

**Report to the Local Government Board on enteric fever in the city of  
Chichester. / By Dr. Theodore Thomson and Colonel J. T. Marsh.**

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1899

GB LOCAL GOVERNMENT BOARD

Report on Enteric Fever in the  
City of Chichester

by

Theodore Thomson

Col. J. T. Marsh

HMSO



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By Dr. THEODORE THOMSON and  
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REPORT

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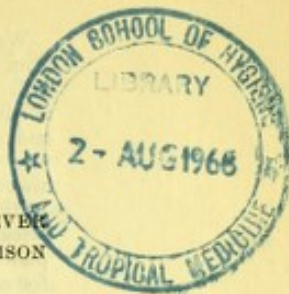
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REPORT to the LOCAL GOVERNMENT BOARD on ENTERIC FEVER  
in the CITY OF CHICHESTER; by Dr. THEODORE THOMSON  
and COLONEL J. T. MARSH, R.E.

THE city of Chichester, in the county of Sussex, has, on several occasions, attracted attention by reason of its liability to repeated recurrence of enteric fever in serious amount. Thus, in 1865, Dr. Seaton, in a report to the Privy Council on "Circumstances Endangering the Public Health of Chichester," called attention to the frequency with which outbreaks of enteric fever were wont to occur in this district. Again, in 1878, Dr. Airy, in a report to the Local Government on "An Outbreak of Enteric Fever in Chichester," alludes to the persistence of a high death rate from this cause in the locality. Yet again, in 1896, Dr. Bulstrode, in a report to the Local Government Board upon "Prevalence of Enteric Fever in the City of Chichester," points out that "in the decennium 1871-80 there were, 'excluding a few districts in which alterations had been effected, only 'some 31 out of 630 districts in which the combined enteric and continued fever rates were higher than those of Chichester; and 'similarly in the next decennium there were but sixteen districts out 'of the 631 in England and Wales which had higher rates in this 'respect than Chichester.' It may be noted that the occasion of Dr. Bulstrode's investigations in 1896 of prevalence of enteric fever in Chichester, was the occurrence in that year of a serious outbreak of the disease there.

In 1897 there was again notable recurrence of enteric fever in Chichester; and, as result, certain residents in the district presented to the Mayor a memorial containing request that he should "take immediate steps to obtain an independent inquiry into, and a report upon, the prevalence of enteric fever in the city, by an experienced engineer and medical officer."

On June 13th, 1898, the Board received from certain inhabitants of Chichester a petition setting forth that an inquiry, such as requested in the memorial to the Mayor, by an engineer and a medical officer, was urgently called for. "Not," continued the petitioners, "a formal inquiry, costing money and stirring up strife, but a walking inquiry 'by scientific experts accessible to all and anxious only to arrive at 'the truth.' The petitioners therefore prayed the Board "either to "make such inquiry, or to take some other step to ascertain the reason "of the outbreak of typhoid fever, and to apply the necessary remedy."

Thereupon we were instructed by the Board to make inquiry into the circumstances attending the frequent recurrence of enteric fever in the city of Chichester.

To this end we visited Chichester on August 3rd, 1898, and on many subsequent occasions, making inquiry in the sense indicated. The facts and considerations that appear to us to bear upon the subject of our inquiry are hereinafter set out at length; saving those conditions, topographical, geological, or sanitary, of which account has been given by Dr. Bulstrode in his report already referred to. (See Appendix C. to this Report.) To these matters but brief reference will now be made, except as regards the system of sewerage of the district, which will be treated of by us in some detail. Any changes, also, that have come about in any of the above-mentioned conditions since the date of Dr. Bulstrode's inquiry, will be duly noted.

The city of Chichester had, at the census of 1891, a population of 7,830 persons upon an area of 722 acres. Since 1891, however, the city boundaries have twice been extended; in 1893, and again in 1895. The present area of the district is 1,595 acres, while the population is locally estimated as having been about 11,500 in the middle of 1898. Chichester stands on ground which is for the most part flat or slopes but slightly, the main direction of slope being from north to south. The soil underlying houses is, in most instances, coarse gravel of varying and, commonly, uncertain depth; which gravel overlies the clay of the London and Reading Beds.



