3, but to a less degree.

Another set of experiments worth recording was as follows: — Four one-gallon bottles, each containing a piece of clean lead pipe, three-fourths of an inch in diameter and eight inches long, were filled at the Lawrence Experiment Station as follows: No. 1, with distilled water; No. 2, with the effluent from Sewage Filter No. 2, containing almost no free and albuminoid ammonia, but a large amount of nitrogen in the form of nitrates, no nitrites, very little color, but high in dissolved oxygen, and containing some carbonic acid; No. 3, with the effluent of Water Filter No. 68, this water containing about the same amount of free and albuminoid ammonia as the effluent of Filter No. 2, about one-tenth as much nitrogen in the form of nitrates, no nitrites, about an equal amount of dissolved oxygen, and four times as much color. The lead pipe remained in these waters for one hundred and eighty-five days, and they were then analyzed, with the following results: —

SERIES No. 9.

		Lead in Solution (Parts per 100,000).	Lead in Suspension (Parts per 100,000).
1	Distilled water,	1.0950	89.6333
2	Effluent of Filter No. 2,	4.9640	0.5700
3	Effluent of Filter No. 68,	0.3796	0.2268

It will be seen that a very large amount of lead was taken from the pipe by the distilled water, most of this lead precipitating in the bottom of the bottle as the heavy white hydroxide. The sewage effluent, containing considerable carbonic acid, took a large amount of lead from the pipe, but most of this remained in solution, while the effluent of the water filter took a comparatively small amount of lead from the pipe.

A temperature experiment was as follows: Six half-gallon bottles, each containing a piece of lead pipe eight inches long, were completely filled with tap water (Boston city water), the analysis of which was as follows: —

[Parts per 100,000.]

Color,	0.22	Nitrites,	0.0001
Free ammonia,	0.0002	Total solids,	3.75
Albuminoid ammonia,	0.0166	Hardness,	1.4
Chlorine,	0.23	Oxygen consumed,	0.38
Nitrates,	0.0040	Iron,	0.0280

Three of the bottles were placed in a dark closet in the laboratory, and three in an ice chest. At the end of three days, one bottle was withdrawn from each place; at the end of six days, a second; and at the end of nine days, a third. The results are in the following table: —

SERIES No. 10.

Number of Days Bottle stood.	Dark Closet. Temperature. — Degrees F.	Dark Closet. Lead found (Parts per 100,000).	Ice Chest. Temperature. — Degrees F.	Ice Chest. Lead found (Parts per 100,000).
3, ...	84, 84, 84	.1343	50, 50, 50	.0993
6, ...	-, 86, 84	.1080	-, 64, 55	.1168
9, ...	86, 86, 81	.1256	57, 55, 52	.1168

A review of results of all the experiments indicates strongly that the two active agents in the waters, causing them to take lead into solution, were oxygen and carbonic acid. The purer the water (for instance, distilled water), the more active these agents were upon lead when in this water. The presence of nitrates and ammonia in distilled water together with free access of air caused a very violent action upon the lead to take place; but they had much less influence when present in natural waters containing some organic matter. When organic matter (peptone, for instance), as shown in the experiments, was added to distilled water, it reduced very greatly the action caused by the presence of ammonia or nitrates with free access of air. The addition of substances which increased the fixed solids tended to decrease the action of water upon lead very greatly.

In order to prove the relative action of oxygen and carbonic acid, a series of experiments was made, as follows: Four half-gallon bottles of distilled water were first freed from dissolved oxygen and carbonic acid in the usual way, and then known amounts of each of these bodies, both separately and together, were added to the samples, and they were then sealed and allowed to stand for one week, at an approximately constant temperature of 68° F. The results were as follows: —

SERIES NO. 11.

No.	Substance Added and Amount.	Lead Found (Parts per 100,000).
1	Oxygen to saturation, ...	2.4100
2	Carbonic acid (4.0 parts per 100,000), ...	.4993
3	Carbonic acid (20.0 parts per 100,000), ...	.8935
4	Ten per cent. of oxygen necessary for saturation, and 4.0 parts of CO_2, . . .	.0861
5	Ten per cent. of oxygen necessary for saturation, and 4.0 parts of CO_2, . . .	.1635

These results are somewhat contradictory, but seem to show that oxygen acts more quickly in distilled water than carbonic acid. The amount of lead taken from the pipes may vary in the case of natural waters, according to varying proportions of oxygen and carbonic acid present in these waters. The amount of lead taken into solution and the amount in suspension in the waters may and probably does vary from the same cause. For instance, laboratory experiments with water from two sets of driven wells in Lowell showed that, when lead pipe was introduced into a bottle of water from the boulevard wells, so called, containing about 20 per cent. of the volume of oxygen necessary for saturation and about 2 parts of carbonic acid per 100,000, much lead was taken from the pipe in a few days, which largely precipitated as the white hydroxide of lead, but the pipes were more or less coated also with the oxide and hydroxide. When, however, lead pipe was introduced into a bottle of water from the Cook wells, so called, containing about 10 per cent. of the volume of oxygen necessary for saturation, but over 4 parts of carbonic acid per 100,000, not any precipitate appeared on the bottom of the bottle and the pipe remained clean and without a coating; but at the end of a few days the water contained about 2.5 parts of lead per 100,000 parts, practically all of which was in solution.

From many previous experiments, in which pieces of lead pipe were exposed to the action of water containing various substances in solution, it was found that certain substances seemed to accelerate the action of the water on the lead, while others seemed to retard the action. Among the latter, silica, calcium carbonate and chlorine were those that appeared to exert the most decided retarding action, and a series of experiments was prepared in order to show, if possible, in what way this retarding action was effected,—whether it was due simply to the presence of the substance in solution, or whether the pipe was first attacked and a coating formed by combination with the lead, which prevented further action.

One series of six bottles was prepared, using ordinary redistilled water, which contains considerable dissolved oxygen and a very small amount of carbonic acid; and another series of six bottles, using redistilled water freed from both gases. The plan was to allow the waters, containing known amounts of the different substances in solution, to act upon the lead for a certain time, then to withdraw the pipes from the bottles, rinsing off any easily detachable coating back into the bottles, and putting the pipes into fresh portions of water similarly prepared, and allowing them to remain the same length of time as before. By determining the amount of lead taken up by the water in each bottle after the first period of time, and then again after the second period of action with the fresh portion of water, it was hoped to show whether the action was continuous, or whether the pipes would become coated with compounds which would prevent as much action as occurred in the first case; also, after the final period of action, any coating which appeared in sufficient quantity was to be tested, to determine if possible its composition.

These experiments are not satisfactorily completed, as yet, but seem to indicate that, as generally supposed, certain mineral matters prevent action not only by aiding the formation of a protective coating upon the pipes, but also by their simple presence in the water.

Relation that the Amount of Carbonic Acid and Oxygen in Solution in Waters bears to the Amount of Lead taken from Lead Pipes by Ground and Surface Waters.

During the latter part of the summer of 1898 and up to the present time determinations of the amount of dissolved oxygen and carbonic acid have been made in a number of the water supplies of the cities and towns from which we have obtained samples for the determination of lead. In order that these determinations of oxygen and carbonic acid may have a value, they have to be made in the various towns and cities with water taken directly from the supplies, as water, when transported from these towns and cities to the laboratory, loses in some instances a large percentage of both the oxygen and free carbonic acid during this transportation. Enough of these determinations have been made up to the present time to present in the form of tables, together with the lead found in the samples of water from the various places, and the degree of hardness of that water. The first table is an arrangement of ground-water supplies: —

Town or City.	Lead. (Parts per 100,000.)		Free CO_2. (Parts per 100,000.)	Oxygen Dissolved. (Per Cent. of Saturation)	Hardness. (Parts per 100,000.)
	Water in Pipes over Night.	Water in Daytime Use.			
Lowell,*	.1933	.1899	2.85	10	2.80
North Easton,	.1667	.0414	2.34	64	1.30
Fairhaven,	.2461	.0959	2.17	47	1.40
Kingston,	.1962	.0944	2.03	85	1.00
Sharon,	.0274	.0140	1.96	93	2.90
Milford,	.1991	.1258	1.55	49	1.00
West Brookfield,†	.0779	.0437	1.52	104	0.60
Framingham,	.0340	.0189	1.51	43	3.60
South Hadley,	.1194	.0385	0.92	105	0.40
Ashburnham,	.1210	.0307	0.80	102	1.10
Revere,	.0185	.0101	0.74	11	7.90
Malden,	.0200	.0057	0.70	54	4.40
Methuen,	.0056	.0056	0.29	9	2.90
Reading,‡	.0142	.0055	0.00	105	9.30

* Average of three systems of wells. † Settled in cisterns.

‡ Filtered water, alum and lime having been added.

A study of this table shows that the clear and practically colorless supplies, which most actively attack lead, are those containing the most carbonic acid and a small or medium amount of mineral matter, as shown by the determination of hardness. Fairhaven and Kingston, where many cases of lead poisoning have occurred during the past few years, stand first and second on the table in regard to the amount of lead found in the samples which we have analyzed of water that has remained in the pipes for a number of hours; while Lowell and Milford, where many cases of lead poisoning are now occurring, stand third and fourth upon the table. Lowell samples show the most lead taken from the pipes during daytime use. West Brookfield water attacks lead pipes actively, but the lead remains to a great extent in the cisterns, as previously explained, and the figures in this table give only the lead in solution in this water; the total amount in the samples averaging over 8 parts (see page 543). While the table is not exactly regular in respect to the carbonic acid, hardness and lead, still it must be remembered that the length of the lead pipes from which the samples were taken varied very much in different towns and in different places in the same town, and that the water remained in the pipes for different periods of time. Sharon water, although containing nearly 2 parts of carbonic acid and much free oxygen, is prevented, apparently by its hardness of 2.90 parts, from attacking lead, and it is probable that this degree of hardness is sufficient to prevent action in some waters containing this amount of carbonic acid, but varies with the character of the mineral constituents causing the hardness. Taken as a whole, the table is as regular as could be expected.

The second table presented is that of towns and cities having surface-water supplies: —

Town or City.	Lead. (Parts per 100,000.)		Free CO_2. (Parts per 100,000.)	Oxygen Dissolved. (Per Cent. of Saturation.)	Hardness. (Parts per 100,000.)
	In Pipes over Night.	Daytime Use.			
Boston,	.1778	.0099	1.57	84	1.60
Stoughton,	.2178	.0774	1.48	73	.50
Ipswich,	.0099	.0031	.78	1	1.30
New Bedford,	.1466	.0177	.67	54	.80
Norwood,	.0581	.0310	.50	104	.30
Palmer,	.0829	.0511	.50	92	.50
Chicopee,*	.1037	.0490	.40	97	.50
Lawrence,	.1094	.0276	.31	85	1.10
Chicopee,*	.3921	.0778	.28	97	1.40
Concord,	.0663	.0060	.27	75	.80
Fall River,	.0256	.0080	.00	98	.60
Rockland,	.1055	.0283	.00	83	.80
Springfield,	.0687	.0195	.00	97	.30

* Two different supplies.

A study of this table shows that its regularity is much less than that of the ground-water supplies, but this can be accounted for by an accurate study of the figures given, and the sanitary analyses of the water supplies of these towns and cities given in previous tables. In the first place, all of these waters are soft; in the second place, most of them contain but a small amount of carbonic acid, as compared with the amount present in the ground-water supplies which violently attack lead, but a large amount of free oxygen.

The experiments given on previous pages have proved that oxygen, under certain conditions, is quite as active as carbonic acid in attacking lead pipes when the lead is placed in distilled water, and a study of this table, together with previous tables, will show that some of these waters, which contain little or no carbonic acid but are saturated with oxygen, are comparatively soft and colorless surface waters, containing little organic matter. The waters of Chicopee, Concord, Norwood and Rockland are of this character, and, in their freedom from organic mineral matter, resemble to a certain extent distilled water, and therefore the oxygen, as was shown by the experiment with distilled water with and without peptone, having little organic matter to attack, is left free to attack the lead. Again, it was shown by our experiments that highly colored water would attack lead if sufficient time and air were allowed for the change of this carbonaceous coloring matter to carbonic acid in the presence of oxygen. This change probably occurs when some highly colored surface waters remain in the service pipes for some hours, as shown by the lead in the New Bedford and Boston samples taken after the water had stood in lead pipes for a number of hours, most of these Boston samples having been taken when the water was more highly colored than at the present time. Determinations of carbonic acid have also shown that this gas sometimes increases as the water stays in the pipes.

Lawrence water is a filtered surface water, and hence resembles to a certain extent a ground water. It contains, moreover, more free ammonia than any other surface water on the table, and is high in nitrates.

In New Bedford we have a marked example of a water which, while not acting so violently upon lead that much is taken from the pipes when the water is drawn frequently, still is of such a character that, when allowed to remain for a considerable period of time in the pipes, it takes considerable lead both in solution and suspension from them; that is, a coating of organic and mineral matter forms upon the pipes, carbonic acid is generated, which, together with the oxygen present, attacks the lead, and this deposit is, when the water is drawn quickly after hours of rest, apparently easily detached from the pipe and drawn out, thus increasing the amount of lead in water drawn after periods of rest above that actually taken into solution by the water during this period of rest.

In the various supplies the pressure of the water in the pipes varies, but in all the supplies it is several atmospheres, and the amount of lead taken into solution by carbonic acid and oxygen increases as the pressure increases.

It will be seen from the tables that in Kingston and Fairhaven, towns having a large number of cases of lead poisoning during the past few years, the average amount of lead found in the samples taken when the water was in ordinary daytime use was in each case nearly .1000 of a part per 100,000 parts. Milford and Lowell, the samples from which contained a greater average, have had and are having many cases of lead poisoning. In all of these four places, however, the average amount of lead, found when the water was allowed to stand in the pipes for a number of hours, was about .2000 of a part. Many of the samples from these places contained, moreover, much more lead than these averages and at times many of the inhabitants must have drunk water containing much more lead than the averages indicate.

Interviews with physicians in the towns and cities where series of samples have been taken fail to show a prevalence of lead poisoning in any except the four places mentioned above, although occasional cases have been noted in several other towns that have ground-water supplies. Our investigations so far made in the towns and cities having surface-water supplies have failed to reveal any cases whatever, although many of these waters attack lead, the amounts found in some samples not being inconsiderable, and the lead, taken in this manner into the systems of many of the inhabitants of these cities and towns, may cause mild or unrecognized cases of lead poisoning.

Experimental Pipes.

In the course of this investigation, pipes of different metals have been placed for experimental purposes in the following towns of the State: Fairhaven, Kingston, New Bedford, West Brookfield and Lowell.

In Fairhaven the pipes were of lead, iron, galvanized iron and block tin, and were placed in the pumping station, attached to the main. The pipes were ⅝ of an inch in diameter and 45 feet in length, with a faucet at the end of each pipe. Instructions were given that the water should be allowed to flow slowly through these pipes during each day, so that at least 100 gallons should pass through the pipes each twenty-four hours. Samples have been taken for analysis at various dates, with the following results: —

Fairhaven.

Gallon samples from the iron pipe showed the following amounts of iron in parts per 100,000: —

Date of Collection.	Time Sample stood in Pipe.	Iron.	Date of Collection.	Time Sample stood in Pipe.	Iron.
Jan. 25, 1898, . .	Over night, . .	1.2720	Nov. 26, 1898, . .	One hour, . .	0.2500
Jan. 25, 1898, . .	One hour, . .	0.4600	Dec. 13, 1898, . .	Over night, . .	0.2200
Feb. 24, 1898, . .	Over night, . .	0.8800	Dec. 13, 1898, . .	One hour, . .	0.0720
Aug. 4, 1898, . .	Over night, . .	1.2240	Feb. 24, 1899, . .	Over night, . .	1.2000
Aug. 4, 1898, . .	One hour, . .	0.8960	Feb. 24, 1899, . .	One hour, . .	0.6800
Nov. 26, 1898, . .	Over night, . .	0.7500			

Samples collected from the galvanized-iron pipe showed the following amounts of zinc in parts per 100,000: —

Date of Collection.	Time Sample stood in Pipe.	Zinc.	Date of Collection.	Time Sample stood in Pipe.	Zinc.
Jan. 25, 1898, . .	Over night, . .	1.7038	Aug. 4, 1898, . .	One hour, . .	0.4701
Jan. 25, 1898, . .	One hour, . .	1.2458	Nov. 26, 1898, . .	Over night, . .	1.7256
Feb. 24, 1898, . .	Over night, . .	1.5249	Nov. 26, 1898, . .	One hour, . .	0.8428
Feb. 24, 1898, . .	One hour, . .	1.1443	Dec. 13, 1898, . .	Over night, . .	1.6913
April 7, 1898, . .	Over night, . .	1.1236	Dec. 13, 1898, . .	One hour, . .	1.2371
April 7, 1898, . .	One hour, . .	0.2591	Feb. 24, 1899, . .	Over night, . .	1.7971
Aug. 4, 1898, . .	Over night, . .	1.2154	Feb. 24, 1899, . .	One hour, . .	1.6485

Samples collected from the lead pipe showed the following amounts of lead in parts per 100,000 : —

Date of Collection.	Time Sample stood in Pipe.	Lead.	Date of Collection.	Time Sample stood in Pipe.	Lead.
Jan. 25, 1898, . .	Over night, . .	.4140	Aug. 4, 1898, . .	One hour, . .	.2337
Jan. 25, 1898, . .	One hour, . .	.2208	Nov. 26, 1898, . .	Over night, . .	.4672
Feb. 24, 1898, . .	Over night, . .	.3971	Nov. 26, 1898, . .	One hour, . .	.1752
Feb. 24, 1898, . .	One hour, . .	.1051	Dec. 13, 1898, . .	Over night, . .	.2570
April 7, 1898, . .	Over night, . .	.1986	Dec. 13, 1898, . .	One hour, . .	.2570
April 7, 1898, . .	One hour, . .	.1051	Feb. 24, 1899, . .	Over night, . .	.3504
Aug. 4, 1898, . .	Over night, . .	.7300	Feb. 24, 1899, . .	One hour, . .	.2803

Samples collected from the block-tin pipe gave the following amounts of tin in parts per 100,000 : —

Date of Collection.	Tin found, after Sample stood in Pipe —		Date of Collection.	Tin found, after Sample stood in Pipe —	
	Over Night.	One Hour.		Over Night.	One Hour.
Jan. 25, 1898, . .	.0360	.0180	Nov. 26, 1898, . .	.1029	.0457
Feb. 24, 1898, . .	.0247	-	Jan. 7, 1899, . .	.0269	.0114
April 7, 1898, . .	.0697	-	Feb. 24, 1899, . .	.0229	.0086
Aug. 4, 1898, . .	.0382	.0247			

Kingston.

At Kingston four kinds of pipe were experimented with, namely, iron, galvanized iron, lead and block tin. The pipes were each ⅝ inch in diameter, 45 feet in length, and were attached to the main in the pumping station. Instructions were given that the water should be allowed to flow slowly through these pipes during each day, so that at least 100 gallons should pass through the pipes each twenty-four hours.

These results cannot be compared, however, directly with the samples showing the amount of lead taken from service pipes in this town, and summarized on previous pages, as the water supply had been changed before these experiments were made.

Samples collected for analysis from the iron pipes showed the following amounts of iron in parts per 100,000 : —

Date of Collection.	Time Sample stood in Pipe.	Iron.	Date of Collection.	Time Sample stood in Pipe.	Iron.
Jan. 22, 1898, . .	Over night, . .	.0350	March 4, 1898, . .	Over night, . .	.0180
Jan. 22, 1898, . .	One hour, . .	.0080	March 4, 1898, . .	One hour, . .	.0020

Samples collected from the galvanized-iron pipe showed the following amounts of zinc in parts per 100,000 : —

Date of Collection.	Time Sample stood in Pipe.	Zinc.	Date of Collection.	Time Sample stood in Pipe.	Zinc.
June 22, 1898, . .	Twenty-four hours,	1.0657	Nov. 26, 1898, . .	One hour, . .	.1686
July 29, 1898, . .	Sixteen hours, .	1.4942	Feb. 19, 1899, . .	Seventeen hours, .	.6571
July 29, 1898, . .	One hour, . .	.9371	Feb. 19, 1899, . .	One hour, . .	.2428
Nov. 26, 1898, . .	Fifteen hours, .	.9457			

Samples collected from the lead pipe showed the following amounts of lead in parts per 100,000 : —

Date of Collection.	Time Sample stood in Pipe.	Lead.	Date of Collection.	Time Sample stood in Pipe.	Lead.
Jan. 22, 1898, . .	Fifteen hours, .	.1173	July 29, 1898, . .	Sixteen hours, .	.0920
Jan. 22, 1898, . .	One hour, . .	.0345	July 29, 1898, . .	One hour, . .	.0350
March 2, 1898, . .	Sixteen hours, .	.0204	Nov. 26, 1898, . .	Fifteen hours, .	.0321
March 2, 1898, . .	Two hours, . .	.0117	Nov. 26, 1898, . .	One hour, . .	.0321
April 6, 1898, . .	Sixteen hours, .	.0073	Feb. 19, 1899, . .	Seventeen hours, .	.0584
April 6, 1898, . .	One hour, . .	.0058	Feb. 19, 1899, . .	One hour, . .	.0175

Samples collected from the block-tin pipe showed the following amounts of tin in parts per 100,000 : —

Date of Collection.	Time Sample stood in Pipe.	Tin.	Date of Collection.	Time Sample stood in Pipe.	Tin.
Jan. 22, 1898, . .	Fifteen hours, .	.0674	April 6, 1898, . .	One hour, . .	.0000
Jan. 22, 1898, . .	One hour, . .	.0000	Nov. 26, 1898, . .	Fifteen hours, .	.0429
March 2, 1898, . .	Sixteen hours, .	.0743	Nov. 26, 1898, . .	One hour, . .	.0029
March 2, 1898, . .	One hour, . .	.0674	Feb. 19, 1899, . .	Seventeen hours, .	.0286
April 6, 1898, . .	Sixteen hours, .	.0337	Feb. 19, 1899, . .	One hour, . .	.0249

Lowell.

In Lowell experimental pipes of galvanized iron, lead and tin were placed in the pumping station of the boulevard wells, in the pumping station of the Cook wells and in the city hall, where the supply is sometimes from the boulevard wells and sometimes from the Cook wells. These pipes were approximately 45 feet in length and ⅝ inch in diameter, with a faucet attached to each pipe, and water was allowed to run through them approximately the same as through the Fairhaven and Kingston pipes. The greater action occurred in the pipes receiving water from the Cook wells, undoubtedly due to the fact that the average amount of free carbonic acid in this water at the times of collecting samples was 3.90 parts per 100,000; while in the water from the boulevard wells it was 2.00 parts per 100,000. The city hall is supplied with boulevard well water. Samples were collected from these pipes as follows: —

Boulevard Wells. — Samples collected from the galvanized-iron pipe showed the following amounts of zinc in parts per 100,000: —

Date of Collection.	Time Sample stood in Pipe.	Zinc.	Date of Collection.	Time Sample stood in Pipe.	Zinc.
March 16, 1899,	Twelve hours,	1.3391	April 18, 1899,	Twelve hours,	1.1167
March 16, 1899,	One hour,	.5939	April 18, 1899,	One hour,	.5228

Samples collected from the lead pipe showed the following amounts of lead in parts per 100,000: —

Date of Collection.	Time Sample stood in Pipe.	Lead.	Date of Collection.	Time Sample stood in Pipe.	Lead.
March 16, 1899,	Twelve hours,	.1197	April 20, 1899,	Twelve hours,	.1460
March 16, 1899,	One hour,	.0380	April 20, 1899,	One hour,	.0409

Samples collected from the block-tin pipe showed the following amounts of tin in parts per 100,000: —

Date of Collection.	Time Sample stood in Pipe.	Tin.	Date of Collection.	Time Sample stood in Pipe.	Tin.
March 16, 1899,	Twelve hours,	.0114	May 10, 1899,	Twelve hours,	.0135
March 16, 1899,	One hour,	.0114	May 10, 1899,	One hour,	.0068

Cook Wells. — Samples collected from the galvanized-iron pipe showed the following amounts of zinc in parts per 100,000: —

Date of Collection.	Time Sample stood in Pipe.	Zinc.	Date of Collection.	Time Sample stood in Pipe.	Zinc.
March 16, 1899, .	Twelve hours, .	1.9900	April 18, 1899, . .	Twelve hours, .	1.1418
March 16, 1899, .	One hour, . .	1.5500	April 18, 1899, . .	One hour, . .	0.8736

Samples collected from the lead pipe showed the following amounts of lead in parts per 100,000: —

Date of Collection.	Time Sample stood in Pipe.	Lead.	Date of Collection.	Time Sample stood in Pipe.	Lead.
March 16, 1899, .	Twelve hours, .	.6424	April 18, 1899, . .	Twelve hours, .	.4672
March 16, 1899, .	One hour, . .	.0511	April 18, 1899, . .	One hour, . .	.3504

Samples collected from the block-tin pipe showed the following amounts of tin in parts per 100,000: —

Date of Collection.	Time Sample stood in Pipe.	Tin.	Date of Collection.	Time Sample stood in Pipe.	Tin.
March 25, 1899, .	Twelve hours, .	.0382	May 11, 1899, . .	Twelve hours, .	.0235
March 25, 1899, .	One hour, . .	.0140	May 11, 1899, . .	One hour, . .	.0180

City Hall. — Samples collected from the galvanized-iron pipe showed the following amounts of zinc in parts per 100,000: —

Date of Collection.	Time Sample stood in Pipe.	Zinc.	Date of Collection.	Time Sample stood in Pipe.	Zinc.
March 17, 1899, .	Twelve hours, .	10.5893	April 20, 1899, . .	Twelve hours, .	1.0480
March 17, 1899, .	One hour, . .	.4333	April 20, 1899, . .	One hour, . .	.4219

Samples collected from the lead pipe showed the following amounts of lead in parts per 100,000: —

Date of Collection.	Time Sample stood in Pipe.	Lead.	Date of Collection.	Time Sample stood in Pipe.	Lead.
March 17, 1899, .	Twelve hours, .	.1110	April 18, 1899, . .	Twelve hours, .	.2336
March 17, 1899, .	One hour, . .	.0350	April 18, 1899, . .	One hour, . .	.0526

Samples collected from the block-tin pipe showed the following amounts of tin in parts per 100,000 : —

Date of Collection.	Time Sample stood in Pipe.	Tin.	Date of Collection.	Time Sample stood in Pipe.	Tin.
March 17, 1899, .	Twelve hours, .	.0514	May 17, 1899, . .	Twelve hours, .	.0160
March 17, 1899, .	One hour, . .	.0023	May 17, 1899, . .	One hour, . .	.0090

New Bedford.

In the pumping station of the New Bedford water works, experimental pipes were connected with the main, a faucet attached to each one and water allowed to flow through them as at the other places. The pipes were iron, galvanized iron, lead and block tin, and were each 45 feet in length and ⅝ inch in diameter. Samples were collected as follows : —

Samples collected from the iron pipe showed the following amounts of iron in parts per 100,000 : —

Date of Collection.	Time Sample stood in Pipe.	Iron.	Date of Collection.	Time Sample stood in Pipe.	Iron.
Feb. 18, 1898, . .	Twenty-four hours,	1.6640	Sept. 14, 1898, . .	Fourteen hours, .	.3300
Feb. 18, 1898, . .	One hour, . .	.2700	Sept. 14, 1898, . .	One hour, . .	.1560
April 5, 1898, . .	Twenty hours, .	.2300	Nov. 25, 1898, . .	Twelve hours, .	.1800
April 5, 1898, . .	One hour, . .	.0550	Nov. 25, 1898, . .	One hour, . .	.1750
July 29, 1898, . .	Fourteen hours, .	.5900	Feb. 21, 1899, . .	Thirteen hours, .	.5200
July 29, 1898, . .	One hour, . .	.3000	Feb. 21, 1899, . .	One hour, . .	.2000

Samples collected from the galvanized-iron pipe showed the following amounts of zinc in parts per 100,000 : —

Date of Collection.	Time Sample stood in Pipe.	Zinc.	Date of Collection.	Time Sample stood in Pipe.	Zinc.
Feb. 18, 1898, .	Twenty-four hours,	0.7797	Sept. 14, 1898, .	Fourteen hours, .	.0143
Feb. 18, 1898, .	One hour, . .	0.4036	Sept. 14, 1898, .	One hour, . .	.0057
April 5, 1898, .	Twenty hours, .	3.0315	Nov. 22, 1898, .	Twelve hours, .	.9942
April 5, 1898, .	One hour, . .	1.4539	Nov. 22, 1898, .	One hour, . .	.1943
July 29, 1898, .	Fourteen hours, .	0.6428	Feb. 21, 1899, .	Thirteen hours, .	.7685
July 29, 1898, .	One hour, . .	0.3971	Feb. 21, 1899, .	One hour, . .	.6085

Samples collected from the lead pipe showed the following amounts of lead in parts per 100,000 : —

Date of Collection.	Time Sample stood in Pipe.	Lead.	Date of Collection.	Time Sample stood in Pipe.	Lead.
Feb. 18, 1898, . .	Twenty-four hours,	.8877	Sept. 14, 1898, . .	Fourteen hours, .	.4672
Feb. 18, 1898, . .	One hour, . .	.2570	Sept. 14, 1898, . .	One hour, . .	.1080
April 5, 1898, . .	Twenty-one hours,	.7008	Nov. 22, 1898, . .	Twelve hours, .	.4088
April 5, 1898, . .	One hour, . .	.0876	Nov. 22, 1898, . .	One hour, . .	.1168
July 29, 1898, . .	Fifteen hours, .	.2628	Feb. 21, 1899, . .	Thirteen hours, .	.4672
July 29, 1898, . .	One hour, . .	.1110	Feb. 21, 1899, . .	One hour, . .	.2803

Samples collected from the block-tin pipe showed the following amounts of tin in parts per 100,000 : —

Date of Collection.	Time Sample stood in Pipe.	Tin.	Date of Collection.	Time Sample stood in Pipe.	Tin.
Feb. 18, 1898, . .	Twenty-four hours,	.0629	Sept. 14, 1898, . .	Fourteen hours, .	.0657
Feb. 18, 1898, . .	One hour, . .	.0225	Sept. 14, 1898, . .	One hour, . .	.0286
April 5, 1898, . .	Twenty-one hours,	.0292	Nov. 22, 1898, . .	Twelve hours, .	.1286
April 5, 1898, . .	One hour, . .	.0000	Nov. 22, 1898, . .	One hour, . .	.0743
July 29, 1898, . .	Fourteen hours, .	.0429	Feb. 21, 1899, . .	Thirteen hours, .	.1486
July 29, 1898, . .	One hour, . .	.0057	Feb. 21, 1899, . .	One hour, . .	.0171

METHODS FOR THE DETERMINATION OF LEAD, TIN, ZINC AND COPPER IN DRINKING WATERS.

The making of many analyses for the determination of lead, etc., necessitated the employment of a method capable of determining very small amounts of lead in a reasonably short time, and with the use of one gallon or less of water. Consequently, much thought and study have been given to improving methods; and to the laboratory force and especially to Mr. F. B. Forbes much of the credit is due. The ordinary gravimetric methods not sufficing, resource was had to a colorimetric method, in which the lead is precipitated as sulphide, which in this finely divided state colors the solution brown, and this color is compared with the color of a standard solution of a lead salt similarly treated. The method employed by Dr. Worcester, who made a number of analyses, was first used with a few slight modifications, and was as follows: —

Three thousand five hundred cubic centimeters of the sample were evaporated in a porcelain dish, with the addition of 5 cubic centimeters of nitric acid to complete dryness. The dish was then heated strongly in order to char the organic matter and dehydrate the silica. After cooling, acetic acid was added and the contents of the dish boiled. A little dilute sulphuric acid was then added to convert the lead to sulphate, and then an excess of ammonia. If iron was present in the water, it was here precipitated as ferric hydrate and filtered off, while the lead sulphate was dissolved by the ammonium acetate and remained in solution. If copper was present, the filtrate was colored blue by its hydrate, soluble in excess of ammonia, and this color was compared with the color of a standard copper solution. If copper was found, it was prevented from being precipitated by the hydrogen sulphide water that was next added by adding a few drops of potassium cyanide to the solution. The lead was precipitated as sulphide by the hydrogen sulphide, and the brown color imparted to the solution compared with the colors obtained by treating with hydrogen sulphide various known amounts of a standard solution of lead acetate made alkaline with ammonia. If zinc was present, as was quite frequent on account of the use of galvanized-iron pipes in connection with the lead pipes, its sulphide, which is white and precipitates in alkaline solution, tended to interfere with the reading of the lead. If the amount of zinc sulphide was, however, very small compared with the lead, its effect on the latter was neglected. If considerable zinc was present, the mixed sulphides were dissolved in hot dilute hydrochloric acid, and the lead separated by hydrogen sulphide in acid solution. The zinc was then precipitated as a sulphide in alkaline solution, the precipitate filtered off, ignited and weighed as zinc oxide.

This method of determining lead, when employed with clear waters which contained very little iron, gave quite satisfactory results; but with waters containing considerable iron and also organic coloring matter, the results were not so satisfactory. The filtrate from the iron precipitation was frequently so highly colored that it was impossible to read the color of the lead sulphide obtained when hydrogen sulphide was added. Strong heating of the residue from the evaporation of the water with sulphuric acid did not insure a colorless filtrate from the precipitation of the iron, and in some cases the heavy iron precipitate contained lead. There was also experienced with some waters high in organic coloring matters, a difficulty in obtaining a complete separation of iron. The slightest amount of iron in the filtrate precipitates with hydrogen sulphide in alkaline solution, and imparts a green color to this solution, thus rendering the determination of the amount of lead present by color reading difficult.

In order to learn how to obviate these difficulties a series of experiments was made. In the previous method the standard lead solution consisted of a weighed quantity of lead acetate dissolved in a known volume of water; but this solution did not remain of constant strength when kept in glass bottles. As in every case the final condition in which the lead was obtained before precipitating it by hydrogen sulphide was as sulphate dissolved in ammonium acetate, it was thought advisable to have the lead in the standard solution in the same condition. A solution was prepared as follows: —

To a strong solution of lead acetate, sulphuric acid was added in slight excess, and the lead sulphate filtered off and washed free from acid with water. The lead sulphate was then dissolved in ammonium acetate solution, made by neutralizing glacial acetic acid (sp. gr. 1.075) with concentrated ammonia (sp. gr. 0.90). This solution was then made up to a known volume, and the lead determined in aliquot portions by precipitating with potassium bichromate, drying the lead chromate and weighing. Two portions of 25 cubic centimeters each gave

1.	.5329 g. $PbCrO_4$.	1 c. c. = .01361 lead.
2.	.5321 g. $PbCrO_4$.	1 c. c. = .01364 lead.

Seventy-five cubic centimeters of this solution were diluted to 1 liter for our standard solution, of which 1 cubic centimeter contains .001022 lead. The strong solution did not deposit sediment on standing, and frequent determinations extending over a period of two years have shown that the strength of this solution remains constant.

In all our work it has been customary to make standards containing the following amounts of lead solution: 0, .1, .2, .3, .4, .5, .6, .7, .8, .9, 1.0, 1.5 and 2.0 cubic centimeters. The standards are made up in 100 cubic centimeter tubes such as are ordinarily used for determining nitrites, and the determinations are made in similar tubes. In the case of the lower standards of the scale, the colors are compared by looking through the whole depth of the liquid, the tube being so held that the light is reflected up through the bottom. With the higher standards, however, the comparison is made by looking through the sides of the tubes while holding them against a white background. With waters whose lead contents are unknown, 3,500 cubic centimeters are evaporated in a 7-inch porcelain dish over a Bunsen flame, and the final solution of the lead sulphate in ammonium acetate made up to the mark in a 100 cubic centimeter tube. Half of this is then treated with hydrogen sulphide water, in order to get an approximate idea of the amount of lead present. In case the lead is high, such an amount of the solution is taken as will make the reading fall within the range of our standards, as 2.0 cubic centimeters of our standard solution is as high as can be read with accuracy. The tubes containing the waters and standards are made up to about two-thirds full with distilled water, enough hydrogen sulphide water added quickly to fill them to the mark, and, after shaking, the readings are made as rapidly as possible, as the standards grow turbid with separation of sulphur.

In order to determine the effect of iron upon the separation of the lead from waters containing coloring matters, portions of 3,500 cubic centimeters each of Boston water were evaporated, with the addition to each of the same amount of standard lead solution and different amounts of iron varying from .025 to 2.50 parts per 100,000. The samples were evaporated with the addition of 5 cubic centimeters of nitric acid to a volume of about 500 cubic centimeters, an excess of ammonia added, and the iron precipitate filtered off and washed with water. The filtrates were then evaporated to dryness, heated strongly in order to char the organic matter, and a few drops of sulphuric acid added to convert the lead to sulphate. Acetic acid was then added and an excess of ammonia, and, after filtering from the charred organic matter and dehydrated silica, the lead, which was then as sulphate dissolved in ammonium acetate, was determined by precipitating with hydrogen sulphide water and comparing with standards. The amounts of lead found varied inversely with the amounts of iron added. Where only .025 part iron was added, all the lead was obtained again; but with increasing amounts of iron, less lead was found, and with 2.5 parts iron present, no lead at all.

Two samples of water, each containing the same amount of lead, were evaporated to dryness in porcelain dishes with nitric acid, and while one was heated gently and cautiously, the other was heated in the full flame of the blast lamp. They were then treated with sulphuric acid and ammonium acetate as above, and the amounts of lead found were in both cases the amount added. There was apparently no loss by volatilization where strong heat was applied to the residue from the evaporation. It was thus evident that in the above experiments the lead had been dragged down by the heavy precipitate of ferric hydrate. As this provided a means of separating the lead together with the iron from the soluble coloring matter, the following method was adopted and used for the determination of lead in a considerable number of samples of water which contained both iron and organic coloring matters: —

To 3,500 cubic centimeters of the sample enough ferrous ammonium sulphate solution was added to insure the presence of over 2½ parts per 100,000 of iron. If an excessive amount of lead was suspected, more iron was used, and in addition a drop or two of sulphuric acid. The water was then concentrated in a porcelain dish, with the addition of 5 cubic centimeters of nitric acid to a volume of about 500 cubic centimeters, an excess of ammonia added, boiled a few moments, and filtered through a large plaited Swedish filter. By this procedure the lead was changed to sulphate and was carried down by the heavy precipitate of ferric hydrate. The very soluble coloring matter went through in the filtrate, as did also copper, if present, its hydrate being soluble in excess of ammonia. Zinc was also found in the filtrate, its hydrate being soluble in excess of ammonia. This filtrate was acidified with hydrochloric acid and its freedom from lead proved by addition of hydrogen sulphide. In case a precipitate appeared it was filtered off, dissolved in hydrochloric acid and the solution added to the main hydrochloric acid solution. The precipitate of iron containing the lead was washed once with hot water, then dissolved off the filter into a beaker with hot dilute hydrochloric acid. About 10 cubic centimeters of concentrated sulphuric acid were then added, and all the hydrochloric acid expelled over a lamp. After cooling, about 200 cubic centimeters of a mixture of 1 part water and 2 parts 95 per cent. alcohol were added, and the beaker allowed to stand over night. The lead sulphate was then filtered off and washed with 50 per cent. alcohol until the washings were free from iron. The filter was then transferred to a beaker and boiled with about 40 cubic centimeters of ammonium acetate, made by neutralizing glacial acetic acid (sp. gr. 1.075) with concentrated ammonia (sp. gr. .90). Lead sulphate being easily soluble, boiling once with a strong ammonium acetate solution and washing once with hot dilute solution and then with water was generally sufficient to extract all the lead sulphate, and the last of the wash water from the filter through which the solution was poured was generally free from lead. The filtrate was made up to a definite volume, and an aliquot portion treated with freshly prepared hydrogen sulphide water. The color was compared with a set of standards made by treating with hydrogen sulphide water various amounts of the standard solution of lead sulphate in ammonium acetate. The filtrates obtained by this method were generally colorless and clear, and good colors were obtained with hydrogen sulphide water in either acid or alkaline solution. For convenience, both the ammonium acetate solution, used for dissolving the lead sulphate, and the standard solution were made slightly acid with acetic acid.

This method, as before stated, gave quite satisfactory results, but was open to the following objections : —

1. The concentration of the filtrate from the iron precipitation, in order to test it and insure its freedom from lead, was a time-consuming operation, as was also the washing of the lead sulphate free from the large amount of iron.

2. The lead was precipitated from solution twice as sulphate during the process, thus increasing the liability of loss on account of its slight solubility, and also the possibility of subsequent incomplete solution from the filters.

In order to obviate these difficulties, the following method was devised and has been used for the past year : 3,500 cubic centimeters of the sample are evaporated in a porcelain dish to a volume of 25 or 30 cubic centimeters, 10 or 15 cubic centimeters of ammonium chloride solution added to assist the separation of the sulphides, and a considerable excess of strong ammonia. Hydrogen sulphide water is then added and the dish allowed to stand some hours, after which more ammonia and hydrogen sulphide water are added. The contents of the dish are then boiled a few moments to expel excess of hydrogen sulphide and, after allowing the precipitate to settle, filtered. The precipitate contains all the lead and iron and suspended organic matter, also copper and zinc, if present, as sulphides, while the soluble coloring matter passes into the filtrate. After washing once with hot water, the filter is placed in the original dish and the sulphides dissolved by boiling in dilute nitric acid (1 part acid, sp. gr. 1.2, to 5 parts water), rubbing the sides of the dish with a bit of filter paper if necessary to detach any sulphide precipitate which adheres. After filtering and washing free from acid, the filtrate is evaporated to a bulk of 10 or 15 cubic centimeters, cooled, 5 cubic centimeters concentrated sulphuric acid (sp. gr. 1.84) added, and heated until copious fumes of sulphuric acid come off. At this point, if the original water contained little iron (less than .025 part), acetic acid and ammonia are added directly, and after boiling and filtering off the iron, dehydrated silica and insoluble organic matter, the lead is read in the alkaline filtrate, the standards being also made alkaline with ammonia.

If the original water contains over .025 part iron, however, the lead sulphate is washed into a beaker with alcohol and water, and allowed to settle over night, as before. The lead sulphate is then filtered off, washed with 50 per cent. alcohol until free from iron, and then dissolved by boiling the filter with ammonium acetate in the porcelain dish. After filtering, the lead is determined in alkaline solution. Portions of Boston tap water, to which standard lead solution was added, gave by this latter method, using alcohol separation, the following: —

Lead Solution added (Cubic Centimeter).	Lead Solution found (Cubic Centimeter).	Lead Solution added (Cubic Centimeter).	Lead Solution found (Cubic Centimeter).	Lead Solution added (Cubic Centimeter).	Lead Solution found (Cubic Centimeter).	Lead Solution added (Cubic Centimeter).	Lead Solution found (Cubic Centimeter).
0.5	0.50	3.00	3.10	10.0	10.00	25.0	25.00
1.0	0.95	5.00	5.10				

Portions of Boston tap water, which contained .020 part iron and to which lead was added, were treated by the above method, except that, after obtaining the lead as sulphate freed from the coloring matter, acetic acid and ammonia were added directly, without separating out the lead sulphate in alcohol. The ferric hydrate was filtered off and the lead sulphate in ammonium acetate solution determined in the usual manner. The following results were obtained: —

Lead Solution added (Cubic Centimeter).	Lead Solution obtained (Cubic Centimeter).	Lead Solution added (Cubic Centimeter).	Lead Solution obtained (Cubic Centimeter).	Lead Solution added (Cubic Centimeter).	Lead Solution obtained (Cubic Centimeter).
0.2	0.2	2.0	2.0	5.0	4.5
0.5	0.5	3.0	2.8	10.0	9.9
1.0	0.9	4.0	3.9	20.0	17.9

Further experiments were made with larger amounts of iron than .025 part present to see if, after disposing of the organic coloring matter, the iron could be successfully separated from the lead sulphate dissolved in ammonium acetate. Portions of 3,500 cubic centimeters of Boston tap water which contained .028 part iron were evaporated with the addition to each of 1 cubic centimeter standard lead solution and different amounts of iron. The following results were obtained: —

Iron originally present (Parts).	Iron added.	Lead found.	Iron originally present (Parts).	Iron added.	Lead found.	Iron originally present (Parts).	Iron added.	Lead found.
.028	.005	1.00	-	.025	0.95	-	.300	.90
-	.010	1.10	-	.035	1.00	-	.500	.40
-	.020	0.95	-	.100	0.85			

This method of separating the metals as sulphides from the soluble coloring matter at the start has proved the most satisfactory of any yet tried. It has been customary to determine the iron contents of all our waters, and knowing this, the variation of the method to be applied is determined. With a small amount of iron present, no difficulty is experienced in separating the iron by ammonia from the solution in which the lead sulphate remains dissolved in ammonium acetate; but with moderate amounts of iron, it is best, in order to insure colorless filtrates in which to read the lead, to first separate the lead sulphate by alcohol, leaving the iron in solution, and after filtering and washing free from iron, to dissolve the lead sulphate by boiling with ammonium acetate.

In the absence of both organic coloring matter and iron and other metals, the water is evaporated dry, fumed with sulphuric acid and treated directly with ammonium acetate. The solution is then treated with hydrogen sulphide water and compared with standards.

Lead may be precipitated by hydrogen sulphide in either an acid or alkaline solution, and compared with standards made either acid or alkaline, to correspond. It has been found, however, that the colors obtained in acetic acid solution are more easily read and slower in changing than those in alkaline solution.

Copper occurs so rarely and in such small amounts in the waters that we have examined, that it has not interfered with the lead determination. If present, it is detected by the blue color imparted to the ammoniacal filtrate from the iron precipitation.

Zinc is frequently found in waters which have been drawn through galvanized pipes. It precipitates with the other metals as sulphide in alkaline solution, and is converted to sulphate with the lead. While the lead sulphate is separated insoluble in alcohol and water, the zinc sulphate, being soluble, is found in the filtrate with the iron. The iron is precipitated by excess of ammonia, and the zinc then precipitated in the ammoniacal filtrate by hydrogen sulphide.

The zinc sulphide is filtered off, ignited carefully in a porcelain crucible to zinc oxide, and weighed. When zinc alone is to be determined, the first precipitate of sulphides is dissolved in dilute hydrochloric acid, and the iron precipitated by excess of sodium hydrate. The filtrate is made slightly acid with acetic acid, and the zinc precipitated by hydrogen sulphide water in a stoppered flask, which is allowed to stand several hours with occasional shaking. The zinc sulphide is then filtered off, ignited to zinc oxide and weighed.

Tin has seldom occurred in waters containing lead and zinc, but when present alone has been precipitated as the sulphide, filtered, washed, dried and carefully ignited in a porcelain crucible to tin oxide (SnO_2) and weighed.

THE

PURIFICATION OF THE SEWAGE OF CITIES AND TOWNS IN MASSACHUSETTS.

By X. H. GOODNOUGH, *Chief Engineer of the Board*, and WILLIAM S. JOHNSON, *Asst. Engineer*.

THE

Purification of the Sewage of Cities and Towns in Massachusetts.

By X. H. Goodnough, *Chief Engineer of the Board*, and William S. Johnson, *Asst. Engineer.*

The investigations of the Massachusetts State Board of Health with reference to the purification of sewage were begun in 1887. At that time works had been constructed for the purification of the sewage of a few public institutions and two or three small towns, but in general the cities and towns which were provided with sewerage systems discharged the sewage in a crude state into the sea or into some convenient stream.

Very little was definitely known anywhere of the conditions most favorable for the purification of sewage by filtration or the methods of operation necessary to produce the most satisfactory results, and the Lawrence Experiment Station was established for the purpose of obtaining reliable information as to what could be accomplished by the filtration of sewage through soils, sands and gravels found at places suitably located for filtration areas, and through other materials which might be proposed for the purification of sewage. This information was urgently needed in advising cities, towns, corporations, etc., in the State as to the purification and disposal of sewage, and the results of the experimental work of the Board at the Lawrence Experiment Station have been published in the reports of the Board since 1887.

At the present time works for the purification of sewage by filtration, based largely upon the information obtained by experiments at Lawrence, are in operation in 14 towns and cities of the State, ranging in population from 600 to 35,000, and also in many large public and semi-public institutions, and it is now possible to consider the results which have been accomplished in a practical way in the filtration of sewage for several years at various filtration areas where the works are operated on a large scale and under various conditions.

While at nearly all of the works which will be described herein the method of purification followed is the same, that is, the sewage is applied intermittently to areas of prepared beds of sand or gravel about 5 feet in depth, there is a great difference in the character of the sewage, in the arrangement of the works, in the character of the filtering material and in the methods of operating the filter-beds. Many samples of sewage and effluent from the various works have been analyzed by the Board, to determine the character of the sewage and the degree of purification effected, and the quality of the soil of the filters has been determined by mechanical and chemical analyses. Records of measurements of the quantity of sewage and of the method of operating the works have in some places been kept by the officials in charge of the works, and in other cases, where no records are kept, measurements and observations have been made under the direction of the Board.

The results obtained by applying the information furnished by the experiments at Lawrence to the purification of sewage in a practical way and upon a large scale have been highly satisfactory, and the information obtained from the operation of these works, taken in connection with the results of the experiments carried on at Lawrence, is of great value in designing and operating sewage-disposal works.

It may be added, that the works herein described were built under various legislative acts, and that the State Board of Health has no control over the ordinary management of the works.

Brockton.

Estimated population in 1898, 36,688.

The city of Brockton is situated within the water-shed of Salisbury Plain River, a small stream which flows through the centre of the thickly populated section of the city. The principal industry is the manufacture of shoes, and there is a large number of factories in various parts of the city.

A water supply was introduced in 1880 and is in general use throughout the city. The average daily consumption of water in 1898 was 1,012,000 gallons, or 28 gallons per capita.

The sewerage system was first put in operation in the latter part of the year 1894. The sewage is conveyed through main sewers to a pumping station located in the southerly part of the city. At the pumping station the sewage is received into a covered masonry reservoir, from which it is pumped to the filtration area located about 3½ miles away upon land draining into the head waters of the Taunton River.

In designing the system, it was planned to take house sewage only, and to exclude all surface water and, so far as practicable, all ground water from the sewers. Special care was taken in constructing the sewers to prevent the entrance of ground water, and underdrains are placed beneath all sewers which are laid below the ground-water level. There are several main lines of brick sewers, but the principal part of the system is constructed of pipe sewers. The main sewer, which is of brick, is laid in the valley of the river at a level considerably below the level of the water in the stream, and at times of high water in the river the surface of the ground in the vicinity of the sewer is flooded. When the main sewer was completed, and before any connections had been made, the amount of leakage was measured at a time when the water in the stream was low, and the results are given in a report of the city engineer. In a section of the sewer about 2,000 feet long, just above the pumping station, the leakage was found to be about 17,000 gallons per day, or about 45,000 gallons per day per mile of sewer. The entire amount of leakage in the main sewer, which had, at the time measurements were made, a length of 10,400 feet, was about 120,000 gallons per day, or 61,000 gallons per mile of sewer, at a time when the water in the river was low. At a time of high water, when the meadows along the river were flooded, it was found that the leakage in this length of sewer was in the vicinity of 350,000 gallons per day, or 178,000 gallons per mile of sewer. This was in a section of brick sewer of a maximum size at the lower end of 32 inches by 48 inches, where underdrains were built beneath the sewers, and particular care was taken to make the sewers tight.

At the end of the year 1898, 18.27 miles of sewers had been constructed and there were 647 connections with the system, 40 of which were from factories.

Careful records have been kept by the city, so that reliable data have been obtained of the quantity of sewage flowing from the city each day since the works were first operated. The following table gives the average monthly flow of sewage according to these records since 1895: —

Quantity of Sewage flowing from City of Brockton.

[Gallons per Day.]

Month — 1898.	1895.	1896.	1897.	1898.
January,	215,000	474,000	614,000	497,000
February,	109,000	568,000	542,000	885,000
March,	142,000	648,000	659,000	777,000
April,	250,000	475,000	702,000	809,000
May,	338,000	322,000	530,000	780,000
June,	228,000	382,000	565,000	602,000
July,	195,000	323,000	537,000	503,000
August,	273,000	366,000	568,000	748,000
September,	275,000	527,000	468,000	510,000
October,	488,000	600,000	369,000	746,000
November,	474,000	616,000	492,000	844,000
December,	513,000	559,000	597,000	977,000
Average,	293,000	488,000	554,000	722,000

The following table gives the average, maximum and minimum daily flow of sewage during the year 1898, and the flow per inhabitant, per connection with the sewer system and per mile of sewers in use : —

	Average (Gallons per Day).	Maximum (Gallons per Day).	Minimum (Gallons per Day).
Total flow,	722,000	2,440,600	325,200
Flow per inhabitant,	19.7	66.5	8.9
Flow per connection,	1,116	3,772	503
Flow per mile of sewers,	39,520	133,600	17,800

The sewage is received at the pumping station in a masonry reservoir having a capacity of 619,000 gallons, designed to hold the night flow, in order that the pumping may be done in the daytime. From this reservoir the sewage passes through screens consisting of iron slats with an open space between them of three-quarters of an inch, and thence passes to the pumps.

The screens are so arranged that they are entirely submerged when the reservoir is full, and the entire screen area of about 100 square feet is available at that time. As the level of the sewage in the reservoir goes down the available screen area is diminished, the bottom of the screens being but slightly below the bottom of the reservoir. It is necessary to clean the screens several times each day while the pumps are being operated. The material removed is burned beneath the boilers.

The solid matter which accumulates at the bottom of the reservoir is removed by stirring it up when there remains only about a foot of sewage in the reservoir and pumping it to the filter-beds. This stirring is done by means of an agitator which consists of perforated pipes laid on the bottom of the reservoir and connected with the force main, through which the sewage can be discharged under a head. In this manner the solid matter on the bottom is mixed with the sewage remaining in the reservoir and passes into the pump well.

An overflow has been provided at the point where the main sewer enters the reservoir, so that crude sewage can be discharged directly into the Salisbury Plain River either from the reservoir or from the main sewer. At times when the flow of sewage is large it appears that this overflow has been used frequently, although the filtration area has a sufficient capacity to provide for all of the sewage flowing. As already stated, records are kept at the pumping station of the quantity of sewage discharged from the main sewer, a summary of which has been given in a preceding table. Records are also kept of the quantity of sewage pumped, and the difference between these two quantities represents approximately the quantity which is discharged directly in an unpurified state into the Salisbury Plain River. The following table gives the quantity discharged into the river during each month of the year 1898, as shown by the records kept at the pumping station: —

MONTH. 1898.	Quantity of Sewage discharged into Salisbury Plain River.		MONTH. 1898.	Quantity of Sewage discharged into Salisbury Plain River.	
	Total Gallons.	Gallons per Day.		Total Gallons.	Gallons per Day.
January, . . .	-	-	July, ...	118,000	3,800
February, . . .	6,709,000	239,600	August, . . .	1,147,000	37,000
March, . . .	725,000	23,400	September, . .	-	-
April, . . .	3,861,000	128,700	October, . . .	4,690,000	151,300
May, ...	2,448,000	78,900	November, . .	2,049,000	68,200
June, ...	696,000	23,200	December, . .	6,144,000	198,100

Sewage is forced to the filter-beds by two pumping engines, each of which has a capacity of 5,000,000 gallons in twenty-four hours. These pumps are provided with ordinary water valves which are said to require frequent attention, on account of substances getting caught beneath them.

The force main from the pumping station to the filtration area is a cast-iron pipe 24 inches in diameter and 17,500 feet in length. It is so arranged that the contents of about 1,500 feet of the pipe flow by gravity upon the filter-beds when the pumps are stopped. The sewage in the remaining length of pipe remains there until pumping is resumed. The total quantity of sewage remaining in the pipe when pumping ceases is about 376,000 gallons.

The filtration area is located in the south-westerly corner of the city, adjoining the towns of Easton and West Bridgewater. The area purchased by the city comprises 38.7 acres, on which 23 filter-beds have been prepared having an average area of about an acre. The beds were prepared for receiving sewage by the removal of all of the loam from the surface. In 12 of the beds all the subsoil was removed; 6 beds have a surface in some parts of sand and in others of subsoil, and in the remaining 5 beds the entire surface is covered with a layer of subsoil. None of the material left in the filter-beds was disturbed except that necessary in grading the beds and constructing the underdrains. The sewage is distributed on the beds by means of wooden carriers which are laid across the bed from the centre of one side and so arranged as to discharge the sewage at several points.

A large number of test pits was dug previous to the construction of the filter-beds, in order to determine the character of the filtering material, but no samples of soil have been examined since the beds were completed. The subsoil in general has an effective size* of about 0.07 of a millimeter, and contains about 100 parts per 100,000 of albuminoid ammonia, while the effective size of the sand varies from 0.04 to 0.75 of a millimeter. The sand is stratified, but the different strata are not separated, in most cases, by a distinct line of stratification, and the material in general is coarse and porous. In some places a thin stratum of clay is found in the sand at a depth of from 7 to 8 feet beneath the surface of the bed. This stratum of clay is found in 10 of the beds and these beds have been very thoroughly underdrained, the underdrains being laid just above the stratum of clay.

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* See foot-note on page 608.

The underdrains are laid about 60 feet apart and discharge into two main underdrains, one of which discharges into the Coweeset River and the other into Daly Brook, a tributary of Coweeset River.

As already stated, the solid matter which accumulates in the bottom of the reservoir is mixed with a small quantity of sewage remaining when the reservoir is nearly empty, and then pumped into the force main. After the reservoir is emptied the pumps are stopped and this heavier sewage remains in the lower end of the force main until pumping is resumed next day, when it is discharged at the filter-beds. The heavier sewage is usually discharged upon a separate bed from the rest of the sewage, and a record is kept of the quantity received each day. The sewage remaining in the force main over night becomes somewhat decomposed, and when it is received at the beds it is very foul smelling, but it is disposed of upon the beds without much difficulty. After this heavy sewage is dried there remains upon the surface of the bed a thin layer of solid matter, which is raked up, removed from the beds and burned or used as a fertilizer.

As before stated, a large quantity of sewage is discharged at times into the Salisbury Plain River near the pumping station, so that the record previously given of the quantity of sewage flowing in the sewers does not represent the quantity purified at the filtration area. The average daily quantity of ordinary sewage and of heavy sewage from the bottom of the reservoir purified each month during 1898 as shown by the records kept at the filter-beds, is given in the following table. Four of the filter-beds have as yet never received any sewage, and the remaining beds are evidently capable of purifying a considerably greater quantity of sewage than they now receive.

Month — 1898.	Quantity of Ordinary Sewage purified (Gallons per Day).	Quantity of Heavy Sewage purified (Gallons per Day).	Total Quantity purified (Gallons per Day).
January,	444,300	56,300	500,600
February,	639,000	53,800	692,800
March,	671,300	64,000	735,300
April,	608,300	60,000	668,300
May,	624,400	59,600	684,000
June,	528,100	36,200	564,300
July,	533,600	46,000	579,600
August,	692,200	36,200	728,400
September,	498,800	11,200	510,000
October,	588,800	-	588,800
November,	695,400	67,000	762,400
December,	702,200	52,600	754,800
Average,	598,800	42,500	641,300

Records are kept of the quantity of each kind of sewage which is applied to each of the beds daily. The following table, which is compiled from these records, shows the quantity of ordinary sewage and heavier sewage from the bottom of the reservoir purified by each of the beds during the year 1898, and the quantity purified per acre :* —

No. Bed.	Area (Acres).	Number of Doses of Ordinary Sewage.	Average Daily Quantity of Ordinary Sewage applied (Gallons).	Number of Doses of Heavy Sewage.	Average Daily Quantity of Heavy Sewage applied (Gallons).	Total Daily Quantity applied (Gallons).	Average Daily Quantity applied per Acre (Gallons).
1, . .	1.01	96	22,400	41	6,500	28,900	28,600
2, . .	1.05	100	21,600	50	7,700	29,300	27,900
3, . .	0.95	97	20,800	49	7,800	28,600	30,100
4, . .	1.00	105	23,000	22	3,300	26,300	26,300
5, . .	0.99	109	24,000	22	3,300	27,300	27,600
6,† . .	0.99	229	47,400	3	600	48,000	48,500
7,† . .	0.99	93	19,700	19	3,200	22,800	23,100
8, . .	0.93	224	42,000	–	–	42,000	45,200
9,‡ . .	0.97	220	34,500	–	–	34,500	35,500
10, . .	0.98	192	44,700	–	–	44,700	45,600
11,‡ . .	0.99	221	27,200	–	–	27,200	27,500
12,‡ . .	0.98	190	30,100	–	–	30,100	30,700
13, . .	0.87	195	46,300	–	–	46,300	53,200
14, . .	0.99	118	37,500	31	5,000	42,400	42,900
15,§ . .	0.99	–	–	–	–	–	–
16,† . .	0.89	131	34,200	–	–	34,200	38,500
17,‖ . .	0.97	142	35,400	–	–	35,400	36,500
18, . .	0.98	120	24,200	26	4,400	28,600	29,200
19,‖ . .	0.89	141	34,300	–	–	34,300	38,500
20,† . .	0.97	128	28,400	–	–	28,400	29,300
21,§ . .	0.70	–	–	–	–	–	–
22,§ . .	0.41	–	–	–	–	–	–
23,§ . .	0.99	–	–	–	–	–	–

* The averages given in the table are for 365 days. † Out of use one month.
‡ Out of use four months. § Not in use. ‖ Out of use two months.

The ordinary method of operating the beds is to apply sewage one day and allow the bed to rest for one or two days before the next dose is applied. In this way the beds rest frequently and the best results are obtained.

The average monthly temperature, for the year 1898, of the sewage as it is received at the pumping station and as it is discharged upon the beds, together with the temperature of the effluent in the underdrains, is given in the following table: —

Month — 1898.	Temperature Degrees F.		
	Sewage at Reservoir.	Sewage at Filter-beds.	Effluent.
January,	48.1	45.7	41.2
February,	45.7	44.2	41.1
March,	46.5	44.9	40.1
April,	47.6	46.4	42.1
May,	50.2	49.5	45.2
June,	54.7	54.2	48.9
July,	60.2	59.6	52.3
August,	62.4	62.8	57.2
September,	62.5	62.8	59.8
October,	60.4	59.3	59.4
November,	55.8	53.9	55.6
December,	50.0	48.8	47.6

The temperature of the sewage appears to be affected considerably by the quantity of ground water with which it is mingled, so that it is warmer in the winter and colder in the summer season than in other places where the conditions are otherwise similar.

Crops are raised on some of the beds during the summer, the principal crop being corn, although other vegetables have been raised with considerable success. During the time the crops are growing both the ordinary sewage and the heavier sewage are applied to the beds which are cropped, and it is said that when the heavier sewage, which has quite an offensive odor, is discharged upon the beds in which corn is growing there is very little odor noticeable in the vicinity.

When the beds are used for growing crops, the surfaces receive the attention necessary to keep the crops in good condition, and this is sufficient to keep the surfaces of the filters from becoming clogged. After the crop is removed all of the corn stalks and roots are removed from the beds as far as possible. The beds which are not planted are raked occasionally and all weeds are removed and not ploughed in. The beds are prepared for winter by ploughing, the surface being left with ridges and furrows. The cost of maintaining the filter-beds during the year 1898, as given in the report of the sewer commissioners for that year, was $2,282.72. The amount received from the crops was $250.62, making the net cost of maintaining the beds $2,032.10.

The character of the sewage of Brockton is not affected in any considerable degree by the discharge into the sewers of waste liquors from manufacturing establishments.

In order to show the character of the sewage at different hours of the day, and to observe the changes which occur in the sewage while it is stored in the reservoir and force main, a series of samples has been collected, analyses of which are given in the following tables. The analyses in the first table represent the sewage as it was received in the reservoir; the second and third tables contain analyses of the same sewage and the accumulated sludge when it was being pumped from the reservoir on the following morning; and the fourth table gives analyses of the sewage as it was received at the filtration area, the first portions of the sewage having remained in the force main over night. The last table contains the results of a second series of analyses of samples from the sewer outlet.

Chemical Examination of Sewage from

[Parts per 100,000.]

	Number.	Date.	Hour.	Temperature. Deg. F.	Residue on Evaporation.					
					Total Residue.			Loss on Ignition.		
					Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
		1898.								
1	23644	June 21	12.00 and 1.00 P.M.	–	66.30	42.50	23.80	35.50	16.10	19.40
2	23645	June 21	2.00 and 3.00 P.M.	56	71.90	44.90	27.00	39.20	15.60	23.60
3	23646	June 21	4.00 and 5.00 P.M.	56	83.50	47.60	35.90	46.30	15.30	31.00
4	23647	June 21	6.00 and 7.00 P.M.	57	56.40	37.10	19.30	32.80	16.20	16.60
5	23648	June 21	8.00 and 9.00 P.M.	57	50.10	34.60	15.50	25.20	13.00	12.20
6	23649	June 21	10.00 and 11.00 P.M.	56	63.40	45.70	17.70	24.30	12.40	11.90
7	23650	June 22	12.00 and 1.00 A.M.	56	64.30	30.20	34.10	42.00	10.00	32.00
8	23651	June 22	2.00 and 3.00 A.M.	55	72.50	22.30	50.20	53.50	6.70	46.80
9	23652	June 22	4.00 and 5.00 A.M.	54	20.80	18.70	2.10	6.30	4.30	2.00
10	23653	June 22	6.00 and 7.00 A.M.	54	18.10	17.00	1.10	4.50	3.70	0.80
11	23654	June 22	8.00 and 9.00 A.M.	54	19.50	17.20	2.30	6.50	4.50	2.00
12	23655	June 22	10.00 and 11.00 A.M.	–	74.60	35.70	38.90	48.00	15.60	32.40

The samples were collected from the sewer at the point where it discharges into

Chemical Examination of Sewage from the

[Parts per 100,000.]

	Number.	Date.	Hour.	Residue on Evaporation.					
				Total Residue.			Loss on Ignition.		
				Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
		1898.							
1	23656	June 22	9.30 A. M.	49.70	39.80	9.90	22.20	13.50	8.70
2	23657	June 22	10.15 A. M.	43.40	36.00	7.40	17.60	10.80	6.80
3	23659	June 22	10.30 A. M.	44.00	35.80	8.20	17.50	10.80	6.70
4	23660	June 22	11.25 A. M.	140.90	37.60	103.30	109.40	13.00	96.40

The samples were collected from the pump well during the time that the pumps were being oper-
on the bottom had been mixed with the sewage.

the Outlet of the Main Sewer at Brockton.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
Free.	Albuminoid.				Nitrates.	Nitrites.	Unfiltered.	Filtered.	
	Total.	Dis-solved.	Sus-pended.						
5.5000	0.7600	.3200	.4400	9.35	.0000	.0000	7.10	3.36	1
5.3500	0.7100	.2800	.4300	10.95	.0010	.0000	5.95	2.88	2
4.5000	0.7100	.3000	.4100	12.98	.0010	.0000	6.27	2.94	3
3.7500	0.5200	.2500	.2700	6.68	.0000	.0000	5.95	2.80	4
3.9500	0.5400	.2400	.3000	7.60	.0000	.0000	4.58	2.45	5
3.3500	0.5100	.2500	.2600	14.75	.0000	.0000	5.22	2.61	6
2.6000	0.5300	.2200	.3100	6.43	.0000	.0000	4.00	2.06	7
1.9000	0.2360	.1120	.1240	4.79	.0000	.0000	3.01	1.41	8
1.2000	0.1480	.0760	.0720	4.13	.0010	.0000	1.41	1.01	9
0.7600	0.0800	.0400	.0400	3.35	.0370	.0120	1.09	0.80	10
0.5800	0.0800	.0400	.0400	3.15	.1380	.0180	1.06	0.69	11
5.2500	1.0900	.4400	.6500	6.15	.0010	.0000	7.74	3.31	12

the reservoir. Each sample is made up of two equal portions collected hourly.

Sewage Pumping Station at Brockton.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
Free.	Albuminoid.				Nitrates.	Nitrites.	Unfiltered.	Filtered.	
	Total.	Dissolved.	Suspended.						
3.7500	0.5400	.2600	0.2800	9.55	.0010	.0000	4.45	2.82	1
3.4500	0.3900	.2400	0.1500	8.58	.0000	.0000	3.94	2.51	2
3.1500	0.4800	.3000	0.1800	8.48	.0000	.0000	3.87	2.75	3
4.0000	1.9600	.5200	1.4400	7.38	.0000	.0000	13.92	4.22	4

ated. The samples represent the sewage in the upper portion of the reservoir before the solid matter

Chemical Examination of Sewage from

[Parts per 100,000.]

	Number.	Date.	Hour.	Residue on Evaporation. Total Residue. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Suspended.
		1898.							
1	23661	June 22	11.30 A.M.	178.50	40.30	138.20	128.30	16.70	111.60
2	23662	June 22	11.30 A.M.	186.80	39.70	147.10	133.50	15.70	117.80

The samples were collected from the pump well during the time when the agitators were in oper-
the pump.

Chemical Examination of Sewage

[Parts per 100,000.]

	Number.	Date.	Residue on Evaporation. Total Residue. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Suspended.
		1898.						
1	23671	June 23	41.60	32.00	9.60	16.30	7.90	8.40
2	23670	June 23	173.00	32.00	141.00	125.30	8.90	116.40
3	23672	June 23	46.50	27.30	19.20	22.90	5.80	17.10

The samples were collected from the gate-chamber at the end of the force main at the filter-beds.
The second sample represents the heavy sewage from the bottom of the reservoir, which had also
which remained in the reservoir over night but was drawn from the reservoir on the same day that it

Chemical Examination of Sewage from the

[Parts per 100,000.]

	Number.	Date.	Hour.	Residue on Evaporation. Total Residue. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Suspended.
		1898.							
1	24834	Sept. 27	6.00 and 7.00 P.M.	72.10	55.80	16.30	30.60	17.20	13.40
2	24835	Sept. 27	8.00 and 9.00 P.M.	111.70	37.00	74.70	86.10	15.60	70.50
3	24836	Sept. 27	10.00 and 11.00 P.M.	61.00	35.10	25.90	39.70	16.30	23.40
4	24837	Sept. 27	12.00 and 1.00 A.M.	207.60	29.80	177.80	181.80	12.40	169.40
5	24838	Sept. 28	2.00 and 3.00 A.M.	26.40	21.00	5.40	13.10	8.30	4.80
6	24839	Sept. 28	4.00 and 5.00 A.M.	16.50	13.80	2.70	6.20	3.90	2.30
7	24840	Sept. 28	6.00 and 7.00 A.M.	15.40	13.50	1.90	5.20	4.00	1.20
8	24841	Sept. 28	8.00 and 9.00 A.M.	28.80	19.80	9.00	14.70	7.00	7.70
9	24854	Sept. 28	10.00 and 11.00 A.M.	111.90	40.40	71.50	85.70	19.00	66.70
10	24855	Sept. 28	12.00 and 1.00 P.M.	76.80	48.40	28.40	41.80	17.40	24.40
11	24856	Sept. 28	2.00 and 3.00 P.M.	84.20	40.10	44.10	57.20	17.40	39.80
12	24857	Sept. 28	4.00 and 5.00 P.M.	119.70	61.50	58.20	84.50	30.30	54.20

The samples were collected from the sewer at the point where it discharges into *the Bottom of the Reservoir at Brockton.*

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
Free.	Albuminoid.				Nitrates.	Nitrites.	Unfiltered.	Filtered.	
	Total.	Dissolved.	Suspended.						
3.7500	2.7000	.3600	2.3400	7.63	.0000	.0000	18.72	4.29	1
4.4500	3.0500	.3400	2.7100	7.63	.0000	.0000	21.60	4.29	2

ation and the heavy sewage which had accumulated at the bottom of the reservoir was being drawn into

from the Brockton Filter-beds.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
Free.	Albuminoid.				Nitrates.	Nitrites.	Unfiltered.	Filtered.	
	Total.	Dissolved.	Suspended.						
3.2500	0.4700	.2800	0.1900	8.32	.0000	.0000	4.10	2.72	1
3.8000	2.8500	.3600	2.4900	7.81	.0000	.0000	19.60	4.13	2
2.8000	0.5800	.2600	0.3200	6.95	.0000	.0000	4.45	1.65	3

The first sample represents sewage which had remained in the force main for about twenty-two hours. remained in the force main for a period of about twenty-two hours. The last sample represents sewage was delivered at the filter-beds.