Water supply is derived partly from private wells, partly from a public service in the hands of the Corporation. This public supply is obtained from two wells situated about one and a half miles to the west of Chichester, and near the village of Fishbourne. One of these wells was sunk in 1874, and is described by Dr. Bulstrode in his report. (See Appendix C.) The other was sunk in 1898, and is 120½ feet in depth. The upper 16½ feet of this well are lined with brickwork in cement, 14 inches in thickness, and surrounded by clay puddle two feet in thickness. Below the brickwork the well is lined for a further depth of 50 feet with cast-iron cylinders.

In sinking the well, the following layers were encountered:—

	Feet.
Mould ... ..	1
"Gravelly loam" ... ..	1½
"Porous shingle" ... ..	1½
Clay and gravel ... ..	2
Reading clay ... ..	22
Clay and Chalk ... ..	4
Chalk with flints ... ..	88½

Both wells are situated near the southern margin of the Reading Beds, the Chalk coming to the surface along this margin and within a few yards of the wells.

Excrement disposal in Chichester is effected partly by the water-carriage system, partly by cesspit privies. Water-closets drain either to sewers or to cesspools. Since 1896 there has been progressive reduction alike of the number of houses draining to cesspools, and of those furnished with cesspit privies, with corresponding increase in the number of houses fitted with water-closets draining to sewers. Thus, in the middle of 1898 nearly three-fourths of the houses in Chichester drained to sewers; whereas in 1896, Dr. Bulstrode stated that "only a limited number of houses were connected with the sewers." More detailed information on this matter will be found at a later stage of this report.

The sewerage scheme, as shown in Map F., was carried out in 1893-95, and no important deviations from the original plan have been discovered by us. The sewage gravitates to the outfall works, which are situate on the banks of the Fishbourne Channel, about 1½ miles south-west of Chichester Cross. The sewage is there treated with sulphates of lime and alumina in three precipitation tanks, each having a capacity of 34,375 gallons. The tank effluent is passed over some six acres of land, underdrained at a depth of three feet, and the "land effluent" passes into a cement-lined tidal basin having a storage capacity of 320,000 gallons. Two precipitation tanks are worked at a time, hence their capacity and that of the tidal basin equal 388,750 gallons. In normal weather the basin is emptied into the Fishbourne Channel every second tide during the first three hours of ebb. The normal dry-weather flow is regarded as 250,000 gallons.\* But we learned that considerable difficulty has been experienced at the disposal works in dealing with the large volume of subsoil water which at times finds its way into the sewers.

"The following record of the average daily flow of "sewage" at different periods of the year has been compiled from statistics furnished by the manager of the Corporation's outfall works:—

Year.	Month.	Average daily flow of Sewage.	Year.	Month.	Average daily flow of Sewage.
1895	October ...	166,500 gallons.	1897	August ...	623,570 gallons.
"	November ...	342,760 "	"	September ...	583,400 "
"	December ...	477,660 "	"	October ...	643,760 "
1896	April ...	835,260 "	"	November ...	302,200 "
"	May ...	1,017,500 "	"	December ...	273,120 "
"	June ...	764,600 "	1898	January ...	271,830 "
"	July ...	474,300 "	"	February ...	276,840 "
"	August ...	310,830 "	"	March ...	262,080 "
"	September ...	454,890 "	"	April ...	246,280 "
"	October ...	615,000 "	"	May ...	254,780 "
"	November ...	565,800 "	"	June ...	249,650 "
"	December ...	1,108,800 "	"	July ...	269,680 "
1897	January ...	2,011,300 "	"	August ...	282,880 "
"	May ...	1,731,400 "	"	September ...	277,770 "
"	June ...	1,521,700 "	"	October ...	284,850 "
"	July ...	993,870 "	"	November ...	272,850 "
			"	December ...	278,120 "

\* Exclusive of the daily flow of trade effluents to the sewers, viz.:—

	Gallons.
Tannery ... ..	6,300
Brewery ... ..	40,000



From the large quantities of subsoil water admitted into the sewers, as indicated above, some idea may be formed of the amount of sewage which may possibly leak from the sewers into the subsoil when the conditions are favourable.

A good deal of patching and repairs have been carried out since the sewers were laid, with a view of excluding the subsoil water. The pipes are stated to have been provided with patent joints; however, it was admitted that in many cases they were laid in flooded trenches, hence the leakages are not to be wondered at.

We were informed that during the years 1897-8 leaky sewers were rectified at the following twenty-nine places:—

Leaks.	Locality.	Position.
1	Franklin Place ... ..	59ft. from B. 11 towards L. 1.
1	Junction of New Park Road with Franklin Place	Manhole L. 2.
1	North Gate ... ..	118 ft. from B. 10 towards B. 9.
1	St. Paul's Road ... ..	39 ft. " B. 9 " J. 1.
1	Orchard Place ... ..	24 ft. " B. 7 " B. 6.
1	Do. ... ..	165 ft. " B. 6 " B. 7.
1	Do. ... ..	31 ft. " B. 6 " B. 7.
1	Do. ... ..	66 ft. " B. 5 " B. 6.
1	Do. ... ..	191 ft. " B. 5 " B. 6.
1	Orchard Street ... ..	39 ft. " B. 5 " B. 4.
1	Do. ... ..	20 ft. " B. 5 " B. 4.
1	Orchard Terrace ... ..	39 ft. " B. 8 " B. 7.
1	Do. ... ..	48 ft. " B. 7 " B. 8.
1	Junction of West Lane with Orchard Terrace	Manhole G. 1.
1	Westgate ... ..	6 ft. from B. 4 " B. 3A.
1	Do. ... ..	271 ft. " B. 3A " B. 3.
1	Whyke Road ... ..	7 ft. " M. 7 " M. 6.
1	Do. ... ..	70 ft. " M. 5 " M. 6.
1	Do. ... ..	51 ft. " M. 5 " M. 4.
1	Do. ... ..	Manhole M. 5.
1	Do. ... ..	Do. M. 6.
1	Do. ... ..	Do. M. 7.
1	Junction of Bognor Road with Whyke Road...	Do. N. 2.
1	Canal Wharf ... ..	Do. M. 1.
1	Whyke Fields ... ..	Do. M. 3, No. 296, Ordinance Map.
1	Do. ... ..	Do. M. 4. do.
1	Do. ... ..	114 ft. from M. 3 towards M. 4.
1	York Road ... ..	110 ft. " M. 9 " M. 10.
1	Do. ... ..	Manhole M. 10.
Total 29		

The manholes we inspected appeared to be well constructed, but in three cases we found that the sewers leading from the manholes were defective, viz., one in the Hornet, to the east of the town, marked B on map F; one at C, south of the railway station; and one at Old Place, south-east of the town, marked A on map.

According to the deposited plans, the gradients of the sewers are good, inasmuch as the velocities, when running half full, would not be less than  $2\frac{1}{2}$  feet per second, which may be regarded as rendering the sewers self cleansing. If the original scheme has not been departed from, the sewers have sufficiently good gradients; and if any defects now exist they must be due to faulty construction and to the fact that some of the pipes were submerged when they were laid. (See ante.)

There is no systematic ventilation of the sewers by ventilators at the street level, but ventilating shafts have been provided. The shafts are 30 feet high, and about 300 yards apart.

There are seventeen 500-gallon flushing tanks. The contents are discharged by 6-inch siphons in about three minutes. Fifty dead ends of the sewers are flushed weekly by vans, each capable of holding 450 gallons. The sewers along the route are also flushed by damming up the sewage at various points in the system. Generally, the flushing arrangements seem to be satisfactory.

On the occasion of our visit in November, 1898, there were over 500 houses not drained to the sewers, although in each instance a drain had been carried from the sewer towards the house as far as the footway, and an intercepting trap provided. The iron grating forming the air-inlet for each house drain invariably coincides with the kerb in the footway, and this must act as a sewer ventilator where the house connection has not been made. We heard of many complaints about offensive smells from these intercepting traps on the footways.



*Fever prevalence in Chichester.*

The following table (Table I.) shows the number of deaths referred to enteric and continued fevers in the area now comprised by the city of Chichester, year by year, during the 29 years 1870-98.

TABLE I.