Outlet of the Main Sewer at Brockton.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
Free.	Albuminoid.				Nitrates.	Nitrites.	Unfiltered.	Filtered.	
	Total.	Dis-solved.	Sus-pended.						
3.3500	0.8500	.3700	0.4800	16.80	.0000	.0000	5.84	2.88	1
3.6000	0.5800	.3000	0.2800	7.60	.0000	.0000	5.04	2.78	2
3.2500	0.6100	.2800	0.3300	6.45	.0000	.0000	5.36	2.78	3
2.3000	0.4300	.2200	0.2100	5.78	.0000	.0000	4.96	2.50	4
1.5500	0.2800	.1800	0.1000	3.55	.0000	.0000	2.72	1.86	5
0.7500	0.1300	.0800	0.0500	2.58	.0010	.0000	1.15	0.96	6
0.5000	0.1300	.0700	0.0600	2.41	.0200	.0352	1.28	0.80	7
2.2500	0.6100	.2600	0.3500	3.25	.0000	.0000	3.76	1.98	8
5.4000	1.7500	.5600	1.1900	5.89	.0000	.0000	11.68	5.60	9
5.9000	1.4200	.6000	0.8200	11.37	.0000	.0000	8.48	3.65	10
6.0000	0.9300	.4800	0.4500	7.45	.0000	.0000	6.96	2.11	11
4.5500	1.4500	.4400	1.0100	6.92	.0000	.0000	26.88	18.48	12

the reservoir. Each sample is made up of two equal portions collected hourly.

Analyses of the sewage and the effluent from one of the main underdrains have been made frequently during the past two years, the averages of which are given in the tables which follow : —

Yearly Averages of Chemical Examinations of Sewage from Brockton.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.							
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.		Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.
1897	39.15	29.32	9.83	18.40	10.41	7.99	2.3636	0.5728	0.3317	0.2411	6.29	.0029	.0000	3.67	1.99
1898	45.63	31.47	14.16	23.15	11.70	11.45	3.1179	1.0483	0.3400	0.7083	6.59	.0005	.0003	4.90	2.90

The samples were collected as the sewage flowed out upon the filter-beds and were composed of several equal portions collected at intervals during the time that the pumps were in operation.

Yearly Averages of Chemical Examinations of Sewage pumped from the Bottom of the Sewage Reservoir at Brockton.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.							
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.		Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.
1897	234.00	36.49	197.51	167.11	15.47	151.64	4.4133	3.7578	0.8167	2.9411	6.82	.0026	.0000	24.69	3.53
1898	253.00	34.75	218.25	188.96	15.09	173.87	4.3540	4.2500	0.5680	3.6820	5.88	.0007	.0000	33.19	3.51

The samples were collected as the sewage flowed out upon the filter-beds and represent the heavy sewage which settled to the bottom of the reservoir, mixed with a small amount of the supernatant sewage. Each sample was composed of several equal parts collected at intervals during the time that the heavy sewage was flowing upon the beds.

Yearly Averages of Chemical Examinations of the Effluent from an Underdrain at the Brockton Sewage Disposal Works.

[Parts per 100,000.]

Year.	Residue on Evaporation. Total Residue. Total.	Residue on Evaporation. Total Residue. Dis-solved.	Residue on Evaporation. Total Residue. Sus-pended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dis-solved.	Residue on Evaporation. Loss on Ignition. Sus-pended.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dis-solved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed. Unfiltered.	Oxygen Consumed. Filtered.
1897	27.75	-	-	-	-	-	.0911	.0105	-	-	4.80	1.2245	.0016	.11	-
1898	28.68	-	-	-	-	-	.1766	.0123	-	-	4.88	1.7292	.0012	.13	-

The samples were collected from the underdrain on Pearl Street, which receives, in addition to the effluent from several of the filter-beds, a considerable amount of ground water from the territory in the vicinity of the filtration area.

As a record is kept both of the quantity of ordinary sewage and of the stronger sewage from the bottom of the reservoir received at the beds each day, it is possible to calculate an average analysis of the sewage. The amount of free and albuminoid ammonia and oxygen consumed in the whole quantity of sewage calculated in this manner, together with the percentage of purification as indicated by this analysis, and the analysis of the effluent from one of the main underdrains for the year 1898, is given in the following table. There is a considerable amount of ground water flowing at all times in the effluent underdrains, which tends to dilute the effluent and to make the purification appear greater than it actually is.

Purification effected by Brockton Filters.

[Parts per 100,000.]

Free Ammonia. Sewage.	Free Ammonia. Effluent.	Free Ammonia. Per Cent. removed.	Albuminoid Ammonia. Sewage.	Albuminoid Ammonia. Effluent.	Albuminoid Ammonia. Per Cent. removed.	Oxygen Consumed. Sewage.	Oxygen Consumed. Effluent.	Oxygen Consumed. Per Cent. removed.
3.01	.1766	94.1	1.36	.0123	99.1	6.44	.13	98.1

There is a very small population in the immediate vicinity of the filtration area and the population within half a mile of the area is about 215. The effluent from the filter-beds is discharged into Coweeset River, one of the tributaries of the Taunton River. There is no population in the immediate vicinity of the river at the point where the effluent enters it. A large cranberry bog is situated on the stream a short distance below the effluent drain, and large quantities of microscopical organisms are said to have appeared in a pond formed during the winter season by flooding this bog, since effluent has been discharged into the stream. The stream has a watershed of 7.9 square miles at the point where the effluent from the filter-beds enters it.

Framingham.

Estimated population in 1898, 9,676.

The town of Framingham is situated within the water-shed of the Sudbury River and a part of it drains naturally into that portion of the river from which water is taken for the supply of the Metropolitan District. The town has three principal villages, only one of which, South Framingham, is at present provided with a system of sewers. This village contained, according to the census of 1895, about 60 per cent. of the entire population of the town.

A water supply was introduced into the town in 1885, and the water is now in general use in the village of South Framingham and is supplied to some extent in the village of Framingham Centre. The average quantity of water used during 1898 was 344,000 gallons per day, or 36 gallons per capita. Sewerage facilities are now available to the greater portion of the people who are supplied with water from the public works.

The sewerage system was constructed in 1889. The sewage is collected by a system of pipe sewers discharging into a main sewer built of brick, through which the sewage flows to a pumping station located about a mile from the village. At the pumping station the sewage is received into a covered masonry reservoir from which it is pumped during the daytime to the filtration area located about 2 miles away upon land draining toward the Sudbury River below the portion of the water-shed of this stream used for the supply of the Metropolitan District.

The system is designed to carry house sewage and sewage from manufacturing establishments, but all roof water and cellar drainage are excluded from the sewers. Underdrains were laid beneath the sewers when the system was first built, but in making extensions to the system underdrains have been omitted. The total length of underdrains at the present time is about 15,000 feet. The underdrains discharge into a main underdrain laid beneath the main sewer, through which the water flows to the pumping station, where it is received in an open reservoir, from which it is pumped to a filter-bed near the pumping station which has been prepared for the purification of this water. At times when the flow of sewage is small the water from the underdrains is pumped to the sewage filtration area with the sewage.

The Reformatory Prison for Women, which is located in the town of Sherborn and which contains a population of about 300, is connected with the Framingham system. The quantity of sewage from this institution, as indicated by one measurement, is about 30,000 gallons per day. This institution has an independent water supply.

At the end of the year 1898 there were 10.8 miles of sewers in use. The total number of connections at the end of the year 1898 was said to be 1,099, of which 49 are from business blocks, factories or public buildings.

Records of the quantity of sewage pumped each day have been kept since 1892, and while these records are probably somewhat inaccurate because the slip of the pumps has not been carefully determined, they serve to indicate the approximate quantity of sewage purified and the variations in the flow. The following table gives the average quantity of sewage pumped each month since 1892, as shown by these records: —

Average Quantity of Sewage pumped at Framingham.

[Gallons per Day.]

Month.	1893.	1894.	1895.	1896.	1897.	1898.
January,	–	236,400	303,200	398,400	424,200	467,200
February,	–	260,800	291,300	476,400	433,500	648,300
March,	341,000	380,100	359,100	570,100	448,400	698,400
April,	303,500	354,800	494,900	444,100	441,600	525,400
May,	406,500	254,700	366,900	376,300	384,900	509,600
June,	245,000	209,600	242,100	400,800	367,300	450,800
July,	173,400	191,600	220,200	365,700	327,300	389,500
August,	163,400	171,400	231,900	360,700	316,400	397,800
September,	150,100	174,300	214,500	371,300	337,600	385,600
October,	143,400	176,900	314,800	368,500	316,200	378,300
November,	156,900	235,300	604,900	379,900	354,600	499,000
December,	205,400	246,000	502,100	399,700	478,700	607,400
Average for year,	229,100	240,800	345,500	409,100	385,600	495,500

Several special measurements have been made to ascertain the hourly flow of sewage, and continuous observations were made, by means of an automatic recording gauge, of the flow over a weir during several weeks in the spring of 1899. The results of these observations are given in the following table: —

Date — 1899.	Day of Week.	Total Flow in Twenty-four Hours (Gallons).	Maximum Rate (Gallons per Day).	Hour at which Maximum Flow occurred.	Minimum Rate (Gallons per Day.)	Hour at which Minimum Flow occurred.
March 22,	Wednesday,	700,000	852,000	9 A.M.	591,000	3-6 A.M.
23,	Thursday,	746,000	904,000	6 P.M.	575,000	3-5 A.M.
24,	Friday,	811,000	940,000	10 A.M.	670,000	3-6 A.M.
25,	Saturday,	805,000	930,000	9 A.M. 10 A.M. 12 M.	678,000	3-5 A.M.
April 7,	Friday,	564,000	707,000	11 A.M.	439,000	5 A.M.
8,	Saturday,	612,000	814,000	4 P.M.	458,000	1-3 A.M.
9,	Sunday,	563,000	663,000	11 A.M. 12 M.	504,000	4, 5 A.M.
10,	Monday,	643,000	810,000	11 A.M.	487,000	5 A.M.
11,	Tuesday,	593,000	741,000	9, 10 A.M.	470,000	3-6 A.M.
12,	Wednesday,	575,000	740,000	10 A.M.	450,000	4-6 A.M.
13,	Thursday,	550,000	696,000	10 A.M.	450,000	12 mid.
14,	Friday,	581,000	753,000	11 A.M.	438,000	3-6 A.M.
15,	Saturday,	549,000	714,000	10 A.M.	440,000	12 mid.
16,	Sunday,	447,000	554,000	12 M.	368,000	5, 6 A.M.
17,	Monday,	547,000	750,000	10 A.M.	408,000	4 A.M.
18,	Tuesday,	533,000	680,000	3 P.M.	404,000	3-6 A.M.
19,	Wednesday,	490,000	618,000	10 A.M.	394,000	4-6 A.M.
20,	Thursday,	507,000	652,000	10 A.M.	390,000	3-6 A.M.
21,	Friday,	507,000	632,000	9, 10 A.M.	365,000	6 A.M.
23,	Sunday,	415,000	490,000	4 P.M.	358,000	5, 6 A.M.
24,	Monday,	503,000	727,000	10 A.M.	340,000	4, 5 A.M.
25,	Tuesday,	496,000	640,000	10 A.M.	351,000	4, 5 A.M.
26,	Wednesday,	489,000	606,000	12 M. 1-3 P.M.	361,000	3-6 A.M.
27,	Thursday,	506,000	648,000	1 P.M.	350,000	4-6 A.M.
28,	Friday,	489,000	630,000	11 A.M.	348,000	4-6 A.M.
29,	Saturday,	478,000	621,000	11 A.M. 12 M.	340,000	4-5 A.M.
30,	Sunday,	407,000	502,000	12 M.	320,000	6 A.M.
May 1,	Monday,	478,000	–	9 A.M.	320,000	4-6 A.M.
2,	Tuesday,	482,000	675,000	11 A.M.	336,000	3 6 A.M.
3,	Wednesday,	463,000	620,000	12 M.	338,000	3 6 A.M.
4,	Thursday,	465,000	602,000	11 A.M.	331,000	4-6 A.M.
7,	Sunday,	387,000	485,000	11 A.M.	320,000	4-6 A.M.
8,	Monday,	443,000	–	–	303,000	4-6 A.M.
9,	Tuesday,	428,000	596,000	10 A.M.	310,000	2-5 A.M.
10,	Wednesday,	427,000	570,000	10 A.M.	285,000	4-5 A.M.
11,	Thursday,	417,000	570,000	3 P.M.	302,000	3-5 A.M.
12,	Friday,	426,000	570,000	11 A.M.	284,000	3-5 A.M.
13,	Saturday,	419,000	570,000	12 M.	280,000	5 A.M.
14,	Sunday,	356,000	495,000	10 A.M.	278,000	5, 6 A.M.
June 9,	Friday,	375,000	500,000	10 A.M.	240,000	4, 5 A.M.
10,	Saturday,	373,000	521,000	12 M.	235,000	4-6 A.M.
11,	Sunday,	305,000	394,000	11 A.M.	242,000	4-6 A.M.
12,	Monday,	372,000	540,000	11 A.M.	228,000	4, 5 A.M.
14,	Wednesday,	375,000	478,000	11 A.M.	246,000	12 mid.

The following table gives the average, maximum and minimum daily flow of sewage during the year 1898, and the flow per inhabitant, per connection with the sewer system and per mile of sewer constructed: —

	Average Flow (Gallons per Day).	Maximum Flow (Gallons per Day).	Minimum Flow (Gallons per Day).
Total,	495,500	1,020,500	340,500
Per inhabitant,	51	105	35
Per connection,	451	928	310
Per mile of sewer,	45,900	94,500	31,500

The Framingham sewage is very strong, being by far the strongest sewage that is purified on any filtration area in the State. The strength of the sewage is due in part to the fact that there is ordinarily very little leakage of ground water into the sewers.

There is a very small quantity of manufactural sewage entering the sewers, the principal sewage of that sort being the spent dyes discharged from the straw factories, which give a decided color to the sewage at times. Aside from the straw works, none of the factories produce any considerable quantity of waste liquors which it is necessary to discharge into the sewers.

The sewage from the main sewer, before entering the reservoir, is received in a gate-house, where it is passed through a screen constructed of wooden slats with an open space between the slats of one inch. The screen is cleaned twice weekly and a small amount of matter is removed, which is composted. From the screen the sewage passes into the covered masonry reservoir, which has a capacity of 431,000 gallons, in which the night flow of the sewage is stored, so that pumping is necessary only during the day. The pmups are ordinarily started at seven o'clock in the morning and operated until about five o'clock in the afternoon, so that sewage entering the reservoir after five o'clock in the afternoon remains there until it is pumped out some time during the next day. It is found that very little solid matter accumulates on the bottom of the reservoir. The reservoir has been cleaned occasionally by stirring up the solid matter which has accumulated and pumping it to the filter-beds with the sewage. The pumps which force the sewage to the filtration area have specially designed flap valves, each of which has an area of about 43 inches, so that any solid matter which passes through the screens can pass through the pumps.

The force main is a cast-iron pipe 12 inches in diameter and 9,740 feet long. This pipe is so laid that when pumping ceases the pipe remains full of sewage throughout nearly its entire length, although arrangements have been made so that the contents of the pipe can be drawn back into the reservoir by opening a gate. The pipe contains, when full, 57,200 gallons of sewage, and the sewage which is in the pipe at the time when pumping ceases remains there until the following morning, when it is discharged upon the filter-beds.

The filtration area is located about 2.5 miles north-east of the village of South Framingham, near the line between the towns of Natick and Framingham, in the water-shed of Bannister Brook, one of the tributaries of the Sudbury River, below the point where water is taken for the supply of the Metropolitan District. The area owned by the town comprises 100 acres and is naturally very nearly level.

On this area there have been prepared 18 filter-beds having an average area of about an acre; of these, all but one have been prepared for the reception of sewage by the removal of the loam from the surface. The surface of one of the beds has been left in its natural state, and is covered with soil, and the stumps of trees have not been removed. There are two lines of underdrains, each of which passes through the centre of three of the beds; the remaining beds are not underdrained.

The sewage is distributed on the beds through pipes from manholes at the corners of the beds. In some cases the pipe discharges into a channel which passes along the foot of the inside slope of the embankment by means of which the sewage is delivered at different points along the edges of the beds. In many of the beds, however, sewage is discharged only at the corners. None of the original soil beneath the surface loam was disturbed except where it was necessary in order to make the surface of the beds level, or in laying the very limited amount of underdrainage.

The character of the filtering material has been ascertained by analyses of samples of soil collected from near the middle of each of the filter-beds in 1898. The results show that the filtering material, especially near the surface, is quite fine, being much finer than the filtering material at Gardner. The fineness of the material is doubtless principally due to the fact that at this filtration area the subsoil was not removed when the beds were constructed. No analyses of the soil of the beds were made when they were first used so that it is at present impossible to tell whether the fineness of the soil has been increased by the method of operating the beds. The soil in the lower portion of the beds is coarser and more porous. The following table gives the averages of the results of the analyses of samples from all of the beds at different depths: * —

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* The size of each particle is considered to be the diameter of a sphere of equal volume. The "effective size" is such that 10 per cent. by weight of the material is composed of smaller grains than the size given. The "uniformity coefficient" is the ratio $\frac{A}{B}$, where the values of A and B are such that 60 per cent. of the material is finer than A and 10 per cent. finer than B.

Depth Beneath Surface (Feet).	Effective Size (Millimeter).			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Surface, . . .	.06	.32	0.03	13.9	26.3	5.9	64.4	119.1	33.4
0.25, ...	.06	.37	0.03	12.8	26.9	6.3	54.2	89.1	24.8
0.50, ...	.07	.39	0.03	13.1	25.7	5.4	45.2	80.4	21.1
1.00, ...	.12	.36	0.03	10.7	23.4	2.9	24.4	86.2	7.0
2.50, ...	.11	.21	0.03	8.0	22.4	2.0	10.0	20.7	2.2

The filter-beds at Framingham have a much larger area in proportion to the quantity of sewage flowing from the town than the filter-beds at Gardner, for example, but the Framingham beds are probably capable of purifying a much greater quantity of sewage than has thus far been discharged upon them.

It has been the custom in the operation of these filters to grow crops upon the beds, and in consequence of this the application of the sewage has been less regular than it would otherwise have been, and the quantity of sewage applied to certain of the beds has often been much smaller than the filters were capable of purifying, especially in seasons of high rainfall, when the crops might be injured by the application of too great a quantity of sewage.

In the spring the filters are ploughed and harrowed and all are planted with corn. During the summer the corn is hoed at frequent intervals, and in the fall, after the corn stalks have been cut, the stubble is left in the hills and the surfaces are not disturbed until spring. The ice which forms upon the beds in winter rests upon the tops of the corn hills, and protects the low places between the hills from freezing, so that no difficulty is experienced in disposing of the sewage even in the coldest weather. The sewage is applied to the beds generally in rotation, but in the summer, when the crops are growing, it is applied where it is most needed by the crops. In general, at other times, all of the sewage for one day is applied to two of the beds at times of high flow, and at times of low flow one bed generally receives the daily flow of sewage, and in some cases one bed has received the entire flow of sewage for two days in succession. All of the sewage has been purified upon the beds since the works were first put in operation, and it has never been necessary to discharge sewage in an unpurified state either at the pumping station or at the filtration area.

During the year 1898 a record has been kept of the applications of sewage to each bed, and by comparing this record with the record kept at the pumping station of the quantity of sewage pumped, an approximate estimate has been made of the quantity of sewage applied to each bed during the year. The following table shows the average daily quantity applied to each bed during the year 1898 and the quantity purified per acre: —

Number of Bed.	Area of Bed (Acres).	Average Quantity of Sewage applied during 1898.	
		Gallons per Day.	Gallons per Acre per Day.
1,	1.16	17,000	15,000
2,	1.30	16,000	12,000
3,	1.30	29,000	22,000
4,	1.30	39,000	30,000
5,	1.30	26,000	20,000
6,	1.13	43,000	38,000
7,	1.63	38,000	23,000
8,	1.15	58,000	50,000
9,	1.15	53,000	46,000
10,	1.15	30,000	26,000
11,	1.04	25,000	24,000
12,	1.01	28,000	28,000
13,	0.44	10,000	23,000
14,	0.70	12,000	17,000
15,	0.55	13,000	24,000
16,	0.64	11,000	17,000
17,	1.43	28,000	20,000
Stump bed,	1.52	24,000	16,000
Average,	1.11	28,000	25,000

Two series of analyses have been made of samples of sewage collected from the main sewer at frequent intervals for a period of twenty-four hours, to show the variation in the character of the sewage during the day. The results of these analyses are shown in the following table: —

Chemical Examinations of Sewage from Framingham.

[Parts per 100,000.]

Number.	Date.	Hour.	Temperature. Deg. F.	Residue on Evaporation. Total Residue. Total.	Total Residue. Dissolved.	Total Residue. Suspended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved.	Loss on Ignition. Suspended.
	1898.								
23466	June 8	5.00 and 6.00 P.M.	60	102.00	41.40	60.60	46.80	17.40	29.40
23467	June 8	7.00 and 8.00 P.M.	56	53.00	34.00	19.00	25.00	11.00	14.00
23468	June 8	9.00 and 10.00 P.M.	55	34.40	26.90	7.50	14.40	7.60	6.80
23469	June 8	11 00 and 12.00 P.M.	54	27.00	22.60	4.40	9.00	4.60	4.40
23470	June 9	1.00 and 2.00 A.M.	55	27.00	22.50	4.50	9.80	5.50	4.30
23471	June 9	4.30 A.M.	54	21.00	20.50	0.50	4.60	4.10	0.50
23472	June 9	5.00 and 6.00 A.M.	54	21.00	19.90	1.10	5.10	4.70	0.40
23476	June 9	7.00 and 8.00 A.M.	55	27.80	21.60	6.20	8.60	4.30	4.30
23477	June 9	9.00 and 10.00 A.M.	56	79.40	35.10	44.30	48.40	10.10	38.30
23478	June 9	11.00 and 12.00 A.M.	58	62.40	34.30	28.10	31.60	11.80	19.80
23479	June 9	1.00 and 2.00 P.M.	57	67.00	36.70	30.30	39.20	11.10	28.10
23480	June 9	3.00 and 3.45 P.M.	57	68.00	36.30	31.70	39.80	11.40	28.40
24255	Aug. 10	5.00 and 6.00 P.M.	-	55.40	37.00	18.40	28.20	12.20	16.00
24256	Aug. 10	7.00 and 8.00 P.M.	65	60.20	39.40	20.80	29.40	9.20	20.20
24257	Aug. 10	9.00 and 10.00 P.M.	65	43.80	25.40	18.40	20.80	5.60	15.20
24258	Aug. 10	11.00 and 12.00 P.M.	65	30.40	26.20	4.20	8.20	4.80	3.40
24259	Aug. 11	1.00 and 2.00 A.M.	65	25.00	24.20	0.80	5.00	4.20	0.80
24260	Aug. 11	3.00 and 4.00 A.M.	65	26.80	25.60	1.20	7.00	6.20	0.80
24261	Aug. 11	5.00 and 6.00 A.M.	64	51.80	46.80	5.00	9.00	7.80	1.20
24262	Aug. 11	7.00 and 8.00 A.M	67	64.20	49.60	14.60	19.00	9.80	9.20
24263	Aug. 11	9.00 and 10.00 A.M.	68	70.40	49.60	20.80	30.40	13.40	17.00
24279	Aug. 11	11.00 and 12.00 A.M.	67	55.00	41.00	14.00	19.80	8.60	11.20
24280	Aug. 11	1.00 and 2.00 P.M.	67	87.00	49.80	37.20	40.60	9.40	31.20
24281	Aug. 11	3.00 and 4.00 P.M.	67	69.60	45.80	23.80	29.00	9.40	19.60

Chemical Examinations of Sewage from Framingham — Concluded.

[Parts per 100,000.]

Number.	Ammonia. Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed. Unfiltered.	Oxygen Consumed. Filtered.
23466	2.7500	1.3000	.7500	.5500	6.08	.0100	.0000	6.76	3.60
23467	4.4500	0.5700	.3700	.2000	7.21	.0010	.0000	4.40	2.34
23468	2.3500	0.4600	.2200	.2400	6.12	.0000	.0000	2.82	1.54
23469	1.6000	0.2400	.1600	.0800	5.32	.0010	.0001	1.60	1.07
23470	0.8800	0.2640	.1400	.1240	4.69	.0000	.0000	1.41	0.93
23471	0.5600	0.1000	.0440	.0560	4.28	.1400	.0160	0.61	0.35
23472	0.4200	0.0920	.0440	.0480	4.17	.1850	.0120	0.45	0.35
23476	2.0500	0.5100	.2700	.2400	4.55	.0090	.0000	2.11	1.38
23477	3.3500	0.8400	.4500	.3900	5.59	.0030	.0000	5.92	3.02
23478	4.0500	0.8200	.3700	.4500	7.02	.0030	.0000	5.47	3.39
23479	3.7500	0.7900	.4700	.3200	7.72	.0060	.0000	4.70	2.78
23480	2.8500	1.1600	.5800	.5800	7.32	.0100	.0008	5.15	3.12
24255	3.2500	0.6000	.3600	.2400	7.15	.0000	.0000	4.16	2.40
24256	3.3000	0.6300	.4300	.2000	8.10	.0100	.0000	4.40	2.62
24257	1.5000	0.5200	.1800	.3400	5.95	.0020	.0000	3.04	1.54
24258	1.7500	0.2300	.1500	.0800	7.30	.0000	.0000	1.82	1.06
24259	0.5700	0.1400	.0600	.0800	5.69	.0160	.0360	0.74	0.54
24260	0.3000	0.1100	.0450	.0650	5.42	.0510	.0360	0.69	0.43
24261	0.5100	0.1800	.0650	.1150	14.94	.0200	.0550	1.15	0.61
24262	2.7500	0.6500	.2800	.3700	14.62	.0000	.0000	3.71	1.66
24263	4.2000	0.9400	.3900	.5500	11.75	.0000	.0001	6.32	2.50
24279	3.2500	0.6700	.3800	.2900	9.83	.0000	.0000	4.32	2.18
24280	3.0000	0.7900	.4200	.3700	9.50	.0000	.0000	5.92	3.20
24281	2.5500	0.9000	.6300	.2700	11.65	.0000	.0000	8.40	3.04

The samples were collected from the main sewer at its entrance to the reservoir near the pumping station. Each sample was composed of 2 equal portions.

As before stated, the night flow of sewage is stored in the reservoir at the pumping station and pumped only during the daytime. When the pumps are stopped a large quantity of sewage remains in the force main until the pumps are started, so that some of the sewage is quite stale by the time it reaches the filtration area. In order to ascertain the changes which occur in the character of the

Chemical Examination of Sewage from

[Parts per 100,000.]

	Number.	Date.	Hour.	Rate of Flow. — Gallons per 24 Hours.	Temperature. — Deg. F.	Residue on Evaporation.					
						Total Residue.			Loss on Ignition.		
						Total.	Dissolved	Suspended.	Total.	Dissolved.	Suspended.
		1899.									
1	26760	Apr. 14	6.00 to 11.30 P.M.	-	47.4	48.00	40.50	7.50	19.90	14.30	5.60
2	26761	Apr. 15	12.00 to 5.30 A.M.	-	45.5	27.00	25.50	1.50	10.70	9.50	1.20
3	26771	Apr. 15	6.00 to 11.30 A.M.	-	46.6	27.50	24.70	2.80	10.80	10.60	0.20
4	26779	Apr. 15	12.00 to 5.30 P.M.	-	49.7	65.80	54.80	11.00	38.00	31.80	6.20
5	26787	Apr. 15	6.00 to 11.30 P.M.	-	48.4	50.00	43.20	6.80	22.00	18.00	4.00
6	26788	Apr. 16	12.00 to 5.30 A.M.	-	48.0	27.60	27.50	0.10	10.80	10.70	0.10
7	26793	Apr. 16	6.00 to 11.30 A.M.	499,000	47.9	20.00	19.30	0.70	7.00	6.80	0.20
8	26807	Apr. 16	12.00 to 5.30 P.M.	451,200	47.2	33.50	28.50	5.00	13.00	9.00	4.00
9	26811	Apr. 16	6.00 to 11.30 P.M.	419,500	46.6	28.50	24.00	4.50	10.00	7.50	2.50
10	26812	Apr. 17	12.00 to 5.30 A.M.	384,800	44.7	21.50	20.50	1.00	6.00	5.80	0.20
11	26818	Apr. 17	6.00 to 11.30 A.M.	588,400	47.3	36.20	33.00	3.20	16.70	14.00	2.70
12	26851	Apr. 17	12.00 to 5.30 P.M.	593,800	46.3	51.10	43.00	8.10	23.20	16.70	6.50
13	26853	Apr. 17	8.00 to 1.30 A.M.	438,500	48.3	33.30	28.70	4.60	12.00	8.50	3.50
14	26854	Apr. 18	2.00 to 7.00 A.M.	395,000	46.3	18.40	18.20	0.20	5.70	5.50	0.20

The samples were collected at the lower end of the main sewer as it discharges into the reservoir. sample was made up of 11 equal portions.

Chemical Examination of Sewage from

[Parts per 100,000.]

	Number.	Date.	Hour.	Rate of Flow. — Gallons per 24 Hours.	Temperature. — Deg. F.	Residue on Evaporation.					
						Total Residue.			Loss on Ignition.		
						Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
		1898.									
1	26769	Apr. 15	7.30 to 10.00 A.M.	-	48.2	35.40	32.20	3.20	15.00	13.00	2.00
2	26777	Apr. 15	10.30 to 1.00 P.M.	-	47.7	34.10	31.50	2.60	14.50	14.00	0.50
3	26778	Apr. 15	1.30 to 3.30 P.M.	-	49.4	678.00	43.20	634.80	552.40	23.00	529.40
4	26791	Apr. 16	7.30 to 10.00 A.M.	1,978,600	48.4	43.60	32.90	10.70	21.00	13.70	7.30
5	26792	Apr. 16	10.30 to 1.00 P.M.	1,229,500	47.7	29.20	26.20	3.00	13.00	11.70	1.30
6	26805	Apr. 16	2.00 to 4.30 P.M.	570,000	47.1	45.80	33.00	12.80	23.00	13.50	9.50
7	26819	Apr. 17	7.30 to 10.00 A.M.	1,572,600	48.1	28.00	25.90	2.10	12.70	12.40	0.30
8	26835	Apr. 17	10.30 to 2.00 P.M.	1,833,400	48.1	41.80	35.70	6.10	15.50	12.70	2.80
9	26836	Apr. 17	2.00 to 4.30 P.M.	981,245	49.1	57.10	44.50	12.60	28.10	18.00	10.10

The samples were collected from a tap in the sewage pump while pumping sewage from the ressewage between the time it reaches the pumping station and the time that it is distributed on the filters, a series of analyses was made in the spring of 1899, the results of which are shown in the tables which follow. Several samples of effluent were also collected in the course of a single day, the results of which are also appended.

the Main Sewer at Framingham.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
	Albuminoid.								
Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.	
1.6400	0.4600	.3760	.0840	5.58	.1220	.0160	5.60	4.16	1
0.8880	0.2480	.1920	.0560	4.29	.1280	.0160	2.64	2.08	2
1.0960	0.2760	.2280	.0480	3.40	.0940	.0140	3.44	2.21	3
2.2900	1.0400	.6600	.3800	6.06	.0120	.0320	9.28	6.40	4
1.5500	0.5700	.4700	.1000	5.75	.1180	.0180	7.52	5.76	5
1.4500	0.3200	.2200	.1000	4.95	.2500	.0200	2.96	2.46	6
0.4560	0.0920	.0740	.0180	3.03	.3750	.0280	0.70	0.62	7
2.3500	0.4700	.3600	.1100	6.33	.1300	.0200	5.60	4.19	8
1.8200	0.4100	.2600	.1500	4.70	.0660	.0180	3.71	3.10	9
1.1800	0.1880	.1560	.0320	3.81	.2000	.0160	2.34	1.79	10
1.3000	0.4100	.3000	.1100	4.58	.0600	.0300	4.56	3.55	11
2.4800	0.6000	.5000	.1000	7.92	.0150	.0180	9.12	7.36	12
1.4500	0.4000	.3280	.0720	4.75	.0920	.0160	5.52	3.97	13
0.7500	0.2300	.1200	.1100	3.25	.1760	.0180	1.76	1.25	14

Each sample, except the last, was made up of 12 equal portions collected every half hour. The last

the Pumping Station at Framingham.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
	Albuminoid.								
Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.	
1.2400	0.2640	.2080	0.0560	4.59	.0580	.0180	4.64	3.14	1
1.5400	0.4250	.3750	0.0500	4.38	.0180	.0200	4.00	2.02	2
3.8000	9.8000	.6800	9.1200	5.47	.0000	.0300	75.20	4.16	3
1.7400	0.4900	.3400	0.1500	4.95	.1100	.0240	5.60	3.68	4
1.3000	0.2900	.2300	0.0600	4.14	.0980	.0280	3.28	2.14	5
2.6000	0.6600	.3880	0.2720	7.02	.1200	.0240	6.80	4.38	6
1.3900	0.3500	.1840	0.1660	4.25	.1900	.0240	3.28	2.43	7
1.6800	0.4900	.3700	0.1200	6.05	.0250	.0200	6.16	4.58	8
2.2300	0.7800	.5200	0.2600	7.10	.0250	.0200	9.44	6.34	9

ervoir to the filtration area. Each sample was made up of equal portions collected each half hour.

Chemical Examination of Sewage from

[Parts per 100,000.]

	Number.	Date.	Hour.	Rate of Flow. — Gallons per 24 Hours.	Temperature. — Deg. F.	Residue on Evaporation. Total Residue. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Suspended.
		1899.									
1	26767	Apr. 15	7.35 to 7.55 A.M.	-	44.7	42.30	34.20	8.10	20.30	13.20	7.10
2	26768	Apr. 15	8.05 to 8.25 A.M.	-	45.3	43.70	35.00	8.70	19.70	14.70	5.00
3	26770	Apr. 15	8.30 to 11.00 A.M.	-	46.7	34.00	30.00	4.00	13.20	10.50	2.70
4	26780	Apr. 15	11.30 to 2.00 P.M.	-	46.8	33.30	31.10	2.20	14.30	13.00	1.30
5	26781	Apr. 15	2.30 to 4.00 P.M.	-	47.6	65.30	40.50	24.80	38.30	19.00	19.30
6	26795	Apr. 16	7.40 to 8.00 A.M.	1,857,400	45.0	143.40	35.10	108.30	117.00	15.60	101.40
7	26794	Apr. 16	8.10 to 8.30 A.M.	2,069,100	46.2	717.60	40.40	677.20	573.20	20.80	552.40
8	26796	Apr. 16	8.30 to 11.00 A.M.	2,007,200	47.3	39.00	31.50	7.50	17.60	12.50	5.10
9	26797	Apr. 16	11.30 to 2.00 P.M.	815,760	46.7	27.40	24.40	3.00	10.40	7.70	2.70
10	26806	Apr. 16	2.30 to 4.30 P.M.	518,000	45.8	26.50	25.00	1.50	8.00	7.40	0.60
11	26815	Apr. 17	7.35 to 7.55 A.M.	1,003,900	44.0	38.90	35.50	3.40	17.90	15.50	2.40
12	26816	Apr. 17	8.05 to 8.25 A.M.	1,497,600	44.7	149.10	30.80	118.30	105.60	11.50	94.10
13	26817	Apr. 17	8.30 to 11.00 A.M.	1,626,600	45.5	35.30	24.00	11.30	17.00	9.50	7.50
14	26837	Apr. 17	11.30 to 2.00 P.M.	1,682,400	46.1	34.50	28.50	6.00	13.60	8.00	5.60
15	26838	Apr. 17	2.30 to 4.30 P.M.	989,800	46.6	50.10	40.00	10.10	19.00	12.00	7.00
16	26859	Apr. 18	7.30 to 8.20 A.M.	2,089,300	45.4	81.60	48.00	33.60	47.00	18.00	29.00
17	26860	Apr. 18	8.30 to 10.30 A.M.	1,643,000	47.1	31.00	26.20	4.80	10.30	6.40	3.90

The samples were collected from a manhole at the end of the force main as the sewage was dis-
vals; the first samples each day represent sewage which has remained in the force main for about

Chemical Examination of Effluent from the West

[Parts per 100,000.]

	Number.	Date of Collection.	Hour.	Appearance. Turbidity.	Sediment.	Color.	Odor. Cold.	Hot.
		1899.						
1	26822	April 17	8.05 A.M.	Slight.	Cons.	.08	V. faintly musty.	Distinctly musty and disagreeable.
2	26820	April 17	9.03 A.M.	None.	V. slight.	.05*	V. faintly musty.	Distinctly musty and disagreeable.
3	26821	April 17	10.03 A.M.	None.	V. slight.	.06	Faintly musty.	Distinctly musty and disagreeable.
4	26823	April 17	12.00 M.	None.	V. slight.	.06	V. faintly musty.	Distinctly musty and disagreeable.
5	26839	April 17	3.13 P.M.	V. slight.	Slight.	.07	V. faintly musty.	Distinctly musty and disagreeable.
6	26840	April 17	5.05 P.M.	V. slight.	Slight.	.06*	V. faintly musty.	Distinctly musty and disagreeable.

The samples were collected from the underdrain at its

* Turbid.

the Filtration Area at Framingham.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
Free.	Albuminoid				Nitrates.	Nitrites.	Unfiltered.	Filtered.	
	Total.	Dis-solved.	Sus-pended.						
2.6360	0.6480	.3800	0.2680	5.67	.0280	.0130	4.88	3.52	1
2.5480	0.5640	.3640	0.2000	5.30	.0080	.0160	5.52	3.68	2
1.4160	0.2640	.2080	0.0560	4.69	.0500	.0240	4.72	2.50	3
1.6300	0.4900	.4200	0.0700	4.44	.0100	.0220	4.00	2.98	4
2.2400	1.0300	.5100	0.5200	5.38	.0030	.0320	8.80	5.12	5
3.0000	1.8500	.5400	1.3100	5.10	.0070	.0000	10.56	3.62	6
4.4000	12.3000	.7600	11.5400	5.19	.0000	.0000	86.40	3.65	7
1.5500	0.4750	.2950	0.1800	4.90	.0900	.0280	3.92	2.94	8
1.0700	0.3000	.2100	0.0900	3.99	.1060	.0300	2.08	1.76	9
2.0000	0.3800	.2520	0.1280	4.41	.1200	.0340	2.88	2.11	10
3.4400	0.5100	.3320	0.1780	5.60	.0050	.0120	5.52	3.42	11
3.8000	2.7000	.3700	2.3300	8.39	.0050	.0080	21.20	3.76	12
1.5000	0.5300	.1760	0.3540	4.37	.1200	.0340	4.08	2.18	13
1.8100	0.5600	.3100	0.2500	5.30	.1000	.0240	4.40	3.55	14
2.1750	0.5750	.4700	0.1050	6.97	.0150	.0240	6.88	5.70	15
3.0800	0.9000	.5500	0.3500	8.20	.0000	.0000	9.28	7.12	16
1.4700	0.4300	.3500	0.0800	4.60	.0640	.0160	4.00	3.04	17

charged upon the filter-beds. The samples were made up of equal portions collected at frequent inter-
fourteen hours.

Underdrain at the Framingham Filter-beds.

[Parts per 100,000.]

Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.	
Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.				
			Total.	Dis-solved.	Sus-pended.							
22.50	-	.1200	.0150	-	-	3.83	.6400	.0004	.32	4.9	.0500	1
19.70	-	.1200	.0140	-	-	3.79	.8800	.0007	.26	5.0	.0070	2
18.80	-	.1240	.0130	-	-	3.80	.7000	.0007	.26	4.9	.0080	3
19.50	-	.1200	.0175	-	-	3.83	.5900	.0006	.26	5.0	.0080	4
19.50	-	.1200	.0148	-	-	3.83	.6900	.0006	.28	4.7	.0080	5
19.50	-	.1120	.0132	-	-	3.80	.5250	.0007	.29	4.6	.0070	6

outlet while sewage was being applied to the beds.

The temperature of the sewage when it reaches the filtration area, as observed by the superintendent of sewers, is shown in the following table: —

Average Monthly Temperature of Sewage Delivered at Framingham Filter-beds during the Year 1898.

Month.	Temperature. — Degrees F.	Month.	Temperature. — Degrees F.
January,	52	July,	57
February,	52	August,	57
March,	52	September,	58
April,	52	October,	56
May,	52	November,	53
June,	53	December,	50

The temperature of the sewage is doubtless largely influenced by the temperature of the public water supply, which is drawn from the ground, and during the winter months the sewage is delivered at the beds at a higher temperature than the sewage at most of the other filtration areas of the State.

Frequent analyses of samples of sewage collected from the end of the force main, as the sewage flowed out upon the beds, and of the effluent from each of the underdrains, have been made since 1893, the average results of which are given in the tables which follow. Analyses have also been made of samples collected from a spring situated near the filtration area, the water of which is used for drinking purposes by those employed at the filtration area. The analyses indicate that the water of the spring contains a large proportion of purified sewage.

Yearly Averages of Chemical Examinations of Sewage from Framingham.

[Parts per 100,000.]

Year.	Residue on Evaporation. Total Residue. Total.	Dis-solved.	Sus-pended.	Loss on Ignition. Total.	Dis-solved	Sus-pended.	Ammonia. Free.	Albuminoid. Total.	Dis-solved.	Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed. Unfiltered.	Filtered.
1893	57.90	33.80	24.09	30.37	10.95	19.43	2.0283	0.4006	0.2152	0.1854	5.22	.0135	.0115	–	–
1894	57.70	33.78	23.92	31.17	10.83	20.34	2.4380	0.5135	0.2508	0.2627	5.86	.0006	.0042	4.06	2.57
1895	75.95	29.54	46.41	48.92	9.44	39.48	2.7173	0.6986	0.2166	0.4820	5.48	.0021	.0094	5.91	2.24
1896	246.26	37.63	208.63	199.82	13.08	186.74	2.8607	2.7272	0.3438	2.3834	7.23	.0023	.0003	15.92	2.95
1897	399.57	56.88	342.69	341.08	22.70	318.38	3.1400	2.8810	0.4202	2.4608	11.56	.0019	.0010	23.23	3.51
1898	216.00	43.32	172.68	156.69	14.86	141.83	3.1012	3.1450	0.6117	2.5333	8.45	.0082	.0020	25.29	4.17

The sewage was collected as it flowed out upon the beds.

Yearly Averages of Chemical Examinations of Effluent from the East Underdrain of the Framingham Filter-beds.

[Parts per 100,000.]

Year.	Residue on Evaporation. Total Residue. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Suspended.	Ammonia. Free.	Albuminoid. Total.	Dissolved.	Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed. Unfiltered.	Filtered.
1893	24.70	–	–	–	–	–	.1786	.0095	–	–	3.85	1.2202	.0074	–	–
1894	25.84	–	–	–	–	–	.0467	.0089	–	–	4.37	1.0754	.0032	.12	–
1895	29.15	–	–	–	–	–	.2563	.0085	–	–	4.78	1.2235	.0057	.16	–
1896	26.47	–	–	–	–	–	.2067	.0109	–	–	5.24	0.7683	.0029	.15	–
1897	35.01	–	–	–	–	–	.1426	.0125	–	–	8.34	0.9862	.0044	.15	–
1898	32.87	–	–	–	–	–	.6386	.0176	–	–	6.74	1.0533	.0035	.18	–

The samples were collected from the underdrain at its outlet.

Yearly Averages of Chemical Examinations of Effluent from the West Underdrain of the Framingham Filter-beds.

[Parts per 100,000.]

Year.	Residue on Evaporation. Total Residue. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Suspended.	Ammonia. Free.	Albuminoid. Total.	Dissolved.	Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed. Unfiltered.	Filtered.
1893	23.55	–	–	–	–	–	.1071	.0080	–	–	3.64	1.0360	.0045	–	–
1894	27.00	–	–	–	–	–	.0812	.0070	–	–	4.17	1.1959	.0019	.12	–
1895	25.24	–	–	–	–	–	.2145	.0084	–	–	4.47	0.9098	.0048	.19	–
1896	25.89	–	–	–	–	–	.0658	.0106	–	–	4.74	0.7412	.0030	.16	–
1897	28.87	–	–	–	–	–	.1241	.0179	–	–	6.39	0.7115	.0027	.23	–
1898	26.63	–	–	–	–	–	.3276	.0162	–	–	5.80	0.7625	.0026	.24	–

The samples were collected from the underdrain at its outlet.

Yearly Averages of Chemical Examinations of Water from a Spring near Bannister Brook which receives Effluent from the Framingham Filter-beds.

[Parts per 100,000.]

Year.	Residue on Evaporation. Total Residue. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Suspended.	Ammonia. Free.	Albuminoid. Total.	Dissolved.	Suspended	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed. Unfiltered.	Filtered.
1893	13.45	–	–	–	–	–	.0001	.0014	–	–	2.76	.5095	.0000	–	–
1894	18.37	–	–	–	–	–	.0004	.0023	–	–	3.13	.8319	.0000	.02	–
1895	18.71	–	–	–	–	–	.0001	.0018	–	–	3.31	.7856	.0000	.03	–
1896	19.02	–	–	–	–	–	.0003	.0030	–	–	3.43	.6415	.0000	.04	–
1897	19.70	–	–	–	–	–	.0006	.0029	–	–	3.78	.5671	.0001	.02	–
1898	20.37	–	–	–	–	–	.0010	.0092	–	–	4.16	.5862	.0000	.06	–

The following table gives the results accomplished by the filters in the purification of the sewage since 1892, as indicated by the free ammonia, albuminoid ammonia and oxygen consumed in the sewage and effluent. As there is some ground water mixed with the effluent, the results indicate only approximately the purification effected in passing through the filters. An interesting fact in regard to the purification effected is that the sewage is often very highly colored, owing to large quantities of dyes which are discharged into the sewers from the straw factories, while the effluent has never had any traces of this color.

Table showing the Amount of Free and Albuminoid Ammonia and Oxygen Consumed in the Framingham Sewage and in the Effluent from the East Underdrain, together with the Percentage removed from the Sewage by Filtration.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. removed.	Sewage.	Effluent.	Per Cent. removed.	Sewage.	Effluent.	Per Cent. removed.
1893, . . .	2.0283	.1786	91.1	0.4006	.0095	97.6	-	-	-
1894, . . .	2.4380	.0467	98.1	0.5135	.0089	98.3	4.06	.12	97.0
1895, . . .	2.7173	.2563	90.6	0.6986	.0085	98.8	5.91	.16	97.3
1896, . . .	2.8607	.2067	92.8	2.7272	.0109	99.6	15.92	.15	99.1
1897, . . .	3.1400	.1426	95.5	2.8810	.0125	99.6	23.23	.15	99.4
1898, . . .	3.1012	.6386	79.4	3.1450	.0176	99.4	25.29	.18	99.3

Table showing the Amount of Free and Albuminoid Ammonia and Oxygen Consumed in the Framingham Sewage and in the Effluent from the West Underdrain, together with the Percentage removed from the Sewage by Filtration.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. removed.	Sewage.	Effluent.	Per Cent. removed.	Sewage.	Effluent.	Per Cent. removed.
1893, . . .	2.0283	.1071	94.7	0.4006	.0080	98.0	-	-	-
1894, . . .	2.4380	.0812	96.7	0.5135	.0070	98.6	4.06	.12	97.1
1895, . . .	2.7173	.2145	92.2	0.6986	.0084	98.8	5.91	.19	96.8
1896, . . .	2.8607	.0658	97.7	2.7272	.0106	99.6	15.92	.16	99.0
1897, . . .	3.1400	.1241	96.0	2.8810	.0179	99.4	23.23	.23	99.0
1898, . . .	3.1012	.3276	89.5	3.1450	.0162	99.5	25.29	.24	99.1

The effluent is discharged into Bannister Brook, which has a water-shed of 2.05 square miles. There is no population on the banks of the brook for some distance below the point where the sewage is discharged. Analyses of samples of water collected in the summer months from the brook above and below the point where it receives the effluent are given in subsequent tables. There is no population within 1,000 feet of the filtration area. Two streets pass by the filter-beds, but there appears to be no complaint of odors arising from the beds.

Yearly Averages of Chemical Examinations of Water from Bannister Brook above and below the Framingham Filter-beds.

Brook above Filter-beds.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
					Total.	Dissolved.	Sus-pended.					
1898,	0.51	14.47	4.22	.0351	.0251	.0231	.0020	2.65	.1213	.0077	.72	3.9

Brook below Filter-beds.

1893,	1.15	7.37	2.67	.0026	.0259	.0207	.0052	0.96	.0505	.0003	0.96	2.5
1895,	1.31	10.07	3.82	.0060	.0380	.0337	.0043	1.53	.0602	.0009	1.33	2.8
1896,	0.17	21.22	6.25	.0073	.0143	.0081	.0062	3.67	.4700	.0020	0.26	4.4
1897,	0.13	21.32	7.10	.0161	.0127	.0085	.0042	4.43	.2483	.0028	0.23	6.0
1898,	0.48	16.97	5.58	.0980	.0336	.0226	.0110	3.28	.2737	.0170	0.69	4.1

The samples from the brook above the filter-beds were collected from the stream below the point where the effluent from the Natick filter-beds enters the stream and above the point where the effluent from the Framingham filter-beds enters the stream.

Reference has already been made to the system of underdrainage beneath the sewers in Framingham. Samples of water from the main underdrain have been analyzed each month for a number of years, the yearly averages of the results of which are given in the following table. During the year 1898 analyses were also made of the effluent from the filter-bed on which the underdrain water is discharged. It will be observed that the character of the water flowing in the underdrains has improved since the sewer system was first constructed. This is probably due in a large measure to the fact that much of the sewage which was discharged into the ground before the sewer system was constructed is now carried away in the sewers, thus reducing the amount of pollution of the ground water.

Yearly Averages of Chemical Examinations of Water from the Underdrain beneath the Sewers at Framingham.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Sus-pended.						
1890, ...	.01	19.71	-	.0823	.0073	-	-	3.51	.5336	.0026	-	8.4	-
1891, ...	.01	20.44	-	.1029	.0045	-	-	3.51	.5333	.0019	-	8.0	-
1892, ...	.01	19.32	-	.0805	.0042	-	-	3.99	.6667	.0018	-	8.0	-
1893, ...	.02	20.75	-	.0829	.0039	-	-	3.84	.6282	.0014	.06	7.4	-
1894, ...	.00	22.24	-	.0620	.0033	-	-	3.61	.5315	.0028	.08	7.1	-
1895, ...	.03	20.92	-	.0502	.0086	-	-	2.29	.4995	.0023	.09	7.7	.0366
1896, ...	.09	19.99	-	.0462	.0200	-	-	2.07	.3575	.0048	.17	7.2	.0419
1897, ...	.16	16.72	-	.0218	.0101	-	-	1.75	.3169	.0012	.17	6.7	.0132
1898, ...	.08	19.72	-	.0640	.0141	-	-	2.14	.4479	.0020	.12	7.7	.0164

Average of Chemical Analyses of Effluent from the Filter-bed which receives Water from the Underdrain beneath the Sewers at Framingham.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dissolved.	Sus-pended.						
1898, ...	.83	21.62	-	.0065	.0298	-	-	1.13	.1692	.0003	1.14	4.2	.0178

Gardner.

Estimated population in 1898, 9,637.

The town is situated within the water-sheds of the Miller's and the North Branch of the Nashua rivers, the larger portion of the area being within the water-shed of the former stream. The principal part of the population of the town is in several villages which are not widely separated, so that it is practicable to collect the sewage of nearly all the thickly settled portion of the town and convey it to the filtration area by gravity. The topography of the town is uneven and some of the slopes are very steep. There are several large factories in the town, but none of them discharges any considerable quantity of manufacturing sewage into the sewers, the principal industry being the manufacture of chairs and other wooden goods.

A water supply was introduced in the town in 1882, and the average consumption of water per day during 1898 was 729,000 gallons, or 76 gallons per capita.

The sewer system and disposal works were constructed in 1891. The sewers were designed to receive house sewage only, although a few roofs have been connected with the sewers at the ends of branch lines. The sewers are constructed of earthen pipe, excepting a small portion of the main sewer at its lower end, which is constructed of iron pipe, and the largest sewer is 12 inches in diameter. Much water was encountered in the ground when the sewers were constructed, and especial care was taken to prevent the entrance of ground water through the joints of the pipes, but no underdrains were provided beneath the sewers for the removal of ground water.

At the end of 1898 the total length of sewers was 10.02 miles, and there were 363 connections, which can be roughly classified as follows: —

Dwelling-houses,	298
Business blocks,	42
Factories,	11
School-houses,	6
Hotels,	4
Churches,	2
Total connections,	363

The quantity of sewage varies greatly from time to time. No records of the quantity have been kept by the town, but several measurements have been made by the State Board of Health to determine the quantity flowing at different times and under varying conditions of weather and height of water in the ground. The results of these measurements are given in the following table: —

Twenty-four Hours beginning —			Temperature.	Total Flow in Twenty-four Hours (Gallons).	Maximum Rate (Gallons per Twenty-four Hours).	Hour at which Maximum Flow Occurred.	Minimum Rate (Gallons per Twenty-four Hours).	Hour at which Minimum Flow Occurred.
Date.	Hour.	Day of Week.	Deg F.					
1898.								
May 11, . .	10 A.M.	Wednesday, .	46.5	382,800	471,900	3 P.M.	300,400	4 A.M.
May 31, . .	11 A.M.	Tuesday, .	51.4	389,700	486,000	3 P.M.	304,700	4 A.M.
July 19, . .	9 A.M.	Tuesday, .	63.0	206,500	267,800	2 P.M.	144,000	4 A.M.
July 20, . .	9 A.M.	Wednesday, .	63.7	205,200	266,200	9 A.M.	150,700	4 A.M.
July 21, . .	9 A.M.	Thursday, .	64.3	217,700	279,300	3 P.M.	154,600	3 A.M.
July 22, . .	9 A.M.	Friday, . .	63.6	209,100	282,500	9 A.M.	146,600	3 A.M.
July 23, . .	9 A.M.	Saturday, .	63.3	193,000	264,700	9 A.M.	130,100	5 A.M.
July 24, . .	9 A.M.	Sunday, .	63.1	185,300	274,300	8 A.M.	126,600	4 A.M.
July 25, . .	9 A.M.	Monday, .	64.1	204,900	272,600	9 A.M.	130,000	4 A.M.
1899.								
Jan. 31, . .	9 A.M.	Tuesday, .	41.6	338,500	423,400	12 M.	258,600	5 A.M.
Feb. 1, . .	9 A.M.	Wednesday, .	41.5	332,700	440,400	3 P.M.	238,300	4 A.M.
Feb. 2, . .	9 A.M.	Thursday, .	41.3	304,200	433,400	2 P.M.	209,200	3 A.M.
April 17, . .	10 A.M.	Monday, .	40.1	740,500	866,000	1 P.M.	640,500	5 A.M.
April 18, . .	10 A.M.	Tuesday, .	40.2	652,700	770,500	2 P.M.	535,500	2 A.M.
April 19, . .	10 A.M.	Wednesday, .	39.9	588,500	650,000	12 M.	517,500	4 A.M.

From these measurements and from other observations of the flow, it seems probable that the average quantity of sewage flowing during the year is about 350,000 gallons per day. From the above table it will be seen that the maximum daily flow during any day when measurements were made was 740,500 gallons, on Monday, April 17, 1899, and that the minimum daily flow was 185,300 gallons, on Sunday, July 24, 1898. The measurements were not made when the flow was abnormal, but can be said to fairly represent the flow at times of ordinary wet weather and in dry weather. The maximum flow was about four times the minimum flow, and a little less than twice the average flow. The following table gives the maximum, minimum and average daily flow per inhabitant, per mile of sewer and per connection, computed from the information that has been obtained : —

	Gallons per Day.		
	Maximum.	Minimum.	Average.
Amount of sewage per inhabitant, ...	77	19	36
Amount of sewage per connection, ...	2,040	510	964
Amount of sewage per mile of sewer, . . .	73,900	18,490	34,930

The character of the sewage flowing in different parts of a single day varies almost directly with the quantity flowing in the sewers, the stronger sewage being found at time of highest flow and the weaker at time of lowest flow. The character of the sewage also varies with different seasons of the year, and in this case the sewage taken as a whole is weaker at times of highest flow and stronger at times when the flow of sewage is smaller.

The following tables give the results of analyses of samples of sewage collected at times when the measurements of flow were being made : —

Chemical Examination of Samples

[Parts per 100,000.]

	Number.	Date.	Hour.	Rate of Flow. — Gallons per 24 Hours.	Temperature. — Deg. F.	Residue on Evaporation. Total Residue. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Suspended.
		1898.									
1	23355	May 31	11.25 A.M. and 12.12 P.M.	478,500	52.0	79.00	26.50	52.50	55.40	10.00	45.40
2	23356	May 31	1.11 and 2.18 P.M.	474,400	52.0	36.00	24.80	11.20	20.00	10.20	9.80
3	23357	May 31	3.07 and 4.10 P.M.	474,600	52.5	35.00	20.60	15.00	21.00	8.00	13.00
4	23358	May 31	5.08 and 6.09 P.M.	424,400	52.2	24.80	16.20	8.60	11.80	5.20	6.60
5	23359	May 31	7.10 and 8.08 P.M.	391,400	52.5	23.60	18.90	4.70	10.00	6.00	4.00
6	23360	May 31	9.12 and 10.13 P.M.	361,600	51.3	21.40	15.90	5.50	9.20	4.80	4.40
7	23361	May 31	11.15 P.M. and 12.18 A.M.*	335,700	51.0	15.60	13.50	2.10	5.00	3.50	1.50
8	23362	June 1	1.18 and 2.14 A.M.	309,200	50.5	12.20	11.50	0.70	4.40	3.70	0.70
9	23363	June 1	4.09 A.M.	304,700	50.0	12.00	11.20	0.80	3.80	3.30	0.50
10	23364	June 1	5.12 and 6.18 A.M.	311,500	50.5	11.40	11.20	0.20	2.80	2.80	0.00
11	23365	June 1	7.15 and 8.12 A.M.	391,100	50.5	24.00	14.90	9.10	11.40	3.90	7.50
12	23366	June 1	9.10 and 10.02 A.M.	419,400	51.5	47.40	21.50	25.90	30.40	8.10	22.30
13		Average for 24 hours,.....		389,700	51.4	30.90	18.00	12.90	17.10	6.10	11.00
		1898.									
14	23949	July 19	9.00 and 10.00 A.M.	254,200	63.0	46.60	28.40	18.20	26.60	12.00	14.60
15	23950	July 19	11.00 and 12.00 A.M.	239,400	63.2	52.20	35.80	16.40	29.60	15.80	13.80
16	23951	July 19	1.00 and 2.00 P.M.	254,300	63.5	42.00	29.40	12.60	21.00	11.00	10.00
17	23952	July 19	3.00 and 4.00 P.M.	239,800	63.2	46.40	25.80	20.60	28.00	11.00	17.00
18	23953	July 19	5.00 and 6.00 P.M.	220,900	64.0	40.20	30.80	9.40	17.20	9.00	8.20
19	23954	July 19	7.00 and 8.00 P.M.	213,200	64.0	31.60	23.60	8.00	15.20	9.80	5.40
20	23955	July 19	9.00 and 10.00 P.M.	189,300	63.0	22.00	17.00	5.00	11.00	7.40	3.60
21	23956	July 19	11.00 and 12.00 P.M.	175,900	63.7	27.40	17.20	10.20	17.60	9.20	8.40
22	23957	July 20	1.00 and 2.00 A.M.	152,000	62.7	11.40	9.80	1.60	5.00	3.60	1.40
23	23958	July 20	3.00 and 4.00 A.M.	145,300	62.0	9.40	8.80	0.60	3 00	3.00	0.00
24	23977	July 20	5.00 and 6.00 A.M.	158,300	62.0	10.60	9.80	0.80	4.20	4.00	0.20
25	23978	July 20	7.00 and 8.00 A.M.	235,900	62.0	22.60	16.60	6.00	12.00	6.40	5.60
26		Average for 24 hours,.....		206,500	63.0	32.60	22.50	10.10	17.30	9.10	8.20
		1898.									
27	23994	July 20	9.00 and 10.00 A.M.	265,000	62.7	68.40	31.80	36.60	47.00	15.00	32.00
28	23980	July 20	11.00 and 12.00 A.M.	236,400	63.0	51.60	28.60	23.00	31.20	11.40	19.80
29	23981	July 20	1.00 and 2.00 P.M.	240,900	63.0	86.00	26.40	59.60	62.20	10.80	51.40

* June 1.

The samples were collected from the end of the inverted siphon as it *of Sewage from Gardner.*

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
Free.	Albuminoid.				Nitrates.	Nitrites.	Unfiltered.	Filtered.	
	Total.	Dis-solved.	Sus-pended.						
2.3400	0.5900	.3800	.2100	4.90	.0010	.0000	4.51	1.74	1
1.5200	0.5600	.2700	.2900	3.75	.0010	.0000	4.67	1.81	2
0.2170	0.5600	.2800	.2800	3.28	.0010	.0000	3.94	1.81	3
1.4900	0.3100	.1900	.1200	2.65	.0000	.0000	1.76	1.02	4
2.0800	0.4100	.1900	.2200	3.78	.0010	.0000	1.89	1.28	5
1.5300	0.2600	.1600	.1000	2.49	.0010	.0000	1.50	0.99	6
0.8680	0.2360	.1000	.1360	2.37	.0000	.0000	1.25	0.77	7
0.2960	0.0600	.0440	.0160	1.76	.1440	.0192	0.35	0.35	8
0.0960	0.0440	.0200	.0240	1.60	.1600	.0176	0.32	0.31	9
0.1640	0.0440	.0200	.0240	1.59	.1800	.0160	0.32	0.31	10
2.5700	0.3700	.1700	.2000	2.73	.0020	.0000	2.24	1.20	11
3.7700	0.6000	.3600	.2400	3.29	.0000	.0000	4.13	2.10	12
1.4940	0.3680	.2010	.1670	2.98	.0320	.0040	2.48	1.23	13
3.5000	0.8900	.4100	.4800	3.81	.0010	.0000	5.76	2.69	14
3.6500	0.7700	.3900	.3800	4.40	.0020	.0000	6.16	3.81	15
2.5000	0.5300	.2800	.2500	4.92	.0010	.0000	4.00	2.34	16
2.6500	0.7000	.3000	.4000	4.65	.0020	.0000	5.12	3.17	17
2.7000	0.4900	.2600	.2300	8.39	.0020	.0000	3.36	1.89	18
3.3000	0.5800	.4100	.1700	4.47	.0020	.0000	4.00	2.21	19
1.9500	0.3300	.2000	.1300	2.90	.0010	.0000	3.12	1.57	20
1.7500	0.4300	.2000	.2300	2.99	.0020	.0000	3.62	1.76	21
0.8200	0.1520	.0800	.0720	2.03	.0010	.0120	0.80	0.59	22
0.1840	0.0760	.0400	.0360	1.45	.0510	.0072	0.58	0.40	23
0.3720	0.0680	.0440	.0240	1.50	.0580	.0072	0.70	0.53	24
2.3500	0.4300	.2000	.2300	2.35	.0010	.0000	3.00	1.39	25
2.3300	0.4960	.2540	.2420	3.86	.0080	.0020	3.64	2.02	26
5.2000	0.8900	.4100	.4800	5.33	.0000	.0000	6.72	1.76	27
3.9000	0.7500	.3300	.4200	3.95	.0010	.0000	4.84	2.53	28
2.6000	1.0100	.3300	.6800	3.65	.0010	.0000	5.20	2.14	29

enters the settling tanks. Each sample was made up of 2 equal portions.

Chemical Examination of Samples

[Parts per 100,000.]

	Number.	Date.	Day of Week.	Rate of Flow. Gallons per 24 Hours.	Temperature. Deg. F.	Residue on Evaporation.					
						Total Residue.			Loss on Ignition.		
						Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
		1898.									
1	23979	July 19-20	Tues.-Wed., .	206,500	63.0	35.00	20.20	14.80	18.40	6.60	11.80
2	23995	July 20-21	Wed.-Thurs., .	205,200	63.7	39.20	20.00	19.20	23.20	7.00	16.20
3	23997	July 21-22	Thurs.-Fri., .	217,700	64.3	29.20	16.20	13.00	17.40	7.20	10.20
4	24018	July 22-23	Fri.-Sat., . .	209,100	63.6	27.80	20.60	7.20	15.60	11.40	4.20
5	24020	July 23-24	Sat.-Sun., . .	193,000	63.3	29.40	20.60	8.80	8.00	7.60	0.40
6	24039	July 24-25	Sun.-Mon., .	185,300	63.1	27.20	17.80	9.40	14.60	6.00	8.60
7	24047	July 25-26	Mon.-Tues., .	204,900	64.1	36.20	22.60	13.60	21.00	10.40	10.60
		1899.									
8	26111	Jan. 31-Feb. 1.	Tues.-Wed., .	338,500	41.6	22.00	16.00	6.00	11.80	6.30	5.50
9	26113	Feb. 1-2	Wed.-Thurs., .	332,700	41.5	23.00	17.00	6.00	12.20	7.40	4.80
10	26124	Feb. 2-3	Thurs.-Fri., .	304,200	41.3	18.40	14.40	4.00	8.20	5.30	2.90
11	26125	Feb. 3	Friday, . .	384,600	42.0	37.00	21.10	15.90	20.60	8.80	11.80

Each sample was composed of 24 equal portions, collected hourly, beginning at 9 A.M., except the samples were collected from the end of the inverted siphon as it enters the settling tanks.

To reach the filtration area the main sewer crosses the valley of a brook in the form of an inverted siphon. This siphon is a cast-iron pipe 12 inches in diameter and its total length is 1,050 feet. The difference in elevation between the two ends of the siphon is 1.4 feet and the dip is about 25 feet. At the lowest point in the pipe a gate was inserted and a filter-bed was constructed to receive the contents of the pipe whenever it should be found desirable to flush it out. This gate and filter-bed, however, have been used but seldom, as it has been found that no stoppages occur in the iron pipe. At times the flow through the siphon is somewhat diminished, but on such occasions the sewage backs up in the pipe until sufficient head is obtained to remove the obstruction, and the sewage again rushes through the siphon, carrying the foreign matter with it to the filtration area.

The filtration area comprises 19.4 acres of land situated south of the thickly populated portion of the town in the valley of Pond Brook. When the sewage reaches the filtration area it is discharged into two settling tanks having a total capacity of about 10,000 gal-

of Sewage from Gardner.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
Free.	Albuminoid.				Nitrates.	Nitrites.	Unfiltered.	Filtered.	
	Total.	Dissolved.	Suspended.						
2.2500	.4600	.2000	.2600	3.43	.0010	.0000	2.56	1.50	1
2.8500	.6900	.2300	.4600	3.41	.0010	.0000	5.16	2.13	2
1.9500	.4000	.1800	.2200	2.92	.0000	.0000	3.52	1.57	3
2.2000	.3700	.1500	.2200	3.19	.0000	.0000	2.72	1.41	4
1.7000	.4000	.1600	.2400	3.05	.0000	.0000	3.04	1.36	5
1.8000	.4900	.2000	.2900	3.42	.0010	.0000	2.72	1.25	6
2.0000	.5800	.2600	.3200	3.35	.0000	.0000	4.40	1.92	7
1.3500	.4700	.3200	.1500	2.49	.0450	.0120	2.80	1.88	8
1.3000	.3600	.2300	.1300	2.25	.0250	.0060	3.79	2.47	9
1.9500	.3400	.2800	.0600	2.65	.0520	.0140	2.75	2.15	10
3.1000	.9500	.6000	.3500	3.90	.0060	.0080	5.62	3.50	11

last sample, which consisted of 8 equal portions, collected hourly from 9 A.M. to 4 P.M. inclusive. The

lons. The tanks are constructed in duplicate, so that one can be in use while the other is being cleaned; but ordinarily both tanks are used at the same time, except for the short period required for cleaning. The time that the sewage remains in the tank varies from seventeen minutes to two hours, the average time being about forty minutes when both tanks are being used. The solid matter which accumulates in the tanks is discharged upon sludge beds. No screens are used, but the settling tanks are so arranged that the floating matter is kept from being discharged on the filter-beds and is emptied with the solid matter upon the sludge beds when the tanks are cleaned.

Twenty-one filter-beds, exclusive of the sludge beds, have been prepared upon the filtration area, having a combined area of 2.5 acres. The beds vary in size from 0.05 of an acre to 0.21 of an acre, the average size being 0.12 of an acre. In the construction of the beds a large portion of the material was taken from banks of sand in the vicinity, and very little material was found where the beds are located. Such material as was found in the location of the beds was all disturbed and the finest material removed. The beds are underdrained by lines of tile pipe laid about 20 feet apart at a depth of 5 feet beneath the surface. The underdrains discharge into a main underdrain which carries the effluent directly to the brook. The sewage is distributed to the different beds through pipes and wooden troughs, and is applied at only one point on each bed. Overflows have been put in between the beds, so that when one bed is full the sewage will flow to the next bed.

During the summer each of the beds is raked at an interval of about two weeks, and the material which has accumulated upon the surface of the beds is carried away and composted. Two or three times during the season the beds are harrowed. In the fall the beds are ploughed and the surfaces are left in furrows so that the ice and snow will rest upon the ridges, protecting the sewage in the hollows from the action of the frost. Examinations made during the coldest weather in winter have shown that the filter-beds were entirely free from frost.

During the summer, when the beds receive considerable attention, all of the sewage reaching the filtration area is ordinarily properly cared for, but in the latter part of the winter and in the early spring, when it is impossible to rake the surfaces of the beds and when the quantity of sewage is large, the area is insufficient to care for the sewage, and a considerable portion of the sewage is discharged directly into the brook without purification.

The original sludge bed was situated near the tank house and the odor arising from it was noticeable in the vicinity. New sludge beds were subsequently constructed beside the brook on the side of the filtration area farthest from the town and in such a position that odors from them are not noticeable at any considerable distance. There are two sludge beds, having a combined area of 0.17 of an acre. The sludge discharged upon the beds is allowed to stand until it becomes sufficiently dry, and is then shovelled into wheelbarrows and removed from the beds and disposed of by composting. During wet weather and in very cold weather the disposal of the sludge in this way is somewhat difficult, as it is not practicable to dry it sufficiently to remove it, so that there are considerable accumulations of sludge to be disposed of each spring. The sludge is removed from the tanks about once a week and usually contains a large quantity of sand which enters the sewers at times of storms.

In order to ascertain the character of the filtering material in the different beds after having been in use for several years, analyses have been made of samples of soil collected at different depths from the centre of each of the beds. The following table gives the averages of the results of the analyses of samples from all of the beds at each depth: —

Analyses of Filtering Material at the Gardner Filter-beds.

Depth Below Surface (Feet).	Effective Size (Millimeters)			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Surface,	.18	.26	.14	4.4	6.0	2.8	51.5	65.9	22.2
0.25,	.18	.25	.13	4.2	5.6	2.8	48.8	71.9	31.0
0.50,	.17	.26	.12	4.4	7.8	2.3	42.1	62.8	21.0
1.00,	.18	.33	.10	4.3	7.4	2.6	29.7	64.5	9.8
2.50,	.15	.21	.12	4.7	6.8	2.8	18.0	38.9	4.9
4.00,	.12	.18	.02	8.0	24.0	2.5	15.5	37.7	5.1

There is no indication that the material of the filter-beds is becoming finer with continued use.

The estimated average daily flow of sewage, as before stated, is 350,000 gallons, and if all of the sewage were purified upon the filtration area the average amount per acre applied to the beds during the year would be 140,000 gallons per day. The maximum daily flow found was 740,500 gallons, which is equivalent to about 300,000 gallons per acre, while the minimum daily flow found at any time that measurements were made was 185,300 gallons, or about 75,000 gallons per acre.

It is probable that the average quantity of sewage that the beds are purifying is between 100,000 and 140,000 gallons per acre per day. The rate of filtration is larger than that obtained at any of the other filtration areas in the State, but the purification effected is less complete than at some of the other filtration areas. There are several conditions which are favorable to a high rate of filtration through these filters, the principal one of which is that practically all of the sand was handled when the beds were constructed and the fine material and all soil and subsoil carefully removed. The beds are, moreover, thoroughly underdrained, and their surfaces receive constant and careful attention, all of the solid matter accumulating upon them being removed instead of being ploughed into the sand. The sewage, too, is somewhat weaker, especially at times of high flow, than the sewage applied to some of the other filter-beds, and much of the sludge is removed before the sewage is discharged upon the beds.

The temperature of the sewage is affected considerably by the temperature of the ground water which leaks into the sewers and by the method of distributing the sewage upon the beds. On some of the coldest days in winter it has been found that the temperature of the sewage as it flows upon the beds is but little above the freezing point. The results of several observations which have been made upon the temperature of the sewage as it enters the settling tanks are given in the tables on pages 622 to 626.

The beds are cared for by one man, who is occasionally assisted by a second man, and a horse is used for several days at times when the beds are harrowed or ploughed. The cost of maintaining the purification works for the year 1898 was about $1,000.

The approximate character of the sewage applied to the beds and of the effluent from the underdrains is shown in the following table of yearly averages of analyses of monthly samples. The underdrains are laid above the ordinary ground-water level, so that the samples represent effluent from the sewage diluted with but little ground water.

Yearly Averages of Chemical Examinations of Sewage from Gardner.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.							
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.		Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites	Unfiltered.	Filtered.
1892	29.33	19.15	10.18	16.90	8.64	8.26	1.6707	.4150	.2266	.1884	2.60	.0074	.0038	–	–
1893	33.35	20.90	12.45	19.01	9.22	9.79	1.8767	.4769	.2577	.2192	3.48	.0212	.0059	–	–
1894	27.00	16.67	10.33	14.60	6.90	7.70	1.5713	.3695	.2020	.1675	2.47	.0208	.0063	3.27	2.13
1895	32.25	19.76	12.49	18.27	8.56	9.71	1.6517	.5597	.2621	.2976	2.76	.0225	.0100	4.32	2.21
1896	37.07	21.44	15.63	21.04	9.22	11.82	2.6730	.6225	.3318	.2907	3.02	.0229	.0055	3.94	2.43
1897	37.83	22.17	15.66	20.92	9.33	11.59	1.6853	.7089	.4662	.2427	3.04	.0212	.0098	4.09	1.92
1898	36.43	19.67	16.76	20.67	7.64	13.03	2.3683	.6892	.3178	.3714	3.09	.0129	.0070	4.51	2.17

The sewage was collected as it flowed upon the beds.

Yearly Averages of Chemical Examinations of Effluent from the Main Underdrain of the Gardner Filter-beds.

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
		Free.	Albuminoid.		Nitrates.	Nitrites.	
1892, ...	17.54	.5112	.0351	2.40	.6768	.0787	-
1893, ...	14.70	.4628	.0423	2.03	.7783	.0257	-
1894, ...	17.03	.4170	.0403	2.12	.9367	.0253	.43
1895, ...	18.44	.5030	.0552	2.63	.7550	.0119	.60
1896, ...	17.50	.7435	.0767	2.84	.4529	.0186	.54
1897, ...	16.49	.5597	.0505	2.61	.4592	.0109	.55
1898, ...	18.82	.6613	.0645	2.88	.6128	.0159	.53

The samples were collected from the main underdrain at the point where it discharges into Pond Brook.

The purification effected, as indicated by these analyses, was as follows: —

Table showing the Amount of Free and Albuminoid Ammonia and Oxygen Consumed in the Gardner Sewage and in the Effluent from the Filter-beds, together with the Percentage removed from the Sewage by Filtration.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. removed.	Sewage.	Effluent.	Per Cent. removed.	Sewage.	Effluent	Per Cent. removed.
1892, ...	1.6707	.5112	69.4	.4150	.0351	91.5	-	-	-
1893, ...	1.8767	.4628	75.3	.4769	.0423	91.1	-	-	-
1894, ...	1.5713	.4170	73.5	.3695	.0403	89.1	3.27	.43	86.8
1895, ...	1.6517	.5030	69.5	.5597	.0552	90.1	4.32	.60	86.0
1896, ...	2.6730	.7435	72.2	.6225	.0767	87.7	3.94	.54	86.3
1897, ...	1.6853	.5597	66.8	.7089	.0505	92.9	4.09	.55	86.5
1898, ...	2.3683	.6613	72.1	.6892	.0645	90.6	4.51	.53	88.2

The effluent from the filter-beds and all of the sewage which is not purified is discharged into a small tributary of Otter River. The stream has a water-shed, at the point where the effluent enters it, of two square miles. Above the filtration area it flows through a part of the thickly settled portion of the town of Gardner. Below the filtration area it flows through a generally uninhabited country and discharges eventually into Miller's River. Samples of the water of the brook, collected both above and below the point where the effluent is discharged into the stream, have been analyzed during the summer months. The following table gives the results of these analyses : —

Yearly Averages of Chemical Examinations of Water from Pond Brook above and below the Gardner Filter-beds.

Above Filter-beds.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.			
					Total.	Dis-solved.	Sus-pended.						
1893, . .	.26	16.18	3.96	.0264	.0265	.0189	.0076	3.75	.0840	.0022	.69	6.6	-
1895, . .	.38	32.55	10.20	.0276	.0316	.0235	.0081	7.45	.0950	.0054	.60	11.7	-
1896, . .	.40	18.83	4.55	.0063	.0193	.0172	.0021	4.13	.0427	.0038	.41	7.5	-
1897, . .	.48	17.65	5.25	.0433	.0240	.0183	.0057	3.29	.1433	.0030	.42	6.1	-
1898, . .	.24	17.63	5.75	.0284	.0233	.0171	.0062	4.89	.0247	.0014	.38	5.3	-

Below Filter-beds.

1893, . .	.28	17.75	6.08	.0550	.0197	.0151	.0046	3.46	.1850	.0041	.64	6.4	-
1895, . .	.35	27.02	10.37	.0428	.0270	.0231	.0039	6.11	.1522	.0069	.70	9.2	-
1896, . .	.33	18.08	5.42	.0333	.0223	.0192	.0031	3.65	.1917	.0113	.40	5.9	-
1897, . .	.50	18.58	4.95	.0544	.0235	.0189	.0046	3.66	.0893	.0028	.38	7.2	-
1898, . .	.20	17.05	5.07	.0593	.0198	.0161	.0037	4.38	.1350	.0012	.29	5.0	-

Each of the analyses is the average of the analyses of three samples collected in July, August and September.

Leicester.

Estimated population in 1898, 3,310.

The town is located within the water-sheds of the French and Blackstone rivers, the principal part of the thickly settled section of the town draining naturally toward the head waters of French River.

A water supply was introduced into the Leicester water supply district, which comprises the thickly built up portion of the town, in 1891, but no records are available of the amount of water used.

The sewerage system was constructed in 1894. The sewage is collected in a system of pipe sewers and conveyed by gravity to a filtration area located about half a mile south-west of the centre of the village, where it passes through a settling tank and is discharged either on filter-beds or into trenches on the slope of a hill. The system is designed to take house sewage only, and all surface and ground water is excluded from the sewers as far as practicable, and underdrains have been laid beneath many of the sewers.

At the end of the year 1898 there were 2.14 miles of sewers in use and 1.64 miles of underdrains had been constructed. The total number of connections at the end of the year 1898 was 73, which may be roughly classified as follows: —

Dwelling-houses,	56
Tenement-houses,	7
Factories,	5
Public buildings,	4
Stables,	1
Total connections,	73

No records are kept of the amount of sewage flowing in the sewers. On Aug. 16 and 17, 1898, the flow was measured for twenty-four hours by the engineers of the Board, and it was found that the flow for that period was 13,600 gallons. The maximum flow for any one hour was at the rate of 29,400 gallons in twenty-four hours, at 11 A.M., and the minimum flow was at the rate of 3,900 gallons, at 3 A.M.

The flow does not appear to vary much with different seasons of the year, as the system is so thoroughly underdrained that it receives very little ground water. The flow of 13,600 gallons per day, which was found in August, 1898, is equivalent to 4 gallons per capita, 186 gallons per connection, and 6,350 gallons per mile of sewers.

The filtration area is situated about 1,400 feet south of the main street, the area owned by the town comprising 8.7 acres. The sewage is received at the filtration area in masonry settling tanks built in duplicate, having a combined capacity of 12,000 gallons. The sewage is usually allowed to flow into both tanks at the same time, and with the average flow the sewage would remain in the tank nearly twenty-four hours. The solid matter which accumulates in the bottom of these tanks is removed about once a month and discharged on a small sludge bed, where it is allowed to dry until it can be removed and composted.

From the settling tanks the sewage flows either to the prepared filter-beds or to the trenches. There are seven filter-beds having a combined area of 0.35 of an acre, or an average area of 0.05 of an acre.

The material composing the knoll, or ridge, on which the filter-beds are built was examined before the works were constructed, and appeared to be a fine compact soil containing many stones, some of which were partially disintegrated. The material was closely packed together and it appeared probable that little or no sewage would pass through it in its natural state. At one place there was a deposit of coarse gravel extending across the present location of the filter-beds which contained excellent material for sewage filtration, but the deposit was only about 20 feet long and 2 feet wide, and did not extend to a depth of more than about 1½ feet, so that the quantity of this material available was very small.

No favorable soil for the purification of sewage could be found in other parts of the valley upon which the sewage could be delivered by gravity, and the land selected was the best that it was practicable to secure for the purpose. Samples of the material taken from test pits had an effective size ranging from 0.063 to 0.110 millimeter, with the exception of the gravel stratum referred to, which had an effective size of about 0.27 millimeter. The uniformity coefficient is large on account of the number of large stones in the material. In constructing a portion of the filter-beds the material was thoroughly loosened, while in others it was not disturbed except by the laying of the underdrains. The underdrains were laid about 8 feet apart and 5½ feet below the surface in most of the beds. In some of the beds the material was not all loosened, but in two of the beds which were first constructed the underdrains were laid at a somewhat less depth beneath the surface.

A part of the sewage is applied to two trenches, one of which is situated on the slope of the hill west of the filtration area and has a length of 600 to 800 feet. This trench is 1½ feet wide and about 1 foot deep. The soil in which the trench is dug is about the same as the soil of the filtration area. Another trench, having a total length of about 300 feet, has recently been constructed around the summit of a knoll at the southerly side of the filtration area. This trench is constructed in a manner similar to the one west of the filtration area, but the soil is said to be somewhat coarser. Sewage has been applied continuously to the trench west of the filter-beds for a period of several months and disposed of without difficulty. On one of the coldest days during the winter of 1898–99 it was found that all of the sewage was being discharged into this trench and the sewage had entirely disappeared before reaching the lower end of the trench. The surface of the sewage in the trench was covered with ice and snow, but the bottom of the trench was free from frost. At this time the temperature of the sewage as it was discharged into the trench was 36.5° F., while the temperature of the water of the public water supply was 35° F.

Analyses of samples of sewage and the effluent from the filter-beds have been made frequently during the past two years, the average results of which are given in the following tables: —

Yearly Averages of Chemical Examinations of Sewage from Leicester.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.							
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.		Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.
1897	84.02	70.85	13.17	49.64	39.73	9.91	2.8115	0.8418	0.4955	0.3463	5.59	.0013	.0023	23.14	19.65
1898	77.39	69.39	8.00	43.17	36.95	6.22	3.5642	0.8833	0.5400	0.3433	6.18	.0005	.0005	24.30	20.56

The sewage was collected as it entered the settling tank.

Yearly Averages of Chemical Examinations of Effluent from the Main Underdrain of the Leicester Filter-beds.

[Parts per 100,000.]

Year.	Residue on Evaporation.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
	Total.	Loss on Ignition.	Free.	Albuminoid.		Nitrates.	Nitrites.			
1897, . .	47.35	–	1.6475	.2351	5.46	0.0447	.0194	8.38	11.6	.5708
1898, . .	43.19	–	1.1453	.0841	5.32	1.1783	.0187	3.80	10.1	.1689

The samples were collected from the underdrain at the point where it discharges into the brook.

The purification effected by the filter-beds, as indicated by the percentage of removal of free and albuminoid ammonia and oxygen consumed, is shown in the following table. As the underdrains receive very little ground water, the samples collected from them represent the sewage effluent, diluted with but little ground water.

Table showing the Amount of Free and Albuminoid Ammonia and Oxygen Consumed in the Leicester Sewage and in the Effluent from the Filter-beds, together with the Percentage removed from the Sewage by Filtration.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. removed.	Sewage.	Effluent.	Per Cent. removed.	Sewage.	Effluent.	Per Cent removed.
1897, . . .	2.8115	1.6475	41.4	.8418	.2351	72.1	23.14	8.38	63.8
1898, . . .	3.5642	1.1453	67.9	.8833	.0841	90.4	24.30	3.80	84.4

Marlborough.

Estimated population in 1898, 15,680.

The city of Marlborough is situated within the water-sheds of the Sudbury and Assabet rivers, the principal part of the thickly settled portion of the town being within the water-shed of the former stream above the point where water is taken for the supply of the Metropolitan District.

The principal industry is the manufacture of shoes, and there are several large factories of this kind in the city. A water supply was introduced in 1883 and water from the public works is now very generally used. The average daily consumption of water during the year 1898 was 537,000 gallons, or 34 gallons per capita.

The sewerage system was constructed in 1891 and was designed to take house sewage only. The sewage is collected in a system of pipe sewers and conveyed by gravity through a main pipe sewer about 3½ miles in length to settling tanks and filter-beds located within the water-shed of the Assabet River, which is not used as a direct source of public water supply. When the sewers were constructed considerable ground water was encountered, and there is a large amount of leakage into the sewers. No underdrains were laid beneath the sewers of this system.

At the end of 1898 there were 22.14 miles of sewers in use and 1,394 connections had been made with the sewers.

There are no large quantities of manufacturing wastes and the sewage consists almost entirely of house sewage diluted with ground or surface water. No records of the flow of sewage are kept by the city, but several measurements have been made by the Board to determine the flow, and in November, 1898, weirs were constructed in the settling tanks by the Metropolitan Water Board and automatic recording gauges set up to record the height of water on the weirs. These measurements have been continued up to the present time, and a summary of the results which have been obtained is given in the following table: —

Flow of Sewage at Marlborough from Records obtained by the Metropolitan Water Board.

Month.	Average Daily Flow (Gallons).	Maximum Daily Flow.		Minimum Daily Flow.	
		Day of Month.	Quantity (Gallons).	Day of Month.	Quantity (Gallons).
Aug., 1898,*	1,262,000	25	1,583,000	10	605,900
Nov., 1898,†	1,645,000	20	2,380,000	17	1,270,000
Dec., 1898,‡	1,459,000	6	2,592,000	21	966,000
Jan., 1899,	1,441,000	7	2,147,000	31	1,031,000
Feb., 1899,	930,000	27	1,371,000	17	659,000
March, 1899,	1,898,000	29	2,613,000	4	985,000
April, 1899,	1,617,000	9	2,544,000	30	920,000
May, 1899,§	577,000	6	898,000	30	428,000
June, 1899,	400,000	16	533,000	18	330,000
July, 1899,	396,000	13	551,000	30	243,000
Aug., 1899,‖	337,000	23	393,000	27	381,000
Sept., 1899,¶	381,000	6	548,000	16	284,000

* Eight days only. † November 16-30 inclusive. ‡ Six days omitted.
§ Four days omitted. ‖ Five days omitted. ¶ Twelve days omitted.

From this table it will be seen that the quantity of sewage varies between very wide limits, the maximum recorded for any one day being 2,613,000 gallons on Wednesday, March 29, 1899, and the minimum, 243,000 gallons on Sunday, Aug. 27, 1899, about one-eleventh the maximum flow. The average amount of sewage flowing for the period from Nov. 16, 1898, to Sept. 28, 1899, as indicated by these records, was 1,009,000 gallons per day. The maximum rate of flow during the period covered by the measurements occurred from 4 to 5 P.M. March 12, 1899, when the flow was at the rate of 3,116,000 gallons per day. The minimum rate occurred between 4 A.M. and 8 A.M. Aug. 31, 1899, when the flow was at the rate of 122,000 gallons per day. A storm quickly increases the flow of sewage, which indicates that a large amount of surface water enters the sewers. The following table gives the average, maximum and minimum quantity of sewage per day for each inhabitant, each connection and each mile of sewers: —

	Average (Gallons per Day).	Maximum (Gallons per Day).	Minimum (Gallons per Day).
Total flow,	1,009,000	2,613,000	243,000
Flow per inhabitant,	64	167	15
Flow per connection,	724	1,874	174
Flow per mile of sewers,	45,600	118,022	11,000

The filtration area is situated about 3 miles east of the city, within the water-shed of the Assabet River and outside the water-shed of the sources of water supply of the Metropolitan District. The area owned by the town comprises 49.4 acres.

The sewage is discharged at the filtration area into settling tanks built in duplicate, the combined capacity being 16,000 gallons. With the average flow the sewage may remain in the tanks, when both are in use, for twenty minutes, but at times of maximum flow the sewage passes through the tanks in about nine minutes. At times of minimum flow it may remain in the tank about eighty minutes. The material which accumulates in the settling tanks is ordinarily removed about once in two weeks, being discharged upon special sludge beds prepared for the purpose, where it is allowed to dry and is then raked up and shovelled into carts and carried away. This material is used by the farmers in the vicinity as a fertilizer. The sludge, when it is discharged upon the beds, is very foul-smelling, and its odor is noticeable for a considerable distance from the beds. The sewage in the tank passes upward through horizontal screens having a one-inch mesh before it is discharged into the carriers leading to the filter-beds.

On the filtration area 26 beds have been prepared to receive sewage and sludge. Six beds, having a combined area of 0.72 acres, receive the sludge only, while the remaining 20 beds, having a combined area of 11.02 acres, receive only sewage. The average area of the sewage beds is 0.55 of an acre.

The beds were prepared by the removal of nearly all of the loam, but all of the subsoil, and in some cases a small amount of the loam, were left in place. The material found in the beds was disturbed only as much as was necessary to level the beds and construct underdrains. The beds were originally underdrained by lines of pipes about 50 feet apart, at a depth of from 5 to 8 feet beneath the surface. These underdrains receive a large amount of ground water, and it was found that their capacity was insufficient to remove both ground water and effluent, and recently an additional system of larger underdrains has been put in. The material of which the beds are composed is quite uniform. The averages of the results of examinations of sand collected from various beds at different depths are given in the following table: —

Depth Beneath Surface (Feet).	Effective Size (Millimeters).			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Surface,	.14	.16	.12	2.9	5.8	2.3	55.5	105.7	20.2
0.25,	.15	.19	.12	2.9	6.8	2.2	39.0	83.5	14.6
0.50,	.15	.19	.12	3.1	10.2	2.3	21.0	51.1	6.9
1.00,	.14	.18	.09	2.6	3.0	2.0	10.8	29.2	5.2
2.50,	.14	.17	.11	2.6	3.0	1.9	8.9	27.8	3.8
4.00,	.14	.16	.13	2.5	2.5	2.3	7.2	12.5	2.1

The sewage is discharged on the beds near the corners. The method of applying sewage has been to turn all of the sewage on one, two or three beds, according to the quantity flowing, and in dry weather the sewage is not turned off of these beds until twenty-four hours later, so that the entire flow of sewage for twenty-four hours is discharged upon from one to three of the beds. In wet weather, when the flow of sewage is very large, the day flow of sewage is discharged upon the beds, but at night it appears that the gates are shut and all of the sewage flowing is discharged directly into the brook without purification. When the sewage is turned off from the beds the depth of sewage on the filters is from 12 inches to 18 inches. During the summer, when the beds are in good condition, the sewage disappears from the surface in from twelve to thirty-six hours, the length of time varying in different beds. In the winter the sewage frequently stands upon the beds for a week before it disappears.

Sewage is applied to the beds in rotation as far as possible, and once in about five weeks the surface of each of the beds is raked and harrowed, and allowed to rest for a time. All of the weeds and solid matter which accumulate on the surfaces of the beds are raked up and removed from the beds before the surfaces are harrowed. In the fall the beds are ploughed and the surfaces are left in ridges and furrows, so that ice forming upon the beds rests upon the ridges and protects the sand from freezing. The surfaces of the beds receive no attention whatever during the winter. In the spring the surfaces are raked and then the beds are ploughed, harrowed and graded and left level during the summer. No attempt has been made at Marlborough to raise any crops upon the beds.

By the method of operating the beds which has been adopted the filters are much overworked at all times and especially so at times of wet weather and during the winter months, so that the sewage passes through the filters with difficulty and the purification is not as complete as it would be if the beds had an opportunity to rest at more frequent intervals. When the sewage remains on the surface of the beds for a long period there is no opportunity for the air to get into the sand of the filter and complete nitrification is impossible.

A record is kept of the beds which receive sewage each day and the time when the sewage is applied and turned off. The depth of sewage on the beds is also recorded, and from these observations an estimate has been made of the quantity of sewage which each bed has received during the year 1898. This estimate is necessarily very rough but serves to give an approximate idea of the quantity of sewage purified by the filters at Marlborough.

Approximate Quantity of Sewage Purified by the Marlborough Filter-beds during the Year 1898.

Number of Bed.	Area of Bed (Acres).	Average Daily Quantity of Sewage Applied (Gallons).	Average Daily Quantity of Sewage Applied per Acre (Gallons).
7,	.21	20,000	95,000
8,	.32	34,000	107,000
9,	.72	89,000	124,000
10,	.34	36,000	106,000
11,*	.41	5,000	12,000
12,*	.50	7,000	13,000
13,	.80	84,000	105,000

* In use for two months only.

Approximate Quantity of Sewage Purified by the Marlborough Filter-beds during the Year 1898 — Concluded.

Number of Bed.	Area of Bed (Acres).	Average Daily Quantity of Sewage Applied (Gallons).	Average Daily Quantity of Sewage Applied per Acre (Gallons).
14,	.72	66,000	91,000
15,	.54	42,000	78,000
17,	.53	48,000	89,000
19,	.71	91,000	128,000
20,	.80	76,000	95,000
21,	.88	62,000	70,000
22,	.66	86,000	130,000
23,	.75	102,000	136,000
24,	.80	40,000	57,000
25,	.72	54,000	75,000
26,	.61	46,000	75,000
Average,	.61	55,000	88,000

The filter-beds appear to be capable of caring for all the sewage except at times when the flow is increased by an excessive quantity of storm water, and even in the very coldest weather the present beds are capable of receiving and passing all of the sewage of the city. An examination of the beds in February, 1899, at the end of a period of several weeks of very cold weather, when little or no rain or melting snow was flowing into the sewers, showed that the filter-beds were filtering all of the sewage coming from the town. The temperature records for towns in the neighborhood for several days at the end of the period referred to above show that the maximum temperature recorded in the daytime for many successive days was not above freezing, while the minimum was —8° F.

Several series of analyses have been made of samples of sewage collected from the end of the main sewer at times when measurements of the flow were being made. The results of these examinations are given in the following tables: —

Chemical Examination of

[Parts per 100,000.]

	Number.	Date.	Hour.	Rate of Flow. — Gallons per 24 Hours.	Temperature. — Deg. F.	Residue on Evaporation. Total Residue. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Suspended.
		1898.									
1	23435	June 7	3.00 and 4.00 P M.	1,050,650	54	51.20	32.30	18.90	26.40	11.40	15.00
2	23436	June 7	5.00 and 6.00 P M.	1,137,000	54	55.00	30.70	24.30	31.40	11.20	20.20
3	23437	June 7	7.00 and 8.00 P M	938,150	53	36.60	26.70	9.90	16.00	8.40	7.60
4	23438	June 7	9.00 and 10.00 P.M.	009,750	52	37.40	29.50	7.90	14.80	7.30	7.50
5	23439	June 7	11.00 and 12.00 P.M.	845,925	52	32.40	24.80	7.60	13.00	6.50	6.50
6	23440	June 8	1.00 and 2.00 A.M.	803,000	51	26.20	21.10	5.10	9.00	6.60	2.40
7	23441	June 8	3.00 and 4.00 A.M.	715,725	51	21.60	20.10	1.50	6.00	4.50	1.50
8	23442	June 8	5.00 and 6.00 A.M.	690,785	51	20.40	18.70	1.70	5.20	4.10	1.10
9	23458	June 8	7.00 and 8.00 A.M.	764,000	51	19.70	19.70	0.00	5.70	5.60	0.10
10	23459	June 8	9.00 and 10.00 A.M.	924,975	51	28.60	21.40	7.20	10.00	4.10	5.90
11	23460	June 8	11.00 and 12.00 A M.	1,013,650	52	59.00	42.60	16.40	21.80	8.10	13.70
12	23461	June 8	1.00 and 2.00 P.M.	984,250	54	43.20	28.80	14.40	21.40	9.60	11.80
13	Av..	....	....	897,700	52	37.73	27.13	10.60	16.21	7.59	8.62
		1898.									
14	24237	Aug. 9	4.00 and 5.00 P.M.	740,900	-	84.40	37.00	47.40	53.80	16.40	37.40
15	24238	Aug. 9	6.00 and 7.00 P.M.	669,700	-	88.00	31.00	57.00	47.80	11.80	36.00
16	24239	Aug. 9	8.00 and 9.00 P M.	676,450	-	49.00	33.80	15.20	22.60	10.20	12.40
17	24240	Aug. 9	10.00 and 11.00 P.M.	615,200	-	38.20	28.40	9.80	17.40	8.80	8.60
18	24241	Aug. 10	12.00 and 1.00 A.M.	553,300	-	31.00	23.20	7.80	11.20	5.60	5.60
19	24242	Aug. 10	2.00 and 3.00 A M.	487,550	-	22.80	20.60	2.20	5.40	3.40	2.00
20	24243	Aug. 10	4.00 and 5.00 A.M.	471,500	-	22.80	20.20	2.60	7.60	6.60	1.00
21	24244	Aug. 10	6.00 and 7.00 A.M.	478,560	-	21.60	21.00	0.60	5.20	5.20	0.00
22	24245	Aug. 10	8.00 and 9.00 A.M.	545,500	-	23.20	20.20	3.00	5.60	5.20	0.40
23	24246	Aug. 10	10.00 and 11.00 A.M	670,000	65	413.00	34.60	378.40	379.00	11.00	368.00
24	24247	Aug. 10	12.00 and 1.00 P.M.	696,400	65	87.80	48.80	39.00	45.80	19.40	26.40
25	24248	Aug. 10	2.00 and 3.00 P M.	616,650	66	60.20	33.20	27.00	30.80	8.00	22.80
26	Av...	....	....	605,900	-	85.90	30.00	55.90	59.00	9.90	49.10

The samples were collected from the main sewer where it discharges into the

Chemical Examination of

[Parts per 100,000.]

	Number.	Date.	Rate of Flow. — Gallons per 24 Hours.	Temperature. — Deg. F.	Residue on Evaporation. Total Residue. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Suspended.
		1898.								
1	24414	Aug. 23-24	1,583,000	61.4	29.60	22.10	7.50	10.40	5.10	5.30
2	24426	Aug. 24 25	1,563,800	62.5	26.90	22.20	4.70	8.30	4.50	3.80
3	24457	Aug 25-26	1,544,600	60.8	28.30	22.80	5.50	8.60	4.00	4.60
4	24462	Aug. 26-27	1,365,000	60.7	29.40	22.90	6.50	10.50	5.20	5.30
5	24463	Aug. 27-28	1,254,900	59.2	30.70	23.60	7.10	10.90	4.90	6.00
6	24464	Aug. 28-29	1,098,200	58.7	27.90	22.80	5.10	8.90	5.20	3.70
7	24477	Aug. 29-30	1,079,400	59.8	37.10	26.30	10.80	15.50	7.10	8.40

The samples were collected from the main sewer where it discharges into the

Sewage from Marlborough.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
Free.	Albuminoid.				Nitrates.	Nitrites.	Unfiltered.	Filtered.	
	Total.	Dis-solved.	Sus-pended.						
2.3500	.5600	.2400	.3200	6.15	.0020	.0000	5.31	2.48	1
2.5000	.7000	.2500	.4500	5.29	.0020	.0000	6.05	2.59	2
1.9500	.4200	.1800	.2400	4.46	.0010	.0000	3.90	2.01	3
1.8000	.3600	.1400	.2200	7.19	.0120	.0520	2.82	1.74	4
1.7200	.3100	.1500	.1600	4.61	.0020	.0000	2.40	1.44	5
1.2500	.2000	.1100	.0900	3.75	.0900	.0240	1.60	0.86	6
0.5480	.1000	.0520	.0480	3.21	.1850	.0280	0.90	0.58	7
0.1800	.0400	.0200	.0200	2.90	.3170	.0280	0.38	0.28	8
0.1600	.0280	.0200	.0080	3.18	.2700	.0180	0.38	0.32	9
2.2900	.3500	.1600	.1900	4.19	.0010	.0000	1.79	1.06	10
5.3000	.7100	.3200	.3900	14.35	.0030	.0000	4.77	2.32	11
3.4700	.8100	.3600	.4500	5.39	.0030	.0000	3.68	2.16	12
2.1130	.4160	.1800	.2360	5.62	.0610	.0110	3.09	1.61	13
3.5000	1.3500	.3200	1.0300	7.35	.0000	.0000	6.00	2.53	14
3.1000	1.5500	.3100	1.2400	6.15	.0000	.0000	10.24	2.43	15
2.3000	0.5500	.2200	0.3300	8.25	.0000	.0000	5.36	2.59	16
2.5000	0.5300	.2100	0.3200	6.20	.0000	.0003	3.60	1.76	17
1.6500	0.4400	.1500	0.2900	4.25	.0000	.0000	2.56	1.18	18
1.3500	0.1700	.0850	0.0850	3.85	.0110	.0090	1.52	0.64	19
0.4750	0.0750	.0450	0.0300	3.50	.1240	.0300	0.54	0.38	20
0.2500	0.0500	.0350	0.0150	3.22	.1500	.0360	0.51	0.30	21
0.5000	0.1200	.0500	0.0700	3.37	.1500	.0480	0.80	0.43	22
6.0000	1.4400	.4400	1.0000	6.70	.0000	.0000	6.80	2.82	23
3.5500	1.1500	.3400	0.8100	9.95	.0000	.0000	6.88	2.85	24
4.4500	0.8400	.3700	0.4700	6.50	.0000	.0000	6.40	3.62	25
2.6600	0.7580	.2320	0.5260	6.04	.0300	.0090	4.64	1.93	26

settling tank. Each sample was made up of 2 equal portions collected hourly.

Sewage from Marlborough.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
Free.	Albuminoid.				Nitrates.	Nitrites.	Unfiltered.	Filtered.	
	Total.	Dis-solved.	Sus-pended.						
0.9320	.4120	.1240	.2880	4.20	.0020	.0900	1.76	0.96	1
0.6500	.2600	.1040	.1560	4.49	.0370	.2400	1.66	1.04	2
0.9000	.3000	.0680	.2320	5.25	.0020	.0900	1.41	0.67	3
0.8500	.3200	.0840	.2360	4.45	.0020	.0180	2.02	1.10	4
0.9000	.2700	.0920	.1780	4.81	.0020	.0002	2.02	1.02	5
1.0500	.2500	.0880	.1620	4.29	.1440	.0850	1.31	0.70	6
1.2500	.4300	.1760	.2540	5.63	.0020	.0006	3.68	2.05	7

settling tank. Each sample was made up of 24 equal portions collected hourly.

It will be seen from an examination of the foregoing table that here, as in other cases, the strength of the sewage during one day is greatest at the hours of highest flow and least at the hours of lowest flow. On the other hand, comparing the different seasons of the year, the sewage is strongest in times of dry weather, when the flow is small, and is weakest in wet weather, when the flow is large.

Regular monthly examinations of samples of sewage and of samples from each of the two main underdrains have been made for several years. The average yearly results of these examinations are given in the tables which follow. The analyses of the effluent represent the average of the analyses of the effluent from the two underdrains.

Yearly Averages of Chemical Examinations of Sewage from Marlborough.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	
	Total Residue.			Loss on Ignition.				Albuminoid.							
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.
1892	56.02	35.74	20.28	24.10	11.11	12.99	2.1929	.5759	.2598	.3161	6.87	.1388	.0051	-	-
1893	72.36	34.93	37.43	37.27	10.84	26.43	2.0140	.6136	.2164	.3972	7.36	.1125	.0286	-	-
1894	61.11	35.34	25.77	29.56	9.43	20.13	3.2507	.7586	.2700	.4886	6.68	.0332	.0267	5.01	2.40
1895	42.54	28.19	14.35	17.73	7.80	9.93	1.9357	.4048	.1547	.2501	5.25	.0845	.0422	4.75	1.70
1896	43.41	28.48	14.93	21.19	9.61	11.58	2.1080	.4281	.1978	.2303	5.05	.0447	.0263	4.03	2.23
1897	51.90	32.69	19.21	25.88	10.25	15.63	2.3940	.6745	.3196	.3549	6.34	.0772	.0190	4.68	2.29
1898	33.23	24.46	8.77	13.32	6.49	6.83	1.9900	.4598	.2242	.2356	4.91	.1162	.0377	2.59	1.36

The samples were collected from the settling tanks, and represent the sewage after a portion of the suspended matter has been separated from it.

Yearly Averages of Chemical Examinations of the Effluent from the Underdrains of the Marlborough Filter-beds.

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
		Free.	Albuminoid.		Nitrates.	Nitrites.	
1892, ...	26.36	.1986	.0141	4.95	0.8003	.0318	-
1893, ...	28.92	.5931	.0353	5.08	1.0130	.0234	-
1894, ...	32.18	.4983	.0375	5.69	1.1281	.0159	0.36
1895, ...	29.70	.6427	.0299	5.54	0.9056	.0120	0.34
1896, ...	27.96	.6236	.0416	5.54	0.6885	.0096	0.40
1897, ...	28.19	.7613	.0443	6.17	0.5242	.0151	0.41
1898, ...	24.80	.6203	.0328	5.00	0.5441	.0171	0.34

The samples were collected from the effluent underdrains at their outlet, and the results represent the averages of analyses of samples from the two main underdrains.

The degree of purification effected at Marlborough, as indicated by the free ammonia, albuminoid ammonia and oxygen consumed in the sewage and in the effluent, is shown in the following table. There is a considerable quantity of ground water at all times in the underdrains, so that the effluent is somewhat diluted, and the apparent purification is greater than the actual purification.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. removed.	Sewage.	Effluent.	Per Cent. removed.	Sewage.	Effluent.	Per Cent. removed.
1892, . . .	2.1929	.1986	90.9	.5759	.0141	97.6	-	-	-
1893, . . .	2.0140	.5931	70.6	.6136	.0353	94.2	-	-	-
1894, . . .	3.2507	.4983	84.7	.7586	.0375	95.1	5.01	.36	92.9
1895, . . .	1.9357	.6427	66.8	.4048	.0299	92.6	4.75	.34	92.8
1896, . . .	2.1080	.6236	70.4	.4281	.0416	90.3	4.03	.40	90.1
1897, . . .	2.3940	.7613	68.2	.6745	.0443	93.4	4.68	.41	91.2
1898, . . .	1.9900	.6203	68.8	.4598	.0328	92.9	2.59	.34	86.9

Very few observations have been made of the temperature of the sewage, except those made at the time that the special measurements were made, the results of which are given on page 642. During a very cold period in February, 1899, the temperature at various places was observed. It was found that the temperature of the sewage in the reservoir was 41° F., while the temperature of the sewage as it was discharged upon the beds varied from 33° to 38°. The ice upon the beds was 12 inches thick in places. The temperature of the water supply at this time, as drawn from faucets in the city, varied from 34° to 37° F.

Some trouble has been experienced from the growth in the underdrains of an organism which appears to be one of the fungi, which in places appears in such masses as to nearly clog the pipes.

At times of wet weather, and especially during the spring, when the surfaces of the beds have not received attention for a considerable time, a large proportion of the sewage received at the filter-beds is allowed to flow off without purification. No reliable estimate has been made as to the amount of sewage discharged in this way.

The effluent and unpurified sewage flow into a small brook, one of the tributaries of the Assabet River. This brook, at the point where the effluent is discharged into it, has a water-shed of 0.8 of a square mile. There is no population in the immediate vicinity of the brook, or of the filter-beds, and the population within half a mile of the filter-beds is only about 22.

Analyses of samples of water collected from the brook below the point where it receives the effluent from the filter-beds have been made for several years, and the yearly averages of the analyses are given in the following table: —

Yearly Averages of Chemical Examinations of Water from the Brook into which the Effluent from the Marlborough Sewage Filter-beds is Discharged.

[Parts per 100,000.]

Year.	Color.	Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
1893, . .	.22	24.29	7.08	.2949	.0291	.0185	.0106	4.47	1.0063	.0282	.45	5.9
1894, . .	.31	25.88	9.91	.1815	.0260	.0181	.0079	4.30	1.0712	.0253	.44	5.6
1895, . .	.19	27.55	9.40	.2880	.0232	.0162	.0070	5.17	0.7875	.0710	.39	6.3
1896, . .	.17	25.87	6.25	.4667	.0393	.0273	.0120	5.55	0.5333	.0197	.33	6.0
1897, . .	.50	17.62	5.30	.5921	.0359	.0271	.0088	3.45	0.3371	.0154	.48	4.9
1898, . .	.25	22.17	6.43	.3547	.0262	.0222	.0040	4.67	0.3127	.0209	.43	5.3

The samples were collected from the brook at a road crossing below the filter-beds and below where the effluent from the filter-beds enters the stream.

Medfield.

Estimated population in 1898, 2,100.

The town is situated within the water-shed of the Charles River. The principal part of the population is contained in one village, in which there is a large straw factory where about 600 persons are employed at certain seasons of the year. Water is supplied to the straw factory and to a few buildings in the immediate vicinity of the factory by a private company, but there is no general system of water supply for the town.

The sewerage system was constructed in 1886 and was intended primarily to remove the sewage from the straw factory, but at the present time, in addition to the factory, 11 houses and a small hotel have been connected with the sewers. The sewer is laid from the straw factory along the valley of Vine Brook to the filtration area, which is located about half a mile from the centre of the village, where the sewage is received in a settling tank and discharged upon prepared filter-beds. The main sewer is 8 inches in diameter and is built of Akron pipe, except as it passes beneath a brook, where for a short distance it is constructed of iron pipe. At the time the sewer was built it was found that there was a leakage of about 15,000 gallons per day of ground water, which is equivalent to 25,000 gallons per day per mile of sewer. No underdrains were constructed beneath the sewers but care was taken to make the joints as tight as possible.

The principal source of sewage is the straw factory, from which large quantities of spent dyes are discharged into the sewer, giving the sewage a very decided color. No measurement has been made of the quantity of sewage flowing.

At the filtration area the sewage is received in a small tank, circular in section, having a capacity of about 1,800 gallons. The outlet of the tank is so arranged that sewage is taken from a point beneath the surface, so that the heavy matter which settles at the bottom of the tank and all floating substances are prevented from flowing upon the filter-beds. An outlet has been placed at the bottom of the tank through which the sludge is discharged at intervals into a small pit which has been dug near the tank, where it remains until dry.

On the filtration area four beds have been prepared, having a combined area of about $1\frac{1}{3}$ acres. The sewage is discharged on these beds from a manhole situated in the center of the area. When the beds were constructed all the loam and subsoil which were on the surface were ploughed up, but none of the material was removed except where excavation was necessary in the grading of the beds. It was soon found that the layer of loam which was left in place had become very hard and compact and prevented the flow of sewage through the filters, and in 1893 the loam was all removed and replaced with gravel. Since that time the beds have absorbed the sewage much more readily.

The character of the filtering material in each of the beds has been determined by analyses of samples of the soil collected at different depths, the average results of which are given in the following table: —

Depth Beneath Surface (Feet).	Effective Size (Millimeters.)			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Surface,	.19	.32	.11	12.8	15.8	10.5	262.0	344.6	98.9
0.25,	.17	.28	.07	14.6	23.4	10.0	267.4	359.0	83.3
0.50,	.18	.22	.12	14.7	19.1	11.7	223.2	309.4	104.3
1.00,	.17	.24	.10	12.0	15.8	7.6	152.1	254.0	94.5
2.50,	.25	.42	.03	12.1	23.4	4.1	105.4	276.9	20.7

No underdrains were constructed in the filter-beds as the ground water was found to be about 10 feet beneath the surface. The ground slopes toward a small spring situated about 260 feet from the edge of the nearest bed, which forms the head waters of a small brook. This spring receives a considerable quantity of the purified sewage.

Regular analyses of samples of sewage and of water from the spring which receives the effluent have been made for a number of years. The yearly averages of the results are given in the following tables: —

Chemical Examination of Sewage from Medfield.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	
	Total Residue.			Loss on Ignition.				Albuminoid.							
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.
1894	47.64	38.96	8.68	24.44	18.48	5.96	2.6160	0.7164	.5852	.1312	2.11	.0025	.0030	7.16	5.75
1895	57.80	51.38	6.42	25.30	19.72	5.58	1.3613	0.6443	.5227	.1216	3.76	.0056	.0092	11.63	9.22
1896	80.17	68.00	12.17	40.20	30.27	9.93	1.9533	1.2833	.9930	.2903	7.13	.0032	.0000	16.73	11.08
1897	134.63	124.38	10.25	38.95	32.98	5.97	1.7260	1.0650	.9150	.1500	4.71	.0026	.0056	10.64	8.52
1898	90.40	74.20	16.20	34.32	21.10	13.22	1.0877	0.9976	.7713	.2263	10.85	.0006	.0008	12.77	6.82

The samples were collected as the sewage flowed upon the filter-beds.

Chemical Examination of the Water from the Spring below the Filtration Area of the Medfield Sewerage System.

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
		Free.	Albuminoid.		Nitrates.	Nitrites.	
1894,	12.86	.0027	.0101	1.25	.3192	.0001	.19
1895,	13.47	.0115	.0229	1.63	.2950	.0007	.48
1896,	8.78	.0030	.0144	0.68	.0872	.0008	.41
1897,	7.07	.0054	.0274	0.81	.0330	.0002	.34
1898,	8.48	.0051	.0114	0.80	.0883	.0016	.26

The samples were collected from a spring which is located north of the filter-beds and a little over 260 feet from the edge of the nearest bed. The ground where the filter-beds are located slopes in the direction of this spring.

The purification effected by filtration, as indicated by the free and albuminoid ammonia and oxygen consumed in the sewage and in the effluent, is shown in the following table.

The spring receives, in addition to the sewage effluent, a considerable quantity of ground water, so that the actual purification is not as great as is indicated by the results of the analyses of the water of the spring.

Purification effected by the Sewage Filter-beds at Medfield as indicated by the Free Ammonia, Albuminoid Ammonia and Oxygen Consumed in the Sewage and in the Spring which receives the Effluent.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. removed.	Sewage.	Effluent.	Per Cent. removed.	Sewage.	Effluent.	Per Cent. removed.
1894, . . .	2.6160	.0027	99.9	0.7164	.0101	98.6	7.16	.19	97.3
1895, . . .	1.3613	.0115	99.2	0.6443	.0229	96.4	11.63	.48	95.9
1896, . . .	1.9533	.0030	76.1	1.2833	.0144	96.9	16.73	.41	98.0
1897, . . .	1.7260	.0054	65.7	1.0650	.0274	96.6	10.64	.34	95.5
1898, . . .	1.0877	.0051	99.5	0.9976	.0114	98.9	12.77	.26	98.0

The temperature of the sewage applied to the beds is high, especially during days when the straw factory is in operation, as some of the wastes from this factory are discharged into the sewer at a very high temperature. Daily observations of the temperature of the sewage as it is discharged on the filter-beds were made during several months of the winter of 1887–88. The following table, taken from the report of the State Board of Health for the year 1887, gives the record of the temperature for the month of December, 1887 :—

Record of Temperature of Medfield Sewage for the Month of December, 1887.

Day.	Hour.	Temperature. Deg. F.		Day.	Hour.	Temperature. Deg. F.	
1, . . .	12 M.	81	–	17, . . .	11 A.M.	76	–
2, . . .	7 A.M.	72	–	18, . . .	10 A.M.	55	Sunday.
3, . . .	12 M.	82	–	19, . . .	12 M.	75	–
4, . . .	10 A.M.	58	Sunday.	20, . . .	5 P.M.	72	–
5, . . .	4 P.M.	80	–	21, . . .	12 M.	74	–
6, . . .	12 M.	70	–	22, . . .	6 P.M.	70	–
7, . . .	12 M.	75	–	23, . . .	6 P.M.	71	–
8, . . .	7 A M.	60	–	24, . . .	4 P.M.	71	–
9, . . .	12 M.	75	–	25, . . .	2 P.M.	53	Sunday.
10, . . .	7 A M.	65	–	26, . . .	2 P.M.	51	Holiday.
11, . . .	10 A.M.	57	Sunday.	27, . . .	7 P M.	66	–
12, . . .	12 M.	75	–	28, . . .	8 A.M.	72	–
13, . . .	5 P.M.	74	–	29, . . .	12 M.	70	–
14, . . .	5 P.M	70	–	30, . . .	12 M.	68	–
15, . . .	1 P.M.	78	–	31, . . .	7 A.M.	65	–
16, . . .	12 M.	72	–				

On account of the high temperature of the sewage, its disposal during the winter months is accomplished without much difficulty, notwithstanding the fact that the sewage is discharged continuously on large beds at a slow rate. The beds receive very little attention, being ploughed, harrowed and raked occasionally during the summer months at an annual expense of about $50.

There are several dwelling-houses in the vicinity of the filter-beds, and it is said that at times those living in the vicinity are troubled by disagreeable odors which arise from the beds. These odors appear to come from the sludge pit, which receives the sludge which accumulates in the tank for a considerable time and which becomes more or less decomposed. There is no population in the vicinity of the brook into which the effluent naturally finds its way.

Natick.

Estimated population in 1898, 8,632.

The town of Natick is situated within the water-sheds of the Sudbury and Charles rivers, the larger part of the thickly populated section of the town being within that portion of the water-shed of the Sudbury River which drains toward Lake Cochituate, one of the sources of water supply of the Metropolitan District. The principal industry is the manufacture of shoes, although there are several factories of other kinds in the town.

A public water supply was introduced in the year 1874 and is now generally used throughout the town. The average daily consumption of water during the year 1898 was 369,000 gallons, or 43 gallons per capita.

The sewerage system was completed in 1896, the cost of construction being paid in part by the city of Boston. Before the construction of the system much of the sewage found its way directly or indirectly into Lake Cochituate through Pegan Brook, which flows through the densely settled portion of the town, and in addition to removing the sewage, provision has been made for filtering the water of Pegan Brook before it enters the lake. The sewage is collected in a system of pipe sewers and conveyed through a main sewer built of brick and iron to a reservoir situated on the westerly side of Lake Cochituate, from which it is pumped to filter-beds adjacent to the Framingham filter-beds, about 1.5 miles from the pumping station.

The system is in many respects similar to the system in the adjoining town of Framingham, which has been previously described.

The system was built on the separate plan, and was designed to exclude all surface water, so far as practicable, from the sewers. No permanent underdrains were constructed beneath the sewers, as there could be no outlet for them except into Lake Cochituate or its tributaries, unless the water should be pumped. Much water was encountered in the ground when the sewers were constructed, and the leakage of ground water into the sewers is very great, especially at times when the level of the water in the ground is high. The lateral sewers are constructed of earthen pipe. The main sewer is of brick, except in one place where it is laid for a distance of 2,500 feet near the shore of Lake Cochituate, where iron pipe is used instead of brick in order to prevent leakage from the sewer into the lake.

At the end of the year 1898 there were 8.58 miles of sewers in the town and 263 connections had been made with the system, which may be roughly classified as follows: —

Single houses,	96
Tenement-houses,	116
Business blocks,	28
Factories,	8
Hotels,	4
Laundries, school-houses, churches, etc.,	11
Total connections,	263

The quantity of sewage varies greatly and at times of storm is very large. The influence of a storm is quickly felt, which would indicate that surface water gets into the sewers more or less directly. At times when the level of the water in the ground is high the flow of sewage is uniformly large. Records are kept of the quantity of sewage pumped each day, and although these records are not accurate, as the slip of the pumps varies from time to time, they serve to give an approximate indication of the quantity of sewage flowing. The following table gives the average daily quantity of sewage pumped each month since the records have been kept: —

Average Daily Flow of Sewage from Natick.

[Gallons per Day.]

Month.	1897.	1898.	Month.	1897.	1898.
January,	299,000	446,000	August,	293,000	405,000
February,	342,000	631,000	September,	254,000	308,000
March,	447,000	668,000	October,	208,000	341,000
April,	495,000	565,000	November,	294,000	651,000
May,	387,000	567,000	December,	469,000	736,000
June,	360,000	435,000			
July,	288,000	292,000	Average,	345,000	503,000

The average quantity of sewage per day flowing from the main sewer during the year 1898 was 503,000 gallons, while the maximum flow in any one day was 1,562,000 gallons, or about three times the average. The minimum quantity of sewage flowing in any one day was 159,000 gallons, which is only one-tenth of the maximum flow. The following table gives the average, maximum and minimum daily flow for each inhabitant, each connection with the sewers and each mile of sewers constructed : —

	Average (Gallons per Day).	Maximum (Gallons per Day).	Minimum (Gallons per Day).
Total flow,	503,000	1,562,000	159,000
Flow per inhabitant,	58.3	181.0	18.4
Flow per connection,	1,913	5,939	605
Flow per mile of sewers,	58,600	182,000	18,500

In addition to the records of the flow of sewage kept by the engineer at the pumping station, a series of measurements has been made under the direction of the Board by means of an automatic recording gauge which registers the height of water on a weir. These special measurements were continued for several weeks during the spring of 1899, and the following table gives the average daily flow as indicated by the observations, together with the maximum and minimum flow for each day and the hour when each occurred : —

Date.	Day of Week.	Quantity of Sewage (Gallons per Day).	Rate of Maximum Flow (Gallons per Day).	Hour at which Maximum Flow Occurred.	Rate of Minimum Flow (Gallons per Day).	Hour at which Minimum Flow Occurred.
1899.						
March 19,	Sunday,	1,063,000	1,300,000	7 P.M.	832,000	1-5 A.M.
20,	Monday,	1,231,000	1,300,000	3 P.M.	1,162,000	5 and 6 A.M., 12 P.M.
21,	Tuesday,	1,146,000	1,202,000	9-11 A.M.	1,075,000	12 P.M.
22,	Wednesday,	1,118,000	1,170,000	9-11 A.M.	1,045,000	6-7 A.M.
23,	Thursday,	1,200,000	1,308,000	6 P M.	1,125,000	1-5 A M.
24,	Friday,	1,287,000	1,315,000	1-10 P.M.	1,215,000	6-7 A M.
26,	Sunday,	1,153,000	1,220,000	10-12 P.M.	1,102,000	11-12 P.M.
27,	Monday,	1,128,000	1,182,000	5 P M.	1,075,000	6-7 A.M.
28,	Tuesday,	1,154,000	1,222,000	1 P.M.	1,110,000	5-7 A M.
29,	Wednesday,	1,264,000	1,358,000	2-3 P.M.	1,132,000	1-2 A.M.
30,	Thursday,	1,197,000	1,235,000	9 A.M.-5 P.M.	1,128,000	12 P.M.
31,	Friday,	1,145,000	1,182,000	10 A.M.-5 P.M.	1,088,000	12 P.M.
April 1,	Saturday,	1,088,000	1,150,000	11 A.M.	1,045,000	12 P M.
2,	Sunday,	1,047,000	1,075,000	11 A.M.-5 P.M.	1,010,000	12 P M.
3,	Monday,	1,018,000	1,078,000	8-12 A M.	950,000	11-12 P.M.
4,	Tuesday,	974,000	1,048,000	1-2 P.M.	912,000	5-6 A.M., 12 P.M.
5,	Wednesday,	937,000	1,020,000	9-10 A.M.	870,000	12 P.M.
6,	Thursday,	896,000	980,000	11 A.M.	840,000	11-12 P M.
7,	Friday,	882,000	960,000	10-11 A.M.	832,000	2-7 A.M.
8,	Saturday,	992,000	1,150,000	1-2 P.M.	840,000	1-3 A.M.
9,	Sunday,	1,004,000	1,102,000	10 A M.-3 P.M.	942,000	12 P M.
10,	Monday,	978,000	1,102,000	12 M.	895,000	12 P.M.
11,	Tuesday,	930,000	1,025,000	3 P.M.	865,000	12 P M.
12,	Wednesday,	905,000	1,000,000	2-3 P.M.	838,000	12 P.M.
13,	Thursday,	881,000	990,000	10-11 A.M.	802,000	12 P.M.
14,	Friday,	845,000	945,000	3 P.M.	780,000	4-6 A M., 12 P.M.
15,	Saturday,	831,000	912,000	1-4 P.M.	768,000	2-6 A.M.
16,	Sunday,	791,000	875,000	12 M.	745,000	5-7 A.M., 6-10 P.M.
17,	Monday,	858,000	980,000	12 M.	755,000	1 A.M.
18,	Tuesday,	860,000	965,000	5 P.M.	785,000	12 P.M.
19,	Wednesday,	804,000	930,000	10 A.M.	742,000	12 P M.
20,	Thursday,	795,000	900,000	11 A.M.	732,000	2-7 A.M., 10-12 P.M.
21,	Friday,	776,000	858,000	9 A.M.-1 P.M., 3 P.M.	720,000	1-5 A.M.
22,	Saturday,	788,000	1,222,000	5 P.M.	715,000	3, 5, 6 A M.
23,	Sunday,	724,000	875,000	11 A M.	671,000	12 P.M.
24,	Monday,	723,000	804,000	2 P M.	652,000	12 P M.
25,	Tuesday,	713,000	824,000	2 P.M.	635,000	12 P.M.
26,	Wednesday,	689,000	785,000	8 A M.	629,000	10-12 P M.
27,	Thursday,	667,000	758,000	2 P M.	611,000	1-4 A.M., 12 P M.
28,	Friday,	666,000	761,000	8 A.M.	604,000	12 P.M.
29,	Saturday,	677,000	804,000	11-12 A.M.	604,000	1-5 A M.
30,	Sunday,	649,000	790,000	9 A M.	580,000	12 P.M.
May 1,	Monday,	672,000	796,000	2 P M.	585,000	1-4 A.M.
7,	Sunday,	498,000	621,000	10-11 A.M.	463,000	2-7 A.M.
8,	Monday,	530,000	635,000	3 P M.	455,000	4-5 A M.
9,	Tuesday,	516,000	630,000	9-11 A M.	455,000	3-6 A M.
10,	Wednesday,	508,000	602,000	3 P.M.	445,000	5-6 A M.
11,	Thursday,	501,000	595,000	9-10 A.M.	445,000	1-6 A M.
12,	Friday,	500,000	595,000	10 A M.	438,000	2-6 A.M.
13,	Saturday,	494,000	585,000	11 A M.	437,000	2-3 A M.
14,	Sunday,	462,000	556,000	11-12 A.M.	428,000	3-6 A M.
15,	Monday,	491,000	601,000	11 A.M.	426,000	2-4 A.M.
16,	Tuesday,	491,000	628,000	1 P M.	426,000	1-7 A M.
17,	Wednesday,	458,000	589,000	4 P.M.	415,000	4 A.M
18,	Thursday,	480,000	571,000	10 A.M.	409,000	4-6 A M.
19,	Friday,	475,000	574,000	1, 3 P M.	415,000	4 A M.
June 8,	Thursday,	278,000	318,000	11 A M.	252,000	1-4 A.M , 9-10 P.M.
9,	Friday,	321,000	425,000	1 P.M.	253,000	12 P.M.
10,	Saturday,	295,000	401,000	8 A.M.	245,000	2-4 A M.
11,	Sunday,	264,000	283,000	11 A M.	240,000	4 A.M.
12,	Monday,	362,000	614,000	2 P.M.	246,000	2 A M.
13,	Tuesday,	335,000	535,000	11 A M.	250,000	3 A M.
14,	Wednesday,	336,000	535,000	10 A.M.	255,000	3-4 A M.
15,	Thursday,	336,000	515,000	10 A.M.	236,000	1 A.M.

Very little manufacturing sewage enters the sewers, so that the sewage consists chiefly of a mixture of house sewage with a varying quantity of ground water. The average sewage is very much weaker than the sewage from most of the other cities and towns in the State where the sewage is purified.

At the pumping station the sewage passes through screens placed in a screen chamber at the end of the main sewer. These screens consist of vertical iron plates with an open space between them of three-quarters of an inch. The total area of the screens is 17 square feet. The screens are so arranged that when they are clean the sewage will all pass through the lower portion, and as the screens become clogged the sewage will rise until eventually it will flow over the top of the screens. The screens are generally cleaned once in two days, the material removed being burned beneath the boilers. At times of high flow the sewage is so dilute and there is such a small amount of solid matter in the sewage that the screens are removed, and everything brought down by the sewers passes to the pumps.

The sewage, after passing through the screens, is received in a covered masonry reservoir having a capacity of 500,000 gallons, which is designed to receive sewage during the night so that pumping is necessary only during the daytime. The solid matter which accumulates at the bottom of this reservoir is removed occasionally by mixing it with a small quantity of sewage and then pumping the mixture to the filtration area.

The pumping plant consists of two pumps having capacities of 1,000,000 gallons and 2,000,000 gallons per day respectively. The valves in the pumps are ordinary water valves, and some trouble has been experienced by solid matter getting beneath the valves. The force main from the pumping station to the filtration area is of cast-iron pipe 16 inches in diameter and 7,861 feet in length. The force main is so arranged that all of the sewage in the pipe at the time the pumps are stopped remains in the pipe until pumping is resumed the next day. The quantity of sewage remaining in the pipe in this way is 82,000 gallons.

The filtration area is situated about two miles north-west of the village and is adjacent to the Framingham filtration area, which has already been described. The effluent from the two fields enters the same brook and the conditions at the two places are very much the same. The total area of land owned by the town of Natick is 97½ acres, on which six filter-beds have been constructed, having an average area of about an acre each. The beds were prepared for the filtration of sewage by the removal of the soil and subsoil. The character of the filtering material in each bed at different depths has been determined by analysis, and the following table gives the average results of these analyses for each depth: —

Depth Below Surface (Feet).	Effective Size (Millimeters).			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
0, ...	.15	.29	.04	7.0	15.8	2.4	18.2	33.7	7.0
0.25, ...	.13	.26	.04	6.6	12.6	2.5	13.3	21.3	3.6
0.50, ...	.13	.26	.04	6.9	15.1	2.3	12.0	18.1	3.8
1.00, ...	.15	.28	.04	5.3	11.0	1.8	7.0	14.4	1.4
2.50, ...	.18	.25	.09	3.3	5.6	1.9	4.1	11.0	1.0

The beds are underdrained by lines of pipe placed 36 feet apart at a depth of about 6 feet beneath the surface. No provision has been made for the distribution of the sewage at different parts of the surface, but the sewage is applied directly on the beds from manholes at each corner. The sewage is applied to each of the beds in rotation, one of the beds generally receiving the entire flow for a day, but at times of high flow it is allowed to flow upon two of the beds at the same time. The beds are prepared for winter by furrowing the surfaces. A crop of corn was raised on each of the beds in the summer of 1898. The quantity of sewage purified on this filtration area is very large, especially at times of wet weather. The sewage is weak, so that it is possible to purify a much larger quantity per acre than can be purified at Framingham, where the average sewage is several times as strong as at Natick. It is said that practically all of the sewage has been purified since the works were completed, and only a very small quantity has been discharged directly into Bannister Brook without purification. The average quantity of sewage purified per acre during 1898 was 84,000 gallons per day. During the month of maximum flow the average quantity purified was 123,000 gallons per acre daily.

Two series of analyses have been made of samples of sewage collected from the main sewer at frequent intervals for a period of twenty-four hours, to show the variation in character of the sewage during the day. The results of these analyses are shown in the following table: —

Chemical Examination

[Parts per 100,000.]

	Number.	Date.	Hour.	Temperature. Deg. F.	RESIDUE ON EVAPORATION. TOTAL RESIDUE. Total.	Dissolved.	Suspended.	LOSS ON IGNITION. Total.	Dissolved	Suspended.
		1898.								
1	23482	June 8	5.00 and 6.00 P.M.	53.0	29.80	23.00	6.80	9.40	4.20	5.20
2	23483	June 8	7.00 and 8.00 P.M.	52.0	29.00	23.30	5.70	10.60	5.60	5.00
3	23484	June 8	9.00 and 10.00 P.M.	52.0	24.20	23.80	0.40	5.60	5.20	0.40
4	23485	June 8	11.00 and 12.00 P.M.	52.5	20.80	20.70	0.10	3.50	3.50	0.00
5	23486	June 9	1.00 and 2.00 A.M.	52.0	21.30	21.00	0.30	6.40	6.20	0.20
6	23487	June 9	3.00 and 4.00 A.M.	51.5	21.10	20.90	0.20	6.10	6.00	0.10
7	23488	June 9	5.00 and 6.00 A.M.	51.7	20.70	20.10	0.60	6.00	5.60	0.40
8	23489	June 9	7.00 and 8.00 A.M.	51.0	21.10	21.00	0.10	5.00	5.00	0.00
9	23490	June 9	9.00 and 10.00 A.M.	53.7	23.90	23.00	0.90	3.80	3.00	0.80
10	23491	June 9	11.00 and 12.00 A.M.	53.5	31.00	26.90	4.10	6.60	4.40	2.20
11	23492	June 9	1.00 and 2.00 P.M.	54.5	24.30	22.70	1.60	6.20	4.70	1.50
12	23493	June 9	3.00 and 4.00 P.M.	54.0	27.00	22.80	4.20	8.50	4.50	4.00
13	24198	Aug. 8	4.00 and 5.00 P.M.	–	214.00	42.20	171.80	133.20	20.00	113.20
14	24199	Aug. 8	6.00 and 7.00 P.M.	57.0	451.60	47.60	404.00	276.00	22.00	254.00
15	24200	Aug. 8	8.00 and 9.00 P.M.	56.0	3028.40	64.00	2964.40	2772.00	37.20	2734.80
16	24201	Aug. 8	10.00 and 11.00 P.M.	56.0	1972.80	86.80	1886.00	1488.40	46.60	1441.80
17	24202	Aug. 8, 9	12.00 and 1.00 A.M.	57.0	851.20	71.80	779.40	543.20	41.20	502.00
18	24203	Aug. 9	2.00 and 3.00 A.M.	56.0	57.60	23.80	33.80	27.60	7.00	20.60
19	24204	Aug. 9	4.00 and 5.00 A.M.	56.0	30.00	22.20	7.80	9.20	6.40	2.80
20	24205	Aug. 9	6.00 and 7.00 A.M.	57.0	37.20	24.00	13.20	13.60	6.40	7.20
21	24207	Aug. 9	8.00 and 9.00 A.M.	56.0	36.80	29.80	7.00	10.80	4.80	6.00
22	24208	Aug. 9	10.00 and 11.00 A.M.	57.0	117.60	37.20	80.40	45.60	6.20	39.40
23	24209	Aug. 9	12.00 and 1.00 P.M.	77.0	136.00	37.20	98.80	73.60	13.80	59.80
24	24210	Aug. 9	2.00 and 3.00 P.M.	58.0	79.60	31.60	48.00	42.80	12.40	30.40

The samples were collected from the end of the main sewer as it discharges into

As before stated, the night flow of sewage is stored in the reservoir at the pumping station and pumped only during the daytime. When the pumps are stopped a considerable quantity of sewage remains in the force main until the pumps are started, so that some of the sewage is quite stale by the time it reaches the filtration area. In order to ascertain the changes which occur in the character *of Sewage from Natick.*

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
Free.	Albuminoid.				Nitrates.	Nitrites.	Unfiltered.	Filtered.	
	Total.	Dissolved.	Suspended.						
0.5280	0.2120	0.0880	0.1240	4.50	.0010	.0013	1.60	1.00	1
0.6400	0.2960	0.0960	0.2000	3.72	.0020	.0640	2.78	2.06	2
0.4320	0.1200	0.0560	0.0640	4.65	.2750	.0900,	1.18	0.90	3
0.2720	0.1800	0.0500	0.1300	3.63	.2250	.1040	0.74	0.62	4
0.2720	0.0880	0.0300	0.0580	3.25	.4700	.0480	0.54	0.30	5
0.1600	0.0400	0.0300	0.0100	3.14	.4750	.0340	0.38	0.26	6
0.2080	0.1280	0.0260	0.1020	3.09	.4800	.0340	0.45	0.26	7
0.3760	0.1200	0.0400	0.0710	3.25	.3700	.0640	1.12	0.40	8
1.1360	0.2520	0.1040	0.1480	5.15	.1100	.1360	0.80	0.61	9
0.8160	0.2480	0.0980	0.1500	7.09	.0030	.0760	1.57	0.80	10
0.7040	0.2760	0.1280	0.1480	3.87	.0020	.0000	1.76	1.04	11
0.3360	0.1160	0.0520	0.0640	3.91	.0040	.0000	2.11	1.33	12
2.1800	3.6000	0.4400	3.1600	2.83	.0000	.0000	13.60	3.52	13
2.0200	4.3000	0.5200	3.7800	6.35	.0010	.0000	28.00	9.56	14
4.0600	18.8000	1.1000	17.7000	4.20	.1580	.0000	60.80	9.08	15
3.5700	24.4000	1.7000	22.7000	6.42	.2640	.0000	86.40	9.60	16
11.6000	12.1000	1.6700	10.4300	3.55	.0000	.0000	77.60	5.60	17
1.1200	1.0500	0.1100	0.9400	4.41	.0000	.0024	15.20	0.48	18
0.1500	0.2900	0.0550	0.2350	3.80	.0000	.0850	1.28	0.20	19
0.1650	0.1500	0.0450	0.1050	3.55	.0000	.0650	1.12	0.16	20
0.7500	0.2200	0.0900	0.1300	7.91	.0350	.0800	1.60	0.56	21
1.5200	0.3500	0.2000	0.1500	11.98	.0000	.0000	5.12	1.20	22
1.8000	1.2500	0.2900	0.9600	7.95	.0000	.0000	15.20	2.24	23
1.4000	0.7500	0.2100	0.5400	4.38	.0000	.0000	5.60	3.60	24

the reservoir. Each sample was made up of 2 equal portions collected hourly.

of the sewage between the time it reaches the pumping station and the time it is distributed on the filter-beds, a series of analyses was made in the spring of 1899, the results of which are shown in the tables which follow. Several samples of effluent were collected in the course of a single day during the investigations, the results of which are appended.

Chemical Examination of Sewage

[Parts per 100,000.]

	Number.	Date.	Hour.	Rate of Flow. — Gallons per 24 Hours.	Temperature. — Deg. F.	Residue on Evaporation. Total Residue. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Suspended.
		1899.									
1	26762	Apr. 14	6 to 11.30 P.M.	770,880	-	22.40	21.00	1.40	8.80	7.70	1.10
2	26763	Apr. 15	12 P M. to 5.30 A.M.	751,925	-	19.70	18.90	0.80	6.70	5.90	0.80
3	26776	Apr. 15	6 to 11.30 A.M.	837,115	-	22.00	20.00	2.00	8.00	7.00	1.00
4	26784	Apr. 15	12 M. to 5.30 P.M.	836,165	54.2	25.50	24.30	1.20	10.50	10.20	0.30
5	26789	Apr. 15	6 to 11.30 P.M.	754,800	44.3	22.50	21.00	1.50	10.00	8.50	1.50
6	26790	Apr. 16	12 to 5.30 A.M.	711,600	44.0	20.50	19.50	1.00	7.00	7.00	0.00
7	26803	Apr. 16	6 to 11.30 A.M.	773,600	45.7	20.00	19.50	0.50	7.80	7.50	0.30
8	26810	Apr. 16	12 M. to 5.30 P.M.	828,480	46.0	22.50	21.00	1.50	8.00	7.20	0.80
9	26813	Apr. 16	6 to 11.30 P.M.	756,800	44.0	20.90	20.60	0.30	8.50	8.50	0.00
10	26814	Apr. 17	12 to 5.30 A.M.	760,800	43.8	19.80	19.50	0.30	7.20	7.00	0.20
11	26827	Apr. 17	6 to 11.30 A.M.	864,400	44.3	21.00	19.50	1.50	7.50	6.50	1.00
12	26843	Apr. 17	12 M to 5.30 P.M.	919,200	44.5	21.00	19.80	1.20	6.50	5.30	1.20
13	26851	Apr. 17	6 to 11.30 P.M.	836,400	44.0	20.50	19.00	1.50	7.20	6.30	0.90
14	26852	Apr. 18	12 to 5.30 A.M.	795,200	44.0	18.70	18.00	0.70	6.50	6.30	0.20

The samples were collected from the end of the main sewer as it discharges into the

Chemical Examination of Sewage

[Parts per 100,000.]