SHOWING, year by year, for the period 1870-98, the NUMBER of DEATHS referred to ENTERIC and CONTINUED FEVERS, in the area comprised by the present city of Chichester.\*

Year.	Number of Enteric Fever Deaths.	Number of Continued Fever Deaths.	Year.	Number of Enteric Fever Deaths.	Number of Continued Fever Deaths.
1870	3	2	1885	3	...
1871	3	1	1886	4	...
1872	3	2	1887	2	...
1873	4	1	1888	5	...
1874	3	1	1889	1	...
1875	5	...	1890	...	...
1876	7	3	1891	...	...
1877	3	...	1892	3	...
1878	6	1	1893	...	...
1879	8	...	1894	...	...
1880	5	...	1895	...	...
1881	2	1	1896	2	...
1882	4	...	1897	6	...
1883	6	...	1898	13	...
1884	7	...			
Total Deaths from Enteric Fever 1870-98 ...					108
Do. do. Continued Fever do. ...					12

From this table it appears that during these 29 years 108 deaths were referred to enteric fever, and 12 deaths to continued fever, within the area now comprised by the city of Chichester. There has been, it will be observed, considerable variation as regards the number of deaths referred to those causes in one and another year. This feature extends not merely to individual years, but even to periods of years. There is, for instance, notable contrast between the period 1890-95, on the one hand, and 1876-80, or 1896-98, on the other hand. These instances of rise and fall of fever mortality in Chichester are also illustrated in the following table (Table II.), in which the 28 years 1871-98 are grouped in six periods, for each of which is shown the annual death-rate from enteric fever per 1,000 persons living in Chichester; while, for purposes of comparison, like data are furnished for England and Wales as a whole.

TABLE II.

SHOWING, for each of six periods of years, the NUMBER of DEATHS from ENTERIC FEVER, and the annual death-rate per 1,000 living in Chichester from this cause; together with the death-rate from the same cause in England and Wales.

Period.	City of Chichester.			England and Wales; Enteric Fever Death Rate per 1000 living.
	Estimated Population.	Enteric Fever Deaths.	Enteric Fever Death Rate per 1000 living.	
1871-75	7,890	11	0.28	0.37
1876-80	8,020	26	0.65	0.28
1881-85	8,040	17	0.42	0.22
1886-90	7,920	12	0.23	0.18
1891-95	7,760	3	0.08	0.17
1896-98	11,000	21	0.64	0.17

In this table deaths from enteric fever only are reckoned; deaths from continued fever are omitted. Deaths from enteric fever, of persons imported from other districts into public institutions in Chichester, are not included in this table.

It will be observed that the number of deaths from enteric fever is smaller than in Table I. This is because Table I. deals with the extended area comprised in the present City of Chichester, whereas in this table the deaths included anterior to 1893 are those only that occurred in the smaller area that formed Chichester before extension of its boundaries took place. The reason for not dealing throughout, as in Table I., with the larger area is that it was found difficult to ascertain the population of this larger area before it became entirely included in Chichester, and correspondingly difficult, therefore, to arrive at trustworthy estimate of enteric fever death rates in this larger area.

\* Deaths from enteric or continued fever, of persons imported into public institutions in Chichester from other districts, are not included in this table.



From this table it appears that, during the quinquennium 1871-75, the mortality from enteric fever in Chichester was lower than in England and Wales as a whole. In the following quinquennium, however, the death-rate from this cause in Chichester rose far above that of the country as a whole, and did not again fall below that level until 1891-95. This improvement in 1891-95, however, was followed during the period 1896-8 by reversion of Chichester to an enteric fever mortality much higher than that of the country as a whole, the annual death-rate from this cause during that period in the city being 0.64 per 1,000 persons living, while that of England and Wales for the same period was but 0.17 per 1,000 persons living.

Further measure of the prevalence of enteric fever in Chichester in recent years is afforded by the returns of cases of this disease notified as having occurred within the district since 1890, in which year the Local Authority adopted the Infectious Disease Notification Act, 1889. The following list shows the number of these cases notified year by year during the nine years 1890-98, exclusive of cases of the disease imported into public institutions in Chichester from other districts:—

1890 ... ..	7
1891 ... ..	1
1892 ... ..	7
1893 ... ..	7
1894 ... ..	1
1895 ... ..	2
1896 ... ..	116
1897 ... ..	129
1898 ... ..	100

During the five years 1893-97 the mean attack rate from enteric fever in fifty towns in England and Wales is calculated, from returns of notified cases of the disease, to have been 1.03 per 1,000 living per year, while the attack-rate from this disease in Chichester, during the six years 1890-95, was, as may be estimated from the above list, little more than 0.5 per 1,000 yearly. The enteric fever attack rate in Chichester, therefore, during these six years, compares favourably with that of the fifty towns referred to, during the period 1893-97. But in 1896, 1897, and 1898, there was enormous increase in enteric fever prevalence in Chichester, the attack rate from this cause reaching 10.7, 11.4, and 8.7 per 1,000 in these years, respectively.