	Number.	Date.	Hour.	Rate of Pumping. — Gallons per 24 Hours.	Temperature. — Deg. F.	Residue on Evaporation. Total Residue. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Suspended.
		1899.									
1	26775	April 15	7.30 to 10.00 A.M.	-	-	20.50	19.20	1.30	8.20	7.60	0.60
2	26782	April 15	10.30 A.M. to 1.00 P.M.	1,766,928	41.7	25.90	16.40	9.50	10.00	8.00	2.00
3	26783	April 15	1.30 to 4.00 P M.	1,800,576	47.0	23.60	21.50	2.10	8.20	8.00	0.20
4	26802	April 16	7.30 to 10.00 A.M.	1,749,357	46.0	20.50	19.80	0.70	7.60	7.00	0.60
5	26804	April 16	10.30 A.M. to 1.00 P.M.	1,650,400	46.2	20.80	20.80	0.00	7.30	7.30	0.00
6	26808	April 16	1.30 to 4.00 P.M.	1,618,200	46.3	25.50	20.70	4.80	9.80	6.00	3.80
7	26828	April 17	7.30 to 8.30 A M.	2,294,200	45.9	21.00	19.70	1.30	7.00	6.90	0.10
8	26829	April 17	9.00 to 10.00 A.M.	1,967,400	46.6	21.70	20.20	1.50	7.50	7.00	0.50
9	26830	April 17	10.30 to 11.30 A.M.	2,025,200	46.6	20.30	19.50	0.80	6.50	6.30	0.20
10	26844	April 17	12.00 to 1.00 P.M.	1,832,500	46.5	21.50	20.00	1.50	7.70	7.00	0.70
11	26845	April 17	1.30 to 2.30 P.M	1,339,800	46.5	21.30	19.90	1.40	7.60	7.10	0.50
12	26846	April 17	3.00 to 4.00 P.M.	1,873,400	46.5	21.50	20.90	0.60	6.50	6.40	0.10

The samples were collected from a tap in one of the sewage pumps while pumping sewage from the *from the Main Sewer at Natick.*

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
Free.	Albuminoid.				Nitrates.	Nitrites.	Unfiltered.	Filtered.	
	Total.	Dis-solved.	Sus-pended.						
.3160	.1120	.0960	.0160	2.88	.4300	.0340	1.09	0.93	1
.1400	.0880	.0560	.0320	2.61	.5790	.0180	0.42	0.27	2
.3280	.1400	.0900	.0500	2.72	.3800	.0220	0.93	0.83	3
.3600	.1360	.1080	.0280	2.80	.5400	.0340	2.48	2.24	4
.3140	.0980	.0740	.0240	2.83	.5300	.0280	1.60	1.18	5
.1680	.0680	.0430	.0250	2.95	.6200	.0260	0.51	0.29	6
.2000	.0620	.0470	.0150	2.70	.5000	.0240	0.58	0.50	7
.4080	.1180	.0850	.0330	2.90	.1500	.0320	1.76	1.15	8
.3120	.0680	.0580	.0100	2.80	.7000	.0280	0.96	0.78	9
.1600	.0400	.0340	.0060	2.47	.6800	.0240	0.51	0.46	10
.8000	.0980	.0680	.0300	2.68	.4750	.0280	0.86	0.77	11
.6000	.1680	.1200	.0480	3.25	.4400	.0320	2.64	2.02	12
.3040	.1000	.0610	.0390	3.00	.4000	.0260	1.52	1.31	13
.1360	.0420	.0370	.0050	2.60	.4400	.0220	0.48	0.38	14

reservoir. Each sample was made up of 12 equal portions collected each half hour.

from the Pumping Station at Natick.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
Free.	Albuminoid.				Nitrates.	Nitrites.	Unfiltered.	Filtered.	
	Total.	Dis-solved.	Sus-pended.						
.2160	.0480	.0460	.0020	2.68	.5900	.0300	0.83	0.69	1
.3540	.1080	.0950	.0130	2.95	.5200	.0320	1.52	1.15	2
.3140	.0980	.0750	.0230	2.75	.5300	.0380	1.02	0.89	3
.2000	.0620	.0500	.0120	2.67	.5800	.0320	0.54	0.51	4
.3120	.1040	.0810	.0230	2.85	.6200	.0360	0.93	0.82	5
.3680	.2260	.0880	.1380	2.80	.1050	.0420	2.32	2.27	6
.2080	.0640	.0420	.0220	2.56	.4750	.0240	0.74	0.51	7
.3920	.1320	.0880	.0440	2.73	.4850	.0380	1.18	0.94	8
.3440	.0740	.0610	.0130	2.65	.5150	.0340	0.67	0.61	9
.3600	.1180	.0770	.0410	2.82	.4350	.0260	1.18	1.10	10
.3680	.1260	.0870	.0390	2.89	.4600	.0260	2.30	1.94	11
.3440	.0980	.0710	.0270	2.72	.4500	.0300	1.76	1.47	12

reservoir to the filtration area. Each sample was made up of equal portions collected each half hour.

Chemical Examination of Sewage

[Parts per 100,000.]

	Number.	Date.	Hour.	Rate of Flow. — Gallons per 24 Hours.	Temperature. — Deg. F.	Residue on Evaporation. Total Residue. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Suspended.
		1899.									
1	26772	Apr. 15	7.31 to 7.51 A.M.	-	-	22.40	19.50	2.90	7.70	5.50	2.20
2	26773	Apr. 15	8.01 to 8.21 A.M.	-	-	21.00	20.00	1.00	6.30	5.80	0.50
3	26774	Apr. 15	8.30 to 11.00 A.M.	1,746,900	45.5	20.40	20.20	0.20	7.30	7.30	0.00
4	26785	Apr. 15	11.30 A.M. to 2.00 P.M.	1,781,200	46.0	23.40	22.30	1.10	9.20	8.30	0.90
5	26786	Apr. 15	2.30 to 4.50 P.M.	2,198,100	46.2	21.80	21.00	0.80	7.00	6.70	0.30
6	26798	Apr. 16	7.28 to 7.48 A.M.	1,828,800	45.0	20.20	19.80	0.40	6.00	5.80	0.20
7	26799	Apr. 16	7.58 to 8.18 A.M.	1,856,200	45.1	21.30	20.10	1.20	8.10	7.20	0.90
8	26800	Apr. 16	8.30 to 11.00 A.M.	1,685,900	45.5	20.30	20.00	0.30	8.80	8.50	0.30
9	26801	Apr. 16	11.30 A.M. to 2.00 P.M.	1,639,500	45.8	20.50	19.80	0.70	6.50	6.40	0.10
10	26809	Apr. 16	2.30 to 5.00 P.M.	1,608,900	45.5	26.40	20.60	5.80	10.80	7.30	3.50
11	26824	Apr. 17	7.30 to 7.50 A.M.	2,095,800	-	20.40	18.30	2.10	7.50	7.30	0.20
12	26825	Apr. 17	8.00 to 8.20 A.M.	2,337,100	-	25.50	19.00	6.50	10.70	6.00	4.70
13	26826	Apr. 17	8.30 to 11.00 A.M.	2,008,800	-	21.50	19.50	2.00	8.50	8.50	0.00
14	26841	Apr. 17	11.30 A.M. to 2.00 P.M.	1,732,300	-	21.10	19.50	1.60	7.10	6.90	0.20
15	26842	Apr. 17	2.30 to 5.00 P.M.	1,746,700	45.0	21.00	19.00	2.00	7.00	5.70	1.30
16	26861	Apr. 18	7.32 to 8.22 A.M.	-	44.5	21.00	19.50	1.50	7.70	6.50	1.20
17	26862	Apr. 18	8.30 to 10.30 A.M.	-	-	20.60	20.20	0.40	6.70	6.60	0.10

The samples were collected from a manhole at the end of the force main as the sewage was dis-
intervals. The first samples each day represent sewage which has remained in the force main for about

Chemical Examination of Effluent

[Parts per 100,000.]

	Number.	Date of Collection.	Hour.	Appearance. Turbidity.	Sediment.	Color.	Odor. Cold.	Hot.
		1899.						
1	26831	April 17	9.15 A.M.	V. slight.	V. slight.	.07	Faintly musty.	Distinctly musty and disagreeable.
2	26832	April 17	10.00 A.M.	V. slight.	V. slight.	.10	Faintly musty.	Distinctly musty and disagreeable.
3	26833	April 17	11.00 A.M.	V. slight.	V. slight.	.08	Faintly musty.	Distinctly musty and disagreeable.
4	26834	April 17	12.00 M.	V. slight.	V. slight.	.07	Faintly musty.	Distinctly musty and disagreeable.
5	26847	April 17	3.15 P.M.	V. slight.	V. slight.	.07	Distinctly musty.	Distinctly musty and disagreeable.

The samples were collected from the main underdrain at *from the Filtration Area at Natick.*

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		
Free.	Albuminoid.				Nitrates.	Nitrites.	Unfiltered.	Filtered.	
	Total.	Dis-solved.	Sus-pended.						
.2640	.1160	.0500	.0660	2.78	.3900	.0560	1.28	0.80	1
.2720	.1000	.0520	.0480	2.73	.3000	.0260	0.96	0.78	2
.2600	.0700	.0480	.0220	2.69	.5200	.0280	0.83	0.69	3
.3620	.0880	.0720	.0160	2.80	.5200	.0360	1.44	1.02	4
.3020	.0820	.0680	.0140	2.65	.4700	.0360	1.25	1.10	5
.3120	.1080	.0680	.0400	2.74	.3500	.0600	1.34	1.26	6
.3200	.1100	.0680	.0420	2.75	.3300	.0600	1.57	1.28	7
.2160	.0760	.0500	.0260	2.70	.4800	.0400	0.77	0.61	8
.3040	.0820	.0660	.0160	2.88	.4500	.0340	0.90	0.77	9
.4000	.2720	.0730	.1990	2.85	.1000	.0520	2.56	0.93	10
.3360	.0900	.0550	.0350	2.80	.3850	.0700	0.88	0.64	11
.3200	.5920	.0640	.5280	2.72	.3900	.0500	1.36	0.61	12
.3200	.1200	.0400	.0800	2.62	.4750	.0360	1.20	0.70	13
.4160	.1040	.0740	.0300	2.88	.4400	.0260	1.20	0.86	14
.3840	.1060	.0760	.0300	2.87	.4300	.0340	1.84	1.44	15
.3280	.1000	.0520	.0480	2.75	.3900	.0440	1.04	0.74	16
.2720	.0740	.0470	.0270	2.70	.4200	.0300	0.80	0.58	17

charged upon the filter-beds. The samples were made up of equal portions collected at frequent fourteen hours.

from the Natick Filter-beds.

[Parts per 100,000.]

Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.	
	Free.	Albu-minoid.		Nitrates.	Nitrites.				
13.20	.0800	.0125	2.25	.1850	.0022	.22	4.6	.0040	1
11.90	.0800	.0115	2.24	.2350	.0026	.21	4.3	.0030	2
13.30	.0800	.0115	2.20	.2250	.0024	.22	4.4	.0030	3
13.50	.0800	.0115	2.20	.2150	.0028	.22	4.4	.0030	4
14.00	.1060	.0150	2.25	.1400	.0024	.17	4.3	.0030	5

its outlet while sewage was being applied to the beds.

During the past two years, frequent analyses of samples of sewage collected from the end of the force main where it flows on the beds, and of the effluent have been made. The yearly averages of these results are given in the following tables: —

Yearly Averages of Chemical Examinations of Sewage from Natick.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.							
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved.	Sus-pended.		Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.
1897	26.99	24.75	2.24	8.14	6.95	1.19	.5891	.1636	.1030	.0606	3.93	.2858	.0175	1.21	.90
1898	26.12	23.67	2.45	7.07	5.96	1.11	.7812	.1950	.1006	.0944	4.25	.2116	.0490	1.19	.78

The samples were collected from a manhole at the end of the force main as the sewage was discharged upon the filter-beds.

Yearly Averages of Chemical Examinations of Effluent from the Underdrain of the Natick Filter-beds.

[Parts per 100,000.]

Year.	Residue on Evaporation	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
		Free.	Albuminoid.		Nitrates	Nitrites.	
1897, ...	19.68	.0329	.0134	3.46	.4450	.0092	.28
1898, ...	20.55	.0789	.0139	3.42	.5193	.0063	.24

The samples were collected from the underdrain at the point where it discharges into Bannister Brook.

The purification effected, as indicated by the free and albuminoid ammonia and the oxygen consumed, in the sewage and effluent, is shown in the following table. It will be seen that the efficiency of these beds is not so great as those at Framingham. It will be noticed, however, that the effluent from the Natick beds is very nearly as pure as the effluent from the Framingham beds, but the sewage applied is very much weaker.

Purification effected by the Natick Filters.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. removed.	Sewage.	Effluent.	Per Cent. removed.	Sewage.	Effluent.	Per Cent. removed.
1897, ...	.5891	.0329	94.4	.1636	.0134	91.8	1.21	.28	76.9
1898, ...	.7812	.0789	89.9	.1950	.0139	92.9	1.19	.24	79.8

Few regular observations of the temperature of the sewage have been made. During the special investigations, the results of which are given in the preceding tables, the temperature of the sewage was observed at the end of the main sewer, at the pumps and at the filtration area. The results of these observations are given in the preceding tables. The temperature was also observed during a very cold period in February of 1899, when it was found that the temperature of the sewage as it entered the receiving reservoir was 53°, while the temperature as it flowed out upon the filter-beds was 47°.

The effluent from the filter-beds is discharged into Bannister Brook, which is tributary to the Sudbury River below the point where water is taken for the supply of the Metropolitan District. The brook at this point has a water-shed of 2.05 square miles. There is no population in the immediate vicinity of the filter-beds or in the vicinity of the brook below the point where it receives the effluent, and the population within half a mile of the filter beds is only about 50. Analyses of samples of water from Bannister Brook below the point where it receives the effluent from the Natick and Framingham filter-beds are given on page 619.

North Brookfield.

Estimated population in 1898, 5,093.

North Brookfield is situated within the water-shed of the Quaboag River. A large proportion of the population is situated in one village, in which there is a large shoe factory employing about 1,100 persons. The sewerage system was begun in 1892, and at first the sewage was discharged directly into a brook which flowed through the village. In 1893 the main sewer was extended so as to discharge the sewage by gravity upon land at the town farm.

The town is provided with a public water supply, the average daily consumption of water during 1898 being 155,000 gallons, or about 30 gallons per capita. The total length of sewers in use at the end of 1898 was 1.41 miles, and there were 23 houses connected with the sewers, besides the shoe factory already mentioned.

The system is designed to carry only house sewage, but some water from the roofs of the shoe factory is also discharged into the system at present. Only a small quantity of manufacturing sewage, which comes from the vats in the treeing room of the factory, enters the sewers.

A measurement of the flow of sewage was made on Sept. 8 and 9, 1898, at which time it was found that there was a daily flow of 50,000 gallons, a maximum rate of 68,000 gallons per day and a minimum rate of 34,000 gallons per day. The high flow during the night indicated that a large proportion of the total quantity flowing during the day was from leakage, and that the quantity of sewage proper was not much in excess of 16,000 gallons per day. The temperature of the sewage varied from 61° during the minimum flow at night to 63° at midday, when the largest quantity of sewage was flowing.

A sample of sewage composed of 24 equal portions collected hourly was taken for analysis at the same time the measurement was made, and the results are shown in the following table: —

Chemical Examination of Sewage from North Brookfield.

[Parts per 100,000.]

Number.	Date of Collection.	Flow. — Gallons per 24 Hours.	Temperature. — Deg. F.	Residue on Evaporation. Total Residue. Total.	Dissolved.	Suspended.	Loss on Ignition. Total.	Dissolved.	Suspended.
24585	1898. Sept. 8, 9	50,000	62	24.80	18.50	6.30	13.10	7.80	5.30

Chemical Examination of Sewage from North Brookfield — Concluded.

[Parts per 100,000.]

Number.	Ammonia. Free.	Albuminoid. Total.	Dissolved.	Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed. Unfiltered.	Filtered.
24585	1.5000	.3200	.1300	.1900	2.49	.0000	.0000	4.40	3.02

The sample was collected from the sewer as it entered the siphon tank, and was composed of 24 equal portions collected hourly.

In order to reach the disposal area it is necessary for the sewer to cross the valley of a brook, and sewage is conveyed across this valley by means of an inverted siphon, at the upper end of which is a screen chamber and siphon tank. The screens are composed of iron bars with an open space between them of one inch, the total area of the screen varying from nothing, when the tank is empty, to 30 square feet, when the tank is full. When the screens become clogged, the sewage rises and flows over the top of the screens into the tank. The screens are cleaned about once a month and the screenings removed in a cart to the town farm, where they are used as a fertilizer. The total amount removed during the year is said to be about eight cartloads. The tank, which is built of masonry, has a capacity of 6,000 gallons. The tank is emptied, when full, through a siphon which operates automatically, discharging its contents into the inverted siphon. The inverted siphon is constructed of cast-iron pipe 10 inches in diameter and is 1,580 feet in length. At the lowest point in the siphon, which is about 25 feet below the upper end, a blow-off is provided through which the contents of the pipe can be discharged into a brook. This blow-off is opened about four times a year, at times of high flow. The difference in elevation between the two ends of the siphon is 3.75 feet.

The sewage is distributed upon sandy land belonging to the town farm. The area upon which the sewage is applied contains about 20½ acres, its average elevation above the brook which flows near it is about 20 feet, and it has a general slope toward the brook of about 5 feet in 100 feet. The surface is covered with soil and subsoil to a depth of about 2 feet, none of which has been removed. The character of the sand beneath this subsoil, as indicated by analyses of samples collected in 1893, is as follows: —

	Number of Test Pit.						
	1.	2.	3.	4.	5.	6.	7.
Effective size (millimeters),	0.138	0.148	0.132	0.110	0.115	0.115	0.148
Uniformity coefficient,	3.8	3.2	6.8	4.8	3.6	5.1	4.9
Albuminoid ammonia (parts per 100,000),	34.8	9.0	3.7	2.9	1.9	3.6	2.9

The sewage is distributed over the area from the carrier which is laid along the highest portion of the area. During the year 1898 grass was raised on about 17 acres of the area and corn upon the remainder. The land is said to absorb the sewage without any difficulty during the summer months, but during the winter, when the surface of the ground is frozen, much of the sewage finds its way over the slopes into the brook without purification.

The brook opposite the disposal area has a water-shed of 1.2 square miles, and at a point below the disposal area it has a water-shed of 1.7 square miles. It flows for about 3.5 miles through practically unpopulated territory and empties into the Quaboag River. The land upon which the sewage is discharged is naturally very poor, but it is said that the amount of hay obtained from it since the sewage has been applied is more than double the amount which was obtained previously. The crop of corn has also been very satisfactory, the amounts obtained being increased 25 per cent. by the application of the sewage. The population in the vicinity of the area is very small. There are six dwelling-houses within a radius of half a mile, and the total population within this distance is about 40, including the persons living at the town farm.

Spencer.

Estimated population in 1898, 6,934.

The town of Spencer is situated largely within the water-shed of the Quaboag River. The greater part of the population of the town is contained in the village of Spencer, in which there are several shoe factories.

A public water supply was introduced into the town in 1883 and is now in general use in the village of Spencer, but no records are kept of the quantity of water used.

The construction of the sewerage system was begun in 1883, the sewage being discharged directly into the Seven Mile River, one of the branches of the Quaboag River, from two sewer outlets, one of which serves only a small population. Works for purifying the sewage formerly discharged into the river from the principal outlet were constructed in 1897. Previous to the construction of the sewage-disposal works, the system received a considerable quantity of storm water through catch basins in some of the principal streets, but it is said that all of these basins have now been disconnected and the sewers receive only a limited quantity of water from roofs and cellars in addition to the house sewage and leakage. No under-drains have been built beneath the sewers.

At the end of the year 1898 the principal sewer system consisted of 9.5 miles of sewers, with which there were about 480 connections. Very little information is available as to the quantity of sewage flowing in the main sewer. Two measurements, each of which extended over a period of twenty-four hours, have been made by the engineers of the Board: the first on June 14 and 15, 1898, when the flow was found to be 374,000 gallons per day, and the second on August 3 and 4, 1899, when the flow was 371,000 gallons per day. These measurements probably represent about the average flow during the year. The minimum rate of flow during the first measurement was 281,000 gallons per day, at 4 A.M., and the maximum rate, 506,000 gallons, at 12.30 P.M. The minimum rate during the second measurement was 292,000 gallons per day at 1 A.M., and the maximum, 460,000 gallons at 7.30 A M. and 11.30 A.M. The average daily flow, 372,000 gallons, is equivalent to a flow of 54 gallons per capita, 827 gallons per connection and 39,200 gallons per mile of sewers. It is probable that the flow during wet weather is very large, and several storm overflows have been placed on the main sewer line.

The filtration area is located beside the Seven Mile River, about half a mile below the point where sewage was formerly discharged directly into the stream. In constructing the main sewer from the town to the filtration area it was found desirable to lay the pipe below the hydraulic grade line, and at this place an inverted siphon was constructed of iron pipe. At the beginning of the inverted siphon there is a screen chamber containing screens of flat bars of wrought iron having an open space between them of $\frac{3}{4}$ of an inch. The total screen area is 64 square feet, and the screens are so arranged that when they are clean the sewage flows through the bottom, but as they become clogged the sewage is backed up in the screen chamber, until finally, if the clogging material is not removed, the sewage backs up so as to flow over a dam in a diverting manhole just back of the screen chamber, from which it flows through the former sewer outlet into the Seven Mile River. The screens are ordinarily cleaned twice a day, the material removed being composted, but it frequently happens that the screens become sufficiently clogged before they are cleaned to cause the sewage to overflow into the river.

From the screen chamber the sewage enters the inverted siphon, which is constructed of cast-iron pipe 12 inches in diameter, the total length being 3,127 feet. The difference in elevation between the two ends is 16.8 feet, and there are two depressions at the lowest points in which blow-offs have been constructed, through which sewage can be discharged on special beds which have been prepared for the purpose. The blow-offs are said to be used frequently.

The filtration area is located about a mile below the village of Spencer and near the line between Spencer and Brookfield. The total area of land owned by the town for filtration purposes is 22.25 acres.

On this area 12 beds have been prepared, having a combined area of 9.31 acres, or an average area of 0.78 of an acre. The largest bed has an area of 0.99 of an acre, while the smallest bed has an area of 0.31 of an acre. The original contour of the area was very uneven, consisting of gravel knolls with some low swampy places in which the material was not suitable for filtration purposes. The beds were prepared by removing all of the soil and subsoil and using the gravelly material of which the knolls were composed for the construction of beds in the low places. The soil is very coarse and porous, and no general system of underdrainage has been provided. In three of the beds, situated at the southerly end of the field, the ground-water level was quite near the surface, and these beds have been underdrained by lines of pipe placed about 60 feet apart at a depth of 6 feet beneath the surface.

The character of the filtering material in each of the beds has been determined by analyses of samples collected at different depths. The averages of the results are given in the following table: —

Depth Below Surface (Feet).	Effective Size (Millimeters).			Uniformity Coefficient.			Albuminoid Ammonia (Parts per 100,000).		
	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.
Surface,	.34	.65	.13	10.6	19.5	4.9	28.9	91.2	2.1
0.25,	.29	.48	.12	10.0	20.0	4.9	18.1	51.3	4.2
0.5,	.31	.47	.10	8.8	15.5	4.1	13.5	46.8	3.0
1.0,	.24	.41	.08	9.7	26.3	2.5	8.3	24.0	2.2
2.5,	.18	.25	.06	4.2	7.1	2.0	3.1	5.9	1.0
4.0,	.06	.06	.06	2.5	2.5	2.5	2.8	2.8	2.8

Sewage is discharged on the beds from manholes at the corners, from which it is conveyed through ditches constructed at the foot of the inside slopes of the embankments between the beds and discharged at various points along the edges of the beds. The method of operating the beds is ordinarily to allow the entire flow of sewage during the morning to be discharged on one bed; in the afternoon the flow is diverted to a second bed, while the night flow is discharged upon a third bed. The beds are used in rotation, so that they receive sewage once in four days. The amount of sewage purified per acre on three beds, at the time the measurements of flow were made, was

40,000 gallons per day. At times of high flow the rate is considerably more than this, but the capacity of the beds has never been reached. The soil is so porous, that certain portions of the beds do not ordinarily receive any sewage, although the sewage is discharged at several points. The beds are raked only twice each year, but crops are raised on some of them and those beds are hoed occasionally. The material is so coarse that no difficulty is experienced in disposing of the sewage in winter.

At the time that the measurement of flow was made in 1898, samples of sewage were collected for analysis at frequent intervals during the day. The results of these analyses are given in the following table: —

Chemical Examination of Sewage from Spencer.

[Parts per 100,000.]

Number.	Date.	Hour.	Rate of Flow. — Gallons per 24 Hours.	Temperature. — Deg. F.	Residue on Evaporation. Total Residue. Total.	Residue on Evaporation. Total Residue. Dissolved.	Residue on Evaporation. Total Residue. Suspended	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Residue on Evaporation. Loss on Ignition. Suspended.
	1898.									
23561	June 14	12.00 and 1.00 P.M.	482,300	62	28.10	19.70	8.40	13.00	5.40	7.60
23562	June 14	2.00 and 3.00 P.M.	447,800	61	37.10	24.30	12.80	20.80	8.90	11.90
23563	June 14	4.00 and 5.00 P.M.	442,600	61	29.40	29.40	0.00	4.70	4.70	0.00
23564	June 14	6.00 and 7.00 P.M.	395,000	61	21.50	17.90	3.60	7.50	4.00	3.50
23565	June 14	8.00 and 9.00 P.M.	360,700	60	24.50	18.40	6.10	10.00	4.70	5.30
23566	June 14	10.00 and 11.00 P.M.	337,200	60	21.00	15.50	5.50	9.00	4.00	5.00
23567	June 14	12.00 and 1.00 A.M.	296,500	60	13.40	12.50	0.90	2.60	2.60	0.00
23568	June 15	2.00 and 3.00 A.M.	284,700	59	13.20	12.90	0.30	3.10	2.80	0.30
23585	June 15	4.00 and 5.00 A.M.	284,200	59	12.20	12.00	0.20	3.00	2.80	0.20
23586	June 16	6.00 and 7.00 A.M.	363,000	59	15.00	13.90	1.10	3.30	2.80	0.50
23587	June 15	8.00 and 9.00 A.M.	421,300	59	29.80	19.40	10.40	15.10	6.40	8.70
23588	June 15	10.00 and 11.00 A.M.	367,900	57	44.90	25.00	19.90	25.30	7.50	17.80
Average,			373,600	-	25.30	19.10	6.20	10.40	4.90	5.50

Chemical Examination of Sewage from Spencer — Concluded.

[Parts per 100,000.]

Number.	Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	
	Free.	Albuminoid.				Nitrates.	Nitrites.	Unfiltered.	Filtered.
		Total.	Dis-solved.	Sus-pended.					
23561	2.1000	.5200	.2100	.3100	4.22	.0010	.0000	3.14	1.81
23562	2.0000	.5200	.2600	.2600	4.67	.0020	.0000	4.45	2.56
23563	2.0000	.4100	.2100	.2000	10.18	.0020	.0000	2.91	1.70
23564	1.9000	.2300	.1400	.0900	4.20	.0010	.0000	1.79	1.15
23565	1.8500	.3900	.1800	.2100	3.87	.0020	.0000	2.24	1.49
23566	1.1000	.2300	.1300	.1000	2.86	.0020	.0000	1.92	1.28
23567	0.6000	.1160	.0600	.0560	2.60	.0860	.0120	0.64	0.56
23568	0.2400	.0520	.0360	.0160	2.49	.1200	.0160	0.48	0.40
23585	0.1300	.0500	.0220	.0280	2.40	.1540	.0180	0.38	0.32
23586	0.9800	.1200	.0560	.0640	3.01	.0490	.0280	0.90	0.46
23587	2.5500	.6800	.2700	.4100	3.95	.0020	.0000	3.36	1.71
23588	2.5000	.5500	.3200	.2300	5.96	.0010	.0000	3.71	2.06
Av...	1.1350	.3500	.1700	.1800	4.40	.0280	.0050	2.34	1.39

The samples were collected as the sewage flowed out upon the filter-beds. Each sample was composed of 2 equal portions collected hourly.

Analyses of samples of sewage and of effluent from the three beds which are underdrained have been made frequently during the year 1898, the average results of which are given in the following tables: —

Average of Chemical Examinations of Sewage from Spencer.

[Parts per 100,000.]

Year.	Residue on Evaporation.						Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	
	Total Residue.			Loss on Ignition.			Free.	Albuminoid.				Nitrates.	Nitrites.	Unfiltered.	Filtered.
	Total.	Dis-solved.	Sus-pended.	Total.	Dis-solved	Sus-pended.		Total.	Dis-solved.	Sus-pended.					
1898	28.47	18.97	9.50	14.44	6.24	8.20	1.4529	.4903	.2317	.2586	4.05	.0163	.0190	2.84	1.51

The samples were collected as the sewage flowed out upon the filter-beds.

Average of Chemical Examinations of Effluent from the Sewage Filtration Area at Spencer.

[Parts per 100,000.]

Year.	Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	
		Free.	Albuminoid.		Nitrates.	Nitrites.	Unfiltered.	Filtered.
1898, . . .	18.77	.2669	.0411	3.19	.9613	.0511	.45	-

The samples were collected from the underdrain beneath bed "J."

The purification effected, as indicated by the amount of free and albuminoid ammonia and oxygen consumed in the sewage and effluent, is shown in the following table. The underdrains receive but little ground water, so that the samples collected from the underdrains represent sewage effluent diluted with but little ground water.

Purification effected by the Sewage Filters at Spencer.

[Parts per 100,000.]

Year.	Free Ammonia.			Total Albuminoid Ammonia.			Oxygen Consumed.		
	Sewage.	Effluent.	Per Cent. removed	Sewage.	Effluent.	Per Cent. removed.	Sewage.	Effluent.	Per Cent. removed.
1898, . . .	1.4529	.2669	81.6	.4903	.0411	91.6	2.84	.45	84.2

A crop of corn has been raised on some of the beds, but the crops have not been a success, as the quantity of sewage received has not been sufficient in dry weather to properly irrigate the corn. The cost of maintaining the beds during 1898 was $890.43, while the amount received from the sale of the corn was $40.72, making the net cost of operation $849.71.

The effluent finds its way into the Seven Mile River, which has a water-shed at this point of 38 square miles. There is a population of about 45 within half a mile of the filtration area.

Westborough.

Estimated population in 1898, 5,259.

The town of Westborough is situated within the water-sheds of the Sudbury and Assabet rivers, the principal part of the thickly built up portion of the town being within the water-shed of the Sudbury River above the point where water is taken for the supply of the Metropolitan District.

The principal manufacturing establishments are shoe factories and straw factories, the former discharging very little sewage, while the latter discharge a considerable quantity of spent dyes into the sewers. The town is provided with a public water supply, which was introduced in 1879, and water from the public works is now very generally used throughout the village of Westborough.

The sewerage system was constructed in 1892, a portion of the cost of construction being paid by the city of Boston, in consideration of removing the sewage from the water-shed of the Sudbury River. Sewage is collected in pipe sewers and conveyed in a main sewer 15 inches in diameter and about 1.7 miles in length to the filtration area in the valley of the Assabet River. The system is designed to receive sewage only, but a few cellars have been connected with the sewers in a wet district.

At the end of the year 1898, 5.4 miles of sewers, including the main sewer, had been constructed, and there were 194 connections with the sewer system, which may be roughly classified as follows: —

Residences,	149
Business blocks,	28
Factories,	9
Hotels,	4
Miscellaneous,	4
Total connections,	194

No records are kept of the quantity of sewage flowing in the sewers, but several measurements have been made by the engineers of the Board, the results of which indicate that there is a great variation in the flow throughout the year. The results of occasional measurements which have been made of the flow from the main sewer at the filtration area are given in the following table: —

Date.	Day of Week.	Hour.	Rate of Flow (Gallons per 24 Hours).
April 1, 1898,	Friday,	12 M.	717,000
July 15, 1898,	Friday,	12 M. and 3 P.M.	260,000
Oct. 10, 1898,	Monday,	10.30 A.M.	405,000
Oct. 26, 1898,	Wednesday,	10-11 A.M.	708,000
Nov. 1, 1898,	Tuesday,	12.30 P.M.	752,000
April 3, 1899,	Monday,	4.30 P.M.	632,000
April 4, 1899,	Tuesday,	9 A.M.	625,000
		1.30 P.M.	653,000
		5.30 P.M.	719,000

The main sewer from the town to the filtration area was constructed through land which was very wet and there is a large amount of leakage into the sewer, especially when the level of the ground water is high. Measurements were made April 3 and 4, 1899, of the flow at different points in this sewer, in order to ascertain the amount of leakage in the various sections. It was found that in 3,010 feet of the 15-inch sewer the leakage was at the rate of 611,000 gallons per day, or 1,072,000 gallons per day per mile of sewer.

The filtration area is located near the Assabet River, about a mile north-west of the central portion of the village of Westborough. The sewage is received at the filtration area in a screen chamber, where it is passed through screens of diamond mesh having an area of 40 square feet, and through two small tanks having a combined capacity of 675 gallons. In order to clean the screens it is necessary to remove them. The solid matter which accumulates in the tanks is discharged in a sludge pit near the screen chamber, where it is allowed to dry and is then removed and composted. During the winter and spring the screens are removed and the tanks are not emptied, so that everything received from the sewers is discharged on the beds.

From the tanks the sewage is discharged upon four prepared filter-beds and into a large hole which has been formed by excavating material for the construction of the filter-beds. The filter-beds have a combined area of 3.9 acres, and the pit an area of 0.33 of an acre. Two of the filter-beds were prepared to receive sewage by the removal of the soil and subsoil and the addition of from 1 to 3 feet of gravel. The material beneath the subsoil was very fine and almost impervious to water, but the material placed on the surface of the beds was coarse and porous. These beds are underdrained by two lines of pipe laid 75 feet apart. The other two beds were constructed of material found in the vicinity, most of which was very fine. These beds are underdrained by lines of pipe 50 feet apart, laid at depths of from 3 to 5 feet beneath the surface. The pit into which sewage is discharged was formed by removing the material for the two filter beds last described. This pit is usually kept nearly full of sewage, the sewage standing sometimes at a depth of 6 feet.

During the winter the beds receive very little attention, and at times of high flow the sewage stands on the beds for long periods. It is said that much unpurified sewage has been discharged into the Assabet River at times of high flow.

Considerable trouble has been experienced from the growth of the fungus *leptomitus* in the main sewer. This organism grows on the inside of the pipes, and has been present in such quantities that at times the sewer has been clogged, and it has been necessary to scrape the growth from the inside of the sewer. The organism is found only in the portion of the sewer in which the leakage occurs and is not found in other parts of the system above this portion, and its growth appears to be in some way associated with the presence of the large quantity of ground water which enters the sewer between the town and the filtration area. When the flow of sewage is increased, large masses of this fungus are detached from the pipes and carried to the filter-beds. During the winter and spring the sewage is not screened, and at such times the organism tends to clog the surfaces of the filters.

The effluent and the unpurified sewage are discharged into the Assabet River, which has a water-shed at this point of 9.1 square miles. There is no population in the immediate vicinity of the filter-beds or of the river below the filter-beds. There is a population within half a mile of the filtration area of about 35.

Works are now (1899) in process of construction which will provide for the proper purification of the sewage of Westborough. Five new filter-beds are being constructed, having a combined area of about 3 acres, and two of the old beds are being reconstructed with suitable material properly underdrained. A section of the main sewer in which the largest leakage occurred is being replaced by iron pipe.

FOOD AND DRUG INSPECTION.

FOOD AND DRUG INSPECTION.

The following report embraces the operations of the Board under the provisions of the food and drug acts of 1882, and of such amendments as have been enacted since that time.

Earlier investigations made under the direction of the Board having shown that a very considerable ratio of certain articles of food and of drugs in common use was found to be adulterated, the law of 1882 was enacted for the protection of the community. One of the results of this investigation was the proof that the adulterations in common use were mainly of a commercial and not of a harmful character. The staple articles of food, including the principal cereals, with sugar, and very many other useful and nutritious kinds of food are almost never adulterated, so that the actual ratio of adulteration is limited to a minor portion of the food supply.

The public is often led to believe the contrary by means of alarming and sensational statements in the newspapers, such as have recently appeared, but actual inspection does not confirm these statements. For example, a recent statement circulated throughout the country affirmed that wheat flour was being largely adulterated, and in many instances by injurious substances. A collection of many samples of flour from different parts of the State was made by the inspectors, the result of which showed, on examination, that only five samples consisted of anything except pure wheat flour, and in these instances the addition consisted of a small quantity only of corn meal.

The value of the food supply of a State, however, is so great as to warrant a continuous watch over its quality, since the few articles which are liable to adulteration are of sufficient consequence and value to require constant supervision to prevent the occurrence of fraud. New and ingenious methods of adulteration frequently make their appearance and demand the exercise of watchfulness on the part of the officials charged with the execution of the law.

The actual cost of the food supply of the population may be determined approximately by observation among different classes of people. The Bureau of Labor Statistics, in an article by Prof. W. O. Atwater (Report of 1886, page 323) states the average cost of the daily ration, by observation of very many dietaries of persons of different occupations, at twenty-five cents. This does not include luxuries, but the common forms of animal and vegetable food necessary for the support of life in a healthy condition.

The daily ration of two and one-half millions of people upon this basis would be worth $625,000, and the yearly cost $228,125,000. If only one-fourth of this amount represents the value of the articles which are liable to adulteration, the comparatively small sum which the State annually appropriates for the work of careful inspection constitutes a good investment.

The articles most liable to adulteration are milk, butter, spices, coffee, syrups and molasses, cream of tartar, honey, vinegar, jellies and jams, olive oil, and certain kinds of canned goods.

The force employed under the direction of the Board for the purpose of food and drug inspection during the year ending Sept. 30, 1898, was as follows: —

Dr. Charles P. Worcester,*	*Analyst.*
Prof. C. A. Goessmann,	*Analyst.*
Albert E. Leach, S.B.,	*Assistant Analyst.*
Hermann C. Lythgoe, S.B.,	*Assistant Analyst.*
John F. McCaffrey,	*Inspector.*
John H. Terry,	*Inspector.*
Horace F. Davis,	*Inspector.*
Thomas O. Allen,	*Inspector.*

The number of samples of food and drugs examined during the year is shown in the following summary: —

Number of samples of milk examined,	6,247
Number of samples above standard,	4,307
Number of samples below standard,	1,940
Percentage of adulteration or deficiency,	31.1
Number of samples of other kinds of food (not milk),	3,738
Number of samples above standard,	3,238
Number of samples below standard,	500
Percentage of adulteration,	13.4
Number of samples of drugs examined,	812
Number of samples of good quality,	531
Number of samples adulterated, as defined by the statutes,	281
Percentage of adulteration,	34.6
Total number of samples of food and drugs examined,	10,797
Total number found to be of good quality,	8,076
Total number not conforming to the statutes,	2,721
Percentage of adulteration,	25.2

* Died October, 1898.

STATISTICAL SUMMARY.

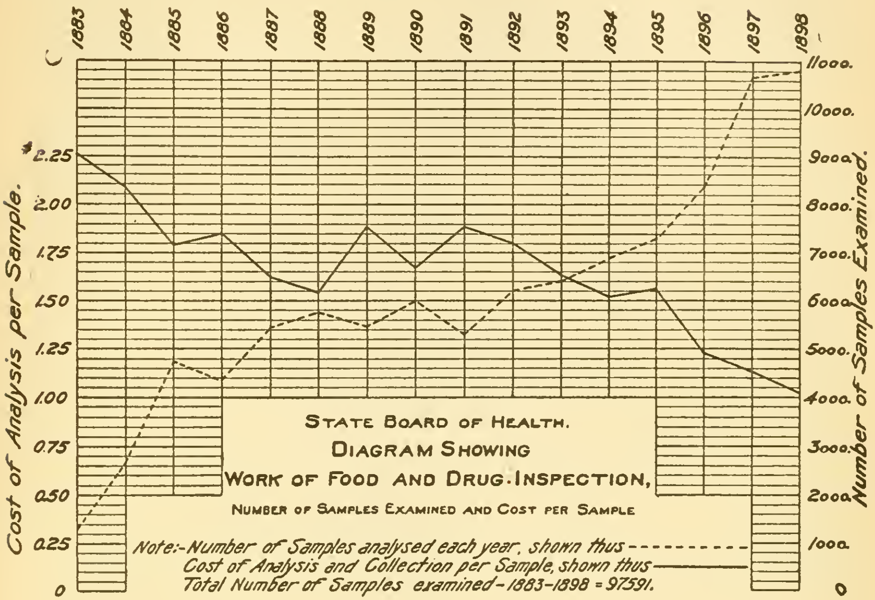
Food and Drug Inspection (1883-98).

Summary.	Years.							
	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.
Number of samples of milk examined,	218	1,123	2,219	2,085	3,081	2,825	3,219	3,236
Number of samples above standard,	35	347	1,297	1,323	1,900	1,705	1,971	1,858
Number of samples below standard,	183	776	922	762	1,181	1,120	1,248	1,378
Percentage of adulteration,	83.9	69.1	41.7	36.5	38.3	39.6	38.7	42.6
Number of samples of other kinds of food (not milk),	477	839	1,552	1,353	1,789	2,079	1,635	2,349
Number of samples of good quality,	328	432	883	863	1,263	1,680	1,242	1,913
Number of samples adulterated, as defined by the statutes,	149	407	669	490	556	399	393	436
Percentage of adulteration,	31.2	48.5	43.1	36.2	29.4	19.2	24.0	18.6
Number of samples of drugs examined,	603	682	1,007	888	550	862	600	400
Number of samples of good quality,	357	431	571	463	400	634	503	325
Number of samples adulterated, as defined by the statutes,	246	251	436	425	150	228	97	75
Percentage of adulteration,	40.8	36.8	43.3	47.8	27.3	26.4	16.2	18.7
Total examinations of food and drugs,	1,298	2,644	4,778	4,326	5,420	5,766	5,454	5,985
Total examinations of good quality,	720	1,210	2,751	2,649	3,563	4,019	3,716	4,096
Total examinations not conforming to the statutes,	578	1,434	2,027	1,677	1,857	1,747	1,738	1,889
Percentage of adulteration,	44.5	54.2	42.7	38.7	34.3	30.3	31.9	31.5
Expense of collection, examination and prosecution,	$2,931 56	$5,529 60	$8,557 43	$8,025 34	$8,803 62	$8,915 41	$10,356 28	$10,013 04
Expense of collection, examination and prosecution, per sample,	2 26	2 09	1 79	1 85	1 62	1 54	1 89	1 67

FOOD AND DRUG INSPECTION (1883-98) — *Concluded.*

SUMMARY.	Years.								Totals.
	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	
Number of samples of milk examined,	2,726	3,271	3,073	3,551	3,794	4,484	6,046	6,247	51,198
Number of samples above standard,	1,629	1,757	1,545	1,794	1,905	2,904	4,150	4,307	30,427
Number of samples below standard,	1,097	1,514	1,528	1,757	1,889	1,580	1,896	1,940	20,771
Percentage of adulteration,	40.2	46.3	49.7	49.5	49.8	35.2	31.3	31.1	40.6
Number of samples of other kinds of food examined (not milk),	2,144	2,441	3,009	2,836	2,971	3,368	3,944	3,738	36,524
Number of samples of good quality,	1,577	2,042	2,637	2,566	2,379	2,978	3,438	3,238	29,459
Number of samples adulterated, as defined by the statutes,	567	399	372	270	592	390	506	500	7,065
Percentage of adulteration,	26.4	16.3	12.3	9.5	19.9	11.6	12.8	13.4	19.3
Number of samples of drugs examined,	424	487	327	487	544	505	690	812	9,868
Number of samples of good quality,	352	312	228	324	212	251	442	531	6,336
Number of samples adulterated, as defined by the statutes,	72	175	99	163	332	254	248	281	3,552
Percentage of adulteration,	17.0	35.9	30.3	33.5	61.0	50.3	35.9	34.6	35.8
Total examinations of food and drugs,	5,294	6,199	6,409	6,874	7,309	8,357	10,680	10,797	97,590
Total examinations of good quality,	3,558	4,111	4,410	4,684	4,496	6,133	8,030	8,076	66,222
Total examinations not conforming to the statutes,	1,736	2,088	1,999	2,190	2,813	2,224	2,650	2,721	31,368
Percentage of adulteration,	32.8	33.7	31.2	31.9	38.5	26.6	24.8	25.2	32.1
Expense of collection, examination and prosecution,	$10,019 41	$11,180 30	$10,454 11	$10,364 64	$11,375 89	$10,921 61	$12,076 43	$11,062 68	$150,587 35
Expense of collection, examination and prosecution, per sample,	1 89	1 80	1 63	1 52	1 56	1 23	1 13	1 02	1 54

The accompanying diagram shows the yearly number of samples analyzed and the cost per sample.



Notices.

The following lists present the names of the cities and towns to which notices were issued relating to the adulteration of different kinds of food and drugs during the year ended Sept. 30, 1898: —

Cities and Towns to which Notices were sent on Account of Adulterated Milk.

Arlington,	1	Marshfield,	1
Attleborough,	5	Nantucket,	1
Beverly,	1	Natick,	2
Boston,	1	New Bedford,	3
Brockton,	5	Newton,	6
Brookline,	3	Orange,	1
Cambridge,	10	Peabody,	1
Chelsea,	22	Plymouth,	3
Clinton,	3	Provincetown,	1
Dedham,	2	Quincy,	4
Fall River,	2	Revere,	7
Fitchburg,	1	Salem,	6
Gloucester,	5	Somerville,	8
Haverhill,	3	Stoughton,	3
Holyoke,	1	Wakefield,	1
Hudson,	1	Waltham,	1
Hull,	2	Watertown,	3
Hyde Park,	6	Winthrop,	2
Lawrence,	1	Woburn,	4
Lowell,	2	Worcester,	11
Malden,	4		
Marblehead,	2	Total,	156
Marlborough,	4		

Cities and Towns to which Notices were sent on Account of Adulterated Articles of Food other than Milk.

Abington,	1	Malden,	1
Boston,	41	Montague,	4
Brookline,	1	Needham,	1
Cambridge,	3	New Bedford,	7
Chelsea,	2	Somerville,	2
Chicopee,	3	Springfield,	1
Dudley,	2	Stoneham,	1
Everett,	2	Walpole,	2
Fall River,	3	Webster,	1
Fitchburg,	1	Wrentham,	2
Haverhill,	1	Worcester,	4
Hingham,	1		
Lowell,	5	Total,	92

Cities and Towns to which Notices were sent on Account of Adulterated Drugs.

Amesbury,	1	Medford,	1
Attleborough,	1	Middleborough,	1
Boston,	7	Onset,	1
Chelsea,	2	Orange,	1
Fall River,	1	Somerville,	1
Fitchburg,	1	Woburn,	1
Haverhill,	1		
Lowell,	2	Total,	22

The milk supply of the State is one of the most valuable constituents of its general food supply. An expenditure of two cents each day per capita for milk amounts to about nineteen million dollars per year for the present population. For the supervision of this supply three sets of officials are provided by the statutes, — the inspectors of the State Board of Health, the Dairy Bureau, and the local milk inspectors of cities and towns.

The work of local inspectors has undergone considerable improvement in late years, partly stimulated, no doubt, by the occasional visits of the State officials. Greater pains have been taken by the local authorities to select men for this office who are familiar with the methods of milk inspection and analysis. In the city of Boston the office is under the supervision of the local board of health, and it seems entirely proper that a similar provision of law should apply to other cities. The law relating to towns (not cities) is not obligatory, but in a few instances milk inspectors have been appointed in large towns in the metropolitan district.

Two questions in connection with the subject of milk adulteration frequently present themselves in the course of the milk inspection of large cities and towns, — the addition of coloring matter and the use of preservatives.

With reference to the propriety of treating the former of these subjects, the addition of coloring matter, as a distinct form of adulteration, in which the motive for its use is usually a fraudulent one, there can be little doubt; and the officials of the Board have been instructed to use every possible means to suppress the practice. Attention is called to further statements of the analyst in the present report, having reference to the question of the methods of detecting the presence of added coloring matter.

With reference to the use of preservatives in milk, the present statute does not admit of any discretion, since any such addition constitutes "a foreign substance" under the provisions of Public Statutes, chapter 57, section 5, and the later amendments of the same statute.

The further question, whether additions of such preservatives as boracic acid, borax, bicarbonate of soda, salicylic acid, formaldehyde or other similar substances in such quantities only as may be required to preserve the milk for a period of twenty-four or forty-eight hours, are injurious to the health of the consumer, does not yet appear to have been definitely settled. The subject has recently been discussed with renewed vigor in the British medical and sanitary journals without arriving at conclusions which may be deemed satisfactory.

If the use of such substances for the preservation of milk is to be permitted, it is plain that some definite quantitative limit should be fixed, an excess of which should be deemed a violation of statute.

The samples of milk containing preservatives were not large in number, but were obtained from fourteen different places. Their use is most commonly resorted to during the warm season of the year.

The following cases which occurred during the year are worthy of note: —

In the ordinary course of inspection a sample of tincture of opium was purchased by an inspector at an Italian drug store in Boston. The amount obtained was six ounces. The dealer stated to the inspector at the time of the sale that the article in question was an Italian preparation and was twice as strong as the ordinary tincture of the United States Pharmacopœia. Upon analysis, however, it was found to be very much below the required standard of the United States Pharmacopœia; the official standard of 1890 calling for 1.3 to 1.5 per cent. of morphia. The article as purchased at the drug store in question contained only .70 per cent. of morphia.

At the trial of this case the defendants produced an Italian dispensatory or manual to show that the article sold was Sydenham's laudanum, and not tincture of opium. The label on the bottle in which it was dispensed contained the word "laudanum" only. It was also claimed that the article sold was Italian laudanum and not that of the United States Pharmacopœia. The government produced an Italian pharmacopœia which showed that the Italian and the American preparations were practically identical. The defendant was convicted.

In 1898 several wholesale dealers were found to be selling a brand of ground mace which on examination was found to consist largely of wild mace (myristica fatua), and in some instances with a considerable mixture of starch. The wholesale dealers furnishing this article were outside the State and complaints could not be maintained against them. They claimed that the article in question (wild mace) was mace, and hence not an adulteration. The principal authorities on the subject of spices, however, pronounce wild mace an adulteration, and the retailers therefore agreed to label these preparations as compounds, with the percentage of ingredients, under the provisions of chapter 344, Acts of 1897.

The therapeutic value of diabetic food preparations depends upon the absence of starch, its place being supplied by other elements of the cereal grains, chiefly gluten. Analyses made from time to time by the analysts of the Board show that little dependence can be placed in the published statements of manufacturers of diabetic food preparations as to the actual composition of these articles as offered for sale. The majority of those which have been collected by the Board have been found to contain much larger percentages of starch than those which were claimed upon the label or package. The variation was from 0 to more than 60 per cent. of starch. In several instances the analysis showed that the article, sold at a high price as a diabetic flour, contained as much starch as ordinary wheat flour, and for therapeutic purposes was no better than the flour or meal of any common cereal.

In 1897 several amendments to the food acts were made, some of greater and some of less importance, all of which had in view the protection of the general consumer and the prevpntion of special kinds of adulteration.

The following amendment to the general law of 1882 has had a wholesome effect, since it introduced certain provisions which had not hitherto been embraced in any statute.

Section 3, last paragraph of chapter 344 of the Acts of 1897, reads as follows: —

Provided, that the provisions of this act shall not apply to mixtures or compounds recognized as ordinary articles or ingredients of articles of food, if every package sold or offered for sale is distinctly labelled as a mixture or compound *with the name and per cent. of each ingredient therein*, and if such mixtures or compounds are not injurious to health.

The important amendment in the foregoing paragraph consists in the italicized words, which require the name and percentage of each ingredient in a mixture or compound to be distinctly placed upon each package.

The articles to which this applies, as found by the operation of the law during the past two years, are principally coffee preparations, or imitations of coffee, containing chiccory and cereal products, spices, syrups, molasses and baking powders. Several complaints have been made and convictions secured under this provision, and have had a decided effect in securing a better condition of the market so far as the proper labelling of compound articles of food is concerned.

The regular routine work of the Board in the department of food and drug inspection constitutes the chief portion of the operations of this department, and this work has been carried on uninterruptedly for a period of sixteen years. This comprises the collection of articles of food and drugs from all parts of the State by experienced inspectors and their examination by the analysts of the Board, with the preparation of cases for trial in court. In addition to this routine work the office is also open daily for the reception of such articles as may be brought in for examination. The articles of this character have not been very numerous when compared with those which are collected by the inspectors, but have represented very nearly all classes of food. The examinations of this class have also extended occasionally to articles not mentioned in the law, but are usually embraced very properly in the laws of other countries among the things which it is deemed proper for sanitary boards to examine, such as cooking utensils and articles intended for the conveyance and storage of drinking water, wall paper and fabrics used for wearing apparel, children's toys and other articles in common use among the people.

The articles which were brought to the office for examination during the year, and were not collected by the inspectors, are included in the following list: —

Articles of food suspected of containing poisons, milk, spices, coffee, cream, molasses, confectionery, butter, maple syrup, flavoring extracts, flour, honey, diabetic flour, hair dyes, cosmetics and other proprietary medicines, whiskey, wine and cider, wax, wall paper and fabrics to be examined for arsenic, cooking utensils and toys.

Prosecutions.

The following condensed summary is presented in accordance with the custom which has been followed in the reports of the past six years.

The following table presents the same figures with the addition of the data relating to the prosecutions conducted during the year ended, Sept. 30, 1898:—

Number of Complaints entered in Court.

Year.	Food (not including Milk).	Drugs.	Milk.	Total.	Convictions.	Fines Imposed.
1883, . . .	–	5	4	9	8	–‡
1884, . . .	2	1	45	48	44	–‡
1885,* . . .	50	1	68	119	103	–‡
1886,† . . .	10	–	10	20	19	–‡
1887, . . .	30	–	34	64	60	–‡
1888, . . .	22	–	43	65	61	$2,042 00
1889, . . .	74	–	66	140	124	3,889 00
1890, . . .	78	–	24	102	96	3,919 00
1891, . . .	96	5	49	150	135	2,668 00
1892, . . .	52	12	72	136	123	3,661 70
1893, . . .	26	3	67	96	92	2,476 00
1894, . . .	14	–	76	90	77	2,625 00
1895, . . .	13	11	68	92	86	2,895 30
1896, . . .	7	–	68	75	74	2,812 20
1897, . . .	13	1	51	65	64	2,756 60
1898, . . .	10	–	54	64	62	2,060 98
Totals, . .	497	39	799	1,335	1,228	$31,805 78

* To May 1, 1886. † Four months only. ‡ No record kept.

Ratio of convictions to complaints, 92 per cent.

Note. — All complaints entered before May 1, 1886, were under the direction of the Board of Health, Lunacy and Charity, and all after that date were under the direction of the State Board of Health.

The following report was presented to the Legislature in January, 1899, in compliance with the provisions of the statutes, Acts of 1884, chapter 289: —

OFFICE OF THE STATE BOARD OF HEALTH,
STATE HOUSE, BOSTON, Jan. 9, 1899.

To the Honorable Senate and House of Representatives of the Commonwealth of Massachusetts in General Court assembled.

The following summary is made in compliance with the provisions of chapter 289, section 2, of the Acts of 1884, requiring the State Board of Health to "report annually to the Legislature the number of prosecutions made under chapter 263 of the Acts of 1882, and an itemized account of all money expended in carrying out the provisions thereof."

The whole number of prosecutions made by authority of the Board against offenders, under the provisions of the food and drug acts, for the year ending Sept. 30, 1898, was 64.

The cities and towns in which the articles were sold, and in respect to which complaints were entered in court, the character of the articles found to be adulterated, or fraudulently sold, the dates of the trials, and their results, are presented in the following table: —

MILK AND MILK PRODUCTS.

For Fraudulent Sales of Milk.

PLACE.	DATE.	RESULT.
In Cambridge,	Dec. 13, 1897,	Convicted.
Cambridge,	Jan. 21, 1898,	"
Chelsea,	April 28, 1898,	"
Chelsea,	Sept. 23, 1898,	"
Gloucester,	Jan. 19, 1898,	Discharged.
Gloucester,	Jan. 20, 1898,	Convicted.
Gloucester,	May 31, 1898,	"
Gloucester,	Aug. 5, 1898,	"
Gloucester,	Sept. 29, 1898,	"
Gloucester,	Sept. 29, 1898,	"
Gloucester,	Sept. 29, 1898,	"
Gloucester,	Sept. 29, 1898,	"
Fitchburg,	Sept. 28, 1898,	"
Fitchburg,	Sept. 19, 1898,	"
Fitchburg,	Sept. 22, 1898,	"
Fitchburg,	Sept. 24, 1898,	"
Fitchburg,	Sept. 24, 1898,	"
Woburn,	Feb. 18, 1898,	"
Woburn,	Feb. 18, 1898,	"
Woburn,	April 1, 1898,	"

For Fraudulent Sales of Milk — Concluded.

PLACE.	DATE.	RESULT.
In Woburn,	April 8, 1898,	Convicted.
Lowell,	June 9, 1898,	"
Somerville,	Dec. 23, 1897,	"
Somerville,	June 14, 1898,	"
Salem,	Oct. 23, 1897,	"
Newton,	Sept. 21, 1898,	"
Malden,	May 25, 1898,	"
Everett,	May 24, 1898,	"
Westford,	June 15, 1898,	"
Topsfield,	Oct. 30, 1897,	"
Norwell,	Oct. 7, 1897,	"
Charlton,	Oct. 9, 1897,	"
Marshfield,	Oct. 22, 1897,	"
Rehoboth,	Dec. 27, 1897,	"
Hopkinton,	Jan. 21, 1898,	"
Stoughton,	March 19, 1898,	"
Stoughton,	April 15, 1898,	Discharged.
Canton,	March 19, 1898,	Convicted.
Needham,	March 21, 1898,	"
Attleborough,	April 27, 1898,	"
Attleborough,	April 27, 1898,	"
Dover,	May 16, 1898,	"
Wrentham,	July 30, 1898,	"
Lexington,	June 13, 1898,	"
Bedford,	Aug. 9, 1898,	"
Concord,	Aug. 9, 1898,	"
Swampscott,	Sept. 1, 1898,	"
Cottage City,	Sept. 2, 1898,	"
Marblehead,	Sept. 28, 1898,	"
Medway,	Sept. 17, 1898,	"
Spencer,	Sept. 26, 1898,	"
Marshfield,	Sept. 27, 1898,	"

Condensed Milk.

In Cambridge,	Sept. 28, 1898,	Convicted.
Cambridge,	Sept. 28, 1898,	"

FOR FRAUDULENT SALE OF OTHER ARTICLES OF FOOD.

Coffee.

In Lowell,	Oct. 5, 1897,	Convicted.
Lowell,	Sept. 13, 1898,	"
Fall River,	Sept. 29, 1898,	"

Molasses.

In Boston,	May 4, 1898,	Convicted.

Cream of Tartar.

Place.	Date.	Result.
In Boston, ...	May 26, 1898, . . .	Convicted.

Cassia.

In Boston, ...	March 22, 1898, . . .	Convicted.

Allspice.

In Boston, ...	May 26, 1898, . . .	Convicted.

Pepper.

In Boston, ...	May 26, 1898, . . .	Convicted.

Lime Juice.

In Woburn, ...	May 27, 1898, . . .	Convicted.
Woburn, ...	May 27, 1898, . . .	"

Summary.

Complaints entered in court under the acts relating to the inspection of milk and milk products, ...	54
Other articles of food, ...	10
Total, ...	64

Summary.

The whole number of complaints entered by the State Board of Health during the year ending Sept. 30, 1898, in the courts of the Commonwealth, against parties for violation of the statutes relating to food and drug inspection, was 64. In 62, or 96.9 per cent. of these, the parties were convicted; 2 were discharged.

Of the whole number, 54 were for violation of the statutes relating to the adulteration of milk and milk products, and of this number 52 resulted in conviction. The greater number of these were for violation of the statutes providing that milk offered for sale shall be of good standard quality. In 9 of the foregoing cases the complaints were for sales of milk containing coloring matter.

Attention is respectfully called to the provisions of section 23 of chapter 397 of the Acts of 1896, by which the people are now deprived of the legal protection which they enjoyed under the poison act of 1888, against the harmful action of poisonous patent medicines.

All of the parties against whom complaints were entered in court for fraudulent sales of other kinds of food were convicted.

The articles of food and drugs with reference to which these complaints were made were as follows: —

Coffee, 3 cases; molasses, 1 case;* allspice, 1 case; pepper, 1 case; cassia, 1 case; cream of tartar, 1 case; lime juice, 1 case.

In section 5 of the new food statute of 1897, chapter 344, it is required that certain sorts of canned goods, together with packages containing maple syrup and molasses, shall be plainly marked with adhesive labels, in letters not less in size than *two-line Pica*, of legible type. The section reads as follows: —

[ACTS OF 1897, CHAPTER 344.]

SECTION 5. All canned articles of food prepared from dried products which have been soaked before canning shall be plainly marked by an adhesive label, having on its face the word "soaked," in letters not less in size than *two line Pica*, of legible type; and all cans, jugs and other packages containing maple syrup or molasses shall be plainly marked by an adhesive label, having on its face the name and address of the person, firm or corporation which made or prepared the same, together with the name and quality of the ingredients of the goods, *in letters of the size and description above-specified.*

Frequent inquiry having been made relative to the meaning of the term "two-line Pica" of legible type, as employed in this statute, the following line is presented as a sample: —

TWO LINE PICA.

The following statute, as amended in 1896 (by chapter 398 of the Acts of that year), presents the standard of milk in Massachusetts, at the date of publishing this report: —

[ACTS OF 1896, CHAPTER 398, SECTION 2.]

In all prosecutions under this chapter, if the milk is shown upon analysis to contain less than thirteen per cent. of milk solids, or to contain less than nine and three-tenths per cent. of milk solids, exclusive of fat, or to contain less than three and seven-tenths per cent. of fat, it shall be deemed,

* The extent of adulteration in this case amounted to 70 per cent.

for the purposes of this act, to be not of good standard quality, except during the months of April, May, June, July and August, when milk containing less than twelve per cent. of milk solids, or less than nine per cent. of milk solids, exclusive of fat, or less than three per cent. of fat, shall be deemed to be not of good standard quality.

The whole number of samples of food and drugs examined in this department since the beginning of work in 1883 was 97,591, and the number of complaints entered in court was 1,335. The average cost per sample for collection and analysis has been reduced from $2.26 in 1883 to $1.02 in 1898.

The following list presents the total solids in each of the samples of milk upon which complaints were founded, so far as records of the same were kept: —

7.45	10.02	10.83	11.45
7.62	10.12	10.86	11.46
7.68	10.22	10.87	11.50
8.73	10.24	10.89	11.53
8.76	10.40	11.26	11.64
8.80	10.42	11.26	11.64
8.97	10.52	11.33	11.70
9.16	10.55	11.36	11.80
9.16	10.73	11.37	11.90
9.27	10.74	11.40	12.28
9.52			

The total number of samples of food and drugs examined during the year was as follows: —

Milk,	6,247
Other articles of food,	3,738
Drugs,	812
Total,	10,797

Total expenses of collection, examination and prosecution,	$11,062 68
Average expense per sample collected,	1 02

Fines.

The amount of fines paid into the treasuries of counties, cities and towns under the provisions of the general and special laws relative to the inspection of food and drugs was as follows: —

Fines paid for Violation of the Food and Drug Acts upon Cases entered for the Year ending Sept. 30, 1898.

Under the provisions of the laws relating to milk and milk products,	$1,944 78
Under the provisions of the laws relating to other articles of food,	116 20
	$2,060 98

Expenditures

Under the Provisions of the Food and Drug Acts during the Year ending Sept. 30, 1898.

	For the Enforcement of the Statutes relating to Food and Drug Inspection.	
	Relative to Milk and Milk Products.	Relative to Other Kinds of Food and Drugs.
Salaries of analysts,	$2,700 00	$1,895 00
Salaries of inspectors,	2,500 00	1,500 00
Travelling expenses and purchase of samples,	1,200 83	638 00
Apparatus and chemicals,	186 68	112 80
Printing,	13 02	7 32
Index cards,	17 50	10 00
Special investigation,	7 50	7 44
Special services (milk case),	10 00	–
Extra services for inspection,	75 00	79 00
Services (cleaning laboratory),	41 00	41 00
Bottles and stoppers,	5 21	5 00
Sundry small supplies,	5 18	5 20
	$6,761 92	$4,300 76
		6,761 92
Total,	. . .	$11,062 68

REPORT OF THE ANALYST.

REPORT OF THE ANALYST.

Dr. S. W. Abbott, *Secretary of the State Board of Health.*

Dear Sir: — I herewith submit the report of the work of the food and drug laboratory for the year ending Sept. 30, 1898. This period covers the last work as analyst of the late Dr. Charles P. Worcester, whose useful life ended almost coincidently with the close of the year herein reported.*

Milk.

Six thousand and eighty-eight samples of milk have been analyzed in this laboratory during the year, of which 1,906, or 31.3 per cent., were below the standard. The ratio of adulteration for this, the second year under the statute of 1896 (in accordance with which the 12 per cent. standard of milk solids was extended from April 1 to August 31), is almost identical with that of the preceding year.

The samples of milk containing foreign matter are comparatively small in number; 37 samples were artificially colored and 41 contained added preservative.

Artificially Colored Milk.

Of the samples thus adulterated, 29 contained annatto, 6 were colored with caramel and 2 with an orange aniline. By reference to the tables of milk statistics, it will be seen that the cities and towns from which artificially colored milks were obtained during the year are Everett, Gloucester, Malden, Medford, Salem, Woburn and Attleborough.

A very useful method for the detection of foreign coloring matter in milk in use in our laboratory is the following: about a gill of the milk is curdled by heat and acetic acid, the curd being sepa-

* Dr. Worcester's death occurred Oct. 9, 1898.

rated and gathered into one mass by the aid of a stirring rod. The curd, squeezed free from whey, is then shaken with ether in a corked flask and allowed to macerate therein for an hour or more. The appearance of the curd before maceration is often indicative to the practised eye of the presence or absence of artificial color. Of the three coloring matters commonly used, viz., annatto, caramel and the orange aniline, only the annatto is extracted by the ether.

The ether extract, containing the fat and the annatto, if present, is evaporated, and the residue made alkaline with sodium hydrate and filtered through a wet filter. If annatto is present it will permeate the filter paper and be readily apparent thereon by its orange color when the fat is washed off and the filter dried. It is well to apply the usual confirmatory test for annatto by treating the dried filter with stannous chloride and obtaining the characteristic pink color.

After pouring off the ether, the milk curd is then to be examined for caramel or the aniline orange. If the curd is left white, neither of these colors are present. If caramel has been used, the curd will be of a brown color; if the milk has been colored with the aniline dye, the color of the curd will be of a more or less brilliant orange.

A distinguishing test at this stage between the two colors caramel and aniline orange is the color reaction obtained by shaking a small portion of the fat-free curd in a test tube with concentrated hydrochloric acid. The caramel-colored curd will act in a somewhat similar manner to an uncolored fat-free curd on shaking with hydrochloric acid, viz., it will gradually produce a deep blue color in the solution. On the contrary, the aniline orange will *immediately* produce with the hydrochloric acid a deep pink color. If caramel is present in large amount the color, on shaking with hydrochloric acid, will be a brownish blue, readily distinguishable from the blue produced by the curd of an uncolored or pure milk.

If the above test indicates caramel, the presence of the latter had better be confirmed by the well known tests on fresh samples of the milk.

An unusually large number of milk samples containing added coloring matter stood above the standard of total solids. Six samples of one collection of milk, all colored with annatto, contained from 12.40 to 12.76 per cent. of total solids in the month of May, when the standard is 12 per cent. Two samples, colored with caramel, stood respectively at 14.04 and 19.19 per cent. of solids. A sample colored with orange aniline contained 13.10 per cent. of solids. As a rule coloring matter is added to cover up evidence of watering, but not in these instances.

Milk with Added Preservative.

Forty-one samples of milk were found to contain added preservative. Of these, 26 contained formic aldehyde, 4 had sodium carbonate and 11 boracic acid.

Milks with added preservative were obtained from Cambridge, Chelsea, Gloucester, Medford, Newton, Somerville, Worcester, Attleborough, Brookline, Hull, Hyde Park, Revere, Stoneham and Stoughton.

During July and August all the milk samples were systematically examined for preservatives, using in general the methods detailed in our annual report for 1897. The tentative method suggested at that time for testing for formic aldehyde by the aid of concentrated hydrochloric acid and ferric chloride (then somewhat new) has been since thoroughly tested and found most trustworthy in indicating minute quantities of this preservative. It is much more delicate than the usual sulphuric acid test, by reason of the fact that the charring with the latter acid often obscures the color when the aldehyde is present in small amount only.

The use of antiseptics in milk in this State is decidedly on the increase. This is especially true of formaldehyde, which, being in solution, lends itself to the milkman's immediate use, and is the most active of preservatives.

Weak solutions of formaldehyde are put up for milk dealers under a great variety of names, such as "Preservaline," "Freezaline," "Anti Sour," etc. A small sample vial of one of these preparations labelled "Preservaline," and containing what proved on analysis to be a 2.3 per cent. solution of formaldehyde, had these directions: "Add the contents of this bottle (2 cubic centimeters) to one quart of milk." This would be equivalent to 1 part of formaldehyde in about 22,000 parts of milk, and, according to results of experiments in this laboratory on the action of formaldehyde on milk, would keep a sample sweet for four days that would otherwise curdle in two.*

Of the 1,076 samples of milk examined during July and August, 30 samples, or nearly 3 per cent., contained added preservative.

The following tables, arranged in the usual manner, show the milk conditions prevailing in various localities: —

Milk from Cities.

Cities.	Total Samples Collected.	Above Standard.	Below Standard.	Per Cent. below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Samples.	Number of Colored Samples.	Number of Preserved Samples.
Boston, . . .	279	220	59	21.2	9.56	1	-	-
Brockton, . .	163	134	29	17.7	10.03	-	-	-
Cambridge, . .	467	316	151	32.3	11.15	1	-	2
Chelsea, . . .	295	169	126	46.1	9.95	2	-	5
Everett, . . .	121	68	53	43.8	10.96	2	7	-
Fall River, . .	89	65	24	26.9	9.90	2	-	-
Fitchburg, . .	126	76	50	39.7	10.04	7	-	-
Gloucester, . .	193	129	64	33.3	8.39	-	10	1
Haverhill, . .	139	90	49	35.2	11.00	-	-	-
Lawrence, . .	67	58	9	13.4	11.42	-	-	-
Lowell, . . .	29	19	10	34.0	10.92	-	-	-
Malden, . . .	131	73	58	44.3	9.64	-	6	-
Marlborough, .	74	60	14	18.9	10.81	1	-	-
Medford, . .	227	173	54	23.8	11.20	2	4	5
New Bedford, .	71	37	34	47.8	10.18	1	-	-
Newburyport, .	41	31	10	24.4	12.00	-	-	-
Newton, . . .	255	179	76	29.8	9.62	1	-	3
Quincy, . . .	105	77	28	26.7	10.94	4	-	-
Salem, . . .	174	120	54	31.0	9.16	-	1	-
Somerville, . .	537	315	222	41.3	9.27	14	-	6
Taunton, . .	76	67	9	11.8	12.00	8	-	-
Waltham, . .	88	54	34	38.6	11.30	-	1	-
Woburn, . .	197	124	73	37.0	9.66	-	5	-
Worcester, . .	251	160	91	36.2	10.86	4	-	4
Totals, . .	4,195	2,814	1,381	32.9	8.39	50	34	26

* Twenty-ninth Annual Report, State Board of Health, page 559.

Milk from Towns.

Towns.	Total Samples Collected.	Above Standard.	Below Standard.	Per Cent. below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Samples.	Number of Colored Samples.	Number of Preserved Samples.
Attleborough, .	118	93	25	21.2	8.80	7	3	3
Beverly, . . .	60	40	20	33.3	11.10	-	-	-
Brookline, . .	151	126	25	16.5	11.22	-	-	2
Canton, . . .	38	32	6	15.7	10.89	-	-	-
Clinton, . . .	49	38	11	22.4	9.86	9	-	-
Cottage City, . .	33	29	4	12.1	10.42	-	-	-
Dedham, . .	106	72	34	32.1	10.46	-	-	-
Framingham, . .	20	13	7	35.0	12.03	-	-	-
Hudson, . . .	11	9	2	18.2	11.08	-	-	-
Hull, . . .	21	19	2	9.5	10.67	-	-	2
Hyde Park, . .	147	97	50	34.0	10.74	-	-	2
Marblehead, . .	18	8	10	55.5	10.49	2	-	-
Marshfield, . .	11	8	3	27.3	10.40	-	-	-
Middleborough, .	13	10	3	23.1	11.89	1	-	-
Milford, . . .	46	34	12	26.1	11.90	-	-	-
Millbury, . .	9	6	3	33.3	11.10	-	-	-
Nantucket, . .	19	17	2	10.5	11.36	-	-	-
Natick, . . .	61	45	16	26.2	10.93	1	-	-
Norwood, . .	11	11	0	0.0	12.32	-	-	-
Plymouth, . .	34	26	8	23.5	11.21	-	-	-
Provincetown, .	18	15	3	16.6	10.70	-	-	-
Revere, . . .	128	83	45	35.1	9.69	-	-	2
Salisbury, . .	31	27	4	12.9	11.77	-	-	-
Spencer, . . .	17	6	11	64.7	11.22	-	-	-
Stoneham, . .	119	101	18	15.1	9.49	10	-	1
Stoughton, . .	106	72	34	32.0	10.87	-	-	3
Sudbury, . .	13	7	6	46.1	11.29	-	-	-
Swampscott, . .	5	4	1	20.0	11.26	-	-	-
Wakefield, . .	26	16	10	38.4	9.89	1	-	-
Wareham, . .	32	31	1	3.1	11.77	-	-	-
Watertown, . .	47	32	15	31.9	10.88	-	-	-
Westborough, .	15	12	3	20.0	11.04	3	-	-
Winchester, . .	53	40	13	24.5	11.13	-	-	-
Winthrop, . .	109	86	23	21.1	10.73	-	-	-
Totals, . .	1,695	1,265	430	25.4	8.80	34	3	15

Milk from Suspected Producers.

Locality.	Total Samples Collected.	Above Standard.	Below Standard.	Per Cent. below Standard.	Total Solids in Lowest Samples.
Bedford,	15	10	5	33.3	10.73
Burlington,	18	16	2	11.1	12.18
Dedham,	8	5	3	37.5	12.43
Dover,	8	3	5	62.5	11.37
Fitchburg,	4	4	0	0.0	13.40
Hopkinton,	9	0	9	100.0	8.73
Lexington,	32	21	11	34.4	10.94
Marblehead,	10	8	2	20.0	11.80
Marshfield,	5	0	5	100.0	7.68
Medway,	12	1	11	91.7	8.76
Natick,	4	4	0	0.0	12.46
Needham,	9	0	9	100.0	11.36
Northborough,	3	0	3	100.0	12.10
Peabody,	8	7	1	12.5	11.12
Randolph,	9	9	0	0.0	12.30
Sherborn,	3	3	0	0.0	12.80
Spencer,	11	0	11	100.0	10.52
Waltham,	6	6	0	0.0	12.31
Westborough,	11	0	11	100.0	11.23
Woburn,	6	6	0	0.0	12.96
Wrentham,	3	0	3	100.0	10.55
Totals,	194	103	91	46.9	8.73

Summary of Milk Statistics.

	Total Samples Collected.	Above Standard.	Below Standard.	Per Cent. below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Samples.	Number of Colored Samples.	Number of Preserved Samples.
Cities,	4,195	2,814	1,381	32.9	8.39	50	34	26
Towns,	1,695	1,265	430	25.4	8.80	34	3	15
Suspected producers,	194	103	91	46.9	8.73	–	–	–
Miscellaneous,	4	0	4	100.0	–	–	–	–
Totals,	6,088	4,182	1,906	31.3	8.39	84	37	41

A sample of milk sold from a can labelled "Skim-milk" in Clinton, proved on analysis to contain 6.44 per cent. of total solids, of which 0.9 per cent. was fat.

A sample of separator cream was found to contain formaldehyde.

A sample of milk which caused poisoning in Salem showed strong indications of the presence of tyrotoxicon.

Comparative tests have been made in this laboratory from time to time to show the accuracy of the Babcock process of fat determination, which we have used for six years, taking the Adams-Soxhlet method as a standard for comparison. The following figures show the results of such comparative determinations made in duplicate on three samples of milk, viz., a whole milk, (1) and (2), a watered milk, (3) and (4), and a milk centrifugally skimmed, (5) and (6).

Comparative Fat Determination by Adams-Soxhlet and by Babcock Processes.

	Per Cent. of Fat by the Adams-Soxhlet Process.	Per Cent. of Fat by the Babcock Process.
A whole milk (1),	4.27	4.30
(2),	4.28	4.35
A watered milk (3),	2.70	2.80
(4),	2.74	2.85
A skimmed milk (5),	0.16	0.15
(6),	0.14	0.15

Condensed Milk.

Of the 48 samples of condensed milk the analysis of which are given in detail in the accompanying table, at least 18 should be classed as adulterated, being obviously made from skimmed milk.

The actual number of brands represented in the adulterated series is, however, comparatively small, since a large number of samples of each of several such brands were analyzed for purposes of prosecution or otherwise. Fifteen of the adulterated samples were made from centrifugally skimmed milk, and of these, 13 were the product of one manufacturer, who put out virtually the same milk under various names.

Attention is called to the "Dewey Brand," which was put up in glass jars and bore on the label a portrait of the "hero of Manila," together with the assertion that it was made "from the purest milk in Worcester County." Its fat content was only 0.75 per cent., corresponding to a fat in the original milk of 0.25 per cent.

Condensed Milks.

Brand.	Total Solids.	Milk Solids.	Water.	Cane Sugar.	Milk Sugar.	Proteids.	Fat.	Ash.	Fat in the Original Milk.	Price per Pound, in Cents.
Full Weight,	79.17	31.32	20.83	47.85	9.57	7.95	12.00	1.80	5.77	–
J. B. Smith,	72.76	30.30	27.24	42.46	9.57	7.77	11.40	1.56	5.61	9
Thistle,	71.60	37.29	28.40	34.31	16.75	7.91	11.10	1.50	3.90	8
Porcelain,	69.52	33.85	30.48	35.67	14.56	6.63	10.86	1.80	4.00	–
Rose,	80.32	34.54	19.68	45.78	11.96	9.72	10.80	2.06	4.27	9
Hampden,	67.87	31.00	32.13	36.87	9.30	9.20	10.80	1.69	4.98	–
Cape Ann,	68.68	28.87	31.32	39.81	8.37	8.77	10.20	1.53	5.10	9
Diamond W.,	73.89	26.54	26.11	47.35	6.32	8.26	10.20	1.76	4.21	10
Rose,	76.78	33.06	23.22	43.72	11.35	9.87	10.20	1.64	4.11	11
Standard,	73.84	29.56	26.10	44.28	14.56	7.86	10.02	1.84	4.77	10
Maine,	71.56	33.44	28.44	41.72	11.96	9.73	9.90	1.85	3.97	10
Baby,	70.30	27.01	29.70	43.29	17.78	8.27	9.90	1.16	4.67	20
Pure Food,	66.54	28.02	33.46	38.52	8.37	8.55	9.60	1.50	3.35	20
Milk Maid,	74.72	34.19	25.28	40.53	15.23	7.80	9.45	1.70	3.55	14
Milk Maid,	75.77	34.31	24.23	41.46	13.40	10.01	9.00	1.90	3.31	17
Milk Maid,	76.08	35.68	23.92	40.40	15.23	9.70	9.00	1.75	3.15	16
Rose,	76.47	37.71	23.53	38.76	16.75	10.13	9.00	1.83	2.91	11
Rival,	78.19	38.29	21.81	39.90	18.67	9.07	9.00	1.55	2.90	10
Jersey,	75.03	29.18	24.97	45.85	11.17	7.83	8.40	1.78	3.77	12
Bethel,	77.20	31.89	22.80	45.31	11.96	9.76	8.40	1.77	3.33	8
Pine Tree,	75.10	36.08	24.90	39.02	15.23	10.44	8.40	2.01	2.81	11
Gail Borden Eagle,	73.20	30.20	26.80	43.00	14.07	6.98	8.10	1.05	3.42	18
Beacon,	70.41	26.51	29.59	43.90	7.70	9.35	7.80	1.66	2.52	12
Honeysuckle,	71.20	29.76	28.80	41.44	10.47	9.71	7.80	1.78	3.30	11
Challenge,	80.24	30.72	19.76	49.52	12.41	8.77	7.80	1.74	3.18	–
Challenge,	74.14	29.67	25.86	44.47	11.16	9.65	7.20	1.66	2.94	12
Tip Top,	77.75	33.27	22.25	44.48	11.16	13.20	7.20	1.71	2.23	11
Russell's,	74.65	29.93	25.35	44.72	10.46	11.16	6.60	1.71	2.54	–
Gail Borden Eagle,	75.79	30.18	24.03	45.79	13.96	8.40	6.60	1.82	2.31	16
Magnolia,	79.00	30.75	21.00	48.25	11.61	10.74	6.40	1.80	2.54	10
Leader,	78.04	32.52	21.96	45.52	13.40	11.90	5.40	1.82	1.85	10
Standard,	73.04	26.96	26.96	46.08	7.44	13.58	4.80	1.14	2.02	11
Ginter's,	69.30	29.15	30.70	40.15	11.89	12.15	3.06	2.05	1.05	–
Dewey,	70.14	27.29	29.86	42.85	13.40	9.66	1.80	2.43	0.62	14
Defiance,	70.64	31.31	29.36	29.33	14.61	12.04	1.80	2.86	0.57	8
Dewey,	70.68	27.99	29.32	42.69	13.40	10.78	1.35	2.46	0.47	14
Anchor,	70.11	30.24	29.89	39.87	15.02	12.34	1.20	1.64	0.38	–
Sunshine,	76.48	36.29	23.52	40.29	15.95	16.95	0.90	2.71	0.27	6
Dewey,	70.04	26.92	29.26	43.12	14.20	10.06	0.76	1.90	0.26	14
Dewey,	67.07	27.65	32.93	39.42	13.40	11.19	0.75	2.31	0.25	14
Dewey,	69.15	27.26	30.85	41.89	14.50	10.03	0.75	1.98	0.26	14
Monarch,	64.66	30.36	35.34	34.30	15.95	11.12	0.75	2.54	0.24	14
Monarch,	65.27	28.91	34.73	36.36	16.75	9.96	0.30	1.90	0.10	14
Dewey,	65.54	27.41	34.46	38.13	13.40	11.33	0.30	2.38	0.10	14
Dewey,	65.79	27.56	34.21	38.23	13.40	11.50	0.30	2.36	0.10	14
Dewey,	67.28	27.62	32.72	39.66	13.40	11.57	0.30	2.35	0.10	14
Monarch,	66.11	30.36	33.89	35.75	16.34	11.61	0.15	2.26	0.04	14
Dewey,	69.06	25.79	30.94	43.27	11.55	11.78	0.09	2.46	Trace.	14

Butter.

Three hundred and thirty-seven samples were examined, of which 2 were found to be oleomargarine.

Canned Goods.

These consisted mainly of canned fruits and vegetables, such as peaches, plums, apples, tomatoes, peas, beans, etc., examined for metallic contamination, and canned soups for preservatives. Some of the canned vegetables were greened with copper sulphate, and others, found to contain copper, derived it evidently from the kettles or utensils used in cooking. A few contained lead in appreciable amount, probably from the solder of the cans.

The following samples of canned vegetables were kept in the laboratory fifteen months before being examined for copper and lead: —

Character of Sample.	Brand.	Capacity of Can in Grammes.	Grammes of Copper in Contents.	Grammes of Lead in Contents.
Cabbage,	Hatchet,	150	0.0000	0.0003
Clams,	Team,	150	0.0022	0.0002
Peas,	Blue Bells,	150	0.0000	0.0002
Peas,	Oval,	200	0.0000	0.0003
Peas,	Pawtuxet,	200	0.0000	0.0000
Squash,	Marrow,	300	0.0124	0.0000
String Beans (French),	Extra Fine,	200	0.0138	0.0000
String Beans,	First Quality,	250	0.0000	0.0000
String Beans,	Clipper,	200	0.0000	0.0002
Pumpkin,	Seneca,	200	0.0000	0.0000
Tomatoes,	Extra Fine,	200	0.0000	0.0000
Tomatoes,	Mt. Pleasant,	200	0.0000	0.0000

Samples of sardines in mustard and oil were examined for salts of tin, the cans showing considerable corrosion, due to the vinegar with which the mustard was mixed. The contents of a half-pound can were found to contain the equivalent of 0.376 grammes of metallic tin, while that of a quarter-pound can contained 0.072 grammes.

Samples of tomato soup were found preserved with salicylic acid.

Cheese.

Forty-five samples, all genuine, were examined. Several samples of "skim-milk" cheese were found.

Chocolate and Cocoa.

Thirty-six samples were analyzed, of which 17 were adulterated. Those classed as adulterated were mainly cocoas containing added wheat or sugar. The poorest sample contained 15 per cent. of wheat.

COFFEE.

Of 157 samples examined, 15 were adulterated, the worst sample containing 90 per cent. of roasted peas, wheat, pea hulls and chiccory. Other adulterants found were bark, wood and charcoal.

A number of so-called coffee substitutes were examined, most of which were composed, as alleged, of cereals only. Some contained roasted wheat alone; others were mixtures of wheat and peas, and a few contained chiccory. Nearly all of these goods have labels calling attention to the evil effects of coffee, and one of the latter class, purporting to contain nothing but the entire wheat kernel roasted and ground, had also peas and about 30 per cent. of that "most harmful ingredient" coffee itself.

COOKING UTENSILS.

Under this head were examined 15 samples of enamelled iron ware for metallic poison in the glaze. The glaze was treated by boiling at least half an hour with concentrated sulphuric acid, and the resulting solution tested in each case for arsenic and antimony. Six were found free from both these metals, and 9 contained an appreciable amount of antimony. No arsenic was found in any case. It is extremely doubtful if any of the ordinary culinary operations would extract enough antimony to prove harmful even if it were present, so strongly is it held in the glaze.

CONFECTIONERY.

Eighty-nine samples were examined, 3 of which contained chromate of lead. Of late years this pigment has been rarely used as a coloring for candy, since the harmless anilines are much more brilliant and serviceable for this purpose. In the 3 samples reported to contain it, the lead chromate was present in such small amount that it was evidently an impurity in the coloring matter used in each case.

CREAM OF TARTAR.

Of the 392 samples examined, 19 were adulterated. One sample contained 70 per cent. of corn-starch and gypsum. Other adulterants found during the year were alum and acid phosphate of lime.

Flour.

The adulteration of flour has apparently not been largely practised in this State. Of 145 samples of flour collected, only 5 proved on examination with the microscope to contain anything other than the product of the wheat. These 5 samples contained small portions of corn-starch, but by no means to the extent of some of the "mixed flours" sold in the West.

Honey.

Ninety-four samples were tested, of which 14 were adulterated with cane sugar or glucose syrup. In some cases, both these adulterants were found. One sample contained 68 per cent. of glucose syrup and 10 per cent. of cane sugar.

Lard.

Thirty-eight samples were examined, 2 being found to contain cotton-seed oil. The Zeiss Refractometer has been found to be the most ready means of indicating suspicious samples.

Maple Sugar.

Five samples were adulterated out of the 50 examined, consisting wholly or in part of cane sugar other than maple.

One sample of maple sugar known to have been made from sap drawn from the tree through a lead spigot (which is a common practice in New York State) was examined for lead. Only 0.00017 gramme of lead was found in 400 grammes of the sample.

Maple Syrup.

Sixty samples of maple syrup were examined, all pure but 1, which contained 23 per cent. of glucose syrup.

Molasses.

Of 135 samples analyzed, 12 contained commercial glucose, the sophisticated samples containing from 20 to 70 per cent. of this adulterant.

Syrup.

Four samples were examined, all genuine.

Tea.

Eighty-eight samples were tested, 3 of which contained admixtures of stems and dirt.

Vinegar.

Vinegar still takes the lead as the highest adulterated of any article of food on the list, 53 per cent. of the samples being below the standard. Thirty-three out of the 62 samples examined were, in fact, adulterated. The total solids of several samples were abnormally high, having been "reinforced" with caramel, etc.

The following table shows the acidity and total solids of the samples tested. The legal standard requires 4.5 per cent. of acetic acid and 2 per cent. of solids. The full-faced type indicates those samples found below the standard, as well as those otherwise adulterated.

Per Cent. of Acetic Acid.	Per Cent. of Solids.	Per Cent. of Acetic Acid.	Per Cent. of Solids.	Per Cent. of Acetic Acid.	Per Cent. of Solids.	Per Cent. of Acetic Acid.	Per Cent. of Solids.
6.32	5.60	**5.13**	**1.92**	4.70	2.03	4.50	2.40
6.28	5.62	**5.02**	**1.24**	4.70	2.26	4.50	2.06
6.12	**1.73**	**5.06**	**1.56**	4.70	3.22	4.50	2.72
5.98	**1.00**	5.00	2.79	4.66	2.70	4.50	2.21
5.84	**1.50**	**5.00**	**1.46**	4.66	2.40	4.50	2.23
5.73	2.31	4.96	2.20	4.66	2.30	**4.50**	**1.80**
5.66	**1.20**	4.90	2.36	4.66	2.44	**4.46**	**2.51**
5.62	**1.95**	4.86	2.31	4.64	2.50	**4.40**	**2.82**
5.60	–*	4.82	2.13	4.64	2.03	**4.40**	**1.70**
5.36	2.21	4.82	2.83	**4.62**	**1.92**	**4.28**	**1.24**
5.35	**1.00**	4.82	2.00	4.60	2.28	**4.25**	**2.14**
5.30	5.04	**4.80**	**1.90**	4.60	2.16	**4.12**	**2.93**
5.16	2.66	**4.74**	**1.80**	**4.56**	**1.20**	**3.98**	**2.46**
5.14	**1.40**	4.72	2.20	**4.52**	**1.00**	**3.95**	**0.40**
5.14	**1.11**	**4.72**	**1.66**	4.52	2.07	**3.06**	**1.91**

* White wine vinegar.

Spices.

Allspice. — One hundred and sixty-five samples were examined, of which 14 were adulterated. One sample contained 70 per cent. of nut shells, corn, pepper and turmeric.

Cassia. — Of 219 samples, 16 were adulterated, the poorest sample containing 90 per cent. of wheat, powdered charcoal and turmeric. One sample of so-called cassia contained no less than six foreign ingredients mixed, viz., wheat, corn, nut shells, turmeric, pepper and mustard.

Cayenne. — Thirty-eight samples were examined, of which 10 were adulterated. One sample contained 55 per cent. of rice, wheat and turmeric. Other adulterants found in cayenne were ground fruit stones, redwood and buckwheat.

Cloves. — Of 294 samples examined 35 were adulterated. The worst sample contained 70 per cent. of peas and pea hulls. Other foreign substances found in cloves were stems, pepper, fruit stones, wheat bran, sawdust and charcoal.

Ginger. — Two hundred and nine samples were analyzed, of which 27 were adulterated. One sample consisted almost wholly of turmeric, wheat and buckwheat. Other adulterants found in ginger were rice and sawdust.

Mace. — Sixteen samples were tested, half of which were of poor quality. The worst sample contained 30 per cent. of corn. Wild mace is another common adulterant.

Mustard. — This is the most commonly adulterated of all spices. Two hundred and ninety-three samples were tested, 94 being adulterated. One sample contained 80 per cent. of rice, wheat and turmeric. Several samples contained corn-starch.

Nutmeg. — Of 15 samples, 2 were adulterated, 1 containing 25 per cent. of nutshells.

Pepper. — Three hundred and eighty-seven samples were analyzed. Thirty-seven were adulterated. The worst sample contained 70 per cent. of buckwheat, nutshells and turmeric. Corn, cayenne and charcoal were also found as adulterants of pepper.

Miscellaneous Foods.

Baking Powders. — A large number of brands were examined, many of which contained alum.

Bologna Sausages were found colored with Bismarck brown. They were examined for arsenic (as an impurity in the color) but were found free from it.

Cider. — Samples of bottled sweet cider and of boiled cider were examined for preservatives. Of 5 samples of boiled cider examined, 3 contained salicylic acid. Two samples out of 5 of the sweet cider were found to contain salicylic acid.

Cider Jelly. — Several samples of this jelly were found to be preserved with salicylic acid.

Codfish. — It is a common practice to use boracic acid as a preservative in codfish. Several brands were found to be so treated.

Evaporated Apples. — Samples of these were examined for zinc derived in some cases, as experience has shown, from the trays on which they are dried. One sample was found to contain it.

Flavoring Extracts, etc. — Samples of "vanilla extract" were found to depend wholly or in part on coumarin for their flavor.

A sample of "vanilla crystals" was found to be a mixture of granulated sugar and coumarin.

A so-called "vanilla frostlene," intended for use in making frosting for cake, was an aqueous solution of coumarin, gelatine and sugar.

An "extract of pineapple" proved on analysis to be an alcoholic solution of amyl butyrate.

Junket Tablets were found to contain salt and dried extract of rennet.

Lemonade Crystals. — These were found in most cases to be composed of granulated sugar and lemon juice. One sample contained oil of turpentine.

Pickles. — One sample was found to contain sulphuric acid.

Preparations for Hasty Deserts. — A number of these have been examined. Their chief ingredients are gelatine and citric acid, some with and some without sugar. One sample contained gelatine, orange extract and an aniline dye; another, corn-starch, gelatine and chocolate. They contained nothing harmful.

Somatose Biscuit was found to contain an appreciable amount of albumose.

Preservaline. — Attention has been called under the head of milk preservatives to a preparation of this name, consisting of a solution of formaldehyde for use in milk. Another article, called by the same name, and advertised as a "simple, harmless preparation" to keep cider, fruits, vegetables, preserves, jellies, jams, mince meat, grape-juice, etc., from spoiling, was examined and found to consist of salicylic acid. According to directions accompanying the sample, three measures of the preservative were to be dissolved in a quart of water, the measure being a small paper box contained in the package.

This we found to be practically a saturated solution of salicylic acid, and, according to directions, certain fruits and vegetables were to be preserved, without cooking, by simply soaking in this strong solution till used. In the case of fruits thus preserved that are to be eaten without subsequent cooking, such as berries and the like, wherein the fruit juice mingles with the acid solution, it will be seen that the amount of salicylic acid taken into the system is relatively large.

Summary of Statistics of Foods exclusive of Milk.

Foods.	Genuine.	Adulterated.	Total.	Per Cent. of Adulteration.
Allspice,	151	14	165	8.5
Butter,	335	2	337	0.6
Canned Goods,	43	26	69	37.6
Cassia,	203	16	219	7.3
Cayenne,	28	10	38	26.3
Cheese,	45	0	45	0.0
Chocolate,	19	17	36	47.2
Cloves,	259	35	294	11.9
Coffee,	142	15	157	9.5
Condensed Milks,	30	18	48	37.5
Cooking Utensils,	15	0	15	0.0
Confectionery,	86	3	89	3.4
Cream of Tartar,	373	19	392	4.8
Flour,	140	5	145	3.4
Ginger,	182	27	209	12.9
Honey,	80	14	94	14.8
Lard,	36	2	38	5.3
Mace;	8	8	16	50.0
Maple Sugar,	45	5	50	10.0
Maple Syrup,	59	1	60	1.7
Miscellaneous,	156	82	238	34.4
Molasses,	123	12	135	8.9
Mustard,	199	94	293	32.1
Nutmeg,	13	2	15	13.3
Pepper,	350	37	387	9.6
Syrup,	4	0	4	0.0
Tea,	85	3	88	3.4
Vinegar,	29	33	62	53.2
Totals,	3,238	500	3,738	13.4

Pharmacopœial Drugs.

Acidum Benzoicum. — Three samples were examined, all of good quality.

Acidum Hydrobromicum Dilutum. — One sample of this drug was tested and found pure.

Acidum Sulphurosum. — The single sample examined was of poor quality, being a weak sulphuric acid.

Acidum Tannicum. — Two samples were tested, both of good quality.

Æther. — Twenty-five samples were examined, all of good standard quality.

Æther Aceticus. — One sample was analyzed and proved to be of good quality.

Alcohol. — Fifteen samples were examined, of which 3 were below the required standard.

Aloe Purificata. — Eight samples were examined, 2 of which were poor.

Aloe Socotrina. — Six samples were tested, all pure.

Aqua Ammoniæ. — Two samples were examined, both of which conformed to the requirements.

Aqua Ammoniæ Fortior. — Of the 9 samples examined, 3 contained insufficient ammonia.

Aqua Destillata. — Of the 17 samples examined, 13 proved to be poor by reason of high residues. These residues, in parts per 100,000 of the samples analyzed, are as follows: —

14.4	7.6	4.5	0.0
10.0	6.9	3.6	0.0
9.4	5.5	3.4	0.0
9.4	4.7	3.0	0.0
8.0			

Argenti Nitras. — Twenty samples were analysed, of which 1 was of poor quality.

Bismuthi Subcarbonas. — Eighteen samples were examined, of which 3 were not up to the requirements.

Bismuthi Subnitras. — Of the 19 samples examined, 5 were not of standard quality.

Calx Chlorata. — Five samples were tested, all of which were far below the standard fixed by the Pharmacopœia. The following figures show the per cent. of available chlorine found in the samples examined, the standard being 35 per cent: —

Brookman's Brand,	26.00	Red Cross Brand,	0.56
Acme Brand,	7.00	Lion Brand,	7.00
Acme Brand,	0.06		

Capsicum. — Sixty-three samples were examined, of which 13 were adultered by admixture with foreign substances, including wheat, corn and red wood. The worst adulterated sample contained 35 per cent. of wheat and corn.

It is interesting to compare the ratio of adulteration of capsicum as a drug, which is 20.6 per cent., with that of cayenne from the grocery stores, the ratio of adulteration of which has been seen to be 26.3 per cent.

Caryophyllus. — Eleven samples were examined, all pure.

Cera Alba. — Seventeen samples proved to be all of good standard quality.

Cera Flava. — The 2 samples examined were pure.

Cerii Oxalas. — Six samples were tested and found of good quality.

Chloral. — Four samples were examined, all good.

Chloroformum. — Six samples were examined, of which 1 was below the standard.

Cinnamomum Cassia. — Eleven samples, all of good quality, were analyzed.

Extractum Glycyrrhizæ. — Twenty-three samples were examined, of which 18 were found to contain admixtures of corn-starch, 1 sample being found with 30 per cent. of that ingredient.

Extractum Zingiberis Fluidum. — Eight samples were examined, of which 7 were found to be of poor quality, being alcoholic extracts of oil-free or exhausted ginger, colored with caramel.

Ferri et Quininæ Citras. — Nineteen samples were examined. Of these, 13 were below the standard, being deficient in quinine.

Ferri et Strychninæ Citras. — Of the 12 samples tested, 1 contained insufficient strychnine.

Glycerinum. — Forty-six samples were tested, 1 being of poor quality, containing carbonizable impurities.

Limonis Succus. — Twelve samples were submitted, all of poor quality. All were deficient in citric acid, 4 were preserved with salicylic acid and 2 contained formaldehyde. Notable traces of chlorides and sulphates were found in many of them.

Two samples of a brand known as "Santiago West Indian Lime Juice, Triple Refined," were examined and proved to be mixtures of hydrochloric and salicylic acids, containing in fact no lime juice whatever.

Liquor Magnesii Citratis. — Of the 3 samples tested, 1 was of poor quality, containing the equivalent of 0.22 per cent. of sulphuric acid and having a mouldy sediment.

Macis. — One sample was examined and found pure.

Myristica. — One sample of pure ground nutmeg, sold as a drug, was examined.

Oleum Æthereum. — One sample was tested and found of poor quality.

Oleum Limonis. — Six samples were examined, of which one was adulterated with 20 per cent. of oil of turpentine.

Oleum Olivæ. — Of 77 samples tested, 25 consisted wholly or in part of cotton-seed oil. The Zeiss Refractometer proves most useful in distinguishing between the good and the spurious olive oils.

Opii Pulvis. — Sixteen samples were assayed, 6 of which were deficient in morphine while one contained too much.

The following figures show the percentage of morphine found in the various samples, the standard fixed by the Pharmocopœia being not less than 13 nor more than 15 per cent. : —

16.2	13.9	13.0	9.7
15.0	13.9	13.0	8.8
15.0	13.7	12.1	7.2
14.9	13.2	10.5	5.4

Pimenta. — Ten samples were analyzed, all good.

Piper. — Eight samples were tested, one of which was adulterated with 20 per cent. of buckwheat.

Potassii Bitartras. — Thirty-four samples were examined, all pure.

Pulvis Glycyrrhizæ Compositus. — Three samples were examined, of which one was adulterated with 35 per cent. of cornstarch.

Sapo. — One sample was tested and found to be of good standard quality.

Sinapis Alba. — Three samples were examined, of which 1 was adulterated with wheat.

Spiritus Ætheris Compositus. — Seven samples were analyzed, of which 2 were of poor quality, containing no ethereal oil.

Spiritus Frumenti. — Twenty-three samples were examined, none of which conformed in all particulars to the pharmacopœial standard. Several samples having sufficient alcoholic strength and low in solids were found to have insoluble residues.

The percentage of alcohol, and, in some cases, of the solids, are as follows : —

Per Cent. Alcohol.	Per Cent. Solids.	Per Cent. Alcohol.	Per Cent. Solids.	Per Cent. Alcohol.	Per Cent. Solids.	Per Cent. Alcohol.	Per Cent. Solids.
49.00	0.20	44.18	–	41.20	0.57	38.00	–
46.09	–	43.71	–	39.80	–	36.78	0.20
44.64	0.80	43.33	–	39.70	0.02	36.56	1.52
44.27	–	43.05	0.68	39.10	–	36.33	–
44.27	0.73	42.29	0.60	39.00	–	36.33	0.16
44.27	–	42.19	–	38.68	–	–	–

Spiritus Juniperi. — Two samples were examined, both of which were poor. One contained added water and 1 had oil of turpentine.

Spiritus Menthæ Piperitæ. — One sample was examined and found of poor quality, containing no oil of peppermint.

Spiritus Vini Gallici. — Of 4 samples tested, 3 were of poor quality : —

Per Cent. Alcohol.	Per Cent. Solids.	Per Cent. Alcohol.	Per Cent. Solids.	Per Cent. Alcohol.	Per Cent. Solids.	Per Cent. Alcohol.	Per Cent. Solids.
49.00	–	44.14	0.80	42.43	0.30	41.40	–

Syrupus. — Four samples were examined, 2 of which were deficient in sugar.

Vinum Album. — Of the 6 samples examined, all were below the standard. Added alcohol and sugar the chief falsification. The percentages of alcohol and of solids were as follows : —

Per Cent. Alcohol.	Per Cent. Solids.	Per Cent. Alcohol.	Per Cent. Solids.	Per Cent. Alcohol.	Per Cent. Solids.	Per Cent. Alcohol.	Per Cent. Solids.
19.06	5.85	17.25	5.94	16.31	5.20	15.92	4.62
18.08	5.68	16.92	4.55	–	–	–	–

Vinum Rubrum. — Ten samples were analyzed, all being below the standard by reason of too much alcohol or by added sugar. Percentages of alcohol and of solids in the samples were : —

Per Cent. Alcohol.	Per Cent. Solids.	Per Cent. Alcohol.	Per Cent. Solids.	Per Cent. Alcohol.	Per Cent. Solids.	Per Cent. Alcohol.	Per Cent. Solids.
19.67	6.89	16.92	14.44	13.77	19.44	13.23	9.74
19.25	13.46	16.62	15.73	13.31	10.15	11.31	11.75
18.38	10.90	16.23	12.12	-	-	-	-

Tinctura Ferri Chloridi. — The single sample examined was found to be of insufficient strength.

Tinctura Iodi. — Thirty-one samples were tested, of which 27 were below the standard.

It has been our custom to express the results in terms of the percentage of the standard strength required by the Pharmacopœia. The following figures show the results thus expressed of the samples examined: —

Per Cent. of United States Pharmacopœia Strength.

100.0	83.7	79.3	73.3	70.6
100.0	82.5	78.0	72.0	70.0
100.0	81.4	77.1	71.5	63.0
100.0	81.2	76.3	70.8	57.9
96.8	80.2	74.3	70.8	51.2
89.7	80.0	73.9	70.6	38.5
87.5				

Tinctura Opii. — Seventy-one samples were assayed, of which 54 were found deficient in morphine. The Pharmacopœia requires from 1.3 to 1.5 grammes of morphine in 100 cubic centimeters of the tincture. The samples assayed stood as follows: —

Grammes Morphine per 100 Cubic Centimeters.

1.47	1.30	1.18	1.09	1.01	0.91	0.79
1.45	1.30	1.17	1.09	1.01	0.88	0.78
1.42	1.30	1.17	1.07	0.99	0.87	0.77
1.41	1.30	1.14	1.06	0.99	0.86	0.76
1.39	1.30	1.14	1.06	0.96	0.86	0.74
1.39	1.26	1.14	1.06	0.96	0.85	0.71
1.38	1.24	1.13	1.03	0.93	0.84	0.62
1.37	1.23	1.12	1.03	0.93	0.83	0.58
1.37	1.21	1.11	1.02	0.93	0.82	0.57
1.33	1.19	1.09	1.02	0.92	0.82	0.52
1.31						

Zingiber. — Five samples were examined, all of which were pure.

Miscellaneous Drugs.

Borated Talcum was found to be a mixture of talc and borax.

Catarrh Cures. — Five samples were examined, 4 of which were found to contain cocaine.

Cod Liver Oil Emulsion. — Seventeen samples, representing several brands of this preparation, were examined for morphine and found not to contain it.

"*Cold in the Head Tablets*" were found to contain aconite, camphor and creosote.

Extract of Malt and Iron (*Hoff's*) was found to contain 4.18 per cent. by weight of alcohol.

"*Fruit Cream Lotion*" proved to be an emulsion of almond oil containing borax.

Gin. — Several samples were examined, and found to be of sufficient alcoholic strength.

Grape Juice. — Samples of this preparation were found preserved with salicylic acid.

Headache Cures. — Twenty-one samples of these powders were examined. The following ingredients were found in them, viz., celery, sodium bicarbonate, antifebrin, caffeine, phenacetine, starch, gentian and various spices. No chloral, cocaine or morphine was found in any of them.

A favorite prescription, according to which many of these powders is prepared, seems to be a mixture of acetanilide (antifebrin), caffeine and bicarbonate of soda.

Insecticides. — Several samples were examined and found to contain nothing poisonous to man. One sample consisted of turpentine, resin and cresol; another of cocoa, gypsum, starch and borax, and a third was composed almost entirely of borax.

"*Kohol.*" — "The equal of alcohol for burning purposes but not to be used internally." This was found to be commercial wood alcohol.

"*Quince Lotion.*"— This was found to contain borax and oil of bergamot.

Quinine Pills. — Three samples of "two-grain" pills were examined. Of these, 1 sample proved to contain 2.05 grains to the pill of alkaloids, reckoned as quinine sulphate, 89.4 per cent. of the total alkaloids being quinine.

Another sample showed 1.92 grains per pill of alkaloids, 85.9 per cent. being quinine.

A third contained 1.97 grains per pill of alkaloids, of which 84.6 per cent. was quinine.

One sample of "three-grain" pills showed on analysis 2.7 grains to the pill of alkaloids, 91.9 per cent. of which was quinine.

Root Beer. — A sample was found to contain salicylic acid.

"*Skin Success Ointment.*" — This was found to contain red oxide of mercury.

Snuff. — Several samples were examined for cocaine and found to be free from it. Ingredients of these preparations were chosen from the following: camphor, tobacco, sodium bicarbonate, borax and boracic acid.

SUMMARY.

	Genuine.	Adulterated.	Total.	Per Cent. of Adulteration.
Milk,	4,182	1,906	6,088	31.3
Food not milk,	3,238	500	3,738	13.4
Drugs,	531	281	812	34.6
Totals,	7,951	2,687	10,638	25.3

Respectfully submitted,

ALBERT E. LEACH,
Assistant Analyst.

WESTERN MASSACHUSETTS.

The milk of the four western counties of the State (Berkshire, Hampden, Hampshire and Franklin), so far as can be ascertained from the samples collected and examined during the year, was of better quality than the general average of other parts of the State. It was also of better quality than that of the previous year from the same district.

The percentage of the samples below standard quality was 20.3, the total number obtained being 153, and the number of those below the standard being .31, or 20.3 per cent.

The following summary embraces the samples of milk obtained during the year in cities and towns west of Worcester County. The results of analyses were as follows: —

Whole number examined,	153
Number above standard,	122
Number below standard,	31
Percentage below standard,	20.3
Number samples of skimmed milk,	21

Chicopee.

Number of samples examined,	24
Number above standard,	23
Number below standard,	1
Percentage below standard,	4.2
Number samples of skimmed milk,	4

Holyoke.

Number of samples examined,	19
Number above standard,	15
Number below standard,	4
Percentage below standard,	21.1
Number samples of skimmed milk,	2

Northampton.

Number of samples examined,	25
Number above standard,	19
Number below standard,	6
Percentage below standard,	24.0
Number samples of skimmed milk,	7

Springfield.

Number of samples examined,	25
Number above standard,	21
Number below standard,	4
Percentage below standard,	16.0
Number samples of skimmed milk,	1

The results in the towns were as follows: —

	Total.	Above Standard.	Below Standard.	Percentage below Standard.	Skimmed Milk.
Montague,	18	13	5	–	2
Orange,	24	17	7	–	4
Westfield,	18	14	4	–	1
	60	44	16	26.7	7

CHARLES A. GOESSMANN.

REPORT

UPON THE

PRODUCTION, DISTRIBUTION AND USE OF DIPHTHERIA ANTITOXIN.

REPORT

UPON THE

Production, Distribution and Use of Diphtheria Antitoxin,

FOR THE

Twelve Months ending March 31, 1899.

The following report, like its predecessors of the three years 1895, 1896 and 1897, is to a certain extent incomplete, in consequence of the absence of returns from a considerable number of physicians to whom antitoxin was issued during the year for the treatment of diphtheria. It does, however, show a very marked improvement in the ratio of cases in which a bacterial examination was made. This is accounted for chiefly by the much greater ratio of hospital cases treated and reported upon. The reports from the Boston City Hospital for contagious diseases constitute a very considerable proportion of the whole, since antitoxin has been issued to the hospital, by the Board, continuously throughout the twelve months embraced in the report.

Following the same plan which was begun in the twenty-seventh annual report, this fourth report upon the production and use of antitoxin embraces the work done in this direction for the year ending March 31, 1899.

The supervision of antitoxin production has been under the charge of Dr. Theobald Smith, assisted by J. R. Stewart, throughout the year. The distribution has been conducted from the office of the Board at the State House.

The strength of the serum issued was maintained at a higher average standard than that which had been attained in the previous years, while a small amount of a weaker serum was furnished for hospitals and physicians who desired it for the purpose of immunization.

During the principal part of the year the strength of the serum was such that bottles were employed for its distribution containing only 5 cubic centimeters in each, this amount representing 1,000 units of antitoxin. A portion of that which was issued was of still greater strength.

The serum was generally distributed to the boards of health of cities and towns, to contagious disease hospitals and to physicians throughout the State.

The City Hospital of Boston began using the serum furnished by the Board regularly in April, 1898, and from that date continuously to the present the Board has furnished the entire supply of the hospital. This additional demand greatly increased the amount required of the Board, but at no time has the demand exceeded the supply. The experience and observations of past years have enabled the Board to anticipate the necessities of the different seasons in this particular, so that a sufficient quantity of serum may be produced in the summer, during the time of diminished demand, to provide for the usual increase which has followed upon the advent of cooler weather.

The confidence which was expressed quite generally by the members of the medical profession, with reference to the value of antitoxin in diminishing the fatality of diphtheria, has now become so firmly established that few practitioners would be willing to undertake the treatment of the disease without this important remedy. Expressions of doubt which were occasionally heard in 1894 and 1895 are now very rare.

The total number of packages issued by the Board during the four years ending with March 31, 1899, was as follows: —

In 1895–96 (year ending March 31),	1,724 bottles.
In 1896–97 (year ending March 31),	3,219 bottles.
In 1897–98 (year ending March 31),	4,668 bottles.
In 1898–99 (year ending March 31),	12,491 bottles.
Total,	22,102 bottles.

As the contents of each package represent 1,000 antitoxin units of serum, the total quantity in the four years amounts to over 22,000,000 units.

Further comment was also made in the report of last year upon the comparatively small ratio of reports which have been made relative to the use of the product by physicians. This same comment may also be made with reference to the work of the past year. The reports have greatly exceeded in number those of 1897, but the ratio to the number of cases remains about the same.

The figures presented in this report speak for themselves so far as the reduction which has taken place in the fatality of diphtheria is concerned. The fatality in the pre-antitoxin period, as shown in past reports of this Board, was 28.3 per cent. for the period of four years, 1891–94, while during the years 1895–98 the general fatality from diphtheria throughout the State was only 15.6 (see page 766), and for those cases treated with antitoxin it was only 10.7 per cent. (see page 736).

The strength of antitoxin distributed by the Board averaged about 200 units per cubic centimeter, the variability being mainly from 175 to 225 units per cubic centimeter, excepting a small quantity which was produced and issued for the purpose of immunization.

The whole number of cities and towns to which antitoxin was distributed was 110, or 4 less than those which were published in the report of 1897. The actual number in each year was probably somewhat larger than these figures, since a few of the more distant cities acted as distributing centres for small towns in their neighborhood, and in some instances no returns were made from these towns. This serum was distributed to local boards of health and to physicians in the following cities and towns: —

Number of Bottles of Diphtheria Antitoxin distributed from April 1, 1898, to March 31, 1899.

City or Town.	Number Bottles.	City or Town.	Number Bottles.
Boston:		Lowell,	148
City Hospital,	7,984	Springfield,	135
Children's Hospital,	605	New Bedford,	120
General Supply,	438	Everett,	117
Worcester,	394	Waltham,	116
Cambridge,	202	Lynn,	100
Lawrence,	177	Somerville,	93

Number of Bottles of Diphtheria Antitoxin distributed from April 1, 1898, to March 31, 1899 — Continued.

City or Town.	Number Bottles.	City or Town.	Number Bottles.
Peabody,	79	Haverhill,	16
Hyde Park,	74	Winchendon,	15
Fitchburg,	72	Newburyport,	15
Milford,	71	Ipswich,	15
Brookline,	69	Rowley,	15
Newton,	66	Gloucester,	15
Malden,	64	Ware,	15
Danvers,	58	Concord,	14
Watertown,	57	West Brookfield,	13
North Adams,	54	Hanover,	12
Chelsea,	53	Andover,	12
Quincy,	43	Brockton,	12
Tewksbury,	40	West Medway,	12
Arlington,	38	Bridgewater,	12
Marlborough,	38	North Attleborough,	11
Woburn,	35	Northampton,	10
Wakefield,	34	Maynard,	9
Pittsfield,	32	Attleborough,	9
Clinton,	29	Hingham,	9
Beverly,	28	Monson,	9
North Brookfield,	28	Weymouth,	9
Medford,	27	Warren,	8
Fall River,	26	Leominster,	8
Cohasset,	25	Southbridge,	7
Chicopee,	24	Ashburnham,	7
Stoneham,	24	Marblehead,	7
Adams,	23	Dedham,	6
Lexington,	22	Palmer,	6
Winchester,	22	Norton,	6
Taunton,	22	Mansfield,	6
Milton,	22	Middleton,	6
Medway,	21	Norwood,	6
West Springfield,	20	Hopedale,	6
Brookfield,	19	Grafton,	6
Natick,	17	Northbridge,	6
Framingham,	17	Lenox,	6
Rockland,	16	Southampton,	6

Number of Bottles of Diphtheria Antitoxin distributed from April 1, 1898, to March 31, 1899 — Concluded.

City or Town.	Number Bottles.	City or Town.	Number Bottles.
Foxborough,	6	Ayer,	3
Shirley,	5	Middleborough,	3
Belmont,	5	Randolph,	3
Revere,	5	Bedford,	3
South Braintree,	5	Ashland,	3
Huntington,	5	Abington,	3
Medford,	5	Worthington,	3
Spencer,	5	Marshfield,	3
Hardwick,	4	Georgetown,	2
Westborough,	4	Sharon,	2
Uxbridge,	4	Dalton,	2
Hingham,	3	Edgartown,	2
Haverhill,	3	Total,	12,491

The following list presents the names of the cities and towns from which detailed reports were received relative to the use of antitoxin, with the number from each town and the number of physicians reporting in each during the year ended March 31, 1899: —

List of Cities and Towns from which Reports have been received relative to the Use of Antitoxin in the Treatment of Diphtheria, with the Number of Reports from Each and the Number of Physicians reporting in Each.

Places.	Number Physicians reporting.	Cases in which Cultures were made.	Cultures were not made.	Places.	Number Physicians reporting.	Cases in which Cultures were made.	Cultures were not made.
Adams,	1	–	1	Chelsea,	3	3	2
Arlington,	2	2	–	Frost Hospital,	2	1	2
Atlantic,	1	–	1	Chestnut Hill,	1	3	–
Beverly,	3	2	1	Chicopee,	1	–	1
Boston,	29	39	9	Cohasset,	1	1	–
City Hospital,	1	705	25	Dalton,	2	–	3
Brockton,	1	–	1	Danvers,	1	3	8
Brookline,	1	1	–	Everett,	7	6	7
Cambridge,	2	1	1	Fitchburg,	10	19	1
Hospital,	1	16	–	Foxborough,	1	1	1

List of Cities and Towns from which Reports have been received relative to the Use of Antitoxin in the Treatment of Diphtheria, with the Number of Reports from Each and the Number of Physicians reporting in Each — Concluded.

Places.	Number Physicians reporting.	Cases in which Cultures were made.	Cultures were not made.	Places.	Number Physicians reporting.	Cases in which Cultures were made.	Cultures were not made.
Framingham,	1	1	-	North Adams,	3	2	2
Georgetown,	1	-	1	North Attleborough,	1	1	-
Hardwick,	1	-	2	Peabody,	4	1	11
Haverhill,	4	-	4	Somerville,	4	10	2
Holyoke,	2	-	2	South Braintree,	1	1	1
Hyde Park,	1	1	-	Springfield,	13	15	11
Indian Orchard,	2	1	1	Sutton,	1	1	-
Lawrence,	6	-	18	Taunton,	1	-	1
Lincoln,	1	1	-	Three Rivers,	1	-	2
Linwood,	1	1	1	Upton,	1	-	1
Ludlow,	1	-	1	Uxbridge,	2	1	2
Lynn,	2	7	-	Wakefield,	1	-	1
Hospital,	1	8	3	Waltham,	7	17	3
Mansfield,	2	1	5	Ware,	3	-	3
Medford,	2	2	-	Watertown,	6	6	7
Merrick,	1	-	1	Waverly,	1	1	1
Middleton,	1	1	1	West Medway,	1	1	-
Millbury,	1	-	3	Weymouth,	1	-	3
Mittineague,	1	1	-	Winchester,	2	2	2
Natick,	1	1	-	Woburn,	3	6	13
New Bedford,	6	5	7	Worcester,	16	61	5
Newburyport,	1	1	-	Isolation Hospital,	1	4	-
Newton,	2	1	1	Total,	187	966	186

Summary of Results for the Year ended March 31, 1899.

Cases in which a Bacterial Examination was made.

Following the same method of classification which was adopted in the report of the three previous years, the cases in which cultures were made are classified into those which proved on examination to be cases of genuine diphtheria and those which did not; in other words, into positive and negative cases.

Diagnostic examinations by means of culture were made in 1,412 of the cases reported as having been treated with antitoxin, and of these, 1,195 proved to be cases of genuine diphtheria and 217 gave a negative result.

Positive Cases.

Of the 1,195 positive cases, or those in which a diagnosis of diphtheria was made by means of bacterial culture from the throat of the patient, there were 1,100 recoveries and 95 deaths, or 7.9 per cent., an improvement over the results of the three previous years which were, respectively, 13.7, 11.6 and 8.2 per cent.

Sex. — The number of males was 559, and the deaths of these were 50, or 9 per cent. The females were 626, and the deaths of these were 43, or 6.9 per cent. The sex of 10 was not stated; 2 deaths.

Ages. — The following table shows the cases and deaths by ages: —

Year ended March 31, 1899.

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).	
			1898.	1897.
From 0 to 2 years,	143	27	18.9	12.1
From 2 to 5 years,	418	42	10.0	11.2
From 5 to 10 years,	339	15	4.4	8.2
Over 10 years,	292	10	3.4	3.7
Age unknown,	3	1	33.0	0.0
	1,195	95	7.9	8.1

Day of Illness when Antitoxin was first administered. — The following table presents the fatality, according to the day of illness on which the antitoxin was first administered: —

Day.	Cases.	Deaths.	Fatality (Per Cent.).			
			1898.	1897.	1896.	1895.
First,	159	13	8.2	8.0	0.0	0.0
Second,	334	6	1.8	8.9	9.5	9.7
Third,	208	13	6.2	7.0	8.3	8.7
Fourth,	152	20	13.2	3.0	22.7	15.4
Fifth,	102	12	11.8	11.8	0.0	22.2
Sixth,	50	10	20.0	0.0	14.3	20.0
Seventh,	21	2	9.5	30.0	25.0	33.3*
Eighth and later,	67	7	10.4	13.6	16.6	–
Unknown,	102	12	–	–	–	–

* Seventh day and later.

The value of the foregoing table consists mainly in the definite statement of the fatality of cases according to the day of illness at which antitoxin treatment was begun. In general, it shows that the ratio of success in treatment depends largely upon the early date at which antitoxin is first administered. A fuller and more conclusive summary containing greater numbers may be found on a later page.

The figures for 1898 show an improvement over those of 1897 in the fact that 58.7 per cent. of the cases in 1898 were treated as early as the first, second or third days of illness, as compared with 50 per cent. in the previous year.

Hospital and Private Practice. — The fatality of the positive cases treated in hospitals in 1898 was as follows: cases treated and reported upon, 970; deaths, 75, or 7.7 per cent. In private practice: cases, 225; deaths, 20, or 8.9 per cent.

Seasons of the Year. — The cases embraced in the foregoing enumeration occurred in the following order: —

Months.	Cases.	Deaths.	Months.	Cases.	Deaths.
1898.			**1898.**		
April,	67	5	October,	119	7
May,	52	7	November,	178	9
June,	42	4	December,	164	13
July,	61	5			
August,	54	4	**1899.**		
September,	67	7	January,	141	12
			February,	122	11
Total six months,	343	32	March,	126	10
			Total six months,	850	62

By the foregoing table it appears that there were 343 positive cases reported in the warmer months, with 32 deaths, and 850 cases in the colder months, with 62 deaths.

Negative Cases.

The reported cases in which a negative result was obtained were 217, of which there were 11 deaths, or a little over 5 per cent.

Summary of the Four Years, ended March 31, 1899.

Positive Cases treated with Antitoxin.

Whole number for the four years, 2,148; deaths, 194; fatality, 9.03 per cent.

Sex. — The fatality by sexes was as follows: —

Sex.	Cases.	Deaths.	Fatality (Per Cent.).
Males,	983	96	9.8
Females,	1,136	92	8.1

The sex of 29 was not stated. Three deaths.

Ages. — The fatality by ages was as follows: —

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).
0 to 2 years,	248	46	18.5
2 to 5 years,	704	84	11.9
5 to 10 years,	624	43	6.9
Over 10 years,	555	20	3.6
Age unknown,	17	1	–

Hospitals and Private Practice.

	Cases.	Deaths.	Fatality (Per Cent.).
In hospitals,	1,268	107	8.4
In private practice,	878	87	9.9

Cases in which no Bacteriological Examination was made during the Year ended March 31, 1899.

Reports were made of 210 cases where antitoxin was employed, in which no cultures were taken. Out of this number there were 56 cases which proved fatal, or 26.2 per cent. of the whole.

The unsatisfactory character of the information in regard to this class of cases must be acknowledged, since in none of them was a diagnosis made by means of a culture from the throat of the patient. In several instances among this group it was specifically stated in the returns that the patient was "beyond help," "moribund," "in extremis," or in a condition of "great prostration" when antitoxin was administered.

It is not surprising, therefore, that the death rate of this class is large, since a considerable number of the patients treated were undoubtedly beyond the reach of all remedies.

Sex. — The number of males in this class was 110, and the deaths of these were 33, or 30 per cent. The number of females was 92, and the deaths of these were 22, or 23.9 per cent. The number of those whose sex was unknown or not stated was 8, of which number one died.

Ages. — The following table presents the cases and fatality by ages among this class: —

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).
From 0 to 2 years,	44	18	40.9
From 2 to 5 years,	71	28	39.4
From 5 to 10 years,	58	8	13.8
Over 10 years,	33	2	6.1
Age unknown,	4	0	–

Hospitals and Private Practice. — The fatality among the hospital and private cases of this class was as follows: —

	Cases.	Deaths.	Fatality.
Treated in hospitals,	46	29	63.0
Treated in private practice,	164	27	16.4

SEQUELÆ.

Among the cases reported in 1898, some sort of eruption, either urticaria or erythema, is reported to have been noticed in 393 instances. These were usually slight and evanescent in character. Albuminuria was reported in 441 cases, but in fully three-fourths of these it was slight or consisted of a trace only.

In 26 cases rheumatic pains or joint affections were reported.

OPERATIONS.

Notes are made in the returns of 204 cases in which intubation was performed, in 2 cases twice, in 2 cases three times and in 1 case eleven times.

The number of deaths among these intubated cases was 56. Tracheotomy is reported as having been performed five times and was followed by death in each case.

Among the cases reported, diphtheria was said to have been complicated with scarlet-fever in ninety-nine instances; with scarlet-fever and whooping-cough once; with scarlet-fever and chicken-pox three times; with scarlet-fever and measles twelve times; with scarlet-fever, measles and chicken-pox twice; with whooping-cough fifteen times; with mumps once; with measles forty-three times; with pneumonia twenty-six times; with syphilis once.

In the annual report of 1896 a summary of the statistics of fatality from diphtheria in certain other States and countries was presented, comprising about 20,000 cases. Very much additional testimony of the same kind might be added this year, the accumulation of which all tends to show the value of diphtheria antitoxin. The publication of such material, however, is now scarcely necessary, since the medical profession as a whole may be said to have adopted the remedy as one of the most important additions to the list of therapeutic agents.

The following statement, published in the annual report for 1896, applies equally to the results of the year 1898: —

It is quite plain that a comparison of the fatality of cases treated with antitoxin with the general fatality of cases of diphtheria previous to the introduction of this therapeutic agent, or even with cases not treated with antitoxin, which occurred at the same period with those so treated, does not do justice to the merits of antitoxin, for the reason that such a comparison must be made between two groups or classes of cases which are not strictly comparable, since one contains a larger and the other a smaller percentage of severe cases than the average. That is to say, the general run of cases treated with antitoxin by physicians in private practice, and especially of those sent to hospital, must necessarily be a selected class, in which the percentage of severe cases is greater than it is in the whole number of cases of diphtheria occurring or reported in a given community.

It has been urged, and with some degree of reason, that the diminution in the fatality from diphtheria is partly due to the introduction of bacterial diagnosis by means of cultures from the throat, whereby mild cases of illness are shown to be cases of true diphtheria which would otherwise have passed unnoticed. But this statement is in some measure offset by the fact that a considerable number of cases which might have passed for diphtheria before the days of bacterial diagnosis are now classed as "negative."

The most important lesson which is taught by these returns is the necessity of *early administration of the antitoxin in each and every case.*

Out of 486 cases in which antitoxin was administered on the first day of illness there were only 32 deaths, or 6.6 per cent.; and out of 1,281 cases treated during the first two days of illness there were only 81 deaths, or 6.3 per cent.; while the deaths in 307 cases in which antitoxin was not employed until the sixth and seventh days and later were 54, or 17.6 per cent., the patients in the former instances having a chance of living nearly three times as great as in the latter.

General Summary, 1895, 1896, 1897 and 1898.

Positive cases treated in the years ending March 31, 1899, and reported to the State Board of Health,	2,148
Cases in which no bacteriological examination was made,	1,192
Total,	3,340*
Deaths of these,	358
Fatality (per cent.),	10.7

Sexes.

The number of males who were treated was †	1,522
The number of females who were treated was †	1,745
The number whose sex was not stated was †	73
Total,	3,340*

* In this number (3,340) 316 cases in which a bacterial diagnosis showed negative results are not included, so that the whole number treated with antitoxin of which returns were made to the Board was 3,656.

† Except cases determined to be "negative."

Deaths of males,	179
Fatality of males (per cent.),	11.7
Deaths of females,	166
Fatality of females (per cent.),	9.5
Deaths, sex not stated,	13

Deaths by Ages.

Age Periods.	Cases.	Deaths.	Fatality (Per Cent.).
0 to 2 years,	383	82	21.4
2 to 5 years,	1,069	153	14.3
5 to 10 years,	1,018	84	8.3
Over 10 years,	821	34	4.1
Age unknown or not stated,	49	5	10.2
Total,	3,340	358	10.7

Day of Administration.

Day.	Cases.	Deaths.	Fatality (Per Cent.).
First,	486	32	6.6
Second,	795	49	6.2
Third,	559	54	9.7
Fourth,	410	59	14.4
Fifth,	214	33	15.4
Sixth,	111	22	19.8
Seventh and later,	196	32	16.3
Unknown,	569	77	13.5

Diphtheria Cultures examined during the Year ending March 31, 1899.

Bacteriological Diagnosis of Diphtheria for the Year ending March 31, 1899.

During the year bacteriological examination has been made of 1,591 cultures from 103 different towns and cities in the State. Of these cultures, 849 were for diagnosis and 728 for release from quarantine. While the distribution of culture outfits has been wider and the number of cities and towns making use of the service greater than last year, the total number of cultures received for examination was smaller. Several cities and institutions have used the State Board culture outfits, but have made their own examinations. The following table gives the results of the examinations made at the State Board laboratory during the year: —

Place.	Cultures examined for Diagnosis.			Cultures examined for Release from Quarantine.	Whole Number of Cultures examined.
	Positive.	Negative.	Doubtful.		
Adams,	–	3	2	–	5
Andover,	–	5	2	–	7
Arlington,	29	6	12	–	47
Ashland,	–	1	–	–	1
Athol,	–	2	–	–	2
Attleborough,	–	–	4	–	4
Barnstable,	–	–	1	–	1
Bedford,	2	1	–	–	3
Berlin,	2	3	1	–	6
Beverly,	13	9	14	–	36
Bolton,	–	1	1	–	2
Boston,	–	–	1	–	1
Brockton,	–	–	3	1	4
Brookfield,	7	1	1	–	9
Brookline,	–	–	3	–	3
Cambridge,	–	–	1	–	1
Charlestown,	–	–	2	–	2
Chelsea,	44	15	15	–	74

Place.	Cultures examined for Diagnosis. Positive.	Negative.	Doubtful.	Cultures examined for Release from Quarantine.	Whole Number of Cultures examined.
Clinton,	–	–	5	–	5
Cohasset,	–	–	4	–	4
Concord,	8	1	4	–	13
Danvers,	15	12	15	–	42
Dedham,	–	–	1	–	1
Deerfield,	–	–	1	–	1
East Boston,	3	1	–	–	4
East Watertown,	5	2	–	–	7
Everett,	97	16	43	–	156
Falmouth,	1	–	–	–	1
Fitchburg,	59	17	19	–	95
Framingham,	2	1	4	2	9
Foxborough,	–	1	–	–	1
Gloucester,	–	–	9	–	9
Greenfield,	4	1	2	–	7
Groveland,	–	1	–	–	1
Hanover,	4	2	1	–	7
Harvard,	–	–	–	1	1
Haverhill,	2	7	3	–	12
Hingham,	45	7	11	–	63
Hull,	1	1	–	–	2
Hyde Park,	63	16	16	–	95
Ipswich,	–	1	1	–	2
Lancaster,	–	–	1	–	1
Lawrence,	–	15	29	1	45
Lexington,	5	3	1	–	9
Lincoln,	–	–	1	–	1
Lynn,	–	1	–	–	1
Malden,	12	10	9	–	31
Mansfield,	1	–	–	–	1
Marblehead,	2	1	12	–	15
Marlborough,	2	6	7	–	15
Marshfield,	–	1	1	1	3
Maynard,	–	2	2	–	4
Medfield,	–	–	3	–	3
Medford,	6	17	15	–	38
Medway,	–	1	1	–	2
Methuen,	–	1	1	–	2
Middleton,	–	3	1	–	4
Milford,	–	–	1	–	1
Milton,	31	3	12	–	46
New Bedford,	129	23	21	1	174
Newburyport,	1	2	6	–	9
North Adams,	29	9	7	–	45
North Attleborough,	3	5	3	–	11
North Brookfield,	24	8	12	–	44
Newton,	2	–	–	–	2
Norton,	–	1	1	–	2
Norwell,	–	–	1	–	1
Palmer,	–	–	1	–	1
Peabody,	1	4	1	–	6
Quincy,	–	3	8	–	11

Place.	Cultures examined for Diagnosis.			Cultures examined for Release from Quarantine.	Whole Number of Cultures examined.
	Positive.	Negative.	Doubtful.		
Reading,	–	–	3	–	3
Revere,	–	–	2	–	2
Rockland,	3	2	8	1	14
Rowley,	–	4	1	1	6
Salisbury,	–	1	–	–	1
Shirley,	–	–	1	–	1
Somerville,	31	21	40	2	94
Southborough,	–	–	2	–	2
South Framingham,	–	–	2	–	2
South Groveland,	–	–	–	1	1
Spencer,	–	1	–	–	1
State Farm,	1	–	1	–	2
Stoneham,	–	–	5	–	5
Taunton,	4	4	4	–	12
Tewksbury,	–	9	21	–	30
Wakefield,	1	1	2	–	4
Ware,	–	–	1	–	1
Warren,	3	–	8	–	11
Watertown,	16	7	15	–	38
West Acton,	–	1	–	–	1
Westborough,	–	1	2	–	3
West Brookfield,	–	–	5	–	5
Westford,	–	–	3	–	3
West Medford,	–	4	9	–	13
West Medway,	–	–	1	–	1
Westport,	–	1	–	–	1
Weston,	–	1	–	–	1
West Warren,	–	–	1	–	1
Williamstown,	–	–	1	–	1
Winchester,	14	6	15	–	35
Winchendon,	1	2	5	1	9
Woburn,	–	4	7	1	12
Worthington,	–	–	1	–	1
State,	728	323	526	14	1,591

Persistence of Diphtheria Bacilli in the Throats of Patients Convalescent from Diphtheria.

In the following table are included only those cases in which frequent cultures were made until a negative result was obtained. Since cultures were rarely made oftener than once a week, there is a minus error in nearly every case that would increase the average. The time of persistence is given from the date of the earliest symptoms.

Time.	Number of Cases.	Time.	Number of Cases.
1 week, ...	3	7½ weeks, . . .	–
1½ weeks, . . .	1	8 weeks, . . .	1
2 weeks, . . .	8	8½ weeks, . . .	1
2½ weeks, . . .	8	9 weeks, . . .	–
3 weeks, . . .	11	9½ weeks, . . .	–
3½ weeks, . . .	8	10 weeks, . . .	1
4 weeks, . . .	14	10½ weeks, . . .	1
4½ weeks, . . .	9	11 weeks, . . .	–
5 weeks, . . .	4	11½ weeks, . . .	–
5½ weeks, . . .	3	12 weeks, . . .	1
6 weeks, . . .	2		
6½ weeks, . . .	4	Average, 4+ weeks, .	–
7 weeks, . . .	5		

Relation of Clinical to Bacteriological Diagnosis.

Clinical Diagnosis.	Bacteriological Diagnosis.			Percentage of Error in Clinical Diagnosis.
	Positive.	Negative.	Doubtful.	
Positive in 307 cases, ...	160	144	3	46.9
Negative in 184 cases, ...	39	141	4	21.2
Doubtful in 211 cases, ...	58	151	2	–
Not given in 158 cases, ...	37	118	3	–

EXAMINATIONS OF SPUTUM AND OTHER MATERIAL SUSPECTED OF CONTAINING THE BACILLI OF TUBERCULOSIS.

During the year microscopical examinations have been made of 414 specimens of material suspected of containing the bacilli of tuberculosis. This number is nearly twice that of last year, and between three and four times that of the year before. This material was received from 92 different towns and cities in the State, against 51 last year and 38 the year before. In 1896 48 per cent., in 1897 46 per cent., and in the present year 46.8 per cent. of the cases were positive. The following tables show the results of the examinations made during the past year: —

Tabular Statement of Examinations of Material.

Towns.	Number of Cases examined.	Males.		Females.		Sex not Stated.	
		Positive.	Negative.	Positive.	Negative.	Positive.	Negative.
Adams,	1	–	1	–	–	–	–
Arlington,	16	4	3	2	5	–	2
Ashland,	1	–	–	1	–	–	–
Attleborough,	5	2	–	–	3	–	–
Ayer,	2	–	–	1	1	–	–
Beechwood,	1	–	–	–	1	–	–
Belmont,	2	–	–	1	1	–	–
Billerica,	2	–	–	1	1	–	–
Blackstone,	1	–	–	–	–	1	–
Boston,	3	1	–	–	2	–	–
Boylston,	1	1	–	–	–	–	–
Bradford,	4	–	–	1	3	–	–
Brockton,	11	3	1	2	2	2	1
Brookfield,	2	–	1	–	1	–	–
Cambridge,	3	–	1	1	1	–	–
Campello,	1	–	–	–	1	–	–
Chelmsford,	1	–	–	–	1	–	–
Chelsea,	15	3	2	2	3	3	2
Clinton,	2	1	–	1	–	–	–
Cohasset,	1	–	1	–	–	–	–

Tabular Statement of Examinations of Material — Continued.

Towns.	Number of Cases examined.	Males.		Females.		Sex not Stated.	
		Positive.	Negative.	Positive.	Negative.	Positive.	Negative.
Cold Springs,	1	–	–	–	1	–	–
Colrain,	1	–	–	1	–	–	–
Concord,	9	4	4	–	1	–	–
Danvers,	7	1	3	2	1	–	–
Dedham,	9	3	3	1	2	–	–
Dorchester,	1	–	–	–	1	–	–
East Bridgewater,	5	1	1	–	3	–	–
East Cambridge,	1	–	–	–	1	–	–
Edgartown,	1	–	1	–	–	–	–
Everett,	15	1	2	9	3	–	–
Fall River,	39	3	11	16	8	–	1
Fitchburg,	8	1	4	2	1	–	–
Forge Village,	3	–	1	1	1	–	–
Foxborough,	2	–	2	–	–	–	–
Framingham,	7	2	1	–	4	–	–
Franklin,	3	–	1	2	–	–	–
Gloucester,	6	3	1	1	1	–	–
Hanover,	1	–	1	–	–	–	–
Haverhill,	6	2	–	1	3	–	–
Holbrook,	1	–	–	–	1	–	–
Hyde Park,	1	–	–	–	1	–	–
Jamaica Plain,	1	–	–	–	1	–	–
Lawrence,	4	2	1	–	1	–	–
Lexington,	3	–	–	–	1	2	–
Lynn,	1	–	1	–	–	–	–
Maynard,	1	1	–	–	–	–	–
Medford,	4	2	1	1	–	–	–
Medway,	2	–	–	–	2	–	–
Melrose Highlands,	1	–	1	–	–	–	–
Middleborough,	3	2	–	1	–	–	–
Middleton,	1	–	–	–	1	–	–
Mittineague,	1	–	–	–	–	–	1
New Bedford,	30	5	7	9	8	–	1
Newton,	1	–	1	–	–	–	–
North Adams,	27	1	6	12	4	3	1
North Attleborough,	7	2	2	–	2	1	–
North Brookfield,	2	2	–	–	–	–	–
North Cambridge,	1	–	1	–	–	–	–
North Dartmouth,	1	–	–	1	–	–	–
North Woburn,	1	1	–	–	–	–	–
Norwood,	7	4	1	–	2	–	–
Plainville,	2	1	–	1	–	–	–
Quincy,	3	1	–	1	1	–	–
Randolph,	2	–	–	1	1	–	–
Reading,	3	–	1	–	2	–	–
Renfrew,	2	–	–	2	–	–	–
Ringville,	1	–	–	–	1	–	–
Rockland,	12	2	6	1	3	–	–

Tabular Statement of Examinations of Material — Concluded.

Towns.	Number of Cases examined.	Males.		Females.		Sex not Stated.	
		Positive.	Negative.	Positive.	Negative.	Positive.	Negative.
Roxbury,	7	3	3	–	1	–	–
Salem,	4	2	–	–	1	1	–
Saxonville,	2	–	–	1	1	–	–
Somerville,	11	5	–	2	3	–	1
South Framingham,	3	3	–	–	–	-	–
South Weymouth,	4	1	3	–	–	–	–
Spencer,	2	–	–	2	–	–	–
Wakefield,	1	–	1	–	–	–	–
Warren,	5	1	3	1	–	–	–
Watertown,	10	1	6	1	2	–	–
Wellesley Hills,	1	–	–	1	–	–	–
West Chesterfield,	1	–	–	1	–	–	–
Westford,	6	2	4	–	–	–	–
West Hanover,	1	–	–	–	1	–	–
West Quincy,	1	–	1	–	–	–	–
West Somerville,	1	–	1	–	–	–	–
West Worthington,	1	–	–	–	1	–	–
Whitman,	4	1	2	1	–	–	–
Williamstown,	3	–	1	1	1	–	–
Winchendon,	1	–	–	–	1	–	–
Winchester,	14	5	7	1	1	–	–
Winthrop,	2	2	–	–	–	–	–
Woburn,	2	1	–	–	1	–	–
Wollaston,	1	1	–	–	–	–	–
Total,	414	90	107	91	103	13	10

Distribution by Ages.

	Number of Cases examined.	Positive.	Negative.
Between the age of 1–10,	7	–	7
Between the age of 10–20,	52	27	25
Between the age of 20–30,	141	68	73
Between the age of 30–40,	90	49	41
Between the age of 40–50,	42	15	27
Between the age of 50-60,	25	11	14
Between the age of 60–70,	14	3	11
Between the age of 70–80,	3	1	2
Between the age of 80–90,	1	–	1
Age not stated,	39	16	23
Total,	414	190	224

Distribution by Sexes.

	Total.	Males.	Females.	Sex not Stated.
Number of cases examined (positive), .	194	90	91	13
Number of cases examined (negative), .	220	107	103	10
Total, ...	414	197	194	23

Summary of the Three Years ending March 31, 1899.

Sexes. — The whole number examined in the three years was 774, and of these, 354 were males, 374 were females and the sex of 46 was not stated. Of the male cases 46.6 per cent. and of the female cases 45.7 per cent. were positive.

Ages. — Of the whole number examined, 102 were under twenty years of age, 508, or 74.1 per cent., of those whose ages were known were between twenty and fifty years of age and 76 were over fifty. The age was not stated in 88 cases.

Of 350 specimens from persons who were under thirty years of age, 172, or 49.1 per cent. were positive, and of 336 from persons over twenty years of age, 146, or 43.4 per. cent., were negative. These figures refer to those only whose ages were stated in the returns.

MALARIA.

During the past year physicians have continued to avail themselves of the opportunity offered by the Board to make a microscopic examination of dried blood films in cases of suspected malaria. Preparations were received from 132 cases, of which 51 contained malaria parasites. Their distribution is given in the following table: —

Towns.	Number of Patients.	Positive.	Negative.	Towns.	Number of Patients.	Positive.	Negative.
Ayer, ...	2	2	-	North Billerica, .	1	-	1
Billerica, . . .	35	21	14	North Chelmsford, .	1	-	1
Brookline, . . .	2	-	2	Shirley, . . .	1	-	1
Clinton, . . .	4	1	3	Southborough, .	1	-	1
Concord, . . .	12	6	6	South Lancaster, .	1	-	1*
Concord Junction, .	1	-	1	Stoughton, . .	4	1	3†
Dorchester, . .	3	-	3	Uxbridge, . .	7	-	7
Everett, . . .	1	-	1	Waltham, . .	24	10	14
Hyde Park, . .	3	-	3	Weston, . . .	2	-	2
Lancaster, . . .	1	1	-	Williamstown, .	2	-	2‡
Lowell, . . .	4	2	2	Winchester, . .	14	4	10§
Marlborough, . .	3	2	1	Woburn, . . .	1	-	1
Middleborough, .	2	1	1	Total, . .	132	51	81

* Preparations worthless; diagnosis impossible.