As regards enteric fever in Chichester prior to 1870, we give no details; noting merely that this fever is known to have been unduly prevalent in the district anterior to that date. That this was so appears from the report made to the Privy Council in 1865 by Dr. Seaton, already alluded to. In that report it is stated that, in Chichester, "diseases directly associated with unwholesome conditions, especially gastric, enteric, or typhoid fever, are never long absent, and sometimes considerably prevail."

It would seem, accordingly, that Chichester has long been noted as exceptionally liable to occurrence of fever in serious amount; but that extra prevalence of fever has occurred at uncertain intervals, there having been, in the past, groups of years characterised by heavy mortality from fever, alternating with other groups of years in which there was relatively small amount of fatal fever.

As with the incidence of the fever in time, so also as regards its incidence on locality; the fever within the area comprised by the present city of Chichester has been irregularly distributed. This will appear on study of the appended spot-maps showing

(1.) The distribution of known cases of enteric fever during each of the three years 1896, 1897, and 1898. (Maps A, B, and C.)

(2.) The distribution of deaths referred to enteric and continued fevers during (a) the period 1870-84 (Map D), and during (b) the period 1885-98 (Map E).

On reference to maps A, B, and C, on which is shown the distribution of known cases of fever in Chichester in each of the years 1896, 1897, and 1898, it will be observed that during those years the fever manifested marked preference for certain localities; and that these localities were much the same in each year. All these localities lie outside that portion of Chichester which is within the line of the old city walls, and are as follows:—

(1.) Somerstown, with some 300 houses (enclosed by a blue line on maps).

(2.) The neighbourhood of Orchard Street and Franklin Place, comprising about 180 houses (enclosed by a green line on maps).

(3.) St. Pancras and the Hornet, comprising about 250 houses (enclosed by a brown line on maps).

(4.) A group of houses in Portfield, about 330 in number (enclosed by a purple line on maps).



It appears also from these maps that the portion of Chichester that lies within the line of the old city walls (enclosed by a pink line on maps), comprising about 680 houses, suffered but little from the fever during the three years in question.

But examination of maps D and E, on which is shown the distribution of deaths referred to enteric and continued fevers during the consecutive periods 1870-84 and 1885-98, tends to suggestion that the distribution of these fevers in the past has not always accorded, as regards locality, with that indicated by maps A, B, and C, as having been manifested in 1896, 1897, and 1898. Map E, which deals with the period 1885-98, does indeed point to a distribution of the disease like to that indicated in maps A, B, and C; but study of map D, which has to do with the period 1870-84, suggests that the distribution of enteric and continued fevers, as evidenced by deaths from these diseases, in that period differed materially from their distribution in the period 1885-98. For in the former period, the area within the line of the old city walls, so far from exhibiting that comparative immunity from the fever which it appears afterwards to have exhibited, would seem to have suffered from it in nearly as great degree as those areas without the line of these walls that have been noted as suffering heavily in 1896, 1897, and 1898.

The distribution of the fever indicated by these maps is set out, as regards the periods under consideration, in the following table (Table III). A chart also is annexed (Chart I.), showing the number of deaths from enteric and continued fevers in Chichester year by year during the period 1870-98 within and without the line of the old city walls.

TABLE III.

SHOWING for the whole of CHICHESTER, and for each of certain areas in CHICHESTER, the total number of houses, and the number of such houses known to have been invaded by ENTERIC FEVER in 1896, 1897, and 1898; and showing also the number of DEATHS referred to Enteric and CONTINUED FEVERS in each area during each of the periods 1870-84 and 1885-98.