† In one case preparations worthless.

‡ Widal test positive in both cases.

§ One case doubtful.

In this table there is included among the negative cases a small proportion in which the microscopic examination of the blood films suggested a recent attack, though the parasite was not found. The ratio of positive to negative cases may, therefore, be considered somewhat higher than the table indicates.

As hitherto, the parasite of the so-called tertian fever of temperate climates was the only one found, with the exception of one case, — that of a soldier returned from Cuba. In the blood of this individual the parasite of the tropical or æstivo-autumnal type of malaria was present.

The method adopted in the preparation of the blood films * has been found satisfactory and hence no change has been made. Occasionally poorly prepared blood films have been received. In such cases it was evident that the physician had either not seen the directions issued by the Board or had forgotten them. Only when the blood corpuscles are perfectly preserved can a satisfactory microscopic diagnosis be made.

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* See report for 1896.

STATISTICAL SUMMARIES

OF

DISEASE AND MORTALITY.

STATISTICAL SUMMARIES OF DISEASE AND MORTALITY.

The statistical information received by the Board during each year, either through the medium of voluntary returns or in consequence of legal requirements, has, in the last three reports of the Board, been presented under four different heads or groups, which are summarized and defined as follows: —

1. *The Weekly Mortality Returns.* — These consist of the reports of deaths, which are made up weekly and are sent to the office of the State Board by the registration officials of cities and towns. They are voluntary, and serve principally to show the seasonal prevalence of each of the chief infectious diseases, and the mortality of children under five years old in weekly periods. This series of statistics has been continued by the Board for more than twenty years, and has been published as a summary for fifteen years.

2. *The Reports of Certain Infectious Diseases, — Diphtheria and Croup, Scarlet-fever, Typhoid Fever and Measles.* — These are obtained from the annual reports of local boards of health for the year 1898, which are forwarded to the State Board from cities and towns. By comparing the numbers of reported cases with the reported deaths, the mean fatality of each disease in the places from which the reports are made is obtained with a reasonable degree of accuracy.

3. *Reports of Cities and Towns, made under the Provisions of Chapter 302 of the Acts of 1893.* — By this act each local board of health is required to report to the State Board every case of "disease dangerous to the public health" which is reported to the local board. A digest of these reports is presented in Summary No. III.

4. *Annual Reports, made under the Provisions of Chapter 218 of the Acts of 1894.* — The full reports of deaths occurring in each city and town hav-

ing over 5,000 inhabitants comprise another series of returns, which are summarized in No. IV. These reports are made under the requirements of the following statute: —

[Acts of 1894, Chapter 218, Section 3.]

In each city and town having a population of more than five thousand inhabitants, as determined by the last census, at least one member of said board shall be a physician, and the board shall send an annual report of the deaths in such town to the State Board of Health. The form of such reports shall be prescribed and furnished by the State Board of Health.

Note. — A supply of the postal cards necessary for the reporting of voluntary mortality returns such as are required for the data presented in section 1 of the following summary, will be forwarded to the registration officers of any city or town who are willing to contribute the necessary information.

Postal cards are also sent to all boards of health in the State, for the purpose of aiding them to comply with the provisions of chapter 302 of the Acts of 1893, relative to the reporting of diseases dangerous to the public health to the State Board immediately after reports of the same are received by the local board.

Annual blank forms are also sent to each local board of health in cities and towns having over 5,000 inhabitants, for the return of such information as is called for by the provisions of chapter 218 of the Acts of 1894.

I.

Summary of the Weekly Mortality Reports from Cities and Towns.

The following summary comprises the returns of deaths made at the end of each week by the town clerks, city registrars and other officials having in charge the vital statistics of cities and towns.

These returns are compiled each week and published as a bulletin, one copy of which is sent to the registering officer of each city and town in the State. These reports are necessarily incomplete, since they are voluntary, and comprise the mortality statistics of a part of the population only, the reporting places being chiefly the cities and larger towns. The value of the weekly mortality returns consists very largely in the fact that they constitute a continuous history of the prevalence of the principal infectious diseases throughout the State, so far as can be learned from the mortality which they cause.

In connection with the results of the information obtained as a consequence of the enactment of chapter 302 of the Acts of 1893, these weekly mortality reports furnish to the Board an important index of the health of the people, as influenced by the prevalence of epidemic diseases at different seasons of the year. The estimated population of the cities and towns contributing to the returns of 1898 was 1,611,780, or about two-thirds of the total population.

The data embraced in this summary are the following: —

Average height of barometer for each week.
Mean maximum temperature.
Mean minimum temperature.
Rainfall, expressed in inches.
Total deaths reported for each week.
Deaths of children under five years.
Deaths from infectious diseases.
Deaths from consumption.
Deaths from acute lung diseases.
Deaths from typhoid fever.
Deaths from diarrhœal diseases.
Deaths from scarlet fever.
Deaths from measles.
Deaths from diphtheria and croup.
Deaths from puerperal fever.
Deaths from whooping-cough.
Deaths from malarial fever.
Deaths from small-pox.
Deaths from erysipelas.
Deaths from cerebro-spinal meningitis.

The following table contains a summary of the statistics compiled from these weekly returns of mortality: —

Summary.

1898.	Barometer.	Mean Maximum Thermometer for Each Week.	Mean Minimum Thermometer for Each Week.	Humidity.	Rainfall, in Inches.	Total Deaths.	Deaths under Five Years of Age.	Consumption.	Acute Lung Diseases.	Typhoid Fever.	Diphtheria and Croup.	Scarlet Fever.	Measles.	Diarrhœal Diseases.	Whooping-cough.	Malarial Fever.	Puerperal Fever.	Erysipelas.	Cerebro-spinal Meningitis.
Jan. 8, ...	29.94	37	18	65	-	590	140	56	94	8	14	4	-	5	1	-	3	1	7
15, ...	30.02	44	30	73	-	527	149	52	91	1	17	-	1	-	1	-	-	1	5
22, ...	30.17	37	25	80	-	554	146	64	93	5	10	2	-	6	4	-	-	2	5
29, ...	29.80	29	18	68	4.92	487	126	59	74	5	10	2	-	9	3	-	-	1	7
Feb. 5, ...	30.09	26	8	68	-	491	137	69	77	2	9	3	-	3	4	1	-	-	6
12, ...	30.29	46	32	79	-	521	153	50	100	6	11	1	1	5	4	-	1	-	5
19, ...	29.93	40	24	74	-	525	166	56	98	9	10	4	-	2	5	-	1	-	7
26, ...	29.96	42	32	84	4.55	521	161	54	85	2	10	2	2	6	-	-	-	-	5
March 5, ...	30.06	41	28	74	-	588	181	68	113	1	16	3	1	11	3	-	-	3	8
12, ...	30.36	56	37	70	-	564	167	77	105	3	9	-	1	5	5	-	1	1	7
19, ...	30.11	53	39	70	-	552	172	61	73	7	14	1	1	11	4	-	-	-	15
26, ...	30.22	49	36	71	2.35	538	115	70	91	7	2	-	1	7	3	-	1	2	11
April 2, ...	30.20	45	35	76	-	547	170	67	100	5	11	1	7	7	1	-	-	5	11
9, ...	30.00	46	29	61	-	559	166	71	87	3	9	1	2	6	4	-	-	3	13
16, ...	29.86	51	41	70	-	616	190	60	100	11	9	1	4	12	6	-	1	1	6
23, ...	29.93	58	42	66	-	592	175	67	91	4	9	1	2	6	7	-	-	1	7
30, ...	29.98	44	38	87	4.89	475	121	59	74	5	10	3	1	2	3	-	1	-	4
May 7, ...	29.97	58	75	74	-	537	149	53	88	5	7	4	-	7	4	-	-	5	12
14, ...	29.99	62	46	67	-	553	160	58	84	3	11	3	2	5	2	-	-	3	11
21, ...	30.02	68	51	69	-	559	148	59	81	6	10	-	2	8	6	-	2	1	10
28, ...	30.01	60	49	86	4.49	471	129	72	70	2	7	-	3	7	4	1	-	1	9
June 4, ...	29.98	64	54	87	-	459	131	47	53	6	2	2	3	10	6	-	-	3	13
11, ...	30.07	73	57	79	-	429	128	56	44	4	7	1	-	10	3	-	-	-	4
18, ...	30.01	67	56	69	-	473	142	61	39	5	3	-	1	14	6	-	-	-	11
25, ...	29.81	74	62	70	2.67	468	149	56	35	2	3	-	3	22	4	-	-	2	11
July 2, ...	29.99	81	65	69	-	479	175	61	28	5	6	-	-	42	6	-	-	1	10
9, ...	29.99	84	63	63	-	526	184	64	36	5	4	2	1	57	4	-	-	1	7
16, ...	30.13	73	59	72	-	474	176	52	39	1	5	-	1	72	4	-	-	2	1
23, ...	30.19	80	66	81	-	476	194	42	34	4	6	2	-	92	5	-	2	-	3
30, ...	29.98	79	66	91	4.51	598	284	62	27	4	5	2	-	152	7	-	-	2	6
Aug. 6, ...	29.99	80	67	81	-	707	420	41	32	4	8	-	1	244	8	-	1	-	10
13, ...	29.95	79	66	81	-	728	418	41	12	7	1	1	2	260	5	-	-	-	6
20, ...	30.06	80	64	78	-	783	449	58	29	9	8	4	-	260	12	-	1	-	12
27, ...	29.87	84	66	75	7.02	716	340	52	27	11	5	-	-	185	6	-	-	-	7

Sept. 3,	30.00	81	65	71	-	665	345	52	23	12	7	1	-	179	8	-	2	2	15
10,	30.04	81	65	74	-	647	315	49	27	14	5	-	-	168	4	-	-	-	10
17,	30.19	70	55	76	-	654	311	52	21	18	8	-	-	131	7	-	-	-	7
24,	30.00	73	54	73	2.04	595	253	60	30	12	9	-	-	97	7	2	-	1	5
Oct. 1,	30.07	71	53	77	-	582	246	65	38	19	8	3	-	63	5	-	-	-	4
8,	30.22	71	56	81	-	581	242	50	54	17	7	1	1	52	9	-	1	-	5
15,	30.01	60	46	75	-	544	187	60	48	17	8	2	-	45	6	-	1	-	7
22,	30.11	57	46	81	-	500	144	58	57	17	16	2	-	18	3	-	2	-	6
29,	30.03	60	44	78	7.38	574	166	50	50	13	11	-	-	19	4	-	1	-	2
Nov. 5,	30.05	54	41	77	-	490	152	47	58	15	19	1	1	18	-	-	-	-	3
12,	30.06	53	40	73	-	483	110	52	52	16	15	1	-	7	-	-	1	-	3
19,	29.99	49	39	79	-	515	150	70	84	9	10	1	-	11	4	-	-	-	7
26,	30.04	45	34	73	6.70	506	130	57	35	4	18	6	3	4	2	-	-	1	3
Dec. 3,	29.73	39	27	75	-	608	176	62	93	14	21	1	2	12	6	-	-	1	5
10,	29.90	38	31	63	-	572	146	72	80	7	14	2	-	6	3	2	2	-	3
17,	30.09	52	17	65	-	592	135	57	100	13	20	3	1	7	-	-	-	-	2
24,	30.02	43	30	79	-	619	158	68	113	15	13	4	-	5	1	-	2	2	10
31,	29.99	42	22	70	2.64	623	165	63	154	6	14	1	-	8	4	-	-	-	4
Totals,	-	-	-	-	54.16	29,033	9,949	3,039	3,421	405	514	79	44	2,498	223	6	27	49	373
Weekly averages,	-	-	-	-	-	558	191	58	66	8	10	1.52	0.84	48	4.29	.11	.52	.94	7.17
Rate per 1,000 deaths,	-	-	-	-	-	-	326.79	104.67	117.83	13.95	17.70	2.72	1.51	86.04	7.68	0.20	0.93	1.68	12.84
Rate per 1,000 population,	-	-	-	-	-	18.01	6.17	1.88	2.12	0.25	0.32	0.05	0.03	1.55	0.13	0.003	0.02	0.03	0.23

Average reporting population, ... 1,611,780

Total Deaths.

The whole number of deaths reported for the year 1898 from the cities and towns contributing to these reports was 29,033, and the average per week was 558. The greatest number of deaths reported in a single week was 783, in the week ending August 20; the least number was 429, in the week ending June 11. The weekly average number of deaths reported for each month was as follows: —

January,	539	July,	510
February,	514	August,	733
March,	560	September,	640
April,	558	October,	556
May,	530	November,	498
June,	451	December,	603

The percentage of mortality in each of the four quarters of the year were as follows: —

	All Ages.		Ages under 5 Years.	
	Numbers.	Percentages.	Numbers.	Percentages.
First quarter,	6,468	22.27	1,820	18.29
Second quarter,	6,736	23.20	1,958	19.60
Third quarter,	8,048	27.71	3,864	38.83
Fourth quarter,	7,789	26.82	2,307	23.28
	29,033	100.00	9,949	100.00

Deaths under Five Years of Age.

The reported number of deaths of children under five years of age was 9,949. The average weekly number was 191. The greatest number reported in one week was 449, in the week ending August 20; and the least number was 110, in the week ending November 12. The ratio of the deaths of this class to the total reported mortality was 32.6 per cent. The average weekly number of deaths of children under five years of age by months was as follows: —

January,	142	July,	203
February,	154	August,	407
March,	159	September,	306
April,	164	October,	197
May,	147	November,	135
June,	137	December,	176

The months having the greatest number of deaths of children under five years of age were July, August and September, and those having the least number were January, June and November.

Consumption.

The number of reported deaths from consumption was 3,039. The weekly average was 58. The greatest number of deaths reported from this cause in a single week was 77, in the week ending March 12; and the least number was 47, in the weeks ending June 4 and November 5. The average weekly number of reported deaths from this cause in each month was as follows: —

January,	58	July,	54
February,	57	August,	51
March,	69	September,	53
April,	65	October,	57
May,	60	November,	56
June,	55	December,	66

The following table presents the variations from the weekly average number of deaths from this cause for the past four years: —

	1895.	1896.	1897.	1898.		1895.	1896.	1897.	1898.
January,	−4	+1	+8	0	July,	−9	−1	+3	−4
February,	+17	+3	+7	−1	August,	−13	+10	−7	−7
March,	+15	−1	+7	+11	September,	−7	−7	−6	−5
April,	+4	+21	+6	+7	October,	−1	−5	−4	−2
May,	-	+2	+4	+2	November,	−1	−10	+2	−2
June,	+2	+1	−1	−3	December,	−4	−9	−3	+8

The ratio of reported deaths from consumption to the mortality reported from all causes was 104.6, while that of previous years was as follows: —

1889,	125.0	1894,	111.8
1890,	130.0	1895,	107.7
1891,	116.5	1896,	105.3
1892,	111.3	1897,	104.2
1893,	106.5	1898,	104.6

The ratio to the reported living population in 1898 was 1.88 per 1,000, as compared with 1.97 in 1897.

Acute Lung Diseases.

The number of reported deaths from acute lung diseases (bronchitis, pneumonia, pleurisy and asthma) during the year was 3,421, and the weekly average was 66. The greatest number of deaths reported from this group of causes in a single week was 154, in the week ending December 31; and the least number was 12, in the week ending August 12. The average weekly number of reported deaths from these causes for each month was as follows: —

January,	88	July,	34
February,	90	August,	25
March,	95	September,	22
April,	90	October,	49
May,	81	November,	57
June,	42	December,	108

The months having the greatest number of reported deaths from these causes were March, April and December, and those having the least number were July, August and September. The ratio of reported deaths from acute lung diseases to the reported mortality from all causes was 117.8 per 1,000. The estimated death-rate per 1,000 of the reporting population from these causes was 2.12, as compared with 2.43 in 1897.

Diarrhœal Diseases.

The diseases included in this group are diarrhœa, dysentery, cholera morbus and cholera infantum. From these causes combined the number of deaths reported in 1898 was 2,498, and the weekly average number was 185 in the week ending August 27; and no deaths were reported from these causes in the weeks ending January 15 and February 19. The average weekly number of reported deaths from these causes in each month was as follows: —

January,	5	July,	66
February,	3	August,	220
March,	9	September,	144
April,	6	October,	39
May,	7	November,	10
June,	14	December,	7

The months having the greatest number of reported deaths from these causes in 1897 were July, August and September, and those having the least were January, February and April.

The deaths from these causes in the third quarter of the year constituted 70.7 per cent. of the number of deaths from the same causes for the entire year. The ratio of the reported deaths to the reported mortality from all causes was 86.0 per 1,000, and the death-rate of reporting population from these causes was 1.55 per 1,000, as compared with 1.84 in 1896.

Typhoid Fever.

The total number of reported deaths from this cause in 1898 was 405, and the average weekly number was 8. The greatest number reported in any single week from this cause was 19, in the week ending October 1, and there was only 1 death reported from typhoid fever in each of the weeks ending January 15, March 5 and July 16. The average weekly number of deaths reported from this cause for each month was as follows: —

January,	5	July,	3
February,	5	August,	7
March,	4	September,	14
April,	6	October,	17
May,	4	November,	11
June,	4	December,	11

The months having the least number of deaths from this cause were May and July, and those having the greatest number were September and October. The ratio of reported deaths from typhoid fever to the reported mortality from all causes was 13.9 per 1,000, and the ratio to the reporting population was .25 per 1,000, as compared with .26 in the previous year.

Diphtheria and Croup.

The total number of reported deaths from diphtheria and croup in 1898 was 514, and the average number in each week was 10. The greatest number reported in a single week from these combined causes was 21, in the week ending December 3, and the least number was 2, in the week ending June 4. The average weekly number of reported deaths from these causes for each month was as follows: —

January,	13	July,	5
February,	10	August,	5
March,	10	September,	7
April,	10	October,	10
May,	9	November,	16
June,	4	December,	16

The ratio of deaths from diphtheria and croup to the reported mortality from all causes was 17.70 per 1,000 and the death-rate for the reporting population was .32 per 1,000, as compared with .60 in the previous year.

Scarlet Fever.

The reported deaths from scarlet fever in 1897 were 79. The greatest number reported from this cause in a single week was 4. There were 12 weeks in which no deaths from scarlet fever were reported. The average weekly number reported in each month was as follows: —

January,	2	July,	1
February,	2	August,	1
March,	1	September,	0
April,	1	October,	2
May,	2	November,	2
June,	1	December,	2

The ratio of deaths from this cause to the reported deaths from all causes was 2.72 per 1,000, and the death-rate of the reporting population from this cause was .04 per 1,000, as compared with .15 in the previous year.

Cerebro-spinal Meningitis.

The total number of reported deaths from this cause was 373, and the weekly average was 7, the greatest number reported in any week from this cause was 15, in the weeks ending March 1 and September 3; and the least number was 1, in the week ending July 16. The average weekly number of deaths reported from this cause for each month was as follows: —

January,	6	July,	5
February,	6	August,	9
March,	10	September,	9
April,	8	October,	5
May,	10	November,	4
June,	10	December,	5

The months having the greatest number of reported deaths from this cause were April and May, and those having the least were February and November.

Whooping-cough, Malarial Fever, Erysipelas and Puerperal Fever.

The essential statistics relating to these five diseases are embraced in the following table : —

Diseases.	Total Deaths reported.	Weekly Average.	Ratio per 1,000 of Total Reported Deaths.	Ratio per 1,000 of Reporting Population.
Whooping-cough, ...	223	4.3	7.68	.130
Erysipelas, ...	49	0.9	1.68	.034
Puerperal fever, ...	27	0.5	0.93	.016
Malarial fever, ...	6	0.1	0.20	.004

II.

Fatality (Ratio of Deaths to Cases) from Certain Infectious Diseases in 1898.

The statistics presented in the following table are compiled from the published reports of local boards of health for the year 1898 which have been forwarded to the office of the State Board of Health. They are the figures representing the numbers of cases reported to certain local boards of health under the provisions of section 79 of chapter 80, Public Statutes.

The numbers of deaths are also obtained from the same reports, and the comparison of these two series of figures presents a fairly accurate method of arriving at the fatality from these diseases in the places from which they are reported. The figures representing the numbers of cases are probably less than the actual numbers, since some cases must necessarily escape registration through neglect to report or in consequence of faulty diagnosis.

Cases of Infectious Diseases and Deaths reported to Local Boards of Health, 1898.

City or Town.	Diphtheria and Croup.		Scarlet Fever.		Typhoid Fever.		Measles.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
Adams,	9	3	6	0	40	7	-	-
Amesbury,*	6	2	17	-	4	-	3	-
Arlington,	18	1	-	-	21	-	-	-
Attleborough,	3	-	13	-	4	1	31	-
Ayer,	1	-	3	-	14	1	-	-
Barre,†	-	-	-	-	4	1	2	-
Belmont,	3	-	4	-	3	-	5	-
Beverly,	9	1	15	1	20	2	3	-
Boston,	1,661	185	877	33	555	185	2,177	27
Brockton,	6	1	21	1	13	3	16	-
Brookline,	23	3	17	2	23	2	104	2
Cambridge,	152	29	122	6	96	14	53	1

* Whooping-cough, many cases.

† Whooping-cough, 20 cases; mumps, 2; chicken pox, 2; German measles, 1.

Cases of Infectious Diseases and Deaths reported to Local Boards of Health, 1898 — Continued.

City or Town.	Diphtheria and Croup.		Scarlet Fever.		Typhoid Fever.		Measles.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
Canton,	-	-	-	-	-	-	-*	-
Chelsea,	47	3	214	1	23	7	79	-
Chicopee,	19	5	5	-	-	-	45	-
Concord,	3	-	5	-	10	3	36	-
Danvers,	18	1	13	-	10	1	7	-
Dedham,	2	-	2	-	1	-	38	-
Dracut,	-	-	17	-	1	-	3	-
Duxbury,	-	-	1	-	-	-	-	-
Easthampton,	1	-	6	-	-	-	2	-
Everett,	43	8	49	1	27	5	26	-
Fall River,	55	14	134	5	63	21	-	-
Fitchburg,	38	1	16	1	32	6	32	-
Foxborough,	5	-	1	-	1	-	7	-
Franklin,	-	-	-	-	4	-	12	-
Gardner,	5	3	49	2	14	1	-	-
Gloucester,	14	5	53	2	25	2	-	-
Great Barrington,	-	-	3	-	-†	-†	-	-
Greenfield,‡	12	-	13	-	8	2	4	1
Haverhill,§	61	13	58	-	94	8	397	7
Holyoke,	35	10	50	1	27	8	88	1
Hudson,	2	2	13	2	6	2	4	-
Hyde Park,	68	10	26	-	9	1	39	-
Ipswich,	27	4	-	-	15	-	3	-
Lee,	-	-	45	1	-	-	-	-
Leicester,	1	-	13	-	2	-	1	-
Leominster,	1	-	16	-	16	2	118	-
Lexington,	1	-	1	-	2	-	32	-
Lincoln,	-	-	1	-	1	-	4	-
Lowell,	156	36	309	6	119	24	33	-
Lynn,	105	7	92	3	108	15	13	-
Malden,	56	5	72	1	52	5	32	-
Manchester,	-	-	3	-	-	-	-	-
Marblehead,	5	1	-‖	-	4	1	-	-
Marlborough,	-	-	39	-	6	-	3	-

* Many. † Several. ‡ Small-pox, 4 cases.
§ Whooping-cough, 108 cases, 24 deaths. ‖ Few.

Cases of Infectious Diseases and Deaths reported to Local Boards of Health, 1898 — Continued.

City or Town.	Diphtheria and Croup.		Scarlet Fever.		Typhoid Fever.		Measles.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
Maynard,	12	-	-	-	-	-	-	-
MEDFORD,	21	3	22	-	21	3	8	-
MELROSE,	5	-	20	-	-	-	98	-
Milford,	16	2	-	-	-	-	-	-
Millbury,	3	-	10	-	3	-	-	-
Natick,	7	1	9	1	7	5	-	-
NEW BEDFORD,	78	18	101	4	129	17	11	-
NEWBURYPORT,	6	3	2	-	7	2	3	-
NEWTON,	39	6	53	3	44	7	44	-
NORTH ADAMS,*	38	8	29	2	36	10	13	-
NORTHAMPTON,	17	1	21	-	9	3	71	-
North Andover,	4	1	13	-	5	2	40	-
North Attleborough,	10	1	8	-	2	2	36	1
North Brookfield,	23	6	36	4	-	-	-	-
Norwood,	-	-	1	-	7	-	65	-
Palmer,	4	1	32	1	6	1	-	-
Pepperell,	2	-	7	-	-	-	-	-
PITTSFIELD,	112	7	8	1	15	3	2	-
Plymouth,	2	-	-	-	13	4	-	-
Reading,	1	-	-	-	9	-	2	-
Rockland,	2	-	7	-	8	4	-	-
SALEM,	32	4	53	-	36	5	-	-
Saugus,	1	-	1	-	3	-	-	-
SOMERVILLE,	74	12	80	-	54	11	-	-
SPRINGFIELD,	164	29	78	1	31	15	86	1
Southbridge,	-†	-†	-†	-†	-	-	-	-
Swampscott,	5	1	7	-	5	-	2	
TAUNTON,	11	1	27	1	19	8	17	-
Tewksbury,	-	-	10	1	2	-	-	-
Wakefield,	7	3	22	-	11	1	21	-
Walpole,	1	-	6	-	4	-	8	-
WALTHAM,	53	3	25	1	35	7	1	-
Ware,	6	2	49	1	4	1	-	-
Watertown,‡	22	2	57	5	13	2	2	-
Wellesley,	1	-	1	-	3	-	8	-

* Chicken-pox, 3; mumps, 12. † Several. ‡ Whooping-cough, 3.

Cases of Infectious Diseases and Deaths reported to Local Boards of Health, 1898 — Concluded.

City or Town.	Diphtheria and Croup.		Scarlet Fever.		Typhoid Fever.		Measles.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
West Brookfield,*	-	-	3	-	-	-	3	-
Westfield,†	-	-	4	-	9	3	12	-
Westford,	2	-	41	-	10	2	1	-
West Springfield,	17	-	10	-	-	-	34	-
Whitman,	3	-	-	-	-	-	-	-
Winchester,	13	1	16	-	3	1	92	1
Winthrop,	1	-	3	-	11	-	1	-
WOBURN,	61	4	8	1	11	2	4	-
WORCESTER,	296	34	215	5	81	13	23	-
Totals,	3,843	507	3,509	101	2,143	464	4,160	42
Fatality (per cent),	13.2		2.9		21.7		1.0	

* An epidemic of chicken-pox and of measles. † Small-pox, 1.

The figures for 1898 are as follows:—

Reported cases of diphtheria and croup,	3,843
Registered deaths from diphtheria and croup in the same cities and towns,	507
Fatality (per cent.),	13.2
Reported cases of scarlet fever,	3,509
Registered deaths from scarlet fever in the same cities and towns,	101
Fatality (per cent.),	2.9
Reported cases of typhoid fever,	2,143
Registered deaths from typhoid fever in the same cities and towns,	464
Fatality (per cent.),	21.7
Reported cases of measles,	4,160
Registered deaths from measles in the same cities and towns,	42
Fatality (per cent.),	1.0

Ninety cities and towns are embraced in this table, a slightly smaller number than those of last year. The cities of the State, and especially all the large cities, are included, and the whole number included in the table contains about three-quarters of the population of the State.

The reported cases of diphtheria and croup were less than half as many as those of the preceding year, and the number of deaths was less than that of either of the four preceding years. The fatality being only 13.2 per cent. as compared with 14.1 per cent. in 1897. This progressive reduction in the fatality of diphtheria since the introduction of antitoxin is worthy of note.

The reported cases of scarlet fever were more than those reported in 1897, and the fatality (2.9 per cent.) was less than that of any previous year of record.

The reported cases of typhoid fever were less than those of any previous year since 1892, and the fatality (21.7 per cent.) was greater than that recorded in any previous year since 1892.

The reported cases of measles were less than one-third as many as those of 1897, and the fatality (1 per cent.) was slightly greater.

The following table presents the summary of these statistics for the eight years 1891–98 : —

Reported Cases of Infectious Diseases in Massachusetts.

Diphtheria and Croup.

[Pre-Antitoxin Period.]

	1891.	1892.	1893.	1891.	Total.
Reported cases,	2,444	3,033	2,919	4,936	13,332
Deaths,	575	891	926	1,376	3,768
Fatality (per cent),	23.5	29.2	31.7	27.9	28.3

Diphtheria and Croup.

[Antitoxin Period.]

	1895.	1896.	1897.	1898.	Total.
Reported cases,	7,856	8,915	7,856	3,843	28,470
Deaths,	1,484	1,348	1,107	507	4,446
Fatality (per cent.),	18.9	15.1	14.1	13.2	15.6

Scarlet Fever.

	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Total.
Reported cases, . .	4,517	6,112	7,420	7,416	6,050	3,873	5,406	3,509	44,303
Deaths, ...	151	281	624	504	357	220	253	101	2,489
Fatality (per cent.),. .	3.3	4.6	8.8	6.8	5.9	5.7	4.7	2.9	5.6

Typhoid Fever.

	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Total.
Reported cases, . .	2,414	1,892	2,457	2,814	2,665	3,016	2,151	2,143	19,552
Deaths, ...	460	435	492	488	458	471	454	464	3,717
Fatality (per cent.),. .	19.0	23.0	20.0	17.0	17.2	15.6	21.1	21.7	19.0

Measles.

	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Total.
Reported cases, . .	5,861	783	6,290	2,051	5,033	6,861	13,705	4,160	44,804
Deaths, ...	84	31	98	37	75	65	96	42	528
Fatality (per cent.),. .	1.4	4.0	1.6	1.8	1.5	0.9	0.7	1.0	1.2

In the foregoing table the statistics relating to diphtheria and croup have been arranged in two periods, which may properly be called the pre-antitoxin and the antitoxin periods, since antitoxin came into general use in the State about the beginning of the year 1895. The mean fatality in the former period (1891–94) was 28.3 per cent. (ratio of deaths to cases), and in the latter period (1895–98) it was 15.6 per cent., or but little more than half as large.

In order to compare the general fatality from diphtheria in Massachusetts with that of another country in which systematic notification of a large number of cases has been conducted for a period of several successive years, the following figures for England are presented, as published in the annual reports of the Local Government Board: —

England.

[Local Government Board figures.]

	Diphtheria.		Croup.		Total.		Per Cent.
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	
1890,	-	-	-	-	2,953	753	25.5
1891,	-	-	-	-	11,919	2,829	23.7
1892,	13,977	3,177	1,169	401	15,146	3,578	23.6
1893,	20,712	4,751	1,436	685	22,148	5,436	24.5
1894,	17,581	4,236	1,256	486	18,837	4,722	25.1
1895,	18,700	4,225	1,263	540	19,963	4,765	23.9
1896,	25,498	5,372	1,365	556	26,863	5,928	22.1
1897,	24,290	4,521	1,153	473	25,443	4,994	19.6
Total,	120,758	26,282	7,642	3,141	143,272	33,005	-
Mean fatality (per cent.),	21.8		41.1		-		23.0

The following figures present the fatality from diphtheria and croup, scarlet fever and typhoid fever in England, as reported by the Local Government Board of England for the years 1890–97 : —

	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
Diphtheria and croup,	25.5	23.7	23.6	24.5	25.1	23.9	22.1	19.6
Scarlet fever,	8.0	5.8	4.4	4.2	4.8	4.2	4.0	3.9
Typhoid fever,	19.9	20.8	17.8	17.0	17.5	16.9	17.7	16.8

III.

Official Returns of Notified Diseases Dangerous to the Public Health, 1898.

The following summary embraces the returns of diseases "dangerous to public health," made to the State Board of Health under the provisions of chapter 302 of the Acts of 1893. Since the act in question did not specify the diseases intended to be reported to the Board (except small-pox) the Board issued a circular, in which it expressed its opinion as to the particular diseases which should be reported under the provisions of this act. They were the following: *small-pox, scarlet fever, measles, typhoid fever, diphtheria, membranous croup, cholera, yellow fever, typhus fever, cerebro-spinal meningitis, hydrophobia, malignant pustule, leprosy and trichinosis.*

The report of 1893 embraced the returns of the fractional year only which immediately followed the enactment of the statute, while those of 1894, 1895, 1896, 1897 and 1898 were each for a full year.

The whole number of cases of infectious diseases reported in 1898 was 14,331, which were divided as follows: —

Reported cases of small-pox,	10
Reported cases of diphtheria and croup,	3,980
Reported cases of scarlet fever,	3,667
Reported cases of typhoid fever,	2,196
Reported cases of measles,	4,478
Total,	14,331

The summary for the six years 1893–98 is as follows: —

	Reported Cases of					Total.
	Small-pox.	Diphtheria and Croup.	Scarlet Fever.	Typhoid Fever.	Measles.	
1893 (four months only),	35	1,109	2,914	1,525	1,503	7,086
1894,	131	4,178	6,731	2,372	2,133	15,595
1895,	1	7,806	6,194	2,438	4,868	21,307
1896,	5	8,515	3,801	2,637	6,362	21,320
1897,	18	7,613	5,495	2,104	12,695	27,925
1898,	10	3,980	3,667	2,196	4,478	14,331
Total,	250	33,201	28,802	13,272	32,039	107,564

Seasonal Distribution. — By months these diseases were reported as follows in 1898: —

Cases of Infectious Diseases reported to the Board by Months during 1898.

	Small-pox.	Diphtheria and Croup.	Scarlet Fever.	Typhoid Fever.	Measles.		Small-pox.	Diphtheria and Croup.	Scarlet Fever.	Typhoid Fever.	Measles.
January, . .	–	467	349	112	242	August, .	–	168	154	240	108
February, .	4	359	215	76	316	September,	–	243	227	471	72
March, . .	3	322	287	104	346	October, .	–	367	396	393	164
April, . .	–	325	295	95	527	November, .	–	573	449	253	463
May, . .	–	250	458	86	644	December, .	3	517	430	178	833
June, . .	–	187	253	95	465						
July, . .	–	202	154	93	298	Total, .	10	3,980	3,667	2,196	4,478

In order that the foregoing figures may be interpreted with greater facility the following table is appended: —

Intensity of Prevalence.

	Diphtheria and Croup.			Scarlet Fever.			Typhoid Fever.			Measles.		
	1898.		1897.	1898.		1897.	1898.		1897.	1898.		1897.
	A	B	B	A	B	B	A	B	B	A	B	B
	Daily Number of Reported Cases in Each Month.	Decimal Ratio for Each Month.	Decimal Ratio for Each Month.	Daily Number of Reported Cases in Each Month.	Decimal Ratio for Each Month.	Decimal Ratio for Each Month.	Daily Number of Reported Cases in Each Month.	Decimal Ratio for Each Month.	Decimal Ratio for Each Month.	Daily Number of Reported Cases in Each Month.	Decimal Ratio for Each Month.	Decimal Ratio for Each Month.
January, .	15.1	13.8	16.8	11.3	11.2	11.6	3.6	6.0	10.1	7.8	6.4	18.5
February, .	12.8	11.8	12.5	7.7	7.6	9.6	2.7	4.5	5.0	11.3	9.2	18.4
March, .	10.4	9.5	9.6	9.3	9.2	12.9	3.4	5.6	4.4	11.2	9.1	19.9
April, .	10.8	9.9	10.5	9.8	9.8	14.7	3.2	5.3	5.0	17.6	14.3	20.0
May, . .	8.1	7.4	10.8	14.8	14.7	17.3	2.8	4.6	5.3	20.8	16.9	22.4
June, . .	6.2	5.7	9.7	8.4	8.4	12.3	3.2	5.3	5.6	15.5	12.6	13.0
July, . .	6.5	6.0	7.2	5.0	4.9	6.6	3.0	5.0	5.6	9.6	7.8	4.6
August, .	5.4	5.0	5.2	5.0	4.9	5.6	7.7	12.9	13.7	3.5	2.8	1.0
September,	8.1	7.4	6.3	7.6	7.5	5.0	15.7	26.1	18.3	2.4	2.0	.4
October, .	11.8	10.9	10.7	12.8	12.7	7.4	12.7	21.1	23.3	5.3	4.3	.4
November,	19.1	17.5	13.1	15.0	14.9	8.8	8.4	14.0	13.3	15.4	12.6	.5
December,.	16.7	15.3	11.1	13.9	13.8	8.1	5.7	9.6	10.1	26.9	21.9	1.3
Mean, .	10.9	10.0	10.0	10.1	10.0	10.0	6.0	10.0	10.0	12.3	10.0	10.0

The figures in the foregoing table are not introduced for the purpose of comparing the prevalence of one disease with another, but for the purpose of presenting the reports of each month upon a uniform basis of comparison, month by month, so that the relative intensity of each disease is shown for each month. The method also has the advantage of eliminating the apparent errors of computation arising from the unequal length of the months.

The figures may be read as follows: for example, the mean daily number of reported cases of diphtheria and croup in January, 1898, was 15.1; of scarlet fever, 11.3; of typhoid fever, 3.6; and of measles, 7.8 (see columns marked A); and the mean daily number of the same diseases for the whole year 1898 was respectively 10.9, 10.1, 6 and 12.3. Assuming a standard of 10 as the daily mean of each disease for each year, the ratios for January were as follows: diphtheria and croup, 13.8; scarlet fever, 11.2; typhoid fever, 6; and measles, 6.4 (see columns marked B). That is to say, for each 10 cases of diphtheria and croup reported daily throughout the year 1898, as a mean, there were 13.8 in January, 11.8 in February, 9.5 in March, etc.

By the foregoing table it appears that the seasonal prevalence of diphtheria and croup, so far as can be learned from the reported cases, followed a somewhat similar course with that of 1897. Beginning in January with a high prevalence, there was a comparatively uniform decline to a minimum in August, and then a more rapid rise to a maximum in November. December furnished a smaller number of daily reports than November, as it did also in 1897.

Scarlet fever prevailed most severely in May and November, 1898, and in April and May, 1897, and reached its minimum in the months of July and August in each year.

The prevalence of typhoid fever was considerably below the mean during the first seven months of 1898, but rose rapidly to a maximum in September, while in 1897 the maximum was in October.

Measles prevailed with less than the mean intensity in the first quarter, rising above the mean in the second quarter, then falling below the mean in the third quarter, and reaching a minimum in October, and rising rapidly to its maximum in December. The entire number of reported cases of measles in 1898 was but little more than one-third as many as those of 1897. The history of this disease in the State for the past forty years has shown that epidemics have occurred about once in every three or four years. There have been ten epidemic years in the past forty years, as follows: in 1858, 1862, 1864, 1872, 1878, 1883, 1887, 1891, 1893 and 1897. More than 80 per cent. of the deaths from measles are those of children under five years old. After each epidemic year a period of comparative freedom from the disease occurs, until a new crop of children comes into existence, who have never had measles, and hence furnish material for a new epidemic. The practice of isolation has not been applied so thoroughly to this disease as has been done for scarlet fever, hence the diminution in mortality has not been so apparent.

The following table presents the numbers of cases of each disease reported from each city and town in 1898. The whole number of reporting cities and towns is 167, that of the previous year being 172.

Where the name of a city or town occurs both in Section II. and in Section III. of this summary, the difference in numbers may be taken as the deficiency in returns made by the local board to the State Board of Health.

Cases of Infectious Diseases reported to the State Board of Health from One Hundred and Sixty-seven Cities and Towns during 1898.

	Diphtheria and Croup.	Scarlet Fever.	Typhoid Fever.	Measles.		Diphtheria and Croup.	Scarlet Fever.	Typhoid Fever.	Measles.
Adams,	5	3	-	1	BEVERLY,	8	13	19	1
Amesbury,	6	16	3	1	Bolton,	4	-	1	-
Amherst,	-	11	-	45	BOSTON,	1,701	914	552	2,063
Andover,	15	12	3	5	Boxborough,	1	-	-	-
Arlington,	6	7	14	-	Bridgewater,	-	2	1	-
Ashfield,	-	1	-	-	BROCKTON,	5	15	10	9
Attleborough,	8	16	4	18	Brookfield,	1	-	-	1
Auburn,	2	1	-	-	Brookline,	21	17	20	99
Avon,	-	1	-	-	CAMBRIDGE,	156	122	94	53
Ayer,	1	1	5	-	Carver,	1	1	4	-
Barnstable,	2	4	2	1	Chelmsford,	1	13	-	-
Barre,	-	-	2	1	CHELSEA,	37	193	19	72
Bedford,	1	-	1	1	Cheshire,	-	2	-	-
Berlin,	3	1	-	-	Chester,	1	-	-	-

Cases of Infectious Diseases reported to the State Board of Health from One Hundred and Sixty-seven Cities and Towns during 1898 — Continued.

	Diphtheria and Croup.	Scarlet Fever.	Typhoid Fever.	Measles.		Diphtheria and Croup.	Scarlet Fever.	Typhoid Fever.	Measles.
CHICOPEE,	31	8	25	28	Greenwich,	1	-	-	-
Clinton,	5	-	8	3	Groton,	-	9	-	-
Concord,	3	5	8	15	Groveland,	3	-	3	21
Colrain,	-	8	-	-	Hadley,	-	-	1	9
Cottage City,	-	-	6	-	Hamilton,	-	1	-	-
Dalton,	1	2	-	1	Halifax,	-	2	-	-
Dana,	2	-	-	-	Hardwick,	7	1	-	-
Danvers,	18	10	11	7	HAVERHILL,	65	60	100	397
Dartmouth,	-	3	-	-	Hingham,	13	-	-	-
Dedham,	-	1	2	42	Hinsdale,	1	-	1	-
Dighton,	7	3	-	-	Holliston,	-	4	9	2
Douglas,	2	22	7	-	HOLYOKE,	31	41	25	46
Dover,	2	1	-	2	Hopedale,	1	-	-	6
East Bridgewater,	2	1	7	-	Hopkinton,	1	-	-	-
East Longmeadow,	4	-	1	-	Hudson,	3	10	4	7
Edgartown,	-	-	6	-	Hyde Park,	36	12	5	44
EVERETT,	45	48	20	29	Ipswich,	27	-	15	3
Fairhaven,	4	2	11	-	Lanesborough,	1	-	-	-
FALL RIVER,	33	108	74	-	LAWRENCE,	205	184	74	490
Falmouth,	1	1	-	-	Leicester,	1	10	2	1
FITCHBURG,	38	16	29	30	Lenox,	-	1	-	-
Foxborough,	5	1	1	7	Leominster,	2	16	13	113
Franklin,	1	1	1	-	Lexington,	1	1	2	32
Gardner,	4	42	16	-	Leyden,	1	-	-	-
Gill,	-	1	-	-	Lincoln,	-	1	-	-
GLOUCESTER,	12	52	9	-	LOWELL,	159	313	123	35
Grafton,	1	1	-	-	LYNN,	86	92	116	12
Granby,	-	-	1	-	MALDEN,	49	70	51	28
Granville,	1	-	-	38	Manchester,	-	1	-	-
Great Barrington,	-	1	-	-	Mansfield,	4	-	-	-
Greenfield,*	5	8	8	1	MARLBOROUGH,	-	25	3	3

* Small-pox: —

Greenfield,	4
Russell,	3
Sherborn,	2
Westfield,	1
	10

Cases of Infectious Diseases reported to the State Board of Health from One Hundred and Sixty-seven Cities and Towns during 1898 — Continued.

	Diphtheria and Croup.	Scarlet Fever.	Typhoid Fever.	Measles.		Diphtheria and Croup.	Scarlet Fever.	Typhoid Fever.	Measles.
Marshfield,	–	–	2	1	Rowley,	5	–	6	1
Medfield,	–	–	–	1	Royalston,	4	–	1	–
MEDFORD,	13	4	13	5	SALEM,	23	55	39	–
Medway,	4	1	3	22	Sandisfield,	–	8	5	7
Middleton,	4	–	–	–	Saugus,	1	4	3	10
Milford,	25	–	8	51	Seekonk,	–	1	–	–
Millbury,	6	8	2	–	Shelburne,	1	–	–	–
Milton,	8	15	2	21	Shirley,	6	1	–	–
Monson,	9	3	4	–	Somerset,	1	11	1	–
Needham,	2	–	–	5	Southborough,	1	–	–	–
NEW BEDFORD,	77	101	129	12	Southampton,	–	–	–	59
NEWBURYPORT,	5	3	6	2	Spencer,	–	–	1	–
NEWTON,	30	45	27	30	Sturbridge,	7	–	–	–
Norfolk,	–	1	–	–	Swampscott,	5	4	1	1
North Adams,	18	9	9	–	SOMERVILLE,	79	75	49	4
NORTHAMPTON,	5	3	1	–	SPRINGFIELD,	102	62	33	89
North Andover,	5	20	6	35	TAUNTON,	9	33	20	18
North Attleborough,	10	7	2	22	Templeton,	2	3	–	6
Northbridge,	1	–	–	–	Upton,	1	1	2	–
North Brookfield,	23	43	–	–	Uxbridge,	9	4	4	3
Norton,	2	2	–	–	Wakefield,	10	21	1	12
Norwood,	–	1	6	27	Walpole,	–	5	3	8
Orange,	3	–	–	–	WALTHAM,	47	19	23	1
Oxford,	1	4	–	–	Ware,	5	7	1	1
Palmer,	6	16	2	–	Wareham,	–	–	2	1
Peabody,	77	1	5	–	Warren,	1	10	1	1
Pepperell,	3	8	1	–	Watertown,	21	49	9	2
Plymouth,	–	–	8	–	Webster,	4	5	4	22
QUINCY,	19	55	37	88	Wellesley,	–	1	4	2
Randolph,	4	5	–	–	West Brookfield,	1	–	–	–
Reading,	2	–	8	1	Westfield,*	–	8	9	11
Revere,	5	9	3	–	Westford,	1	36	10	1
Rockport,	5	–	4	1	Westhampton,	–	1	–	4

* See note on preceding page.

Cases of Infectious Diseases reported to the State Board of Health from One Hundred and Sixty-seven Cities and Towns during 1898 — Concluded.

	Diphtheria and Croup.	Scarlet Fever.	Typhoid Fever.	Measles.		Diphtheria and Croup.	Scarlet Fever.	Typhoid Fever.	Measles.
Weston,	5	4	3	3	WOBURN,	40	6	5	-
Weymouth,	6	5	3	-	Worthington,	-	-	-	5
Whitman,	2	12	7	3	WORCESTER,	263	192	75	19
Williamstown,	2	5	13	3	Wrentham,	7	7	-	4
Winchendon,	10	81	9	7	West Springfield,	15	19	4	22
Winthrop,	1	2	5	1	Totals,	3,980	3,667	2,196	4,478

The following list comprises the cities and towns which failed to report (under the provisions of the statute) to the State Board of Health. It is but just to state that in many of the towns named in group IV., and in some of those in group III., it is quite probable that no cases of infectious disease occurred.

List of Towns from which no Reports were received.

I. Cities.

PITTSFIELD.

II. Towns having a Population of More than 5,000 in Each.

Athol,
Blackstone,
Braintree,
Framingham,
Marblehead,
Melrose,
Methuen,
Middleborough,
Montague,
Natick,
Rockland,
Southbridge,
Stoneham,
Stoughton,
Westborough,
Winchester. — 16.

III. Towns having a Population of More than 1,000 but Less than 5,000 in Each.

Abington,
Acton,
Acushnet,
Agawam,
Ashburnham,
Ashland,
Auburn,
Avon,
Belchertown,
Belmont,
Bellingham,
Billerica,
Bourne,
Bradford,
Buckland,
Canton,
Cohasset,
Conway,
Charlemont,
Chatham,
Charlton,
Clarksburg,
Dennis,
Deerfield,
Dracut,
Dudley,
Duxbury,
Easthampton,
Easton,
Essex,
Freetown,
Georgetown,
Hanover,
Hanson,
Harwich,
Hatfield,

List of Towns from which no Reports were received — *Concluded.*

III. Towns having a Population of More than 1,000 but Less than 5,000 in Each — Concluded.

Holbrook,
Holden,
Hubbardston,
Hull,
Huntington,
Kingston,
Lancaster,
Lee,
Littleton,
Ludlow,
Lunenburg,
Marshfield,
Mattapoisett,
Maynard,
Merrimac,
Millis,
Nantucket,
Newbury,
Northfield,
New Marlborough,
Norwell,
Orleans,
Pembroke,
Provincetown,
Raynham,
Rehoboth,
Rochester,
Salisbury,
Sandwich,
Sharon,
Sheffield,
Sherborn,
Shrewsbury,
South Hadley,
Sterling,
Stockbridge,
Sudbury,
Sutton,
Swansea,
Tewksbury,
Tisbury,
Topsfield,
Townsend,
Wayland,
Wellesley,
West Boylston,
West Bridgewater,
Westford,
Westminster,
West Newbury,
Westport,
West Stockbridge,
Wilbraham,
Williamsburg,
Wilmington,
Yarmouth. — 92.

IV. Towns having Less than 1,000 Inhabitants.

Alford,
Ashby,
Becket,
Berkley,
Bernardston,
Blandford,
Boxford,
Boylston,
Brewster,
Brimfield,
Burlington,
Carlisle,
Chesterfield,
Chilmark,
Cummington,
Dunstable,
Eastham,
Egremont,
Enfield,
Erving,
Florida,
Gay Head,
Goshen,
Gosnold,
Hampden,
Hancock,
Hawley,
Heath,
Holland,
Lakeville,
Leverett,
Longmeadow,
Lynnfield,
Marion,
Mashpee,
Mendon,
Middlefield,
Monroe,
Monterey,
Montgomery,
Mount Washington,
Nahant,
New Ashford,
New Braintree,
New Salem,
Norfolk,
North Reading,
Oakham,
Otis,
Paxton,
Pelham,
Peru,
Petersham,
Phillipston,
Plainfield,
Plympton,
Prescott,
Princeton,
Richmond,
Rowe,
Russell,
Rutland,
Savoy,
Shutesbury,
Southwick,
Stow,
Sunderland,
Tolland,
Truro,
Tyngsborough,
Tyringham,
Wales,
Warwick,
Washington,
Wellfleet,
Wendell,
Wenham,
West Tisbury,
Whately,
Windsor. — 80.

The Board will forward to the local board of health of any place the postal cards necessary for reporting, on application from such local board of health.

IV.

Official Returns of Deaths in Cities and Large Towns (Chapter 218, Acts of 1894).

The following summary comprises the results obtained from the tabulation of the returns required by chapter 218 of the Acts of 1894, whereby the board of health of each city and populous town is directed to send to the State Board of Health an annual statement of the deaths in such city or town upon a blank form furnished by the State Board.

The whole number of cities and towns included in this list is 85.* The total population of these 85 cities and towns by the census of 1895 was 2,034,658.

The death-rates of these towns in the following summary for the year 1898 are calculated upon an estimated population, such estimate being based upon the rate of growth from 1890 to 1895, as taken from the census returns.

This estimate would add several more towns to the list for 1898, and four towns (Easthampton, North Brookfield, Reading and Williamstown) have voluntarily sent returns to the board, although not required by the Statute, thus making (with the omission of Westfield) the total number of cities and towns included in the summary 88.

The estimated population of these 88 towns in 1898 was 2,216,869, or about 80 per cent. of the total population of the State.

The whole number of deaths registered in these towns in 1898 was 38,147, and the death-rate calculated upon the foregoing estimated population was 17.21 per 1,000 living. This rate was considerably less than that of either of the years which have elapsed since the law was enacted requiring returns of deaths from this group of cities and towns.

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* The town of Westfield has failed to make the necessary return for the year 1898.

Sexes. — The number of deaths of males was 19,425, or 50.9 per cent. of the whole number of deaths of those whose sex was known; and the deaths of females were 18,704, or 49.1 per cent. There were 18 in which the sex was not stated in the returns.

Ages. — The deaths shown by four groups of ages, as recommended by Körösi, were as follows: —

Ages.	Deaths. 1898.	Percentages of All Deaths.		Ages.	Deaths. 1898.	Percentages of All Deaths.	
		1898.	1897.			1898.	1897.
Under 1 year, .	9,439	24.77	23.47	20 to 50, . .	9,695	25.44	24.96
1 to 20 years, .	5,735	15.05	18.03	50 and over, . .	13,238	34.74	33.54

The deaths of infants under one were 9,439, or 24.77 per cent. of the total mortality, and those of children under five years were 12,601) or 33.07 per cent. of the total mortality.

All of the percentages in this table are estimated upon the number of deaths of persons whose ages were specified in the returns. The total number of deaths in which the age was not specified was 40.

The most noteworthy fact in the foregoing table is the very low percentage of deaths of persons at age 1–20 years, namely, 15.05, as compared with 18.5, 17.9, 17.7 and 18.0, respectively, for the years 1894, 1895, 1896 and 1897. This unusually low percentage of mortality among children and young persons between the ages of one and twenty years is due mainly to the low death-rate from infectious and preventable diseases which bear most heavily upon the early ages of life.

Months and Quarters. — The number of deaths in each quarter of the year is shown in the following table: —

	Deaths. 1898.	Percentages.	
		1898.	1897.
First quarter, ...	9,038	23.69	26.46
Second quarter, ...	8,797	23.06	23.64
Third quarter, ...	11,046	28.96	27.40
Fourth quarter, ...	9,264	24.29	22.50
Total, ...	38,145*	100.00	100.00

* Two deaths were registered, the date being unknown.

The intensity of the seasonal death-rate is shown in the following table, the method employed being explained on page 771 in Section III., relating to disease notification : —

Seasonal Intensity of the Death-rate.

	Mean Daily Deaths per Month. 1898.	Centesimal Ratio.			Mean Daily Deaths per Month. 1898.	Centesimal Ratio.	
		1898.	1897.			1898.	1897.
January, . .	99.6	95.3	100.5	August, . .	134.9	129.1	115.1
February, . .	99.7	95.4	107.1	September, .	119.1	114.0	101.8
March, . .	101.8	97.4	114.1	October, . .	100.2	95.9	93.8
April, . . .	105.2	100.7	104.3	November, .	95.3	91.2	87.3
May, . . .	97.4	93.2	94.9	December, .	106.5	101.9	86.7
June, . . .	87.4	83.6	85.3	Annual mean,	104.5	100.0	100.0
July, . . .	106.1	101.5	109.0				

The figures in the foregoing table indicate a greater uniformity in the death-rate throughout the year, comparing one month with another, than is shown by the figures of 1897, and reference to the reports of the three preceding years also shows a more uniform death-rate than those of 1894, 1895 and 1896, which would indicate, when taken in connection with an examination of the table of causes of death, a more healthful year than either of the three preceding years, the higher death rate in July and August being more than counterbalanced by a generally lower death-rate in the remaining months.

The mean maximum departure from the death-rate for each month for the period of 20 years, 1856–75, was 32.9 per cent. in August, and in the 20 years period (1876–95) it was 20 per cent. in August, while that of August, 1898, was 29 per cent.

In the two years having the highest death-rates in Massachusetts in the past half century (1849 and 1872) the maximum departures from the yearly means were, respectively, 83.4 per cent. in August, 1849, and 40 per cent. in August, 1872. That of January, 1890, the month in which the epidemic of influenza was at its maximum, was 43.4 per cent. above the mean.

Causes of Death.

Table IV. presents the mortality of the cities and towns embraced in this summary, classified by causes of death for the year 1898. The same figures are again presented in a condensed form in Table V., wherein the comparative mortality from different diseases and groups of diseases for the five years during which the law has been in operation may be examined.

It appears from Table V. on page 796 that the decrease in the general death-rate, which was noted in the last annual report, has continued throughout 1898, so far as can be judged from the usual estimates of population, the principal improvement being shown in the infectious diseases near the top of the column. It is a source of much satisfaction to note that marked changes have taken place in the death-rate from those diseases which are clearly preventable, and this may be taken as an index of better sanitary organization and work in the cities and towns named in the list. Consumption, measles, scarlet fever, diphtheria and puerperal fever are diseases which yield to the action of human agencies; and in every one of these there was a marked drop in the death-rate, not only as compared with that of 1897, but also with that of the four preceding years embraced within the operations of the statute of 1893.

Comment was made in the last report upon the fact that estimates made in intercensal years are liable to error in either direction, and that no method of estimating populations can produce exact results, in the absence of other definite knowledge. It was for this reason that the tables of death-rates made up from the total estimated population have been published in parallel columns, together with the percentages of the total mortality in each of the annual reports since and including 1892 (see pages xlviii, xlix, twenty-fourth annual report, 1892), and especially in the very full report of 1896, embracing the statistics of forty years (1856–95).

The table of percentages of total mortality acts, in a measure, as a check or control in case of erroneous estimates of population. It is for this reason that a similar condensed statement is here introduced in Table V.

The changes in the death-rate from consumption, typhoid fever and puerperal fever (see child-birth in report of 1896, page 804) have been quite fully treated in the report of 1896. To these may be added the later comments on the changes in the death-rate from diphtheria, which appear in the figures of the past four years.

The following preventable causes of death, consumption, measles, scarlet fever, diphtheria, whooping-cough, typhoid fever, puerperal fever and cholera infantum, together constituted 27.2 per cent. of the total mortality in 1894, but had fallen off successively to 24.2, 24.2, 21.9 and 21.1 in the four succeeding years, while the principal acute lung diseases, diseases of the heart, brain, kidneys, cancer, suicide and accident had increased from 35.7 per cent. of the total mortality to 36.9, 36.9, 38.5 and 39.2 per cent. in the same years.

These all combined constituted the greater part of the total mortality in each of the five years 1894–98, and of the diseases specified in the table entitled the "Balance of Mortality," in the annual report of 1896, page 812.

The most notable change in the death-rate from any specific disease in 1898 is the very marked diminution in the death-rate from diphtheria and croup, which is less than half as great as that of 1897, and less than one-third as great as that of 1894. That of scarlet fever is also quite remarkable, being only half as great as its least mortality rate in either of the four preceding years, and but little more than one-sixth of its mortality in 1894. Consumption has also declined with considerable uniformity from a death-rate of 22.34 in 1894 to 18.41 in 1898. Measles from a maximum of .57 in 1897 to .34 in 1898. Cerebro-spinal-meningitis presented a slightly lower mortality than it had in 1897, 2.59 and 2.12. Erysipelas and puerperal fever have notably declined to but little more than half their death-rate in 1894. There was a slight increase in all diarrhœal diseases, as compared with their mortality in 1897. A slight decrease in diseases of the lungs and brain, and a slight increase in those of the heart and kidneys. The mortality from cancer has increased over 40 per cent. since 1895. Deaths from violence have presented a fairly uniform mortality throughout the five years 1894–98.

TABLE I.

Population of Cities and Large Towns estimated for 1898.

Reporting Cities and Towns.	Estimated Population, 1898.	Reporting Cities and Towns.	Estimated Population, 1898.
Adams,	7,011	Lynn,	66,703
Amesbury,	10,098	Malden,	34,611
Andover,	6,147	Marblehead,	7,352
Arlington,	7,046	Marlborough,	15,679
Athol,	7,991	Medford,	16,511
Attleborough,	8,714	Melrose,	14,032
Beverly,	12,397	Methuen,	6,215
Blackstone,	5,979	Middleborough,	7,063
Boston,	528,463	Milford,	9,066
Braintree,	5,588	Millbury,	5,698
Brockton,	37,278	Milton,	6,262
Brookline,	18,600	Montague,	5,914
Cambridge,	89,517	Natick,	8,631
Chelsea,	33,468	New Bedford,	66,340
Chicopee,	17,842	Newburyport,	14,915
Clinton,	12,140	Newton,	29,716
Concord,	5,623	North Adams,	20,971
Danvers,	8,616	Northampton,	17,799
Dedham,	7,263	North Attleborough,	6,485
Easthampton,	5,027	Northbridge,	5,695
Everett,	25,338	North Brookfield,	5,093
Fall River,	99,465	Orange,	5,836
Fitchburg,	29,438	Palmer,	7,060
Framingham,	9,675	Peabody,	10,716
Franklin,	5,319	Pittsfield,	22,643
Gardner,	9,636	Plymouth,	8,342
Gloucester,	30,589	Quincy,	23,549
Grafton,	5,160	Reading,	5,094
Greenfield,	6,814	Revere,	8,476
Haverhill,	37,239	Rockland,	5,709
Holyoke,	43,424	Rockport,	6,009
Hudson,	5,690	Salem,	36,883
Hyde Park,	12,805	Somerville,	61,101
Lawrence,	57,263	Southbridge,	8,607
Leominster,	10,375	Spencer,	6,933
Lowell,	88,641	Springfield,	56,501

TABLE I. — *Concluded.*

Reporting Cities and Towns.	Estimated Population, 1898.	Reporting Cities and Towns.	Estimated Population, 1898.
Stoneham,	6,361	West Springfield,	6,753
Stoughton,	5,524	Weymouth,	11,546
TAUNTON,	28,167	Whitman,	6,525
Wakefield,	9,096	Williamstown,	5,286
WALTHAM,	22,296	Winchester,	6,923
Ware,	7,843	WOBURN,	14,585
Watertown,	8,217	WORCESTER,	108,340
Webster,	8,259	Total,	2,216,869
Westborough,	5,259		

Westfield, no return.

TABLE II.

Total Deaths, Deaths by Sexes and Age Periods, and Still-births in Cities and Towns having over 5,000 Inhabitants in Each, with General Death Rates estimated for 1898.

	Total Deaths.	Males.	Females.	Sex Unknown.	Still-births.	Deaths under 1.	1-2.	2-3.	3-4.	4-5.	5-10.	10-15.	15-20.	20-30.	30-40.	40-50.	50-60.	60-70.	70-80.	Over 80.	Age Unknown.	Rate per 1,000.
Adams,	175	94	81	-	8	56	3	4	1	-	2	5	6	19	18	8	12	24	13	4	-	24.96
Amesbury,	135	68	67	-	17	32	8	-	-	1	1	2	3	10	12	9	10	13	17	15	2	13.37
Andover,	102	50	52	-	1	11	2	-	2	2	3	4	2	4	6	1	9	18	18	19	1	16.59
Arlington,	106	51	55	-	11	20	8	4	1	1	3	-	3	11	6	7	7	13	12	10	-	15.04
Athol,	104	44	59	1	3	19	1	1	-	2	4	1	-	11	7	4	5	14	18	17	-	13.01
Attleborough,	131	74	57	-	4	29	4	-	1	1	7	5	1	8	13	14	10	13	6	15	4	15.03
BEVERLY,	204	107	97	-	17	35	7	2	-	-	7	3	8	28	17	9	13	23	29	23	-	16.46
Blackstone,	118	62	56	-	5	18	7	4	3	1	5	2	-	8	9	12	12	15	14	8	-	19.74
BOSTON,	10,886	5,600	5,286	-	613	2,572	582	226	108	89	226	134	270	1,115	1,215	987	1,022	1,053	818	469	-	20.60
Braintree,	81	48	33	-	4	13	2	-	-	-	3	-	-	10	6	9	5	15	9	9	-	14.50
BROCKTON,	458	225	232	1	35	117	13	9	3	-	2	5	16	40	41	43	39	56	47	27	-	12.29
Brookline,	251	115	136	-	13	50	4	3	1	2	7	4	6	16	18	23	27	38	27	25	-	13.49
CAMBRIDGE,	1,542	775	767	-	126	408	93	29	26	14	33	18	47	145	130	124	125	142	133	75	-	17.23
CHELSEA,	638	369	269	-	36	145	37	16	11	5	8	6	11	50	55	45	76	80	61	32	-	19.06
CHICOPEE,	356	170	186	-	24	147	21	5	4	-	6	6	8	22	24	17	27	29	25	15	-	19.95
Clinton,	207	112	95	-	8	44	10	4	4	-	5	3	6	22	14	25	18	17	23	11	1	17.05
Concord,	72	47	25	-	6	9	3	-	-	-	-	-	6	10	6	5	5	10	7	10	1	12.80
Danvers,	105	52	53	-	7	14	4	1	2	-	2	1	2	8	5	12	7	17	19	11	-	12.19
Dedham,	117	55	62	-	-	20	3	-	-	-	2	2	3	12	16	11	7	14	20	7	-	16.11

Easthampton,	75	31	44	-	3	16	2	2	1	1	2	0	1	4	2	6	5	12	15	6	-	14.92
EVERETT,	325	170	155	-	23	89	18	3	5	3	4	5	6	30	27	17	28	35	33	21	1	12.83
FALL RIVER,	1,813	902	911	-	121	667	*-	*-	*-	*-	42	†-	†-	147	126	159	129	123	81	40	-	18.23
FITCHBURG,	404	210	194	-	33	133	22	6	1	3	7	5	7	40	32	31	22	42	34	19	-	13.72
Framingham,	137	85	52	-	11	24	-	2	5	-	-	3	7	17	14	4	8	17	23	11	2	14.16
Franklin,	79	35	42	2	4	11	3	1	2	-	2	2	3	5	4	11	4	13	8	10	-	14.85
Gardner,	121	67	54	-	16	37	5	4	3	2	1	4	2	9	11	7	8	10	8	10	-	12.56
GLOUCESTER,	372	198	174	-	30	81	‡-	‡-	‡-	‡-	27	§-	§-	21	38	35	15	37	38	32	-	12.16
Grafton,	89	48	41	-	5	22	5	2	-	-	3	1	6	9	4	7	5	4	12	9	-	17.25
Greenfield,	109	57	52	-	4	19	5	-	-	-	1	-	4	13	11	4	13	16	12	11	-	16.00
HAVERHILL,	519	275	244	-	40	106	33	14	9	8	16	5	15	49	31	47	50	43	59	34	-	13.94
HOLYOKE,	783	359	424	-	55	314	41	12	11	9	22	11	23	70	50	47	54	59	45	15	-	18.03
Hudson,	82	49	33	-	9	21	4	2	2	-	4	-	3	5	7	4	5	7	8	10	-	14.41
Hyde Park,	193	101	92	-	21	52	7	5	3	2	7	1	6	15	11	8	17	27	20	12	-	15.07
LAWRENCE,	1,058	515	543	-	66	358	59	24	19	18	27	18	26	65	79	71	91	108	65	28	2	18.48
Leominster,	154	82	72	-	9	30	6	2	2	2	2	3	5	11	14	15	12	16	15	19	-	14.84
LOWELL,	1,808	925	883	-	143	516	106	36	28	21	36	23	57	171	137	129	163	186	134	65	-	20.40
LYNN,	933	469	464	-	74	218	44	25	7	5	20	12	24	68	79	77	96	115	82	60	1	13.99
MALDEN,	475	230	245	-	47	105	23	12	5	4	12	10	14	36	35	27	46	47	58	41	-	13.72
Marblehead,	128	69	58	1	2	15	6	2	2	-	3	1	-	9	10	10	17	17	20	16	-	17.41
MARLBOROUGH,	223	110	113	-	4	31	15	4	2	4	8	1	4	24	17	23	20	35	24	11	-	14.22
MEDFORD,	197	88	109	-	14	56	5	2	1	4	4	-	1	13	19	7	18	26	28	13	-	11.93
Melrose,	190	95	95	-	8	29	4	-	-	1	-	2	7	14	14	11	22	27	28	31	-	13.54
Methuen,	105	55	49	1	16	30	6	7	-	2	3	2	2	9	7	6	4	9	12	4	2	16.89

* Two hundred and eight between the ages of one and five years.

‡ Forty between the ages of one and five years.

† Ninety-one between the ages of ten and twenty years.

§ Eight between the ages of ten and twenty years.

TABLE II. — *Concluded.*

	Total Deaths.	Males.	Females.	Sex Unknown.	Still-births.	Deaths under 1.	1-2.	2-3.	3-4.	4-5.	5-10.	10-15.	15-20.	20-30.	30-40.	40-50.	50-60.	60-70.	70-80.	Over 80.	Age Unknown.	Rate per 1,000.
Middleborough,	85	46	36	3	6	19	-	1	-	-	-	-	1	5	6	6	5	10	20	12	-	12.03
Milford,	157	77	80	-	4	18	1	3	1	-	5	3	7	15	15	15	11	22	26	15	-	17.32
Millbury,	82	43	39	-	3	14	1	2	-	-	2	4	3	4	4	4	10	12	13	9	-	14.39
Milton,	73	44	29	-	7	17	3	2	1	1	2	1	-	4	4	5	6	9	10	8	-	11.66
Montague,	109	60	47	2	14	33	3	2	2	1	2	4	6	9	5	5	7	10	10	8	2	18.43
Natick,	141	64	77	-	7	17	6	2	1	1	4	6	11	14	15	16	12	14	10	12	-	16.34
NEW BEDFORD,	1,111	553	558	-	89	375	68	30	24	6	25	12	28	82	77	57	68	93	105	61	-	16.75
NEWBURYPORT,	254	123	131	-	16	27	7	4	4	-	5	3	6	25	24	14	22	38	45	30	-	17.03
NEWTON,	450	201	249	-	35	115	20	5	3	1	6	11	11	38	32	31	34	53	52	38	-	15.14
NORTH ADAMS,	319	165	154	-	31	91	22	12	3	5	8	2	6	31	18	26	29	35	20	11	-	15.21
NORTHAMPTON,	279	141	138	-	10	62	*-	*-	*-	*-	5	†-	†-	21	27	19	24	35	39	25	2	15.67
North Attleborough,	91	41	50	-	5	14	3	1	-	1	-	1	2	2	4	8	15	12	19	9	-	14.03
Northbridge,	105	49	56	-	5	28	8	3	5	1	3	3	3	7	7	4	8	6	14	5	-	18.44
North Brookfield,	86	39	47	-	-	12	1	5	1	-	4	5	1	7	4	5	3	7	22	9	-	16.89
Orange,	76	36	40	-	5	16	-	1	2	-	1	3	3	5	4	4	12	7	7	11	-	13.02
Palmer,	143	76	67	-	7	67	5	6	4	-	3	4	1	5	5	2	10	10	11	10	-	20.25
Peabody,	230	122	108	-	3	28	12	7	3	2	7	5	8	24	21	23	23	34	18	15	-	21.46
PITTSFIELD,	353	185	168	-	16	65	13	3	7	2	7	15	7	32	34	28	27	45	38	30	-	15.59
Plymouth,	167	83	84	-	10	7	6	2	3	-	1	2	5	13	11	11	14	28	25	39	-	20.02
QUINCY,	329	183	146	-	34	86	20	5	5	6	2	3	9	30	28	24	29	28	36	15	3	13.97
Reading,	74	41	33	-	2	10	2	1	-	-	-	-	-	2	4	3	7	13	19	13	-	14.53

Revere,	135	65	70	-	9	42	9	-	1	2	3	-	-	4	14	9	16	19	9	7	-	15.93
Rockland,	74	39	35	-	-	3	1	1	-	-	1	-	2	13	5	5	8	9	12	14	-	12.96
Rockport,	66	35	31	-	9	15	3	1	1	1	2	-	1	4	1	1	10	17	6	3	-	11.01
SALEM,	544	264	280	-	38	123	18	9	3	-	8	9	13	33	48	38	57	60	74	50	1	14.75
SOMERVILLE,	880	443	437	-	63	195	35	18	8	3	14	11	10	75	55	68	85	131	106	66	-	14.40
Southbridge,	210	117	93	-	6	63	10	7	2	-	7	6	9	11	8	13	21	21	18	4	10	24.40
Spencer,	111	65	46	-	6	20	-	1	1	2	1	2	7	6	15	5	7	16	10	18	-	16.01
SPRINGFIELD,	991	532	459	-	74	207	48	23	16	7	17	7	24	97	86	65	98	107	113	75	1	17.54
Stoneham,	94	52	42	-	4	14	2	-	-	-	1	-	2	11	5	7	9	15	11	16	1	14.78
Stoughton,	124	70	49	5	4	20	8	2	1	-	1	-	5	15	13	7	9	15	15	13	-	22.45
TAUNTON,	558	288	270	-	24	108	20	8	4	2	9	4	11	40	53	58	72	70	66	31	2	19.81
Wakefield,	129	55	74	-	-	24	4	4	-	1	3	1	4	7	10	13	14	12	17	15	-	14.18
WALTHAM,	274	136	138	-	14	58	6	3	1	2	3	6	11	36	25	18	21	34	30	20	-	12.29
Ware,	135	65	70	-	5	37	5	3	2	2	-	3	2	15	6	9	9	15	14	13	-	17.21
Watertown,	132	65	66	1	4	24	5	1	1	2	8	1	3	5	5	14	14	21	20	8	-	16.06
Webster,	155	75	80	-	11	53	17	6	2	3	1	3	3	14	8	1	4	15	16	9	-	18.77
Westborough,‡	114	55	59	-	4	5	-	-	1	-	-	1	1	10	11	14	13	15	24	19	-	21.68§
West Springfield,	106	55	51	-	7	29	8	1	4	-	1	-	1	5	7	6	8	14	9	12	1	15.70
Weymouth,	176	91	85	-	6	28	2	2	-	2	2	1	1	12	12	11	10	30	42	21	-	15.24
Whitman,	80	38	41	1	5	14	4	-	-	1	2	2	1	8	4	7	8	9	13	7	-	12.26
Williamstown,	59	23	36	-	4	14	2	-	1	-	1	-	2	3	4	4	5	4	13	6	-	11.16
Winchester,	65	32	33	-	9	14	2	2	1	-	4	-	4	4	2	7	5	5	11	4	-	9.39
WOBURN,	224	109	115	-	14	57	11	2	1	4	-	4	6	19	19	14	20	32	22	13	-	15.36
WORCESTER,	1,837	941	896	-	106	412	99	43	22	17	41	29	56	154	162	160	164	210	167	101	-	16.96
TOTAL,	38,147	19,425	18,704	18	2,431	9,439	1,751	709	417	285	801	487	918	3,379	3,324	2,992	3,351	4,052	3,575	2,260	40	17.21

* Fifteen between the ages of one and five years.

† Five between the ages of ten and twenty years.

‡ Including forty-eight deaths at Westborough Insane Hospital.

§ Death-rate of the town, 12.55.

TABLE III.

Deaths by Months in Each City and Town having a Population of more than 5,000 by Census of 1895.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Unknown.
Adams,	14	7	11	18	14	15	10	25	19	18	10	14	–
Amesbury,	10	5	12	13	13	13	11	13	13	9	5	17	1
Andover,	5	6	6	8	14	3	8	9	10	8	9	16	–
Arlington,	10	12	7	5	7	5	11	13	9	8	7	12	–
Athol,	13	9	8	8	7	5	6	11	11	12	7	7	–
Attleborough,	11	11	12	6	7	6	12	10	8	16	15	17	–
BEVERLY,	14	10	13	12	24	9	26	29	23	13	12	19	–
Blackstone,	7	9	10	15	11	4	8	12	8	8	11	15	–
BOSTON,	901	785	913	930	868	714	871	1,195	985	896	874	954	–
Braintree,	10	4	6	8	6	7	6	7	9	7	4	7	–
BROCKTON,	44	33	35	49	35	18	34	35	43	46	44	42	–
Brookline,	19	23	17	22	28	20	22	15	29	19	14	23	–
CAMBRIDGE,	148	115	120	120	125	81	135	189	166	129	101	113	–
CHELSEA,	47	44	53	55	47	47	59	58	70	49	61	48	–
CHICOPEE,	28	32	31	24	26	47	48	33	32	12	20	23	–
Clinton,	21	17	24	12	20	14	15	17	28	11	10	18	–
Concord,	6	5	10	4	3	5	6	6	8	5	6	8	–
Danvers,	14	3	11	7	9	7	5	11	9	8	7	14	–
Dedham,	13	10	9	12	5	6	9	13	7	10	12	11	–

Easthampton,	8	3	8	8	5	6	10	4	5	8	5	5	-
EVERETT,	26	23	38	22	21	22	24	21	36	37	30	22	-
FALL RIVER,	115	97	141	166	134	141	233	214	164	158	103	147	-
FITCHBURG,	32	27	36	38	29	30	35	50	36	27	28	36	-
Framingham,	4	16	8	13	14	12	9	15	16	9	12	9	-
Franklin,	7	6	5	5	11	7	2	8	12	8	2	6	-
Gardner,	12	6	8	5	17	3	5	25	12	10	8	10	-
GLOUCESTER,	25	30	34	27	35	31	30	37	32	26	29	36	-
Grafton,	5	9	3	7	5	12	8	7	10	11	5	7	-
Greenfield,	15	9	5	5	10	6	14	15	11	6	4	9	-
HAVERHILL,	38	39	37	48	39	35	42	63	44	47	44	43	-
HOLYOKE,	59	62	50	51	45	63	102	108	102	58	29	54	-
Hudson,	5	8	8	9	5	3	9	5	8	10	8	4	-
Hyde Park,	8	16	23	11	12	14	10	18	25	20	19	17	-
LAWRENCE,	72	70	87	66	60	66	134	137	94	89	80	103	-
Leominster,	17	16	14	7	12	7	10	19	13	16	14	9	-
LOWELL,	125	119	141	137	131	135	226	203	169	151	116	155	-
LYNN,	81	77	84	72	73	66	90	107	72	68	67	76	-
MALDEN,	33	38	36	47	28	34	38	52	55	42	33	39	-
Marblehead,	9	14	8	12	10	10	12	13	11	8	11	10	-
MARLBOROUGH,	13	15	19	17	15	19	15	35	22	19	11	23	-
MEDFORD,	15	17	15	9	17	12	25	19	17	17	19	15	-
Melrose,	12	12	23	22	21	13	12	11	15	16	13	20	-
Methuen,	9	7	10	9	8	15	5	10	13	6	6	7	-
Middleborough,	12	6	11	5	7	6	2	-	11	8	4	13	-

TABLE III. — *Concluded.*

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Unknown.
Milford,	11	16	13	14	12	12	7	14	16	6	17	19	-
Millbury,	9	8	4	6	7	5	3	6	11	10	6	7	-
Milton,	4	10	5	4	5	5	2	7	4	7	6	14	-
Montague,	14	9	8	4	9	8	7	17	17	6	5	5	-
Natick,	11	10	11	15	9	12	9	19	16	10	9	10	-
NEW BEDFORD,	101	99	82	91	70	54	103	133	103	107	78	90	-
NEWBURYPORT,	22	26	12	25	22	21	8	29	24	20	19	26	-
NEWTON,	34	34	38	39	40	22	43	46	40	35	35	44	-
NORTH ADAMS,	33	16	31	28	35	18	18	36	29	23	23	29	-
NORTHAMPTON,	18	17	18	34	22	28	19	29	34	22	22	16	-
North Attleborough,	10	8	7	8	9	7	5	6	8	10	6	7	-
Northbridge,	7	7	7	13	12	6	10	10	10	8	9	6	-
North Brookfield,	4	7	10	10	11	11	5	7	4	5	6	6	-
Orange,	6	8	2	7	6	6	8	9	6	6	7	5	-
Palmer,	16	14	7	10	12	6	14	19	14	7	10	14	-
Peabody,	22	22	20	24	17	22	14	25	22	8	24	9	-
PITTSFIELD,	31	25	33	28	30	28	32	33	31	34	22	26	-
Plymouth,	11	13	16	12	10	16	11	15	14	16	13	20	-
QUINCY,	30	24	34	24	24	17	25	31	35	20	28	37	-
Reading,	7	10	7	5	3	4	2	6	7	7	10	6	-
Revere,	12	10	4	12	5	9	6	24	18	13	9	13	-

Rockland,	5	5	3	8	10	6	4	2	7	7	7	10	-
Rockport,	2	9	4	8	4	7	3	6	5	4	6	8	-
SALEM,	43	20	66	41	62	37	27	66	56	42	45	39	-
SOMERVILLE,	64	65	79	75	69	64	59	112	73	54	68	98	-
Southbridge,	13	14	18	19	25	17	13	22	13	18	18	20	-
Spencer,	7	11	7	9	8	10	9	12	7	16	6	9	-
SPRINGFIELD,	100	65	84	72	68	73	93	90	76	92	83	95	-
Stoneham,	5	2	9	9	8	8	10	13	11	7	4	8	-
Stoughton,	4	8	11	13	6	12	11	18	11	8	10	11	1
TAUNTON,	50	32	47	44	48	41	42	58	46	48	46	56	-
Wakefield,	13	16	11	8	17	11	11	7	10	7	5	13	-
WALTHAM,	25	26	20	17	22	16	19	24	27	25	23	30	-
Ware,	9	9	13	4	14	6	14	13	18	11	13	11	-
Watertown,	11	11	13	15	4	4	7	19	12	9	10	17	-
Webster,	14	8	8	16	13	14	8	21	16	20	9	8	-
Westborough,	10	9	10	7	10	11	6	8	10	11	11	11	-
West Springfield,	8	7	7	2	10	7	15	12	12	5	11	10	-
Weymouth,	17	18	15	20	9	12	11	23	13	9	13	16	-
Whitman,	2	6	8	11	4	6	5	5	10	7	8	8	-
Williamstown,	2	7	4	4	10	3	3	6	3	2	9	6	-
Winchester,	5	8	4	5	3	2	7	6	8	3	12	2	-
WOBURN,	21	23	20	12	15	18	12	22	19	25	20	17	-
WORCESTER,	153	139	166	179	177	125	146	197	155	137	128	135	-
TOTAL,	3,089	2,793	3,156	3,157	3,019	2,621	3,290	4,183	3,573	3,106	2,858	3,300	2

TABLE IV.

Deaths from Specified Causes in Cities and Towns having more than 5,000 Inhabitants in Each.

	Consumption.	Measles.	Scarlet Fever.	Diphtheria and Croup.	Whooping-cough.	Typhoid Fever.	Cerebro-spinal Meningitis.	Erysipelas.	Puerperal Fever.	Influenza.	Malarial Fever.	Cholera Infantum.	Dysentery.	Diarrhœa and Cholera Morbus	Pneumonia.	Bronchitis.	Diseases of the Heart.	Diseases of the Brain and Spinal Cord.	Diseases of the Kidneys.	Cancer.	Suicide.	Accident.	Unknown or Ill-defined Causes.	All Other Causes.
Adams, . . .	16	-	1	9	-	4	4	1	1	-	-	17	4	6	25	8	20	12	10	8	2	2	-	25
Amesbury, . .	25	-	1	2	2	-	-	-	-	-	1	9	-	7	10	8	11	23	12	7	1	3	7	6
Andover, . . .	8	-	-	-	-	-	1	-	-	-	1	-	-	-	6	2	22	8	2	4	-	5	-	43
Arlington, . . .	15	-	-	2	-	1	1	-	-	-	-	1	1	-	13	8	7	15	6	5	1	6	-	24
Athol, . . .	10	-	-	-	1	3	4	-	-	-	-	4	3	-	6	-	13	-	3	3	-	2	-	52
Attleborough, . .	13	-	-	-	1	1	6	-	1	1	-	6	1	-	9	1	11	17	8	4	1	12	-	37
BEVERLY, . . .	25	-	1	1	1	4	3	-	-	1	1	10	-	1	16	6	24	22	12	10	2	14	1	48
Blackstone, . .	12	1	-	-	3	-	1	-	-	-	2	3	5	1	9	6	6	3	7	2	2	6	-	48
BOSTON, . . .	1,241	27	33	185	68	185	97	30	8	29	5	441	41	117	1,169	380	934	568	403	412	83	523	66	3,825
Braintree, . . .	4	-	-	1	-	3	3	-	-	1	1	5	-	-	15	1	7	6	3	3	-	3	-	25
BROCKTON, . .	66	-	1	1	-	3	6	-	2	1	2	21	3	3	25	5	34	20	11	22	5	4	5	218
Brookline, . . .	19	2	2	3	11	2	-	1	1	-	-	10	1	2	24	9	31	17	12	17	2	4	2	78
CAMBRIDGE, . .	187	1	6	29	22	14	19	3	4	16	1	84	5	87	146	46	97	197	65	71	8	49	138	246
CHELSEA, . . .	48	-	1	3	6	7	7	1	-	-	1	19	3	9	44	21	78	7	10	26	3	32	-	312
CHICOPEE, . .	34	-	-	5	2	4	-	-	1	-	2	47	-	2	26	8	22	25	14	6	1	5	10	142
Clinton, . . .	17	-	-	3	-	9	-	-	-	1	3	10	4	2	22	9	20	39	7	5	2	6	1	47
Concord, . . .	5	-	-	-	-	3	-	1	-	-	-	1	1	-	-	-	9	8	1	2	-	6	-	35
Danvers, . . .	15	-	-	2	-	1	3	-	-	1	-	1	1	2	10	2	10	6	12	8	2	1	28	-
Dedham, . . .	18	1	-	-	1	1	-	-	-	-	-	4	-	1	17	2	16	13	3	1	-	7	-	32
Easthampton, . .	3	-	-	-	1	-	1	-	-	-	1	2	-	1	4	2	2	-	1	3	-	-	-	54
EVERETT, . . .	44	-	1	8	-	5	1	-	-	2	-	15	1	4	32	11	21	21	8	12	1	7	1	130
FALL RIVER, . .	149	15	5	4	7	21	8	1	4	24	5	257	25	40	125	119	84	237	52	31	2	1	-	597
FITCHBURG, . .	40	-	1	1	8	6	2	-	-	3	-	32	1	3	22	14	27	39	15	18	-	17	-	154

Framingham,	26	-	2	1	-	11	2	-	-	1	-	6	2	-	9	-	16	-	7	2	-	8	-	44
Franklin,	6	-	-	-	1	2	1	1	-	-	1	2	5	-	3	-	7	16	6	4	-	-	-	24
Gardner,	16	-	1	2	-	-	-	-	-	1	-	12	-	12	4	2	5	25	5	9	-	3	-	24
Gloucester,	40	2	2	5	7	2	-	-	-	-	-	12	-	-	32	31	34	60	17	7	2	29	15	75
Grafton,	5	-	-	1	2	2	1	-	-	-	-	4	1	1	4	2	4	2	2	3	-	6	-	49
Greenfield,	14	1	-	-	-	2	-	-	-	-	-	2	3	-	4	3	10	20	7	5	5	3	-	28
Haverhill,	85	7	-	13	24	8	1	-	4	4	-	21	-	2	43	13	49	48	29	30	5	14	4	115
Holyoke,	93	1	-	10	9	9	52	-	2	4	3	78	8	72	43	22	38	16	34	20	4	30	-	235
Hudson,	6	-	2	2	2	3	2	-	-	2	-	6	1	1	4	3	12	7	5	2	-	2	-	19
Hyde Park,	17	-	-	10	-	1	-	-	-	1	-	4	-	4	15	4	15	4	5	5	1	11	-	96
Lawrence,	88	1	9	50	1	9	1	2	2	-	1	115	2	6	71	28	82	41	15	27	3	21	16	465
Leominster,	16	-	1	1	3	3	5	-	1	-	1	9	2	-	7	4	14	7	10	10	6	8	-	46
Lowell,	209	-	6	36	10	24	4	2	2	5	-	186	7	5	164	99	163	228	91	38	14	42	-	473
Lynn,	94	3	3	7	30	15	36	1	-	5	-	48	4	7	65	18	86	3	17	45	5	1	-	438
Malden,	57	-	1	5	-	5	4	-	-	1	-	25	6	-	46	18	45	44	28	22	1	5	-	162
Marblehead,	8	1	-	-	-	1	3	-	-	-	-	2	-	-	11	-	14	2	5	5	-	3	-	73
Marlborough,	30	-	-	-	2	-	-	-	-	1	-	7	3	-	11	3	29	-	9	9	-	1	-	118
Medford,	14	-	-	3	1	3	-	-	1	1	1	13	-	-	25	8	18	-	-	10	2	1	-	96
Melrose,	24	1	1	-	1	1	2	-	1	-	1	4	3	-	12	3	19	3	6	13	2	-	-	92
Methuen,	10	-	-	10	-	4	2	-	-	-	-	7	-	1	3	-	8	5	4	6	-	4	-	41
Middleborough,	6	-	-	-	-	-	2	-	2	1	-	1	-	-	6	3	23	8	1	2	2	2	-	25
Milford,	29	1	-	2	-	3	4	1	-	-	1	4	-	-	15	1	16	13	7	7	-	-	-	53
Millbury,	10	-	1	-	-	-	3	2	-	-	-	3	1	1	4	5	9	8	5	3	1	1	-	25
Milton,	4	-	-	-	2	-	-	-	-	-	-	3	1	3	14	-	7	7	2	5	2	-	8	15
Montague,	6	-	-	-	-	1	-	-	1	1	2	9	-	1	17	1	12	9	-	2	-	6	2	39
Natick,	22	-	1	4	-	5	3	-	-	-	1	10	-	1	18	5	13	-	6	4	2	5	1	40
New Bedford,	96	-	4	18	7	17	7	1	1	1	-	115	1	9	73	28	82	76	53	50	1	2	6	463
Newburyport,	20	-	-	3	1	2	-	-	-	4	-	6	2	3	11	10	22	2	18	9	-	9	1	131
Newton,	33	-	4	6	6	7	4	-	-	-	-	17	2	3	40	5	33	13	2	15	3	9	-	248
North Adams,	18	-	2	8	-	10	4	-	1	-	-	10	2	6	34	15	24	25	14	17	2	8	-	118
Northampton,	25	-	-	1	-	3	-	1	-	1	1	23	4	-	22	11	20	7	2	10	-	8	-	140
North Attleborough,	7	1	-	1	-	2	-	-	-	1	-	2	-	1	5	-	11	12	2	5	2	2	-	37
Northbridge,	6	-	2	4	1	2	5	-	1	1	3	7	2	2	12	4	8	3	3	2	-	1	-	36

TABLE IV. — *Concluded.*

	Consumption.	Measles.	Scarlet Fever.	Diphtheria and Croup.	Whooping-cough.	Typhoid Fever.	Cerebro-spinal Meningitis.	Erysipelas.	Puerperal Fever.	Influenza.	Malarial Fever.	Cholera Infantum.	Dysentery.	Diarrhœa and Cholera Morbus.	Pneumonia.	Bronchitis.	Diseases of the Heart.	Diseases of the Brain and Spinal Cord.	Diseases of the Kidneys.	Cancer.	Suicide.	Accident.	Unknown or Ill-defined Causes.	All Other Causes.
North Brookfield, .	13	-	4	6	1	-	3	1	-	-	-	4	1	-	1	1	15	10	2	5	1	1	-	17
Orange, . . .	5	-	-	3	-	-	-	1	-	-	1	2	-	2	5	-	6	9	2	4	-	3	-	33
Palmer, . . .	8	-	1	1	3	1	-	-	1	-	-	17	2	-	18	5	11	3	3	1	-	10	15	43
Peabody, . . .	22	-	-	18	1	3	14	-	-	1	-	6	3	1	15	10	21	24	7	15	5	2	-	59
PITTSFIELD, . .	35	-	1	2	1	8	17	-	-	1	-	9	-	2	21	11	38	51	12	16	-	19	-	109
Plymouth, . .	8	-	-	2	-	4	3	-	-	2	-	3	-	-	4	3	19	7	1	8	2	6	23	72
QUINCY, . . .	37	3	-	3	3	8	5	-	2	-	1	33	-	11	35	4	-	71	3	6	3	19	7	72
Reading, . . .	1	-	-	-	-	-	1	-	-	-	-	3	-	-	10	-	10	-	-	2	2	1	-	44
Revere, . . .	6	-	-	2	2	2	1	-	-	-	-	9	-	2	12	2	13	6	5	4	-	8	-	61
Rockland, . . .	17	-	-	-	1	4	-	-	-	-	2	1	-	1	7	-	13	8	4	6	-	1	6	3
Rockport, . . .	6	-	-	-	-	-	4	-	-	-	-	-	-	1	3	-	3	-	3	7	-	4	-	35
SALEM, . . .	36	-	-	4	10	10	3	2	-	6	3	21	3	7	36	21	60	15	3	21	3	13	-	267
SOMERVILLE, . .	70	-	-	12	3	11	43	4	-	5	-	51	7	9	79	23	71	13	30	40	5	21	-	383
Southbridge, . .	22	2	-	4	1	3	4	-	-	-	-	13	-	2	5	4	13	37	8	-	-	2	32	57
Spencer, . . .	14	-	-	1	2	1	4	1	2	-	2	5	-	-	5	-	10	-	4	4	-	2	-	54
SPRINGFIELD, . .	108	1	1	29	9	15	7	-	4	5	4	83	-	13	87	24	75	20	87	45	8	32	65	268
Stoneham, . . .	25	-	-	-	-	2	2	-	-	-	-	1	1	-	7	3	9	11	9	1	-	3	-	20
Stoughton, . .	16	-	-	-	-	1	5	-	-	2	-	8	7	1	6	-	15	11	4	5	2	5	1	35
TAUNTON, . . .	66	-	1	1	-	8	1	1	-	2	4	11	4	31	40	11	50	40	20	13	3	15	-	236
Wakefield, . .	15	-	-	3	1	1	17	-	-	-	-	-	-	-	6	2	24	3	4	1	1	5	3	43
WALTHAM, . .	39	-	1	3	-	7	-	2	-	-	-	7	-	2	21	6	34	13	12	12	1	1	8	105
Ware, . . .	9	-	-	3	-	1	1	-	-	-	1	15	1	4	15	1	14	5	5	2	-	-	-	58
Watertown, . .	11	-	5	2	2	3	7	-	-	3	-	4	2	6	11	5	18	11	10	5	-	6	12	9

Webster, . . .	15	3	3	3	2	3	2	2	-	-	-	21	3	3	8	3	7	18	5	2	-	1	-	49
Westborough, . .	9	-	-	-	-	-	-	-	-	-	-	1	-	-	10	5	9	45	4	4	3	3	-	21
West Springfield, .	3	1	-	4	-	1	1	-	-	-	1	11	1	2	2	2	7	4	6	1	1	2	-	56
Weymouth, . .	27	-	-	1	-	3	1	1	-	1	-	3	1	1	13	5	24	44	1	5	2	5	12	26
Whitman, . . .	18	-	-	-	-	1	5	-	-	-	-	2	-	1	3	-	8	2	1	5	-	-	-	34
Williamstown, . .	9	-	-	-	1	-	3	-	-	3	-	2	-	2	4	2	9	2	-	3	-	-	-	19
Winchester, . .	8	-	-	-	-	1	-	1	-	-	-	2	-	-	7	2	10	4	3	6	-	1	-	20
WOBURN, . . .	26	-	1	4	-	2	-	-	-	2	3	5	3	-	10	6	29	3	6	8	1	3	1	111
WORCESTER, . .	224	-	5	35	29	13	2	9	2	1	3	132	7	7	216	64	190	263	98	60	9	78	3	385
Total, . . .	4,082	76	118	608	316	551	471	74	52	150	67	2,257	208	540	3,344	1,242	3,289	2,770	1,456	1,400	235	1,232	500	13,065

	Homicide.
Attleborough, ...	1
Beverly, ...	1
Blackstone, ...	1
Boston, ...	12
Brookline, ...	1
Fitchburg, ...	1
Greenfield, ...	2
Hudson, ...	1
Lynn, ...	1
North Adams, ...	1
Peabody, ...	2
Quincy, ...	1
Southbridge, ...	1
Springfield, ...	1
Worcester, ...	2
	29

	Anthrax.
Boston, ...	2
	Hydrophobia.
Melrose, ...	1
	Leprosy.
Boston, ...	1
	Malignant Carbuncle.
Lynn, ...	1
Middleborough, ...	1
	2
	Myxœdema.
Cambridge, ...	1
	Tetanus.
Quincy, ...	2
	Typhus Fever.
Peabody, ...	1

TABLE V.

Deaths from Specified Causes, 1898. Death-rates per 10,000 (1894-98). Deaths per 1,000 from All Causes, 1894-98.

Causes of Death.	Deaths. 1898.	Mortality per 10,000 of the Population.					Deaths per 1,000 from all Causes.				
		1898.	1897.	1896.	1895.	1894.	1898.	1897.	1896.	1895.	1894.
Consumption,	4,082	18.41	19.01	20.60	21.19	22.34	107.01	105.00	106.75	110.45	113.64
Measles,	76	0.34	0.57	0.53	0.45	0.35	1.99	3.13	2.72	2.33	1.79
Scarlet fever,	118	0.53	1.32	1.06	2.08	2.95	3.09	7.27	5.50	10.84	15.01
Diphtheria and croup,	608	2.74	5.75	7.20	7.88	9.21	15.94	31.78	37.30	41.05	46.82
Whooping-cough,	316	1.43	0.72	1.01	1.04	1.88	8.28	3.98	5.22	5.42	9.54
Typhoid fever,	553	2.49	2.37	2.77	2.66	3.20	14.50	13 08	14.33	13.88	16.29
Cerebro-spinal meningitis,	471	2.12	2.59	1.54	1.81	1.49	12.35	14.31	7.97	9.44	7.56
Erysipelas,	74	0.33	0.44	0.52	0.55	0.51	1.94	2.44	2.70	2.86	2.60
Puerperal fever,	52	0.23	0.27	0.37	0.41	0.53	1.36	1.52	1.91	2.14	2.71
Influenza,	150	0.68	1.10	0.52	1.73	1.28	3.93	6.09	2.67	9.01	6.53
Malarial fever,	67	0.30	0.23	0.28	0.26	0.28	1.76	1.28	1.44	1.37	1.44
Cholera infantum,	2,257	10.18	9.69	13.22	10.69	12.92	59.14	53.55	68.52	55.73	65.74
Dysentery,	208	0.94	0.79	1.48	0.80	0.87	5.45	4.39	7.65	4.15	4.42
Diarrhœa and cholera morbus,	540	2.44	2.00	2.47	2.08	2.53	14.16	11.02	12.80	10.86	12.84
Pneumonia,	3,344	15.08	17.18	17.76	17.51	16.21	87.66	94.92	92.04	91.28	82.46
Bronchitis,	1,242	5.60	5.81	6.04	6.16	6.61	32.56	32.07	31.31	32.09	33.63
Diseases of the heart,	3,289	14.84	14.81	15.35	15.44	14.62	86.22	81.84	79.53	80.47	74.38
Diseases of the brain and spinal cord.	2,770	12.50	13.23	12.41	13.31	14.14	72.61	73.08	64.31	69.37	71.90
Diseases of the kidneys,	1,456	6.57	6.42	6.87	6.96	6.48	38.17	35.43	35.62	36.27	32.98
Cancer,	1,400	6.32	6.04	6.12	4.47	5.92	36.70	33.35	31.73	23.29	30.11
Suicide,	235	1.06	0.98	1.06	1.06	0.89	6.16	5.40	5.50	5.55	4.52
Accident,	1,232	5.56	5.21	5.68	5.81	5.40	32.30	28.80	29.42	30.30	27.48
Unknown or ill-defined causes,	500	2.26	2.77	3.15	2.38	2.02	1.31	1.53	1.63	1.24	1.03
All Causes,	38,147	172.1	181.0	193.0	191.9	196.6	-	-	-	-	-

The population upon which the foregoing death-rates are calculated is estimated for 1898 by the usual rule, from the rate of increase in the foregoing five-year period (1890–95).

THE

Vital Statistics of Massachusetts for 1897, with a Life Table

based upon the Experience of the Five-year Period 1893–97.

By Samuel W. Abbott, M.D., *Secretary of the Board.*

THE VITAL STATISTICS OF MASSACHUSETTS FOR 1897, WITH A LIFE TABLE BASED UPON THE EXPERIENCE OF THE FIVE-YEAR PERIOD 1893-97.

The following brief digest embraces the vital statistics of the State for the year 1897, to which has been appended a life table, constructed mainly from the State census of 1895, and the mortality of the years 1893, '94, '95, '96 and '97.

POPULATION.

The assumed population in 1897, based upon the rate of increase from 1890 to 1895, was 2,613,023. Assuming the rate of increase of each sex to have been the same as that of the five-year period 1890–95, the males were 1,269,556 and the females, 1,343,467.

The number of registered marriages was 23,038; of births, 73,205; and of deaths, 47,419.

MARRIAGES.

The total number of marriages was 23,038, and the marriage-rate was 8.82 per 1,000 of the living population, or 17.64 per 1,000 (persons married). The following table expresses the seasonal marriage-rate for 1897 and for the period 1876–95: —

Marriages by Months, Quarters and Half-years.

	Marriages, 1897.	Monthly Ratio reduced to a Daily Standard of 100.			20 Years — 1876-95.
		Months.	Quarters.	Half-years.	
January,	1,738	89.2			97.0
February,	1,563	88.8	79.4		92.4
March,	1,188	61.0		96.6	54.9
April,	1,862	98.8			101.8
May,	1,553	79.7	113.6		89.5
June,	3,082	163.5			126.2
July,	1,537	78.9			82.1
August,	1.607	82.5	92.2		80.1
September,	2,187	116.0		104.2	112.0
October,	2,571	132.0			129.4
November,	2,569	136.3	116.2		147.8
December,	1,581	81.2			89.1
Total,	23,038	-	-	-	-
Mean,	-	100.0	-	-	100.0

Births.

The living births in 1897 were 73,205, and the birth-rate was 28.02 per 1,000. This rate was less than that of 1896, but greater than that of any previous year since 1874, except those of 1892 and 1893. The birth-rate of the twenty-year period 1876–95 was 25.86. The following table expresses the seasonal birth-rate for 1897 and for the period 1876–95: —

Births by Months, Quarters and Half-years (1897 and 1876–95).

Months.	Births.	Monthly Ratio reduced to a Standard of 100 per Day — Months.	Quarters.	Half-years.	20 Years — 1876-95.
January,	6,265	100.8			95.6
February,	5,634	100.3	101.3		98.6
March,	6,388	102.7			98.0
April,	5,705	94.8		97.2	94.9
May,	5,665	91.1	93.5		94.0
June,	5,693	94.6			98.1
July,	6,356	102.2			104.1
August,	6,708	107.9	104.6		106.6
September,	6,238	103.7			104.4
October,	6,330	101.8		102.6	101.3
November,	6,015	99.97	100.6		101.5
December,	6,208	99.8			102.7
Total,	73,205	100.0	100.0	100.0	100.0

The order of intensity was as follows, beginning with the month having the highest daily birth-rate: August, September, March, July, October, January, February, November, December, April, June, May. This corresponds fairly with the normal means for the period 1876–95, in which the months having the highest daily birth-rates were August and September, and the lowest in May. For the past forty years the last half of each year has usually had a higher birth-rate than the first half, but the difference which existed at the early part of the period has gradually been growing less.

Still-births. — The number of still-births registered was 2,652, of which number 1,636 were males, 1,005 were females, and the sex of 11 was not stated. The ratio of males to females was as 1,628 to 1,000. The total number of births living and dead was 75,857.

Sexes. — Of the total number of living births, 37,689 were males and 35,489 were females, being in the ratio of 1,062 males to each

1,000 females. In this estimate 27 births are excluded, the sex of which was not stated.

The births for the period 1876–95 indicated a ratio of 10.53 males to 1,000 females.

Deaths.

The registered deaths in 1897 were 47,419 and the death-rate was 18.15. This was lower than that of any year since 1879, and, with the exception of 1878 and 1879, the lowest since 1867.

Sex. — Of the whole number of deaths, excluding the still-born, 24,004 were males and 23,415 were females. The death-rate of males was 18.91 per 1,000 and that of females 17.39 upon the assumed population as stated on page 799.

Ages. — The most important factor in the general death-rate is the death-rate of infants under one year, which is usually expressed as a ratio per 1,000 births, since the census enumeration at the early years of life is unreliable. The numbers dying at this period are high both absolutely and relatively, while those who die at extreme old age are only relatively high in number. For more accurate information on this subject the life tables following this summary may be consulted.

The deaths under one year in 1897 were 10,751, which was equivalent to a death-rate of 146.9 per 1,000 births. The deaths at the next ages of life were as follows: second year, 2,257; third year, 1,058; fourth, 744; fifth, 493; and for the two five-year periods 5–10 and 10–15, 1,287 and 682. For the death-rates at these and later ages see life table.

Infant Mortality.

In the twenty-eighth annual report of the Board, page 753, a table is presented, giving the statistics relative to infant mortality in each of the 32 cities of the State for the ten years 1881–90.

In the following table the figures are presented for the next seven years, 1891–97, with two parallel columns, by means of which the rank of each city may be compared for the two periods.

In these two last columns the infant mortality of the State is taken as a standard of comparison, or mean of the whole period, the figure

100 representing the mean. The results may be read as follows: for every 100 deaths of infants under one year old which occurred in the State during the seven years 1891–97, there were 165 in Fall River, 107 in Boston, 71 in Beverly, etc.

Comparing these columns, there appears to have been a diminished infantile death-rate in the latter period in the following cities: Boston, Lawrence, Salem, Holyoke, Cambridge, Chelsea, Springfield, Haverhill, Marlborough, Pittsfield, Worcester, Somerville, Brockton, Medford, Malden, Waltham and Beverly, and in the remaining cities it was increased.

The death-rate of the whole urban group was also diminished from 174.9 per 1,000 births in the entire period to 164.2 in the later period. That of the rural group, comprising the remainder of the State, remained practically the same (129.5) in both periods, while that of the whole State diminished from 160.4 per 1,000 births to 154.6.

Infant Mortality of Cities, 1891–97.

Cities.	Births.	Deaths 0-1.	Infant Mortality.	Rank — the State = 100.	
				1891-97.	1881-90.
Fall River,	20,910	5,339	255.3	165	149
Lowell,	18,397	4,185	227.5	147	139
Chicopee,	4,282	917	214.2	139	110
Lawrence,	10,788	2,163	200.5	130	133
New Bedford,	12,389	2,478	200.0	129	111
Salem,	6,574	1,106	168.2	109	112
Boston,	108,139	17,834	164.9	107	117
Newburyport,	2,250	364	161.8	105	95
Taunton,	5,031	788	156.6	101	87
Holyoke,	11,609	1,817	156.5	101	105
Cambridge,	17,038	2,590	152.0	98	107
Chelsea,	6,614	998	150.9	98	104
Springfield,	10,001	1,459	145.9	94	98
Haverhill,	5,870	835	142.2	92	98

Infant Mortality of Cities, 1891–97 — Concluded.

CITIES.	Births.	Deaths 0-1.	Infant Mortality.	RANK — THE STATE 100.	
				1891-97.	1881-90.
Gloucester,	4,654	655	140.7	91	86
Lynn,	11,473	1,608	140.2	91	88
Woburn,	3,058	425	139.0	90	79
Fitchburg,	6,273	865	137.9	89	84
Everett,	4,057	552	136.0	88	82
Marlborough,	2,958	400	135.2	87	96
Pittsfield,	3,766	505	134.1	87	90
Northampton,	2,711	362	133.5	86	86
Worcester,	20,659	2,738	132.5	86	97
Somerville,	9,866	1,295	131.3	85	96
North Adams,	4,600	600	130.4	84	72
Brockton,	5,381	687	127.7	83	91
Newton,	4,847	600	123.8	80	70
Quincy,	4,681	555	118.6	77	77
Melrose,*	1,854	217	117.0	76	–
Medford,	2,530	291	115.0	74	81
Malden,	5,667	650	114.7	74	83
Waltham,	3,786	424	112.0	72	82
Beverly,	1,733	191	110.2	71	74
Urban,	344,039	56,493	164.2	106	109
Rural,	132,119	17,113	129.5	84	80
THE STATE,	476,158	73,606	154.6	100	100

* The figures for Melrose are introduced to facilitate future comparison, although that town had not become a city till after the period embraced in the table.

From an examination of the statistics of other towns having over 5,000 inhabitants in each, it appears that the town of Framingham had the lowest infantile mortality (95.9) for the seven years, while Rockport had the highest (203.3 per 1,000 births). Further examination of the record shows that this high infantile mortality in Rockport occurred mainly among infants whose parents were natives of Finland, who were employed upon the granite quarries in Rockport.

The following table presents the infantile mortality of the towns having over 5,000 inhabitants in each (not cities), arranged with those having the highest infantile death-rates at the top of the list.

Infant Mortality of Towns having more than 5,000 Inhabitants in Each (not Cities), 1891–97.

[Deaths (0–1) per 1,000 births.]

Rockport,	203.3	Athol,	130.8
Stoughton,	188.2	Montague,	129.2
Palmer,	171.7	Peabody,	128.1
Ware,	171.2	Spencer,	127.9
Northbridge,	170.7	Clinton,	125.1
Braintree,	164.4	Concord,	124.6
Gardner,	163.2	Hyde Park,	123.7
Revere,	162.1	Dedham,	121.5
West Springfield,	159.5	Orange,	120.3
Southbridge,	159.2	Watertown,	118.9
Grafton,	154.4	Stoneham,	117.3
Hudson,	148.8	Westfield,	116.9
Millbury,	147.9	Franklin,	112.8
Wakefield,	145.6	Greenfield,	112.5
Milton,	145.4	Natick,	109.8
Webster,	143.5	Whitman,	108.0
Methuen,	142.4	Andover,	106.2
Weymouth,	140.4	North Attleborough,	105.2
Marblehead,	139.5	Plymouth,	104.5
Arlington,	138.8	Rockland,	103.5
Adams,	137.7	Milford,	103.4
Winchester,	135.4	Brookline,	101.4
Attleborough,	135.0	Danvers,	99.4
Amesbury,	134.2	Westborough,	96.9
Leominster,	134.0	Middleborough,	96.8
Blackstone,	133.3	Framingham,	95.9

The total living births which furnished the infantile mortality represented in these two periods (shown in the twenty-eighth annual report and in the present report) were nearly 1,000,000 (985,445), and the deaths under one year were 155,277.

Seasons of the Year. — The seasonal intensity of the death-rate is expressed in the following table. The standard employed for comparison is 100 deaths per day throughout the year. The actual number of daily deaths in 1897 was 129.9.

Deaths by Months, Quarters and Half-years (1897 and 1876–95).

Months.	Deaths.	1897. Monthly Ratio reduced to a Standard of 100 Deaths per Day. Months.	Quarters.	Half-years.	20 Years — 1876-95.
January,	4,051	100.6	108.7	101.5	105.0
February,	3,929	108.0			100.0
March,	4,730	120.2			102.3
April,	4,057	104.1	94.3		102.1
May,	3,805	94.4			93.9
June,	3,291	84.4			83.5
July,	4,254	105.6	107.0	98.5	109.3
August,	4,566	113.4			120.0
September,	3,969	101.8			104.5
October,	3,806	94.5	90.1		93.1
November,	3,475	89.1			88.9
December,	3,486	86.6			96.6
Totals,	47,419	-	-	-	-
Means,	-	100.0	100.0	100.0	100.0

By this table it appears that the greatest intensity of the seasonal death-rate was in March and in August and the least was in May and June, in 1897, while the highest in the twenty-year period (1876–95) was in July and August and the lowest was in June and November.

Causes of Death.

In the following table are presented the ten most destructive causes and groups of causes of death in Massachusetts for the ten-year period, 1888–97, arranged in the order of their intensity. From this table it appears that the relative intensity of consumption, brain diseases, pneumonia, heart diseases and cholera infantum continued very much in the same order throughout the period. The only change in the table, as compared with that of 1896, is in the last two causes, diphtheria and croup having taken the tenth place in the list, instead of the ninth. The total number of deaths from these causes was 29,875, as compared with 31,146 in 1896, a difference of 1,271 in favor of 1897. The deaths from consumption, brain diseases, heart diseases, cholera infantum, cancer, old age and diphtheria were less than those of 1896, while those from pneumonia, kidney diseases and bronchitis were more than those of 1896 from the same causes.

In the tables on pages 807–809 are presented the deaths and death-rates from fifteen causes of death for the twenty years 1878–97. These include the principal infectious diseases, together with certain other destructive causes and groups of causes.

The columns contain the absolute numbers in each case, together with the death-rate per 10,000 of the living population and the percentage of the total mortality.

From this table it appears that the death-rate from small-pox, measles, scarlet fever, diphtheria, typhoid fever, cholera infantum, child-birth, consumption, dysentery and whooping-cough in 1897 was less than the mean of the twenty-year period 1878–97, while that of pneumonia, cancer, heart diseases, kidney diseases and brain diseases was greater than the twenty-year mean.

Mortality from Ten Prominent Causes, 1888–97.

Causes of Death.	Deaths. 1897.	Rank — 1888-97.									
		1897.	1896.	1895.	1894.	1893.	1892.	1891.	1890.	1889.	1888.
Consumption, . .	5,431	1	1	1	1	1	1	1	1	1	1
Brain diseases, . .	5,276	2	2	2	2	3	2	2	2	2	2
Pneumonia, . . .	4,796	3	3	3	3	2	3	3	3	3	3
Heart diseases, . .	3,827	4	4	4	4	4	4	4	4	4	4
Cholera infantum, .	2,231	5	5	5	5	5	5	5	6	5	5
Kidney diseases, . .	2,017	6	6	6	7	8	8	8	9	9	9
Cancer, . . .	1,739	7	7	8	10	9	10	9	8	8	10
Old age, . . .	1,602	8	8	9	8	6	6	6	7	7	6
Bronchitis, . . .	1,530	9	10	10	9	7	7	7	10	10	8
Diphtheria and croup, .	1,426	10	9	7	6	10	9	10	5	6	7
	29,875	–	–	–	–	–	–	–	–	–	–

STATISTICS OF CERTAIN CAUSES OF DEATH, MASSACHUSETTS, 1878–97.

Deaths, and Ratios compared with Population and Total Mortality.

Years.	Small-pox.			Measles.			Scarlet Fever.			Diphtheria and Croup.			Typhoid Fever.		
	Deaths.	Death-rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death-rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death-rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death-rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death-rate per 10,000 Living.	Percentage of Total Mortality.
1878,	2	.01	.01	305	1.8	0.97	404	2.3	1.29	2,517	14.6	8.04	679	3.9	2.17
1879,	7	.04	.02	19	0.1	0.06	850	4.8	2.67	2,293	13.1	7.21	637	3.6	2.00
1880,	38	.21	.11	236	1.3	0.67	574	3.2	1.63	2,394	13.4	6.78	882	4.9	2.50
1881,	47	.26	.13	230	1.3	0.63	397	2.2	1.09	2,383	13.1	6.54	1,072	5.9	2.94
1882,	45	.24	.12	68	0.4	0.18	318	1.7	0.86	1,771	9.6	4.81	1,079	5.8	2.93
1883,	5	.03	.01	321	1.7	0.85	575	3.1	1.52	1,621	8.6	4.29	860	4.6	2.28
1884,	3	.02	.01	75	0.4	0.20	627	3.3	1.69	1,646	8.6	4.45	875	4.6	2.37
1885,	19	.10	.05	313	1.6	0.82	587	3.0	1.54	1,523	7.8	4.00	768	3.9	2.02
1886,	–	–	–	130	0.6	0.35	331	1.7	0.89	1,558	7.8	4.18	800	4.0	2.15
1887,	3	.01	.007	455	2.2	1.12	594	2.9	1.46	1,628	7.9	3.99	922	4.5	2.26
1888,	8	.04	.02	219	1.0	0.52	504	2.4	1.20	1,831	8.7	4.35	943	4.5	2.24
1889,	6	.03	.01	171	0.8	0.41	185	0.9	0.44	2,214	10.2	5.30	891	4.1	2.13
1890,	1	.004	.002	114	0.5	0.26	196	0.9	0.45	1,626	7.3	3.74	835	3.7	1.92
1891,	1	.004	.002	236	1.0	0.52	246	1.1	0.54	1,218	5.3	2.70	821	3.6	1.82
1892,	2	.01	.004	88	0.4	0.18	669	2.9	1.37	1,455	6.2	2.98	827	3.5	1.70
1893,	9	.04	.02	276	1.2	0.56	810	3.4	1.65	1,394	5.8	2.84	750	3.1	1.53
1894,	33	.13	.07	98	0.4	0.21	649	2.6	1.39	1,801	7.4	3.85	748	3.1	1.60
1895,	–	–	–	117	0.5	0.25	483	1.9	1.02	1,784	7.1	3.75	680	2.7	1.43
1896,	–	–	–	137	0.5	0.28	249	1.0	0.50	1,677	6.6	3.40	723	2.8	1.46
1897,	4	.02	.008	158	0.6	0.33	342	1.3	0.72	1,426	5.5	3.01	607	2.3	1.28
Totals and means,	233	.06	.03	3,766	0.9	0.46	9,590	2.3	1.16	35,760	8.4	4.34	16,399	3.9	1.99

STATISTICS OF CERTAIN CAUSES OF DEATH, MASSACHUSETTS, 1878–97 — *Continued.*

Deaths, and Ratios compared with Population and Total Mortality — Continued.

Years.	Cholera Infantum.			Consumption.			Child-birth.				Dysentery.	
	Deaths.	Death-rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death-rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death-rate per 10,000 Living	Percentage of Total Mortality.	Percentage of Births.	Deaths.	Death-rate per 10,000 Living.
1878,	1,573	9.1	5.02	5,334	30.8	17.04	297	1.7	0.95	.706	602	3.5
1879,	1,349	7.7	4.24	5,223	29.7	16.42	300	1.7	0.94	.728	372	2.1
1880,	2,118	11.9	6.00	5,494	30.8	15.57	316	1.8	0.90	.700	395	2.2
1881,	1,861	10.3	5.10	5,886	32.4	16.14	370	2.0	1.01	.799	360	2.0
1882,	2,159	11.7	5.87	5,865	31.8	15.94	351	1.9	0.95	.751	398	2.2
1883,	1,941	10.3	5.14	5,931	31.6	15.71	366	1.9	0.97	.755	336	1.8
1884,	2,081	10.9	5.63	5,798	30.4	15.67	323	1.7	0.87	.649	254	1.3
1885,	1,852	9.5	4.86	5,955	30.7	15.63	350	1.8	0.92	.700	253	1.3
1886,	1,931	9.7	5.18	5,897	29.5	15.83	303	1.5	0.81	.581	243	1.2
1887,	2,131	10.4	5.23	5,871	28.6	14.40	280	1.4	0.69	.514	266	1.3
1888,	2,195	10.4	5.21	5,728	27.1	13.61	277	1.3	0.66	.491	248	1.2
1889,	2,156	9.9	5.16	5,581	25.7	13.36	303	1.4	0.73	.517	299	1.4
1890,	2,491	11.1	5.72	5,791	25.9	13.31	365	1.6	0.84	.615	220	1.0
1891,	2,771	12.1	6.13	5,484	24.0	12.14	269	1.2	0.60	.416	234	1.0
1892,	2,898	12.4	5.94	5,739	24.5	11.77	343	1.5	0.70	.508	193	0.8
1893,	2,704	11.3	5.51	5,527	23.1	11.26	317	1.3	0.65	.459	231	1.0
1894,	2,676	10.9	5.72	5,463	22.3	11.67	325	1.3	0.69	.474	216	0.9
1895,	2,377	9.5	5.00	5,486	21.9	11.54	380	1.5	0.80	.549	209	0.8
1896,	2,957	11.6	5.99	5,536	21.7	11.21	328	1.3	0.66	.453	407	1.6
1897,	2,231	8.5	4.70	5,431	20.8	11.45	314	1.2	0.66	.429	209	0.8
Totals and means,	44,452	10.5	5.39	113,020	26.7	13.72	6,477	1.5	0.79	.583	5,945	1.4

STATISTICS OF CERTAIN CAUSES OF DEATH, MASSACHUSETTS, 1878-97 — *Concluded.*

Deaths, and Ratios compared with Population and Total Mortality — Concluded.

Years.	Pneumonia.			Whooping-cough.			Cancer.			Kidney Diseases.			Heart Diseases.			Brain Diseases.		
	Deaths.	Death-rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death-rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death-rate per 10,000 Living	Percentage of Total Mortality.	Deaths.	Death-rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death-rate per 10,000 Living	Percentage of Total Mortality.	Deaths.	Death-rate per 10,000 Living.	Percentage of Total Mortality.
1878, ...	2,171	12.6	6.93	400	2.3	1.28	807	4.7	2.58	615	3.6	1.96	1,442	8.3	4.61	2,778	16.1	8.87
1879, ...	2,647	15.1	8.32	302	1.7	0.95	862	4.9	2.71	693	3.9	2.18	1,515	8.6	4.76	2,820	16.1	8.87
1880, ...	3,076	17.3	8.72	230	1.3	0.65	928	5.2	2.63	698	3.9	1.98	1,726	9.7	4.89	3,210	18.0	9.10
1881, ...	2,967	16.4	8.14	217	1.2	0.59	949	5.2	2.60	825	4.5	2.26	1,937	10.7	5.31	3,355	18.5	9.20
1882, ...	2,932	15.9	7.97	265	1.4	0.72	987	5.3	2.68	877	4.7	2.38	2,025	11.0	5.50	3,393	18.4	9.22
1883, ...	3,045	16.2	8.07	137	0.7	0.36	1,026	5.5	2.72	959	5.1	2.54	2,153	11.5	5.70	3,562	19.0	9.44
1884, ...	2,646	13.9	7.15	410	2.1	1.11	1,060	5.6	2.87	1,000	5.2	2.70	2,117	11.1	5.72	3,669	19.2	9.92
1885, ...	3,468	17.9	9.10	184	0.9	0.48	1,087	5.6	2.85	1,088	5.6	2.86	2,227	11.5	5.85	3,894	20.0	10.22
1886, ...	2,836	14.2	7.61	271	1.4	0.73	1,104	5.5	2.96	1,135	5.7	3.05	2,325	11.6	6.24	3,844	19.2	10.32
1887, ...	3,348	16.3	8.21	232	1.1	0.57	1,174	5.7	2.88	1,120	5.4	2.75	2,690	13.1	6.60	4,257	20.7	10.44
1888, ...	3,716	17.6	8.83	245	1.2	0.58	1,275	6.0	3.03	1,318	6.2	3.13	3,061	14.5	7.27	4,522	21.4	10.74
1889, ...	3,440	15.8	8.23	310	1.4	0.74	1,325	6.1	3.17	1,258	5.8	3.01	3,280	15.1	7.85	4,313	19.8	10.32
1890, ...	4,038	18.0	9.28	363	1.6	0.83	1,387	6.2	3.19	1,273	5.7	2.92	3,417	15.3	7.85	4,389	19.6	10.08
1891, ...	4,337	18.9	9.60	219	1.0	0.48	1,395	6.1	3.09	1,474	6.4	3.26	3,592	15.7	7.95	4,711	20.6	10.43
1892, ...	5,020	21.5	10.30	248	1.1	0.51	1,402	6.0	2.88	1,535	6.6	3.15	3,733	16.0	7.65	5,036	21.5	10.33
1893, ...	5,499	23.0	11.20	274	1.1	0.56	1,533	6.4	3.12	1,685	7.0	3.43	3,511	14.7	7.15	5,144	21.5	10.48
1894, ...	4,101	16.8	8.76	435	1.8	0.93	1,568	6.4	3.35	1,721	7.0	3.68	3,432	14.0	7.33	4,995	20.4	10.67
1895, ...	4,652	18.6	9.79	269	1.1	0.57	1,749	7.0	3.68	1,860	7.4	3.91	3,566	14.3	7.50	5,062	20.2	10.65
1896, ...	4,703	18.4	9.52	282	1.1	0.57	1,798	7.0	3.64	1,945	7.6	3.94	3,664	14.3	7.42	5,404	21.2	10.95
1897, ...	4,796	18.4	10.11	171	0.7	0.36	1,737	6.6	3.66	1,943	7.4	4.10	3,615	13.8	7.62	5,276	20.2	11.13
Totals and means,	73,438	17.3	8.91	5,464	1.3	0.66	25,153	5.9	3.05	25,022	5.9	3.04	55,028	13.0	6.68	83,634	19.7	10.15

A Massachusetts Life Table for the Five Years 1893–97.

The usefulness of life tables is not confined to the work of life insurance. A life table also serves as an index of the sanitary condition of the community out of whose data it is constructed.

Life tables differ for the same group of population from year to year, and they also differ when calculated from the statistics of different portions of a group of inhabitants, as, for example, the city of Boston, compared with any of the outlying districts beyond its borders.

The work of constructing a life table for any American State or city is necessarily less satisfactory in its results than the work of making a similar table for any of the civilized nations or communities of Europe, since most foreign populations are much more stationary than our own.

The English life tables, compiled by Dr. Farr, which have proved universally useful as standards of good work in this direction, were usually calculated from the living population at two successive census enumerations and from the deaths occurring in the intervening period. The factor of migration, however, in an American State affects the accuracy of such a calculation; hence a somewhat different method has been employed in constructing the following table, and a shorter period of five years has been selected. Massachusetts has an advantage not enjoyed by many communities in having an intervening State census five years after the national census, and this advantage is especially useful in any State whose population is far from stationary.

The materials selected as the basis of the following table are the census of 1895, and the deaths, numbering 240,215, which were registered in the State in the five years 1893, 1894, 1895, 1896 and 1897. The mid-year of this period (1895) was the census year, and the census was taken very near the middle of that year (in the months of May and June). The mean annual number of deaths at each age is compared with the population maintained at such age.

The limitations which affect the accuracy of a life table for Massachusetts are the following: —

1. *The Effect of Migration.* — The natural increase of the population, or that which results from the excess of births over deaths, has for many years constituted only a portion of the total increase

from year to year. The census enumerations of 1890 and 1895 showed an increase of 261,240, of which number the excess of births formed only 36 per cent., the balance, 64 per cent., being the difference between the numbers of immigrants and emigrants; or, in other words, the effect of migration exceeded that of natural increase in the ratio of nearly 2 to 1.

Moreover, the increment by means of immigration is not uniform at the different age periods, fully one-half of the immigrants being between fifteen and thirty years of age, while the numbers at the extremes of life are comparatively small.

The following table presents the classified material out of which the life table is constructed: —

Population of Massachusetts, 1895, and Deaths, 1893-97.

Age Periods.	Population, 1895.			Deaths, 1893-97.		
	Total.	Males.	Females.	Total.	Males.	Females.
0-5,	235,647*	118,453*	117,194*	78,779	42,710	36,069
5-10,	224,119	112,296	111,823	6,730	3,345	3,385
10-15,	202,900	101,574	101,326	3,460	1,655	1,805
15-20,	225,881	110,565	115,316	6,305	2,899	3,406
20-25,	265,983	123,692	142,291	9,982	4,899	5,083
25-35,	465,943	227,630	238,313	20,148	10,103	10,045
35-45,	341,535	168,997	172,538	18,832	9,610	9,222
45-55,	245,586	118,417	127,169	19,377	9,895	9,482
55-65,	157,651	72,766	84,885	22,334	11,278	11,056
65-75,	90,088	41,040	49,048	25,561	12,694	12,867
75-85,	35,405	15,460	19,945	20,547	9,675	10,872
85-95,	6,123	2,180	3,943	7,105	2,713	4,392
Over 95,	308	77	231	559	152	407
Age unknown,	3,014	1,554	1,460	496	378	118
Total,	2,500,183	1,214,701	1,285,482	240,215	122,006	118,209

* The population figures in this line (0-5) were not used in the construction of the life table, but the figures employed were estimated from the registered births and the deaths under 5 years of age.

2. *Defects of the Census.* — Mr. Henry Gannett, in a paper contributed to the "Publications of the American Statistical Association" (Vol. IV., p. 99), estimates a "shortage in the census of 1890 of negro children of about a quarter of a million," and of the native white children "about the same." If this be correct, the entire shortage or deficiency in the total population, including that

among foreign whites, must leave at least a million unaccounted for in the United States.

A careful examination of the last two census enumerations of Massachusetts (those of 1890 and 1895) shows that Mr. Gannett's estimate is probably none too large.*

It is possible to supply the actual deficiency for the first four or five years of life, with some degree of accuracy, from the registered births; but beyond this period of life it is hardly practicable to make estimates which are of greater value than mere conjectures.

3. *The Practice of incorrectly reporting the Ages of the Living and the Dead.* — This error is of two kinds: (*a*) It invariably happens that greater numbers of persons are reported at the even ages, 20, 30, 40, etc. (both of the living and the dead), than at 19, 21, 29, 31, etc., in consequence of the common habit of using round numbers instead of giving the more accurate ages. This is in a measure eliminated by employing the periods used in England, 25–35, 35–45, etc., instead of 20–30, 30–40. (*b*) The habit, especially noted among unmarried females, of understating the ages of the living. This appears to a greater or less degree to be a common practice in all countries where census enumerations are made.

4. *Defects in Birth and Death Registration.* — These defects, so far as Massachusetts is concerned, are probably insignificant, and in this respect the material collected by the registration officers of cities and towns compares favorably in its accuracy with that of foreign nations and communities having established systems of registration. Great pains are taken in most of the municipalities to obtain accurate and full returns, since a *pro rata* fee is allowed to the local officers for them; moreover, the certifiers of births and deaths (physicians, midwives and undertakers) are compelled, under penalty, to comply with the statutes requiring such returns.

There is also a comparatively small number of persons included in the census whose sex and ages are unknown, and the same may be said of the registered deaths, the latter being probably mostly deaths of prematurely born infants, and a small number of bodies of unknown persons found dead.

Certain comments and explanatory statements are necessary in relation to the construction of the following tables.

* Mr. E. B. Elliott also assumes an approximate shortage for the first five years of life alone of 100,000 in the United States census of 1870. Volume on Vital Statistics, page 522.

The figures for the first five years of life have been compiled from the births, and from the deaths which occurred among children under five years of age. The census figures for these five years were disregarded, for the reasons already stated in former reports, and in accordance with the common usage in other countries.*

Dr. Farr says, in regard to this subject: "We can scarcely feel surprised to find, in the various censuses of Europe, errors in the statements of age, traceable to ambiguities of language. In the early years of life these mistakes demand attention, otherwise they may lead us into such grave mistakes as we have to notice." These well-known defects may be corrected without serious difficulty for the first years of life.

An exact and accurate life table of any population or community can be made only by taking a definite number of persons, say 100,000 or 1,000,000 at birth, and following their life history, noting the age of each person at death, until the entire number has ceased to live. Such a process is impossible, especially in an American community, subject, as it is, to the variable effect of migration.

In view of this manifest impossibility, it is therefore necessary to construct an approximate table from such data as are accessible, bearing in mind the limitations, to which reference has been made, and making such corrections of errors as are customary in the construction of similar life tables for other communities. Starting with a hypothetical 1,000,000 or 100,000 births, this generation of persons of both sexes may be followed, with a reasonable degree of accuracy, to the extinction of the last survivor, at the age of one hundred or more, by the application of the rules which it is customary to employ. In the case of Massachusetts we have selected the number 100,000 as the basis of the table, since this is the largest round number near the exact number of annual births in the State. The sexes at the time of birth are unequally distributed, the males being in the ratio of 51.350 and the females 48.650 out of each 100,000 born during the period selected for the construction of the table. These numbers are therefore taken as the numbers at birth of the two sexes, out of the hypothetical 100,000 born.

In order to eliminate the effects of epidemic years or of abnormal conditions existing in the census year 1895, the mean annual deaths

* Twenty-sixth Annual Report Massachusetts Board of Health, page liv; also Dr. Farr's Vital Statistics, Memorial volume, page 207.

of the five years 1893–97 are employed to obtain the death-rates at each year of life. In the English life tables it has been customary to estimate the population at the middle of a given year for life-table purposes, the census being taken on the first of April. The State census of Massachusetts being taken at a time quite near the middle of the year, no allowance has been made for the few days elapsing between the time of such taking and the mid-year, since such allowance would at most only affect the second place of decimals in a death-rate expressed as a ratio per 1,000 living of a given age. Moreover, the population enumerated in May, near the middle of a five-year period, differs much less from the actual mean than that which is taken near the middle of a ten-year period, as compared with a mean of the two extremes of such period.

Dr. Billings says, in his introductory remarks in the twelfth volume of the tenth census, 1880 (page cxliii): "The preparation for any given locality, race or occupation, *in this country*, of a life table which shall accurately represent the tendency to death or the probability of survival at each age, is practically impossible, because of the want of accuracy in the necessary data, and because of the irregular migrations of the population. It should be clearly understood that all tables of vital statistics, including data derived from large numbers of people, even when these are obtained by the most accurate census possible, and by the most complete system of registration which can be enforced, give probabilities only, and that scientific accuracy in this field is practically unattainable." The foregoing remarks apply with less force to Massachusetts than to the United States as a whole, since our own State has had a system of registration in existence since 1842, the results of which may now be considered as fairly accurate. Dr. Billings therefore publishes an approximate life table in the volume referred to for Massachusetts and for certain other communities, from such data as were obtainable for the census year 1880.

In the life table on pages 822–826 pains have been taken to make it as accurate as possible from the data at hand. The compiler is entirely responsible for whatever errors or inaccuracies it may contain.

One hundred thousand infants, followed throughout their first year during the period named, in Massachusetts, yield 90,250 years of life. To obtain this mean of the infants living throughout the first year, the following method was employed: —

All of the deaths of infants under one month old which occurred in the years 1893–97 were tabulated from the mortality returns in the office of the Secretary of State, also those of infants who died in the second and the third months of life separately, then those of infants who died in the three succeeding months of life (3–6) in one group, and then those who died in the succeeding six months in another group. From these data, and from the births registered in the five years ending with June 30, 1897, the figures for the first year of life were calculated after the method shown by Dr. Farr in his life table No. 3, page xxiii.

The foregoing mean, 90,250 (the arithmetical mean of the series l_0, $l_{\frac{1}{12}}$, $l_{\frac{2}{12}}$ . . . l_1), is used as the first term of column P (see tables 1 and 2). All of the succeeding terms in the column for the years 1, 2, 3, 4, etc., are the means of the terms in the preceding column l_x, using the formula $P_x = \frac{l_x + l_{x+1}}{2}$

The total number of persons living under five years of age in the State in 1895, as stated by the census, was 235,647 ; but the number as calculated from the living births in these years was 294,604, or 58,957 more than the figures of the census would indicate. No allowance is made in this estimate for migration, which would slightly increase the difference. The effect of migration at this period of life, however, is much less than at later ages, especially from fifteen to thirty years.

Population under 5 Years.

	State Census of 1895.	Calculated from the Births and Deaths under 5.	Difference.
Males, ...	118,453	149,582	31,129
Females, ...	117,194	145,022	27,828
	235,647	294,604	58,957

Description of the Tables.

In tables 1 and 2, column x, ages, presents the ages for each sex from birth up to 100 years.

Column d_x presents the numbers of those dying in each age of life for each sex.

Column l_x presents the survivors of each sex, out of 100,000 of both sexes, at each age of life, beginning with 51,350 males and 48,650 females at birth.

Column P_x presents the population maintained by the numbers in column l_x.

Column Q_x shows the aggregate number of years which the persons at each age in the table will live, until their extinction by death.

Column $E_x \left(= \frac{Q_x}{l_x}\right)$ is the mean future life time of the persons living at each age in the table, the expectation of life.

Column m_x (Table 3), the mortality column, presents the mortality per unit of the population at each age of life, the figures being obtained by dividing the deaths in each age by the population at such ages, the proper corrections and interpolations having been applied. From this column (m_x) the probability of living at each year of age (p_x) (Table 3) is obtained by the formula $p_x = \frac{2 - m_x}{2 + m_x}$ applied to each year of the series.

Column l_x is obtained by the formula $l_x \times p_x = l_{x+1}$, and column P_x is obtained by the formula $\frac{l_x + l_{x+1}}{2}$.

What may be learned from these Tables.

It appears that, out of 100,000 children born alive in Massachusetts in 1895, 16,000, or nearly one-sixth, die before arriving at the age of one year; 78,963, or nearly four-fifths, attain the age of three years: 77,051 survive the age of five years, or 77 per cent.; 50,126, or a little more than one-half, attain the age of fifty-three years; 25,406, or a little more than one-fourth, live to the age of seventy-two years.

These figures present very decided differences as compared with those which were published for 1855 by Mr. E. B. Elliott (sixteenth Massachusetts Registration Report, 1857). In those reports it was shown that the numbers dying before the close of the first year out of 100,000 born were 15,510, or very nearly the same as those for the year 1895 for the same age. At the end of three years the survivors were only 74 per cent., instead of 79 per cent., as in 1895, and that one-half had died before the close of the forty-first year, instead of surviving to the fifty-third, as in 1895.

In consequence of the fact that the numbers of each sex are unequal at birth, the males continue in greater numbers until the fifty-third year, when the greater death-rate of the males has reduced their number below that of the females, and the females continue in excess throughout the remainder of life. Observing the table more closely, it appears that the comparative intensity of the death-rate of the sexes varies at different points in the table. For the first five years the death-rate of males exceeds that of females. From age five to age nineteen inclusive the rate of females exceeds that of males, and from age twenty to the end of life the death-rate of females is less than that of males.

In Table 3 are presented two columns in which are shown the probability of living one year from each age and the mortality per unit of the population at each year. At birth the probability of living a year is for males .82569 and for females .84939, that of boys at birth being about the same as for men of eighty-six, and that of girls about the same as that of women at eighty-six or eighty-seven.

The probability of living a year is at its highest point for boys at age twelve (.99722), and for girls it is about the same for age eleven as at age twelve (.99695 and .99693).

A comparison of the death-rates of Massachusetts at different periods presents certain points worthy of notice.

The death-rate of children under five and especially of those under one year of age has not undergone very marked changes (see table); but that of all ages from five to forty has very perceptibly diminished, while that of ages above forty has increased. This result has been produced by the great reduction in the number of deaths from infectious diseases, including consumption, which occur in the early period of life, from two years up to thirty. By this means a much larger ratio of the population than formerly survives to live throughout the useful and wage-earning period of life. This causes a material increase in the number of years lived at the later ages of life.

These persons being spared from the diseases incident to childhood, the relative mortality from the diseases of adult life and of old age is naturally increased.

This decided increase in the number of survivors throughout the useful ages of life has a marked effect upon the vitality of the population. It is undoubtedly due in no small degree to the increased attention which has everywhere been given in the past twenty-five years to public hygiene.

The population of almost any one of the United States differs essentially from the more stationary populations of the old world in the fact that it is constantly being recruited by the addition of considerable numbers of immigrants at the healthy ages of life. These additions constitute a selected class, not only on account of their age distribution (50 per cent. are between the ages of fifteen and thirty), but also because many of the weaklings must be left behind, in consequence not only of their inability to become wage-earners but on account of the exclusive action of the immigration laws.*

One consequence of this is the comparatively large number of persons at the later ages of life, an effect which has been produced by the long continuance of immigration.

DATA FOR CONSTRUCTION OF DIAGRAM OF SURVIVORS.

Table showing Survivors at Different Ages of Life out of 10,000 born.

	Sweden —† 1881-90.	England and Wales —‡ 1881-90.	Massachusetts — 1893-97.	Massachusetts —§ 1855.	Spain —‖ 1878-82.
0,	10,000	10,000	10,000	10,000	10,000
1,	8,895	8,536	8,400	8,449	8,083
2,	8,586	8,067	8,054	7,733	7,060
3,	8,399	7,878	7,896	7,424	6,433
4,	8,258	7,758	7,786	7,258	6,151
10,	7,882	7,495	7,487	6,873	5,747
15,	7,713	7,423	7,366	6,726	5,602
20,	7,551	7,281	7,167	6,437	5,413
25,	7,338	7,090	6,906	6,100	5,164
30,	7,109	6,844	6,615	5,748	4,908
35,	6,876	6,550	6,308	5,408	4,596
40,	6,628	6,216	5,988	5,078	4,378
45,	6,349	5,839	5,651	4,748	4,088
50,	6,043	5,405	5,275	4,409	3,765
55,	5,687	4,891	4,821	4,022	3,381
60,	5,239	4,275	4,272	3,597	2,914
65,	4,658	3,534	3,622	3,065	2,327
70,	3,900	2,684	2,869	2,475	1,666
75,	2,948	1,786	2,042	1,833	997
80,	1,872	970	1,266	1,059	465
85,	894	388	654	437	149
90,	275	100	259	118	40
95,	–	14	67	20.5	–
100,	–	.9	9	2.2	–

* "If on examination there shall be found among such passengers any convict, lunatic, idiot or any person unable to take care of himself or herself, without becoming a public charge, . . . such person shall not be permitted to land." (Extract from immigration act of Aug. 3, 1882, section 2.)

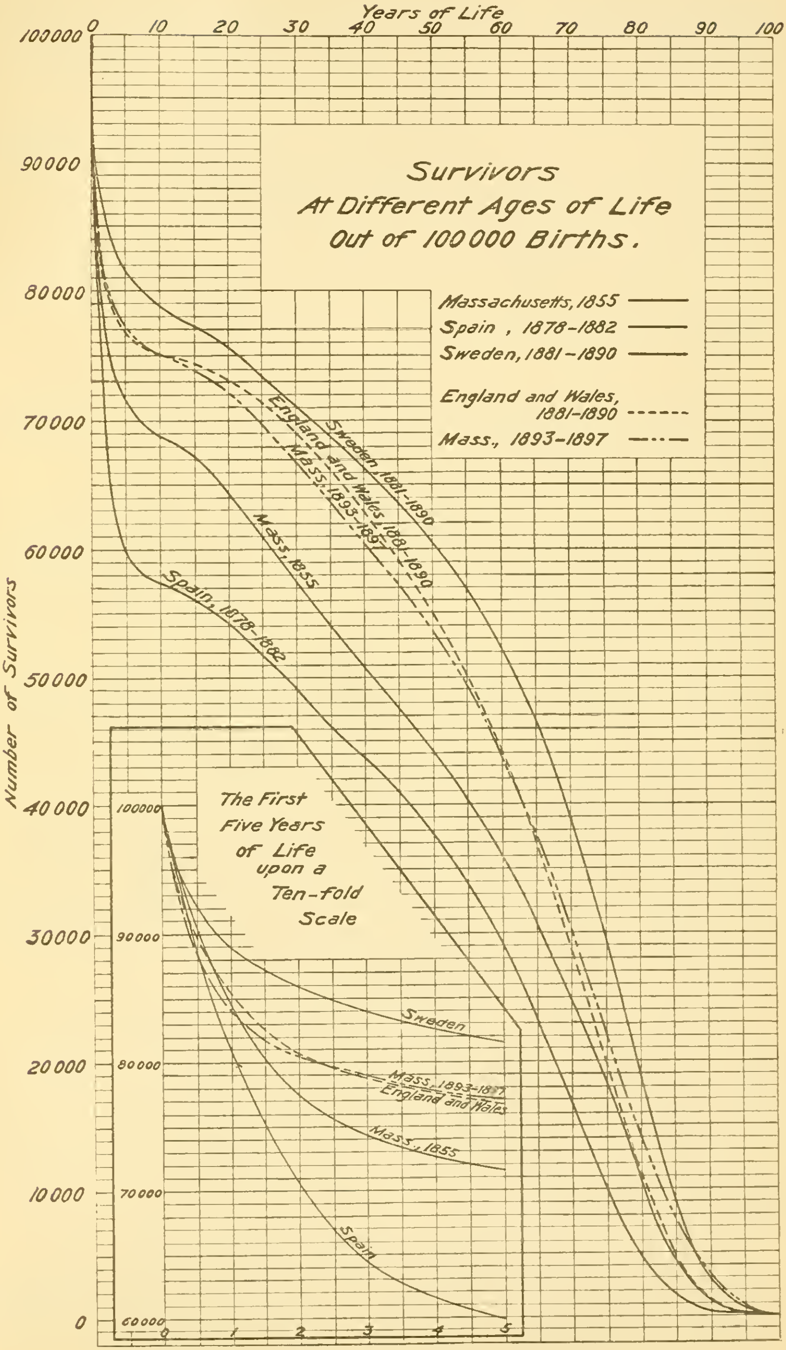
† For convenience of comparison with Mr. Elliott's table of 1855, the figures of this table are reduced to a scale of 10,000, while the diagram is made upon a scale of 100,000.

‡ Fifty-fifth Report of Registrar General. Supplement, vol. 1, page xiv. Vol. 10, part 1, page 75.

§ Sixteenth Registration Report, Massachusetts, 1857.

‖ Bulletin de l'institut international de statistique.

NOTE.—In consequence of corrections made after the construction of the diagram on page 819, the line for Massachusetts survivors, 1893-97, should be placed one to two millimeters lower, after age 15.


Years of Life
0
10
20
30
40
50
60
70
80
90
100
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Number of Survivors
Survivors
At Different Ages of Life
Out of 100000 Births.
Massachusetts, 1855
Spain, 1878-1882
Sweden, 1881-1890
England and Wales, 1881-1890
Mass., 1893-1897
Sweden, 1881-1890
England and Wales, 1881-1890
Mass., 1893-1897
Mass., 1855
Spain, 1878-1882
The First
Five Years
of Life
upon a
Ten-fold
Scale
Sweden
Mass., 1893-1897
England and Wales
Mass., 1855
Spain
100000
90000
80000
70000
60000
0
1
2
3
4
5

The preceding table and diagram present the numbers of survivors at each of several age periods in Sweden, England, Spain and Massachusetts (in the latter for the year 1855 and for the period of 1893–97). Sweden is selected as a country having a very low death-rate, and also because it is occasionally selected as a standard of a healthy population. Spain, on the contrary, has a high death-rate, chiefly due to excessive mortality in the early years of life.

In consequence of the close contiguity of the lines in the first five years of life, the figures for the first five years are given upon a separate diagram, in which the divisions representing the age periods are increased ten-fold.

A brief review of the life tables of Massachusetts shows that quite marked changes have taken place from year to year in the life history of the population.

The earliest life table in existence pertaining to the population of Massachusetts is that of Edward Wigglesworth, D.D., of Harvard University, made from records of bills of mortality collected prior to 1789.* The total number of deaths employed in the construction of this table was 4,893.

Its defects consisted mainly in the limited numbers used for computation, in the crude method of recording the ages of the population by the first census (in five periods only, all under 10, 10–16, 16–26, 26–45, and all over 45), and in the fact that the table was framed on the assumption of a stationary population. This table was for many years an authority in the courts of the Commonwealth.

In 1855 a table for Massachusetts was published in the Sixteenth Registration Report (1857) by the eminent statistician, Mr. E. B. Elliott. This table is calculated from 16,086 deaths, which occurred in 166 towns of Massachusetts in the year 1855.†

In the tenth census of the United States, Vol. 12, part 2, pp. 773–791, Dr. Billings publishes approximate life tables for the population of Massachusetts and other States, and for certain cities. Those of Massachusetts are for the white population of the State, and for the census year 1880, comprising 31,341 deaths, and also for the whole population of the State for the five years ended June 30, 1882, and comprising 171,639 deaths.

* Published in the second volume of the "Transactions of the American Academy," 1793.

† The calculation was limited to the returns of these 166 towns, since the system of registration then in practice in the State was not believed to be "sufficiently complete to furnish data for a life table for the whole State." These 166 towns constituted two-thirds of the population he State in 1855 (Sixteenth Registration Report, Massachusetts, page 199).

The statement of Dr. Josiah Curtis in the Sixteenth Registration Report of Massachusetts (1857)* as to the value of life tables is worthy of note. He says: "There are weightier reasons for desiring correct information concerning the comparative mortality of our communities. The governing powers and enlightened statesmen are enabled better to discharge their high and responsible duties to the people by a correct knowledge of the physical powers, possessions and resources of the inhabitants. . . . The Christian philanthropist and sanitarian will be enabled to give some definiteness and efficiency to their labors, by a correct knowledge of where, and to what purpose, the laws which prevail over life and death teach them to direct their laudable efforts. The question here forcibly arises, Have the records of registration in Massachusetts, or in any considerable portion thereof, ever been sufficiently complete to enable any one to determine with reliable accuracy what law or laws do prevail over the mortality of the inhabitants of the State, or such portions of it? We consider this question, and its answer, taken in their broader sense and application, as the most important practical consideration connected with our system of registration, and it affords extreme gratification to be able to give an affirmative answer to the question. Aside from its intrinsic value, it is creditable to the State of Massachusetts, because it is the first instance where such data have been thus furnished and thus used in any considerable community on this continent. The great practical results in the variety of their applications of such laborious deductions will furnish, not only immediately, but for years to come, the government and intelligent statesmen as well as others, with the means of determining many social and political questions of high practical value hitherto undeterminable."

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* Page 197.

MASSACHUSETTS LIFE TABLE.

Based on the Mortality of the Five Years, 1893–97.

Table No. 1. — *Males.*

Age. x.	Dying in Each Year of Age. d_x.	Born and Surviving at Each Age. l_x.	Population or Years of Life lived in Each Year of Age. P_x.	Years of Life Lived in and above Each Year of Age. Q_x.	Expectation of Life at Each Year of Age. E_x.
0,	8,849	51,350	46,343	2,264,048	44.09
1,	1,794	42,501	41,604	2,217,705	52.18
2,	818	40,707	40,298	2,176,101	53.46
3,	559	39,889	39,609	2,135,803	53.54
4,	424	39,330	39,118	2,096,194	53.30
5,	316	38,906	38,748	2,057,076	52.88
6,	252	38,590	38,464	2,018,328	52.30
7,	205	38,338	38,235	1,979,864	51.64
8,	170	38,133	38,048	1,941,629	50.92
9,	146	37,963	37,890	1,903,581	50.14
10,	123	37,817	37,755	1,865,691	49.33
11,	110	37,694	37,639	1,827,936	48.49
12,	104	37,584	37,532	1,790,297	47.63
13,	111	37,480	37,424	1,752,765	46.76
14,	135	37,369	37,301	1,715,341	45.90
15,	159	37,234	37,154	1,678,040	45.07
16,	181	37,075	36,984	1,640,886	44.26
17,	195	36,894	36,796	1,603,902	43.47
18,	211	36,699	36,593	1,567,106	42.70
19,	226	36,488	36,375	1,530,513	41.94
20,	241	36,262	36,141	1,494,138	41.20
21,	255	36,021	35,893	1,457,997	40.48
22,	268	35,766	35,632	1,422,104	39.76
23,	280	35,498	35,358	1,386,472	39.06
24,	289	35,218	35,073	1,351,114	38.36
25,	296	34,929	34,781	1,316,041	37.68
26,	301	34,633	34,482	1,281,260	37.00
27,	305	34,332	34,179	1,246,778	36.32
28,	309	34,027	33,872	1,212,599	35.64
29,	313	33,718	33,561	1,178,727	34.96
30,	316	33,405	33,247	1,145,166	34.28
31,	318	33,089	32,930	1,111,919	33.60
32,	319	32,771	32,611	1,078,989	32.93
33,	319	32,452	32,292	1,046,378	32.24
34,	320	32,133	31,973	1,014,086	31.56
35,	322	31,813	31,652	982,113	30.87
36,	325	31,491	31,328	950,461	30.18
37,	328	31,166	31,002	919,133	29.49
38,	331	30,838	30,672	888,131	28.80
39,	334	30,507	30,340	857,459	28.11
40,	337	30,173	30,004	827,119	27.41
41,	341	29,836	29,665	797,115	26.72
42,	346	29,495	29,322	767,450	26.02
43,	352	29,149	28,973	738,128	25.32
44,	359	28,797	28,617	709,155	24.63
45,	368	28,438	28,254	680,538	23.93
46,	379	28,070	27,880	652,284	23.24
47,	393	27,691	27,494	624,404	22.55
48,	410	27,298	27,093	596,910	21.87
49,	429	26,888	26,673	569,817	21.19

MASSACHUSETTS LIFE TABLE.

Based on the Mortality of the Five Years, 1893-97.

Table No. 1. — *Males* — Concluded.

Age. $x.$	Dying in Each Year of Age. $d_x.$	Born and Surviving at Each Age. $l_x.$	Population or Years of Life lived in Each Year of Age. $P_x.$	Years of Life Lived in and above Each Year of Age. $Q_x.$	Expectation of Life at Each Year of Age. $E_x.$
50,	448	26,459	26,235	543,144	20.53
51,	466	26,011	25,778	516,909	19.87
52	483	25,545	25,303	491,131	19.23
53	502	25,062	24,811	465,828	18.59
54,	520	24,560	24,300	441,017	17.96
55,	539	24,040	23,770	416,717	17.33
56,	561	23,501	23,220	392,947	16.72
57,	585	22,940	22,647	369,727	16.12
58,	608	22,355	22,051	347,080	15.53
59,	636	21,747	21,429	325,029	14.95
60,	659	21,111	20,781	303,600	14.38
61,	677	20,452	20,113	282,819	13.83
62,	691	19,775	19,429	262,706	13.28
63,	709	19,084	18,729	243,277	12.75
64,	729	18,375	18,010	224,548	12.22
65,	748	17,646	17,272	206,538	11.70
66,	769	16,898	16,513	189,266	11.20
67,	789	16,129	15,734	172,753	10.71
68,	810	15,340	14,935	157,019	10.24
69,	827	14,530	14,116	142,084	9.78
70,	840	13,703	13,283	127,968	9.34
71	845	12,863	12,440	114,685	8.92
72,	847	12,018	11,594	102,245	8.51
73,	842	11,171	10,750	90,651	8.11
74,	831	10,329	9,913	79,901	7.74
75,	816	9,498	9,090	69,988	7.37
76,	794	8,682	8,285	60,898	7.01
77,	769	7,888	7,503	52,613	6.67
78,	741	7,119	6,748	45,110	6.34
79,	707	6,378	6,024	38,362	6.01
80,	672	5,671	5,335	32,338	5.70
81,	632	4,999	4,683	27,003	5.40
82,	590	4,367	4,072	22,320	5.11
83,	546	3,777	3,504	18,248	4.83
84,	499	3,231	2,981	14,744	4.56
85,	452	2,732	2,506	11,763	4.31
86,	402	2,280	2,079	9,257	4.06
87,	353	1,878	1,701	7,178	3.82
88,	307	1,525	1,371	5,477	3.59
89,	263	1,218	1,086	4,106	3.37
90,	220	955	845	3,020	3.16
91,	181	735	644	2,175	2.96
92,	146	554	481	1,531	2.76
93,	116	408	350	1,050	2.57
94,	88	292	248	700	2.40
95,	66	204	171	452	2.22
96,	48	138	114	281	2.04
97,	33	90	73	167	1.86
98,	23	57	45	94	1.65
99,	15	34	26	49	1.44
100,	9	19	14	23	1.21

MASSACHUSETTS LIFE TABLE.

Based on the Mortality of the Five Years, 1893–97.

Table No. 2. — *Females.*

Age. x.	Dying in Each Year of Age. d_x.	Born and Surviving at Each Age. l_x.	Population or Years of Life lived in Each Year of Age. P_x.	Years of Life Lived in and above Each Year of Age. Q_x.	Expectation of Life at Each Year of Age. E_x.
0,	7,151	48,650	43,907	2,267,469	46.61
1,	1,662	41,499	40,668	2,223,562	53.58
2,	763	39,837	39,455	2,182,894	54.79
3,	544	39,074	38,802	2,143,439	54.83
4,	385	38,530	38,337	2,104,637	54.62
5,	318	38,145	37,986	2,066,300	54.17
6,	250	37,827	37,702	2,028,314	53.62
7,	206	37,577	37,474	1,990,612	52.97
8,	170	37,371	37,286	1,953,138	52.26
9,	147	37,201	37,127	1,915,852	51.50
10,	129	37,054	36,990	1,878,725	50.70
11,	113	36,925	36,868	1,841,735	49.88
12,	113	36,812	36,755	1,804,867	49.03
13,	123	36,699	36,637	1,768,112	48.18
14,	146	36,576	36,503	1,731,475	47.34
15,	172	36,430	36,344	1,694,972	46.53
16,	195	36,258	36,160	1,658,628	45.74
17,	206	36,063	35,960	1,622,468	44.99
18,	218	35,857	35,748	1,586,508	44.24
19,	230	35,639	35,524	1,550,760	43.51
20,	241	35,409	35,288	1,515,236	42.79
21,	251	35,168	35,042	1,479,948	42.08
22,	255	34,917	34,790	1,444,906	41.38
23,	261	34,662	34,531	1,410,116	40.68
24,	265	34,401	34,268	1,375,585	39.99
25,	269	34,136	34,001	1,341,317	39.29
26,	274	33,867	33,730	1,307,316	38.60
27,	278	33,593	33,454	1,273,586	37.91
28,	282	33,315	33,174	1,240,132	37.22
29,	286	33,033	32,890	1,206,958	36.54
30,	290	32,747	32,602	1,174,068	35.85
31,	294	32,457	32,310	1,141,466	35.17
32,	297	32,163	32,014	1,109,156	34.48
33,	301	31,866	31,715	1,077,142	33.80
34,	302	31,565	31,414	1,045,427	33.12
35,	306	31,263	31,110	1,014,013	32.43
36,	308	30,957	30,803	982,903	31.75
37,	312	30,649	30,493	952,100	31.06
38,	315	30,337	30,180	921,607	30.38
39,	318	30,022	29,863	891,427	29.69
40,	320	29,704	29,544	861,564	29.00
41,	324	29,384	29,222	832,020	28.31
42,	326	29,060	28,897	802,798	27.62
43,	329	28,734	28,570	773,901	26.93
44,	332	28,405	28,239	745,331	26.24
45,	335	28,073	27,905	717,092	25.54
46,	346	27,738	27,565	689,187	24.85
47,	354	27,392	27,215	661,622	24.15
48,	367	27,038	26,854	634,407	23.46
49,	379	26,671	26,481	607,553	22.78

MASSACHUSETTS LIFE TABLE.

BASED ON THE MORTALITY OF THE FIVE YEARS, 1893–97.

TABLE NO. 2. — *Females* — Concluded.

AGE. x.	Dying in Each Year of Age. d_x.	Born and Surviving at Each Age. l_x.	Population or Years of Life lived in Each Year of Age. P_x.	Years of Life Lived in and above Each Year of Age. Q_x.	Expectation of Life at Each Year of Age. E_x.
50,	395	26,292	26,094	581,072	22.10
51,	410	25,897	25,692	554,978	21.43
52,	423	25,487	25,275	529,286	20.77
53,	437	25,064	24,845	504,011	20.11
54,	457	24,627	24,398	479,166	19.46
55,	476	24,170	23,932	454,768	18.81
56,	494	23,694	23,447	430,836	18.18
57,	512	23,200	22,944	407,389	17.56
58,	530	22,688	22,423	384,445	16.95
59,	550	22,158	21,883	362,022	16.34
60,	572	21,608	21,322	340,139	15.74
61,	588	21,036	20,742	318,817	15.16
62,	606	20,448	20,145	298,075	14.58
63,	625	19,842	19,530	277,930	14.01
64,	644	19,217	18,895	258,400	13.45
65,	665	18,573	18,240	239,505	12.90
66,	689	17,908	17,563	221,265	12.36
67,	715	17,219	16,861	203,702	11.83
68,	743	16,504	16,132	186,841	11.32
69,	771	15,761	15,375	170,709	10.83
70,	793	14,990	14,593	155,334	10.36
71,	809	14,197	13,792	140,741	9.91
72,	821	13,388	12,977	126,949	9.48
73,	825	12,567	12,154	113,972	9.07
74,	824	11,742	11,330	101,818	8.67
75,	818	10,918	10,509	90,488	8.29
76,	806	10,100	9,697	79,979	7.92
77,	790	9,294	8,899	70,282	7.56
78,	768	8,504	8,120	61,383	7.22
79,	742	7,736	7,365	53,263	6.89
80,	711	6,994	6,638	45,898	6.56
81,	678	6,283	5,944	39,260	6.25
82,	640	5,605	5,285	33,316	5.94
83,	600	4,965	4,665	28,031	5.65
84,	559	4,365	4,085	23,366	5.35
85,	518	3,806	3,547	19,281	5.07
86,	476	3,288	3,050	15,734	4.79
87,	434	2,812	2,595	12,684	4.51
88,	393	2,378	2,181	10,089	4.33
89,	351	1,985	1,810	7,908	3.98
90,	310	1,634	1,479	6,098	3.73
91,	270	1,324	1,189	4,619	3.49
92	232	1,054	938	3,430	3.25
93,	194	822	725	2,492	3.03
94,	160	628	548	1,767	2,81
95,	129	468	403	1,219	2.60
96,	100	339	289	816	2.41
97,	77	239	200	527	2.20
98,	55	162	134	327	2.02
99,	40	107	87	193	1.80
100,	27	67	53	106	1,58

MASSACHUSETTS LIFE TABLE.

Based on the Mortality of the Five Years, 1893-97.

Table No. 3.

Age.	m_x. Annual Mortality per Unit at Each Year of Age.		p_x. Probability of living One Year from Each Age.	
x.	Males.	Females.	Males.	Females.
0,	.19095	.16287	.82569	.84939
1,	.04313	.04087	.95778	.95995
2,	.02030	.01933	.97990	.98085
3,	.01411	.01403	.98599	.98607
4,	.01084	.01004	.98922	.99001
5,	.00815	.00835	.99188	.99168
6,	.00655	.00663	.99347	.99339
7,	.00536	.00550	.99464	.99452
8,	.00447	.00456	.99556	.99546
9,	.00386	.00396	.99616	.99606
10,	.00326	.00349	.99675	.99652
11,	.00292	.00306	.99709	.99695
12,	.00277	.00307	.99722	.99693
13,	.00297	.00336	.99703	.99665
14,	.00362	.00400	.99640	.99601
15,	.00428	.00473	.99573	.99528
16,	.00489	.00539	.99511	.99464
17,	.00530	.00573	.99471	.99429
18,	.00577	.00610	.99425	.99392
19,	.00621	.00647	.99381	.99356
20,	.00667	.00683	.99335	.99320
21,	.00710	.00716	.99292	.99286
22,	.00752	.00733	.99251	.99268
23,	.00792	.00756	.99212	.99249
24,	.00824	.00773	.99179	.99230
25,	.00851	.00791	.99153	.99212
26,	.00873	.00812	.99131	.99192
27,	.00892	.00831	.99112	.99170
28,	.00912	.00850	.99092	.99154
29,	.00933	.00870	.99072	.99134
30,	.00950	.00890	.99054	.99114
31,	.00966	.00910	.99039	.99094
32,	.00978	.00928	.99026	.99077
33,	.00988	.00949	.99017	.99055
34,	.01001	.00961	.99004	.99043
35,	.01017	.00984	.98988	.99021
36,	.01037	.01000	.98968	.99005
37,	.01058	.01023	.98948	.98982
38,	.01079	.01044	.98927	.98962
39,	.01101	.01063	.98905	.98942
40,	.01123	.01083	.98881	.98923
41,	.01150	.01109	.98857	.98897
42,	.01180	.01128	.98827	.98878
43,	.01215	.01152	.98792	.98855
44,	.01255	.01176	.98753	.98831
45,	.01302	.01200	.98706	.98802
46,	.01359	.01255	.98650	.98753
47,	.01430	.01301	.98581	.98708
48,	.01513	.01367	.98498	.98643
49,	.01608	.01431	.98404	.98579
50,	.01708	.01514	.98307	.98498
51,	.01808	.01596	.98208	.98417
52,	.01909	.01674	.98109	.98340
53,	.02023	.01759	.97997	.98256
54,	.02140	.01873	.97888	.98144
55,	.02268	.01989	.97758	.98031
56,	.02416	.02107	.97613	.97915
57,	.02583	.02231	.97450	.97793
58,	.02757	.02364	.97280	.97664
59,	.02968	.02513	.97075	.97518
60,	.03171	.02683	.96878	.97353
61,	.03366	.02835	.96689	.97205
62,	.03557	.03008	.96505	.97037
63,	.03786	.03200	.96285	.96850
64,	.04048	.03408	.96032	.96648
65,	.04331	.03646	.95761	.96419
66,	.04657	.03923	.95449	.96152
67,	.05015	.04241	.95107	.95848
68,	.05424	.04606	.94719	.95498
69,	.05859	.05015	.94307	.95108
70,	.06324	.05434	.93869	.94710
71,	.06793	.05866	.93430	.94301
72,	.07306	.06327	.92951	.93867
73,	.07833	.06788	.92462	.93435
74,	.08383	.07273	.91954	.92983
75,	.08977	.07784	.91409	.92508
76,	.09584	.08312	.90854	.92020
77,	.10249	.08877	.90251	.91500
78,	.10981	.09458	.89591	.90969
79,	.11736	.10075	.88915	.90408
80,	.12596	.10711	.88150	.89834
81,	.13496	.11406	.87357	.89209
82,	.14489	.12110	.86490	.88581
83,	.15582	.12862	.85544	.87915
84,	.16739	.13684	.84554	.87192
85,	.18037	.14604	.83455	.86390
86,	.19336	.15607	.82369	.85523
87,	.20752	.16724	.81199	.84567
88,	.22392	.18019	.79863	.83470
89,	.24217	.19392	.78399	.82322
90,	.26036	.20960	.76963	.81028
91,	.28106	.22708	.75357	.79607
92,	.30353	.24733	.73647	.77989
93,	.33143	.26759	.71569	.76399
94,	.35484	.29197	.69863	.74522
95,	.38596	.32010	.67647	.72406
96,	.42105	.34602	.65218	.70502
97,	.45206	.38500	.63128	.67715
98,	.51111	.41045	.59292	.65944
99,	.57692	.45977	.55224	.62617
100,	.64286	.50943	.51351	.59399

The following table presents the mean annual death-rates at each of thirteen periods or groups of years, beginning with birth, for the five years (1893–97). To these are added as a matter of convenience the death-rates at certain other groups (1–4, 0–9, etc.).

TABLE No. 4.

Mean Annual Death-rates at Certain Periods of Life.

Age Periods.	Persons. Death-rate at Each Period.	Males. Death-rate at Each Period.	Females. Death-rate at Each Period.	Age Periods.	Persons. Death-rate at Each Period.	Males. Death-rate at Each Period.	Females. Death-rate at Each Period.
0-4, . . .	56.23	60.12	52.22	45-54, . . .	15.78	16.67	14.88
5-9, . . .	5.75	5.69	5.82	55-64, . . .	28.18	30.42	26.00
10-14, . . .	3.25	3.11	3.40	65-74, . . .	55.34	59.67	51.37
15-19, . . .	5.48	5.29	5.68	75-84, . . .	107.22	116.20	99.88
20-24, . . .	7.40	7.48	7.32	85-94, . . .	199.71	223.50	184.81
25-34, . . .	9.06	9.33	8.78	95+ . . .	384.43	429.20	367.07
35-44, . . .	10.97	11.19	10.74				

Additional Groups or Periods.

1-4, . . .	21.86	22.38	21.33	1-19, . . .	8.61	8.62	8.60
0-9, . . .	31.93	33.97	29.83	20-59, . . .	12.24	12.73	11.74
1-9, . . .	13.10	13.31	12.89	60 and over, .	66.29	69.50	63.42
0-14, . . .	22.73	24.09	21.35				

HEALTH OF TOWNS.

HEALTH OF TOWNS.

The following abstract contains extracts from such annual reports of the boards of health of the cities and towns as have been received at the office of the State Board of Health.

A comparison of these reports from year to year shows marked improvement in sanitary administration, especially in the most important part of public health work, — the management and control of infectious diseases. As a general rule municipal boards of health are at present much better equipped with the means of preventing the spread of infectious diseases than they were five years ago. The cardinal principle of isolation is taking a firmer root, and several cities have erected hospitals for the isolation of persons suffering with diphtheria and scarlet fever, while some of the large cities prefer to wait until a severe epidemic drives them to adopt a course which should have been adopted long ago for the protection of the community.

It is quite probable that the time is soon coming when every city and town having over 10,000 inhabitants will find it necessary to have an isolation hospital as an essential part of its sanitary equipment.

Other matters of importance which appear prominently in the annual reports of local boards are the inspection of milk, animals and provisions, the disposal of garbage and ashes, the continued and increasing use of antitoxin, the adoption of the current methods of diagnosis in diphtheria, tuberculosis and other diseases, as well as of improved modes of disinfection.

The system of medical inspection of schools which has been inaugurated in Boston, and is there giving general satisfaction, has also excited a lively interest in other cities in the direction of similar work.

Adams.

The Board examined the school children and found that there were 1,000 children who had not been vaccinated.

Amesbury.

The health of the community has been exceedingly good, so much so that the oldest resident physicians do not remember an equally healthy year. There have been no epidemics, but a very few contagious diseases, and no case of scarlet fever or diphtheria since July 2. Whooping-cough has been quite prevalent during the autumn and early winter.

Arlington.

Diphtheria has been more prevalent than in 1897, the number of cases having been 18, with only 1 death. Of these 18 cases 7 were under one roof, all having been exposed before medical attendance was sought. Antitoxin was used in each case of diphtheria, and to that remedy is ascribed the very low death-rate.

During the year there have been 21 cases of typhoid fever. Several of these patients evidently brought the disease to their homes, having contracted it elsewhere. From 1 of these cases it is probable that 3 other cases of the above-mentioned 18 originated through the unsanitary condition of the house in which all lived.

Barre.

With a view to prevent the spreading of what are deemed by many to be minor contagious or infectious diseases, but which medical authorities unite in considering dangerous, the board decided it advisable to avail itself of the authority conveyed in chapter 80, section 18, of the Public Statutes, and added the following to the rules and regulations promulgated by previous boards: —

No child affected with whooping-cough, mumps or German measles shall attend any public or private school in this town.

No pupil who, by reason of the foregoing rule, has been debarred from school attendance, shall be readmitted to any public or private school without a written permit from the board of health.

(Boston.*)

Brockton.

The death-rate for the year is 12.28 per 1,000 inhabitants, the lowest rate since the records have been kept in this office.

The following table shows the death-rate for the past ten years: —

1889,	13.63	1894,	14.17
1890,	17.12	1895,	14.65
1891,	15.73	1896,	18.11
1892,	13.05	1897,	13.19
1893,	15.30	1898,	12.28

* The report of the Board of Health was not received at the date of publishing this report.

The board would respectfully recommend school inspection. The importance and value of this method of inspection in preventing the spread of contagious disease of all kinds has been demonstrated so satisfactorily by the experience of other cities that we feel it to be our duty to recommend that it be instituted here.

Brookline.

Neither scarlet fever nor diphtheria has been epidemic the past year, and it was therefore not found necessary to make daily medical inspections of the schools.

The unusually large number of deaths from whooping-cough, 11, shows it is not always the trivial ailment some persons seem to consider it. Much more might be done toward preventing its spread if all parents of school children and all teachers would conscientiously comply with the order of the board forbidding school attendance by children having whooping-cough.

The bacteriological test for making an early and accurate diagnosis in typhoid, the so-called Widal reaction, was made use of in many cases by the physicians of the town, and with most valuable results. Not the least advantage from this test is the detection of light or "walking" cases of typhoid fever, the class of cases most dangerous to the public health, because able to go about more or less, sometimes spreading the disease by engaging in the milk business.

The free bacteriological examinations provided by the board for the early diagnosis of diphtheria and consumption have been even more extensively availed of than in the previous year, and with great benefit to both patients and their families. The board took the necessary steps, and on Feb. 1, 1899, had its laboratory in operation.

To facilitate the making of these tests by physicians, diphtheria culture outfits and sputum bottles will be constantly kept on hand at the drug stores.

Early in the summer the board authorized the preparation by its agent of a circular of general rules for the management of infants during the hot season, and the distribution of several hundred copies of it by the police in such parts of the town as it was believed would benefit most by them.

Intermittent fever (malaria) seems to have been considerably less prevalent than in the previous few years, and it is believed this may be attributed, in part, to the draining of certain districts.

The appreciation of the value as a health measure of frequent bathing continues to be shown by the experience at our public bath-house, where over 46,000 baths were taken the past year, a good increase over the attendance of the previous year.

Cambridge.

The diseases discovered in the schools, and the cases of each disease, are given below : —

Chicken-pox,	41	Whooping-cough,	8
Diphtheria,	3	Diseases of ear,	4
Measles,	2	Diseases of eye,	27
Mumps,	16	Diseases of skin,	32
Pediculosis,	42	All other diseases,	45
Scabies,	1		
Scarlet fever,	4	Total,	225

During the year 560 cultures were examined. The results were positive in 157 instances and negative in 403 instances. The cultures were examined for the purpose of diagnosis in 345 instances, and for the purpose of determining whether or not the proper time had come for releasing the patient in 215 instances.

Pursuant to section 3 of "An Ordinance regulating the Sale and Delivery of Ice," we have caused an investigation of various bodies of water within the State to be made, and have caused analyses to be made of the ice derived from said bodies of water.* We have also caused analyses of the water from the same sources to be made. The factor of prime importance in determining the wholesomeness of water or ice, and their fitness for consumption, is an investigation of the sources of supply from which the water or ice is obtained, and the liability of the source to pollution, especially such pollution as is caused by the excretions of human beings. In comparison with such an investigation, chemical analyses of the water or ice are of secondary importance.

The reported cases of scarlet fever show a decrease of 109 from those reported in 1897.

The reported cases of diphtheria show a decrease of 169 from those reported in 1897.

The reported cases of typhoid fever show a decrease of 9 from those reported in 1897.

The reported cases of measles show a decrease of 357 from those reported in 1897.

Canton.

During the past year more than ever before has the necessity for some adequate system of drainage in the central part of the village been apparent to the board of health. The matter of a sewerage system in this thickly settled portion of the town is one which cannot much longer be deferred, nor can its importance be overestimated.

* This investigation was conducted for the purpose of ascertaining the quality of the ice furnished from different sources to the city of Cambridge.

Chicopee.

The past year has been one in which a great amount of work has been accomplished towards improving the sanitary condition of the city. The almost completing of the sewer connections with residences and other buildings is that in which the city should rejoice.

The city voted to have the garbage collected this year. The first year's trial has demonstrated to us that it is the only way to thoroughly get rid of this menace to public health.

Concord.

We have adopted the formaldehyde gas as a system of fumigation, and find after three years' trial that it works much better than the sulphur system, and gives far less annoyance and trouble to the householder.

We are sorry to note that malaria has obtained a foothold in the town, undoubtedly owing to the digging up of the streets and to the unusually wet season of the past year.

Dedham.

During the past year the complaints in regard to overflowing cesspools have been more numerous than ever, and great difficulty has been experienced in some cases in providing some method of disposal. The season has been unusually wet and many of the cesspools have been overflowed by ground water. At best, a cesspool is an unsanitary affair and the board will welcome some relief from this condition. The board has for a number of years called attention to this serious condition of affairs and repeatedly pointed out the need of sewers. They feel it their duty to again bring this matter to the attention of the town and to urge that some action be taken in this respect.

Dracut.

The report of the Dracut board of health contains an account of an epidemic of scarlet fever which appears to have had its origin at a dairy farm in Dracut and was followed by many cases in Dracut and Lowell.

The epidemic appears to have been promptly suppressed by the conjoint action of the boards of health of Lowell and Dracut.

Duxbury.

The sanitary condition of the town has been very much improved and we have been assisted by the citizens with one or two exceptions in our efforts to carry out the requirements of the regulations issued in 1897. Removal of garbage has been attended with some expense, but has been more nearly self-supporting than during the year previous, and we think if no one is allowed to remove garbage except persons authorized to do so under instruction of the board of health, it would abate many nuisances and would be of no expense to the tax-payers.

Everett.

Municipal cleanliness should rank as one of the foremost features of municipal government. The influence that clean and neatly kept streets, public parks, school buildings and grounds exert upon the individual citizenship of a city or town is a strong educating force for clean homes and more neatly kept premises. This condition tends not alone to a greater degree of health, but to the greater prosperity and happiness of the inhabitants.

Connections with sewers during the past year have been insisted upon whenever a cesspool has once overflowed and a sewer found available, we having in several cases instituted legal proceedings to enforce our order, and in each instance the owner has complied with the judgment of the court. The total number of sewer connections ordered made during the year was 55.

The following gives the death-rate for the last six years, that of 1898 being the lowest ever reached in the city: —

	Death-rate.		Death-rate.
1893, ...	15.50	1896, ...	15.46
1894, ...	16.47	1897, ...	16.50
1895, ...	14.86	1898, ...	14.44

In nearly all the cases of diphtheria, the diagnosis has either been made or verified by means of the culture, and no case has been released until we have first obtained one negative culture. In some instances this enforces a quarantine of six or eight weeks, which seems somewhat of a hardship upon the family, but if we are to do our duty in protecting the public health, with the present knowledge of the contagion, we can see no way of avoiding such hardship.

Fall River.

It is a matter of congratulation that in the abatement or correction of the numerous nuisances or unsanitary conditions with which the board has to deal during the year, the number of second notices requiring to be issued were comparatively few. Only in a solitary case was it found necessary to resort to prosecution to enforce the law, and this case was disposed of by the defendants paying the costs and complying with the original order of the board.

The number of cases of typhoid fever reported for the year was 63 and deaths 21, as against 154 cases and 82 deaths reported in 1897, but of this number we are aware of the fact that at least 4 cases from which 1 death resulted were brought back to the city from the United States army, so that the actual number of cases properly chargeable to the city would be 59, and 20 deaths.

The Widal test, to enable physicians to confirm their diagnosis in doubtful cases of typhoid fever, which has been provided by the board since the autumn of 1897, has been very generally availed of, 19 cultures having been taken and submitted for microscopic examination to our bacteriologist.

From records kept by the department it appears that 28 of the cases of diphtheria were treated with antitoxic serum while 27 were not, and it is worthy of note that while 3 of the fatalities occurred amongst the latter, but 1 death occurred amongst those treated with antitoxin, and in this case the treatment was not commenced for twenty-four hours after the appearance of the disease. We think this record speaks volumes in favor of the efficacy of antitoxin in the treatment of diphtheria patients.

The extent of the board's official action in regard to tuberculosis or consumption consists in the enforcement of a regulation adopted the year previous prohibiting spitting on floors of halls, public buildings, street cars or other public conveyances, the disinfection of rooms or tenements which had been occupied by persons suffering from the disease, and the distribution of culture bottles, furnished by the State Board of Health, to physicians who desire to have a bacteriological test made upon any case of consumption coming within their notice in which there exists any room for a doubt. Such examinations are made and a report thereon furnished by the State Board, free of expense, direct to the physician furnishing the cultures. Thirty cultures have been taken and submitted for examination during the year.

The bacteriological work for the board has continued to be performed at the emergency hospital.

The board renews its recommendation and request for a contagious hospital. We have no guarantee that we may not be visited by an epidemic calling for more commodious quarters, perhaps at a time when least to be expected, and we believe it would be wise on the part of the government during the coming year to acquire a piece of land along the river front or some suitable location upon which a contagious hospital could be erected, or upon which temporary modern buildings could be hastily erected in case of a visitation of small-pox.*

The most fruitful source of nuisance which the board ever had to deal with, viz., the primitive and unsanitary method of collecting and disposing of garbage and house waste promiscuously with ashes and other waste material and dumping it into any convenient vacant lot, there to putrefy

* This suggestion of the local board of health appears to have been fully verified at the time of publication of this report, a severe epidemic of small-pox having visited the city in May, 1899, at a time when no measures had been taken to secure a suitable location for an isolation hospital.

under the summer sun and give off the most noxious gases, to the danger and annoyance of the public in general and the residents of such localities in particular, has, we are pleased to report, been removed by arrangements made by the board of health for the separation, collection, removal and disposal of all garbage and kitchen waste in a sanitary manner, through an appropriation made for that purpose. The system went into operation with the beginning of last May upon a contract made for one year, and the success which has attended it since the first has exceeded our most sanguine expectations.

In accordance with the Public Statutes of the Commonwealth the supervision and periodical inspections of the various bakeries in the city have been made by the inspector of the board, who has seen to it that the premises in all cases have been maintained in strict accordance with the requirements of the law.

In order to guarantee a pure supply of ice and place its responsibility therefor, the city government of 1898 enacted an ordinance delegating the control of its sale and delivery to the board of health. Acting upon the authority therein conveyed the board subsequently adopted a regulation to provide against the sale and delivery of impure ice, a proper enforcement of which cannot fail to be productive of the intended results.

Swine are prohibited within the city by the regulations of the board under a penalty of one hundred dollars.

Fitchburg.

The board desires to renew its request made last year for the establishment of a bacteriological laboratory and contagious disease hospital or hospital ward, and earnestly urges an appropriation therefor. Our experience this year has more than ever demonstrated the necessity for these institutions. One after another the principal cities are establishing their own laboratories, thus enabling the work to be done more quickly and conveniently.

The board is of the opinion that the city should own its own offal teams and directly control the collection and disposal of the offal, as under such a system the collection is more efficient and satisfactory in every way.

The record of diphtheria shows no fatal cases this year, which very satisfactory result is to be attributed solely to the prompt use of antitoxin.

The transfer of the control of milk licenses from the police department to the board of health has brought good results, as expected, and as shown by the report of the milk inspector.

Gardner.

The attention given by the board to the overflow of cesspools, barns, water-closets, etc., has resulted in a very much improved condition in the sanitary arrangement in our town. We realize the benefit of this improvement in the decreased number of contagious diseases. There is one point to which we desire to call attention in this connection ; that is the improvement in the plumbing of buildings from what was the practice some few years ago.

In our report of last year we stated that we looked forward to this year for a closer supervision of the milk supply. In accordance with this plan we notified the milkmen to attend a meeting of the board early in the season, which resulted in a very satisfactory understanding of the requirements for the better protection of the people of the town. The result of this meeting was the adoption of the following regulations : —

All persons wishing to sell milk in the town of Gardner must make application to the milk inspector to make an inspection of their barns, animals, water and food supplies, also the barns, animals, water and food supplies of all persons from whom they may obtain milk, their equipments for collecting and distributing same, and obtain from the inspector a license to vend milk in the town.

There shall be at least two inspections annually, and shall consist in examining into the ventilation and light of the stables, health and cleanliness of the animals, condition of apparatus for collecting and distributing milk, situation of water supply, variety and quality of food, cleanliness of attendants, finding specific gravity of milk and subjecting it to the Babcock test.

Any change in source of milk supply must be reported to the milk inspector within five days.

Barns must be kept clean and well ventilated, the water supply pure and well situated, food of good quality ; animals must be kept clean, and attendants must observe cleanliness in person.

Wagons and cans must be kept clean, and vehicles must have the owner's name and license number painted on each side.

Should the milk inspector find that any person or persons had failed to comply with the requirements of the first inspection. such person or persons shall pay the expenses of each inspection after the first.

Milk tickets must not be used twice.

Milk shall be strained through not less than five thicknesses of suitable cloth or its equivalent.

Venders from other towns shall bear the expense of each inspection, besides paying the regular license fee.

Great Barrington.

The prevalence of typhoid fever last autumn led the board to a consideration of the question as to whether or not the cases of this disease could be attributed to a cause arising within the town. No such cause could be discovered, and we regard it as a fact of some significance that all of the typhoid fever patients, except one, had resided or visited in other towns shortly before the commencement of their illness.

Greenfield.

Our death-rate has been lower this year than it has ever been before since the board began the compilation of statistics, viz., 14.28 per 1,000 of population.

Late in the summer the attention of the board was called to the indiscriminate and careless collection of garbage, and upon investigation it seemed to the board that the collection of garbage and house offal should be under more strict supervision, and the board voted that hereafter all persons desiring to collect garbage must first apply to the board for license to do so and must collect the same strictly in accordance with the rules and regulations of the board of health.

In a town of this size it has seemed to the board that the keeping of swine should be to some extent prohibited in the more thickly settled portions of the town and notice has been given that after May first no one will be allowed to keep swine unless duly licensed to do so by the board of health, and only in such place and manner as the board may deem proper.

The town has been more free from contagious diseases this year than last, the number being 41 this year, as compared with 78 last year, although not having dropped to the figures of preceding years, 19 in 1896 and 28 in 1895. There have been 3 deaths, 2 from typhoid fever and 1 from measles, one of those from typhoid fever being a member of the 2d regiment, M. V. M., and contracting the disease while in service. Early in the year the plan of placarding all houses in which there existed any contagious case was adopted, and it has seemed to meet with universal satisfaction.

Recently the board has issued an order requiring in future, in all cases of diphtheria, before quarantine shall be raised and the patient be allowed to mingle with other people that a negative culture shall be taken from the throat, showing that no germs of the disease are present.

In September last a few cases of scarlet fever were reported. Upon investigation it was found that during the summer two children in one family had been ill for a few days only, at no time sufficiently ill to necessitate the calling of a physician. The symptoms of these illnesses as described later by the parents were strongly suspicious of scarlet fever and recovery in each case was followed by desquamation. These children upon recovery from the acute symptoms were allowed to mingle with other children and in due course of time several cases were reported among these playmates.

The board would recommend that the town erect in some suitable place a building to be used for the care and treatment of contagious diseases. The experience of last spring with small-pox should prove to the town the value of such a building.

Haverhill.

In July all the bakeries in the city were visited by the agent, and a detailed report of the result of his inspections was made to the board in

August. The condition of affairs found in many of them showed that legislation to correct the evils discovered had not been enacted any too soon. Some were very untidy and filthy, and looked as if they had not been cleaned and whitewashed for years, and to make the changes ordered in some of them involved considerable expense, as water-closets had to be removed from the bake rooms, or the location of the bake room changed so as to make indirect communication, in order to have them conform to the statute relating to bakeries and persons employed therein. In August a second inspection was made, the result of which showed a very great improvement in the sanitary condition of the bakeries referred to, and a prompt and willing compliance on the part of the proprietors to comply with the law.

There were 5 prosecutions in the police court, resulting in 4 convictions, with light penalties imposed, and 1 discharged for lack of sufficient evidence. This was the case of a physician summoned into court for neglecting to report a case of scarlet fever. The law requiring physicians and householders to report cases of contagious diseases is so defective and contains so many loopholes that it is almost impossible to secure convictions in the local court, and therefore, the time spent in collecting evidence and in attendance at court is simply time and energy wasted. There have not been many prosecutions in this city under this statute, but what few there have been in previous years have in every instance resulted in the acquittal of the defendant. The evidence upon which these cases have been taken into court has seemed clear and almost conclusive, but when presented to the court, the result, as we have said, has been the discharge of the defendant.

The number of cases of contagious diseases that occurred in the city is approximately correct, with the exception of measles and whooping-cough. It is safe to state that not more than one quarter of these diseases have been reported.

Holyoke.

Much additional work has devolved upon the board this year in carrying out the requirements of the new Public Statutes. Many petitions and complaints have been received requiring the viewing of the premises involved. The board has made all such inspections and also inspected localities thought to be in an unsanitary or unhealthful condition.

Such yearly inspections of bakeries and their surroundings, as required by law, have been made, and the board can report a much improved condition since the last inspection.

The undertakers have been licensed this year according to the State statutes passed in May, 1897, and the additional control thus gained has improved the working of this branch of our department.

In November an ordinance was enacted designating the board of health as the body to issue licenses and superintend the practicing of slaughtering.

Regulations have passed the board insisting that all engaged in this business shall fully comply with the law, and it is our intention that none but inspected meat shall be sold in the city.

Inspection has been made of the fruit stores and the stock of produce dealers in the city, and as a result less fruit and vegetables unfit for sale are presented to the trade.

In compliance with the orders of this board the sanitary condition of the basement of the city hall has been much improved.

The tramp room is not suited to its present use. It lacks ventilation and is too small to accommodate all the tramps who apply for lodging. The police have been obliged to place as many as 34 tramps in this room at one time. The rules of the board are as follows in regard to rooms used as sleeping-rooms: —

Rule 27. In considering the number of occupants, in accordance with the foregoing section, this board will consider a sleeping-room to be overcrowded unless there should be at least four hundred (400) cubic feet of air space for each inhabitant occupying the same.

The present room contains about 2,200 cubic feet of air space, which would permit of its use by no more than 6 persons. The board would request that some other place be provided to accommodate these tramps.

Hudson.

The scarlet fever epidemic that began in December, 1896, continued through every month of 1897 and to April 21, 1898, there being 76 cases reported in that period, and but 3 deaths from it. Two of the deaths came with startling suddenness and in one family, causing the board to investigate exposed cases, and bringing to the attention of parents cases in their families hitherto unsuspected. A circular, containing suggestions for preventing its spread, was distributed among teachers and families, and certain families quarantined, when the disease soon ceased, and not a case has been reported for the last eight months.

Hyde Park.

The remarkable decrease in the death-rate from diphtheria from 27 per cent. in 1896 to 11 per cent. in 1898 can surely be credited to the free use of antitoxin and thorough and systematic disinfection. The disinfection and fumigation by the use of formaldehyde gas has been continued with gratifying results, as there has not been a second case reported from houses where this process has been applied.

Although many years have passed since a case of small-pox has been reported in the town, still it is liable to occur at any time. Should small-pox appear we should be prepared by being provided with facilities to control it. As it is we are not even provided with a place where the patient might be safely isolated and cared for. A sectional building which could be stored in some convenient place, and which could be erected in a few hours, should be provided. In case the emergency should arise we would then be able to meet it successfully.

The vaccination of all children who attend the public and parochial schools should be insisted upon as the Public Statutes provide.

Ipswich.

The sanitary condition of the town has been very good, and complaints to the board of nuisances have been very few, and these have been promptly investigated and our decisions and requirements met in a proper spirit, and our instructions carried out in a satisfactory manner.

Leominster.

The board works in unity and with oneness of purpose for the best interest of the town to preserve its health, to prevent the spread of contagious diseases, to keep the streets clean, and to look after the two perhaps most essential points pertaining to the public health, namely, the proper plumbing of buildings and the extension of sewerage in those portions of the town most needing it.

Malaria, which is usually not prevalent here to any great extent, has this past year been more in evidence. No deaths, however, have been reported from this cause.

Typhoid fever has increased in the number of cases reported, but with the same number of deaths as during the past year.

Though the number of cases reported as sick with some of the contagious diseases has this past year been greater, the mortality has not increased.

Lincoln.

Early in the year the board learned of a contemplated purpose to locate an extensive slaughtering establishment in the south part of the town, near the Weston town line. Assured that such an establishment would be an unmitigated nuisance and detrimental to the town, the board took joint measures with the board of health of the town of Weston against such establishment. Our town of Lincoln, also, in public meeting called to consider the matter, energetically opposed the same. The scheme seems to have been and it is hoped has been abandoned.

The board would in conclusion reiterate its suggestion of last year, that it is the duty of every citizen to himself and the community in which he lives to promptly report all cases worthy of complaint in which disregard of public right to pure air and pure water is manifest.

Lowell.

Lowell was the first New England city to try the cremating process for the destruction of garbage, and there is now very little doubt that cremation is the proper sanitary method of disposing of this waste. Owing to the inadequate size of the furnace as well as insufficient appropriation for carrying on this work, Lowell burns about 50 per cent. of the city garbage, meaning swill and market refuse; the other half is collected by licensed farmers who use it as a fertilizer or feed it to hogs. During the winter months nothing is burned at the cremator, except the market refuse and refuse from hospitals and those houses reported to the health office as containing a case of infectious or contagious disease.

The board refuses to recommend any applicant who keeps cows whose milk is to be sold, and also refuses a swill license to collectors of grease, etc., called "soap men." The ashes and refuse other than swill are collected by the health department and are used for filling in low lands.

Two municipal questions of primary importance for the health and prosperity, consequently the growth, of any city are those relating to pure water supply and proper sewerage.

The necessity for medical inspection of schools becomes more apparent each year. After studying the various methods in use in cities of this country, we believe that if a corps of physicians were appointed by the board of health whose duties would consist of not only inspecting the schools of their respective districts, but should also be held directly responsible for the proper isolation of all cases of infectious and contagious diseases occurring in their districts, the danger to the public from these diseases would be reduced to a minimum. This work could be readily done by tactful physicians without interference or friction to the attending physician. The great benefit a corps of physicians, as described above, would be to the city of Lowell during the summer months when cholera infantum kills more infants than all other causes added together, would sufficiently repay the city for the money expended. That cholera infantum can in a great measure be eliminated by proper instruction to parents and guardians on the errors of infant feeding, and that such education can be best done by physicians mingling in the crowded districts with the people living there, does not admit any doubt.

The board recommends the establishment of an infectious disease hospital and a public morgue.

The large number of deaths from tuberculosis in some form that occur annually in our city has been the subject of much comment. In a city of Lowell's composition there are necessarily factors at work which tend to foster a large death-rate from this cause. Lowell is primarily and chiefly a manufacturing city, with the physical evils that such a life entails. Long hours of hard work in illy ventilated, over-heated, dusty mills, accompanied with crowded, unsanitary dwelling quarters, will produce a soil favorable for the reception and growth of this germ, as well as a most perfect opportunity to transmit it to others in a similar state of debility.

The Lowell board of health has followed the stand taken by other cities and voted "that the deposit of sputum in street cars is a public nuisance, source of filth and cause of sickness, and hereby orders that spitting upon any floor of any street car be and hereby is prohibited."

The remarkably low death-rate from cholera infantum obtained in 1897 has been maintained during 1898. The good results obtained in some of the larger cities, as well as that in our own city, in the summer of 1897 from fresh-air excursions and in spreading knowledge on the care and feeding of infants, would suggest that much is possible in that direction. We would respectfully ask that some provisions be made for such a purpose in the coming year.

It would seem as if there is every reason why the milk inspector should be connected with this department. With a well-equipped laboratory for biological research, there seems to be no reason why the public should not receive the benefits to be derived from a positive knowledge of the purity of the milk supplied to Lowell.

Lynn.

The hospital for contagious diseases has had another successful year.

There have been admitted to the hospital during the past year, 49 patients, 34 cases of diphtheria and 15 cases suffering with scarlet fever.

The quality of milk has shown some improvement over that of preceding years, and some credit is due to the milkmen, who have taken precautions to watch carefully their supply. In many instances these dealers have samples analyzed at regular intervals, and by doing so are able to detect dilution or adulteration which may be practised at the dairy. Several dairymen have been detected in this manner, and upon complaint of the milkmen were brought before the inspector. There are, however, many dealers who still require attention, and whose milk supply indicates lack of care or subsequent modification. The use of formaline has been resorted to, and all dealers have been brought into court and convicted who were found using it. During the year 35 milk dealers have been brought into court for having milk below standard and for use of foreign substance. Two were discharged, 12 put on file, 21 fined.

Malden.

The board contemplates making it obligatory on the part of attending physicians in all cases of diphtheria to secure a negative culture before the quarantine restrictions shall be removed from the patient and the premises.

It is yet to be hoped that a suitable plan may be found where an isolation ward may be located. The proper and humane care of the unfortunate, as well as the rights of the public, demand such an institution.

The board advises the medical inspection of the public schools.

Marblehead.

The health of the town was never better than during the last twelve months. It has been wonderfully fortunate in the small number of contagious diseases, there being but a few cases of scarlet fever, diphtheria and other diseases peculiar to children.

There were but 5 cases of diphtheria and 1 death. In each and every case antitoxin has been administered.

Marlborough.

There were no deaths from contagious diseases during 1898, being the first for ten years to have no record of mortality resulting from contagious or infectious diseases.

The greatest number of cases of scarlet fever were reported in December. The board has continued to enforce the strictest quarantine in these cases and has succeeded in staying the progress of the disease, and with the aid of the new method of disinfection with formaldehyde gas, the danger of the disease spreading was reduced to the minimum.

The school board, by its co-operation with the board of health, has rendered valuable assistance in the prevention of the spreading of contagious diseases among the children in the public schools. As soon as a case appears in any of the school buildings the teacher has instructions to immediately burn all books and papers which were used by the child, also the desk and chair are washed with a solution of corrosive sublimate.

Medford.

The freedom from contagious diseases experienced by our city during the past year is very gratifying, the total number of cases of contagious and infectious diseases being only 72. Of the dreaded diseases, diphtheria and scarlet fever, there have been 42 cases, of which 3 were fatal.

It is evident that the early discovery and care of cases of contagious diseases, so as to prevent epidemics, call for the hearty co-operation of teachers, physicians and citizens with the board of health.

During the year, culture tubes for the bacterial examination of cases suspected to be diphtheritic and supplies of antitoxin have been obtained from the State Board of Health.

Melrose.

A gratifying feature of the record of the past year is the unusual freedom from the prevalence of contagious diseases. The average number of cases of scarlet fever for the last eight years has been 41. The table shows the total number for 1898 to have been only 20. Our annual average of diphtheria for eight years has been 26, but last year brought only 5 cases. On the other hand, the number of cases of measles during the last two years has been about 700.

Attention has been called by the secretary of the State Board of Health to the point that the ice cut from Ell Pond (or Crystal Lake) may be liable to contamination from offensive discharges into the lake. These may be presumed to occur from two sources, dwelling-houses on its border and from two brooks pouring into the lake on its northern and western borders. The former source of danger had already been largely prevented, and any possible cause of pollution still existing from that source will be very promptly extinguished. The latter source of contamination is more difficult to control, beyond preventing brook pollution, and it may be a question if this board has full power to enforce radical action, the authority resting rather with the State Board. Manifestly, ice, to be fit for domestic use, should be made only from water that is fit to drink.

Middleborough.

Not since 1881 has this town been so free from contagious diseases as this year; not a single case has been reported to the board, but a careful and constant watch of the sanitary condition of the village has much to do with its present condition.

Milford.

In these days no town of any considerable size or importance is considered to be a desirable place for residential or business purposes unless it possesses a good water supply and sewerage system. The two go together, and are required by the rules of modern living.

Milford has as perfect a water supply system, with a purity which probably is not surpassed by any town in New England; but it is wofully deficient in its sewerage facilities.

New Bedford.

During the past year we have received numerous complaints of filthy docks caused by accumulated sewage, and so far as has lain in our power we have endeavored to remedy the evil. Unless the docks into which several of the largest sewers empty are cleaned of this filth by spring, these nuisances along the water front will cause trouble.

Another matter which to us seems of vital importance in guarding the health of this community is that of maintaining the streets in a cleanly condition.

Another matter which we call to your attention is the growing need for a contagious disease hospital, as provided by law; not an elaborate structure, but a suitable place where such cases of scarlet fever and diphtheria as cannot be treated at their own homes without great danger to other members of the family, and consequently to the community, can be isolated. The past year the necessity for such an institution was very emphatically forced upon us, and we hope in the near future some provision will be made for such a place independent of any other hospital or public institution.

It is our opinion that the prevalence of diphtheria and the mortality from this once much dreaded disease has been greatly lessened by the use of antitoxin, which is prepared by the State Board of Health and furnished by this board to all physicians free of cost.

The first step in the management of contagious diseases is the notification of each case, which is incumbent on householder as well as attending physician. But few householders know this, but as most physicians rarely neglect to report a case, the board is able to keep an oversight of existing cases. In a number of instances cases have been discovered where no physicians were employed, and generally this has been in families where English is seldom spoken.

The culture method of assisting in the diagnosis of diphtheria should be universally employed by the physicians of New Bedford.

During the year the board has adopted an order prohibiting the attendance at all schools of children afflicted with whooping-cough. This precaution is taken in all large cities of the Commonwealth, and we believe it to be a wise one.

No common source of infection could be discovered during the prevalence of typhoid fever. The cases were pretty evenly distributed over the city. The milk supply was ascertained in each case and only in two instances it was discovered that more than one typhoid patient had been supplied by the same dealer.

Newton.

The bath-house was opened on June 20. The following table shows the number of persons using the bath-house during the season : —

June,	200
July,	2,549
August,	3,985
September,	2,547
Total,	9,281

The board would recommend the establishment of similar bath-houses at other points in the city.

The milk farms have been visited by the agent once a month during the year, and a report of their condition made by him to the board. In this way the board is enabled to keep them in as good condition as possible under the present methods. A much more stringent method of control, and one which the board favors, has been outlined by the Massachusetts

Association of Boards of Health, but unfortunately this cannot be adopted without certain changes in the statutes, which have not as yet been made.

The board adopted a rule in 1897 prohibiting the keeping of swine on milk farms, under which it compelled the removal of a large number of swine.

North Adams.

All the bakeries in the city have been inspected, and with few exceptions were found in good sanitary condition, a great improvement over their condition in past years.

All the stables in the city in which more than four horses are kept have been inspected by the agent, and so far as practicable the nuisances connected therewith have been abated.

The milk ordinance having been passed by the council and approved by the mayor, it became necessary that the stables of all persons selling milk in the city should be inspected, which was accordingly done by the agent of the board. There were seventy stables inspected, and a report of the condition of each stable, together with the orders which were issued by the board regarding them, has been filed with the city clerk.

Early in April this board applied to the State Board for an examination and analysis of the ice and sources of supply, which request was promptly complied with, and samples were sent the State Board and an inspection was made by them.

Adjudication of the Board of Health.

City of North Adams,
Office of the Board of Health,
June 8, 1898.

The board of health of the city of North Adams, acting under chapter 16, as amended, of the Revised Ordinances of said city, have caused to be examined the ice and sources of supply of ice which is offered for sale and distribution in said city, and have taken samples and have caused proper analysis of the same to be made, as appears from the report of the State Board of Health, herewith attached and made part of this report.

We find and do adjudicate that the pond lying between the tracks of the Hoosac Valley Street Railway Company and the Fitchburg railroad, west of Blackinton, is unfit as a source of ice supply; the ice is impure and unfit for use.

We find and do adjudicate that the "lower pond" near Flagg's meadow is unfit as a source of ice supply; the ice therefrom is impure and unfit for domestic use.

We find and do adjudicate that the Zylonite Pond as it now is, with the nuisances existing on the shores thereof, is an unfit source of ice supply, and the ice from said pond until said nuisances are removed is impure and unfit for domestic use.

We also find and adjudicate that the Kemp Pond is an unfit source of ice supply; the ice therefrom is impure and unfit for domestic use.

The ice cut from Stamford Reservoir and Reservoir Pond, though care should be exercised in its use, is not condemned for domestic purposes.

The conditions surrounding Hudson Brook are much more favorable than last year, but the adjudication as to that pond is postponed, as the samples taken from that source were destroyed before reaching the State Board. The attention of the consumer is especially called to the fact that the ice cut from the uncondemned ponds, though not so dangerous as that cut from the condemned ponds, should never be used in drinking water.

Early in March, owing to the fact that one or more cases of small-pox had been reported in a neighboring town, the board thought it advisable that the schools be inspected and all the children that had not been successfully vaccinated should be vaccinated; this was accordingly done.

Owing to the strenuous efforts that have been made and the strict quarantine that has been maintained none of the diseases have been allowed to spread and no epidemic has ensued.

Taking the three principal diseases, diphtheria, scarlet fever and typhoid fever, there has been only 53 per cent. as many cases as last year.

Norwood.

What can we say or do to prevent measles becoming epidemic? We look to the mothers very largely for help in preventing its spread. Having had one experience with the disease, its characteristic cough should be early recognized and the child kept quarantined. Attendance on public and private schools, intermingling in public halls, churches, etc., with others not infected, must be denied to those suffering with the disease. While the disease seems less serious than some of the other diseases with which most children have to struggle, it may leave very serious after effects. We should recognize our moral obligation and carefully restrain suspected subjects from mingling with those not immune. The old idea that all children must have measles, as well as all of the other diseases which children may have, should not be entertained.

Palmer.

It has been our aim to maintain proper regard for the laws of health and sanitation, at the least hardship and inconvenience to the public in general consistent with the safeguarding of the community against unusual increase of contagious disease. We have been fortunate in escaping any epidemic of diphtheria, and while we have suffered from quite the usual number of cases of scarlet fever, yet there has been present a mild form of the disease, with but one fatal case, the virulent infection of some two or three years since not being manifest.

Pittsfield.

The contagious hospital has this year been put in good state of repair.

House disinfection, following infection from contagious diseases, is a matter to which this board has given special attention. The old manner of disinfection by the burning of sulphur is a thing of the past. By the old method, it necessitated the destruction of much property, clothing and bedding, the cost of which amounted to about forty dollars in each case during the year, aggregating several hundred dollars. An agent was appointed and instructed in the proper use of formaldehyde, he having disinfected in all, up to date, forty-five tenements, and in no case has there been a return of the disease where such disinfection has been done by our agent.

During the past year the board has supplied antitoxin to nearly all cases of diphtheria occurring in town, with the happiest results, and have always a supply on hand adequate for any emergency, which may be had on application by physicians. Out of 112 cases reported, there were only 7 deaths. Of these fatal cases, antitoxin was not used in 4, and in the other 3 cases administered too late to be of service.

The herds of the city have been thoroughly inspected. Suspected animals have been eliminated. We have studied the best methods of reaching out-of-town herds supplying milk to this city for the past five years. It is the idea of this board to have the milk supply of our city and all towns in our immediate vicinity, and in fact, by precept, example and influence, the whole of Berkshire County, free from all suspicion of tubercular trouble, to the end that this infectious disease may be eradicated from among our inhabitants, and health and lives saved to usefulness.

Rockland.

The soap factory has been renovated and a thorough system of ventilating fans and blowers installed for conveying the noxious fumes under the furnaces and burning them there, which we trust will prove satisfactory.

The board the past year has made a radical change in the matter of disinfection after infectious and contagious diseases, having adopted, after careful investigation among the foremost authorities in that department, the formaldehyde system of disinfection.

Salem.

The city has been wonderfully fortunate in the small number of contagious diseases during the past year.

There has been one case of typhus fever, a rare occurrence in these latitudes. The origin of the case cannot be traced.

The board of health recommends immediate action looking to the erection of a contagious hospital.

The rigid inspection of milk is becoming more important each year, and some measures should be taken not only to have more than a perfunctory inspection, as exists at present, but the sources of supply should be known and carefully watched. The office of inspector of milk should be under the supervision of this board, conducted in an up-to-date manner, and rigidly enforced. This matter is of great importance, and will well repay the city to consider a change from present methods.

Somerville.

Number of nuisances abated,	880
Number of nuisances referred to board of 1899,	120
Number of nuisances complained of,	1,000
Number of complaints (many covering more than one nuisance),	518
Number of notices mailed,	509
Number of notices served by constables,	23

In addition to the above, 137 dead animals have been removed from the public streets, and many nuisances have been abated on verbal notice from the agent, without action by the board, of which no record has been made.

Glanders. — Forty-one cases of glanders have occurred during the year. Prompt action was taken in every case, and the horses have been killed.

The number of loads of ashes collected during the year was 23,204. The number of loads of offal collected during the year was 5,409.

There are but few privies remaining in the city, and it is the expectation of the board that most of these will be removed during the coming year.

An excellent sanitary map and a revised code of health regulations accompanies this report.

Springfield.

Until August 15 diphtheria was very infrequent, but from that date till January 1 the cases were reported rapidly, so that 70 per cent. of the cases occurred in the last third of the year. The good effects of antitoxin promptly used is now generally recognized, and examination of the fatal cases shows that, in general, death only ensues in cases that have been sick several days before receiving the remedy.

The hospital for contagious diseases recently built is nearly ready for use and will provide an excellent place for the reception and treatment of cases of this kind. The building provides for 24 patients.

Taunton.

The mortality for the year, figured from our estimated population of 27,812, was 16.39 per 1,000, after deducting 102 deaths at the State Insane Hospital.

The introduction of a portion of our proposed sewage system has resulted in the abolishing of a number of cesspools and privy vaults, always a source of nuisance.

The city has been wonderfully fortunate in its freedom from anything approaching epidemic of contagious diseases of any nature during the year. The number of cases of diphtheria was the smallest for years, and but one case was fatal.

Tewksbury.

Two cases of typhoid pneumonia, occurring in the same house within a few days of each other, resulted fatally soon after being removed to the hospital. One year previous there occurred a case of typhoid fever at this house. The premises were then examined, which were not found in a good sanitary condition. Several changes were ordered made, some of which were attended to. The sink drain emptied but a few feet from the back of the house, and the water supply came from a well close to the head of this drain, which, doubtless, overflowed, contaminating the water used for drinking and domestic purposes. The milk used by the family and that sold to customers was kept cool during the summer months in a well that was a sewer for a hog house and pen.

Uxbridge.

Soon after the board began its duties attention was called to the sanitary condition of several factory villages, and the matter thoroughly investigated by a house to house inspection. While this disclosed a bad state of affairs, it was not by any means confined to factory tenement-houses, but included many private residences occupied by the owners.

A bad sanitary condition was shown to be quite general throughout the town, undoubtedly made worse by the remarkably wet season. Within less than a month over twenty-five letters were written to different parties containing official orders for improvements in drainage and disposal of refuse, including five corporations, and it gave the board great pleasure to find that these orders were, almost unexceptionally, carried out according to specifications. In only one case has it become necessary to push the matter to the limit of the law by court trial, and that was in suppression of an offensive piggery, which had long resisted all outside interference.

Malaria, according to the State Board of Health reports, has been more prevalent here than in any other locality in the State. Much time has been employed by the local chairman in the service of the State bacteriologist in canvassing the more thickly settled portion of the town, and this has resulted in showing the far greater frequency of cases in those localities near adjoining pools of stagnant water than elsewhere. This is particularly shown near Clark's Pond, as is graphically exhibited by a map contained in the last board of health report.

Your board has been warned by the State Board that we were transgressing the law in regard to vaccination, a canvass of the centre schools showing only 160 vaccinated out of 600 pupils. The school committee were accordingly notified, and there the matter will probably rest until some day when we have an epidemic of small-pox, and every one becomes suddenly willing to take advantage of vaccination.

Want of uniformity in the weight of a loaf of bread by different bakers has led the board to call the attention of the dealers to the law, and give notice of its enforcement after Feb. 20, 1899.

We ought to employ a properly qualified specialist to visit our public schools occasionally and detect the optical defects in pupils, or else provide simple instruction for our teachers so that they may do it themselves.

Wakefield.

The town has been fortunate during the last twelve months in the small amount of sickness and the absence of any considerable epidemic of disease.

The board would urge the necessity for the early establishment of a sewer for at least the business portion of the town. The method of disposal of sewage in the centre of the town is in the opinion of this board a menace to public health and entirely unfit and discreditable to such a community as ours.

Walpole.

The work of inspecting tenements and other places in regard to drainage and general sanitary conditions, as contemplated the first of the year, has been done, and about 125 buildings have been inspected. Many were found in good condition, and in others the owners were generally willing to correct all defects.

Waltham.

Thanks to the slight amount of contagious disease that it had to meet in this year, the board has in the face of its extremely small appropriation been able to fulfil its duties in such a way that no serious detriment has occurred to its efficiency, yet in many respects the work of the board has not been all that might be wished. This is true particularly in the work of inspection of dairies, sources of milk supply, bakeries, which, being so scattered in extent and demanding such frequent inspection on account of the nature of the business carried on in such places, make it impossible that one man with other duties of this board to attend to can do all the work that would be necessary if this part of the work were carried out in the best possible manner.

This year the board deemed it reasonable and necessary to pass a rule regarding the deposit of sputum in public conveyances, and on April 1 passed such a rule in conformity to similar rules enacted by the boards of health of neighboring cities and towns.

Another rule was passed regarding offensive trades on October 25. The necessity of this order was called to the board's attention by the boards of health of neighboring towns and cities which had passed similar rules lately, and became necessary owing to the proposed location of a large rendering establishment near the source of our water supply.

The general health of the community has been excellent; the contagious cases have reached the minimum that has occurred since 1891.

During the year 447 cultures have been taken and examined for the presence of the diphtheria bacillus. Of these, 104 were positive and 373 negative. The low mortality, $6\frac{1}{2}$ per cent., can be ascribed only to the very general and early use of antitoxin, which has been freely furnished by the State Board of Health.

Seventy-four specimens of sputa have been examined for the presence of tubercle bacilli, of which 26 were positive and 48 negative. Several houses occupied by tubercular patients have been disinfected at the request of the attending physician.

Ware.

Early recognition and report to the board of all cases of contagious disease must be had. The agent of the board has recently, by our request, been appointed by the selectmen a special police officer for securing compliance with health laws and regulations, and for enforcing the orders of the board respecting contagious diseases and its quarantine.

Watertown.

The board publishes a code of its health regulations, revised to 1898.

Wellesley.

The board of health should be entirely separated from the selectmen of the town, and be composed of three members, one lawyer, one business man and one physician.

Whitman.

The past year has again been a remarkably fortunate one as regards contagious diseases, comparing favorably with last year, which was the best ever known in this respect.

The odorless excavator still continues to pay a good margin over all expenses.

Winchester.

At no time within the last five years have we been able to report so favorably upon the health of the town. Contagious diseases of the severer type have been very few as compared with previous years.

Measles, the mildest of all eruptive diseases, has had an extensive run among our school children, and while the physicians have been most prompt in reporting all cases coming under their care, many cases have occurred in families where no medical aid was called, and the cases not reported to the board of health.

During the past year every house within which any contagious disease has been reported has been fumigated with formaldehyde.

With a population of about 7,000 we have had a death-rate of less than 1 per cent., the whole number of deaths during the year being only 65.

WINTHROP.

The number of houses connected with the public sewer the past year was 71.

The number and variety of complaints made to the board the past season were much the same as previous seasons, except that we had but few complaints about the collection of house offal. All complaints were promptly investigated, and nuisances ordered abated.

The number of cases of infectious diseases reported to the board during the year is remarkably small, with the exception of a larger number of cases of typhoid fever than is usual; this increase in typhoid cases can, no doubt, be attributed to the return to our town and to Boston of many soldiers suffering with, or convalescing from, attacks of typhoid fever.

WOBURN.

The sanitary condition of the city of Woburn for the year 1898 was better than any year in the history of the city.

In the record of contagious diseases for the last three years the use of antitoxin has been an important factor in diminishing the fatality of such cases to the minimum.

One thing to be particularly noticed is the unusually small number of deaths among children of school age between the ages of five and fifteen years, which has been only 4.

WORCESTER.

Last year in our annual report we recommended that a second bath-house be constructed for the use of men and boys, and that the one then used by them be given to the use of women and girls exclusively. In accordance with that recommendation the city council appropriated $3,500 for its construction. It was not completed, however, until late in the season.

The practice of the previous year was followed in setting apart one full day each week for the use of women and girls, and giving them a few hours in the early morning of each day also until the new house was finished. Total number of bathers for season, 25,100.

Too much cannot be said in praise of this form of exercise and recreation, and in our judgment it would be wise, if it were possible, to extend it so that it might be indulged in during the entire year.

These all-the-year-round bath-houses have been in use in the cities of Europe for a number of years and latterly have met with favor in several cities of this country. Wherever introduced they have given satisfaction, and it is our earnest hope that the day is not long distant when they may be introduced here.

One hundred cases of typhoid fever were reported in 1897, but this year shows a considerable falling off from the number reported then, as but 81 were reported during the year just closed. This is especially gratifying, as sanitarians have agreed that the prevalence or non-prevalence of this disease shows more clearly than anything else the sanitary condition of the community.

It is also very gratifying because it was expected that, owing to the war and the amount of this disease that prevailed among the troops in the field, the disease would be spread by returning soldiers.

Notwithstanding the fact that Worcester had more than its quota of soldiers in the war, and also that several of them returned suffering with this disease, it is a cause for congratulation that we are able to make so good a report.

Two outbreaks during the closing months of the year, the one of diphtheria and the other of scarlet fever, both of which are due in our opinion to unrecognized cases of these diseases in attendance at school, emphasize the necessity of establishing a system of medical inspection in the schools of the city.

The board of health recommends that medical inspection of schools be commenced at once in the schools of Worcester.

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