Area.	Total Number of houses (1898).	Number of houses known to have been invaded by Enteric Fever in			Number of deaths referred to Enteric and Continued Fevers during	
		1896.	1897.	1898.	1870-84.	1885-98.
Within the old walls ...	682	4	6	13	22	2
Somerstown ...	303	18	36	8	8	11
Portfield ...	335	13	26	21	11	7
St. Pancras and The Hornet	253	21	12	9	11	6
Orchard Street and Franklin Place.	180	11	10	10	5	3
Other areas ...	817	12	11	16	24	10
The whole of Chichester	2,570	79	101	77	81	39

From this table it appears that during the period 1870-84, 81 deaths were referred to enteric and continued fevers in the district comprised by the present city of Chichester, and that during the following period, 1885-98, no more than 39 deaths were referred to these fevers in this district. Further the table shows that of the 81 that occurred during the earlier period, 22 were deaths of persons residing within the line of the old city walls, and 59 were deaths of persons residing without the line of those walls; whereas of the 39 fever deaths during the later period, only two were deaths of persons residing within the line of the old city walls. It has to be borne in mind, indeed, that during the earlier period, the population within the line of the old walls amounted to more than one-fourth of the total population of the district comprised by the present city; but, even if it be taken as having been nearly one-third of this total population, it will be seen that the proportional incidence of fatal fever at that time on the area within the walls was nearly as great as on the areas without the walls. In the later period, the proportion of total fever deaths that occurred within the walls was on the contrary small and inconspicuous. This change of incidence of fatal fever within the limits of the district is also shown, in graphic form, by the accompanying chart. (Chart I.) As regards local distribution of the fever prior to 1870, it is noteworthy that Dr.



Seaton, in his report to the Privy Council, already quoted, states that it was most prevalent about Somerstown, and that "parts of St. Pancras were scarcely less bad." From which it would seem probable that at this still earlier period the local distribution of the fever differed from that of the intermediate period, 1870-84, and bore resemblance rather to that which characterised the later period, 1885-98.

#### CAUSATION OF THE FEVER.

It appears from the foregoing account that in looking for an agency or agencies which shall be held as satisfactorily accounting for fever prevalence in Chichester, several considerations must be borne in mind.

First of these is the fact that undue fever prevalence in Chichester is no new thing, and therefore that explanation of former as well as of recent occurrences of high mortality from this cause is necessary to satisfactory solution of the problem of its causation. It may indeed be that, apart from limited occurrences of fever due to temporary conditions, the more permanent persistence of fever in serious amount in Chichester has been due to more than one agency. This possibility has especially to be borne in mind in regard of the recent re-appearance of fever in epidemic form in the district after a considerable period of comparative quiescence.

It has also to be borne in mind that the fever in Chichester has varied very considerably in amount from time to time, and that, since 1870, there have been two groups of years during which the death-rate from this cause has been below that of England and Wales. In view of the small size of the district and of the population concerned, less significance may be held to attach to this consideration than would otherwise be the case; it is, nevertheless, not devoid of importance. The proclivity of the fever for particular quarters of Chichester has also to be remembered. In this connection the special incidence of the fever on certain areas in Chichester recently manifested in three successive years, as also the diversities of its localisation in earlier years and in recent years, more particularly call for consideration. As with distribution in time, however, so also with distribution in place, the smallness of the areas and populations concerned must not be lost sight of as tending to qualify the value of induction from data of this sort.

With these considerations in mind, the possible agencies of fever prevalence in Chichester may be reviewed in the following order:—

1. Foods (milk; shellfish).
2. Water.
3. Sewerage.
4. Rainfall and subsoil water.
5. Other agencies.

#### FOODS.

Under this heading milk and shellfish will be considered briefly in their possible relationship with fever in Chichester. It is not suggested that either milk or shellfish is to be regarded as an agency accounting for the continuance of unusual amount of fever in Chichester over many years; rather these articles of food require consideration as possibly having had occasional relations of causative sort with fever prevalence. Thus, as regards milk, it appears that in the spring of 1879 an outbreak of enteric fever occurred, regarding which local inquiry was made by Dr. Airy, at that time one of the Board's inspectors. Dr. Airy, as result of his investigations, came to the conclusion that this outbreak was due to infective material conveyed in milk. In all some 50 persons were attacked, and six died. These six persons resided in Westgate and Orchard Street, just without the city walls, and may be noted as mainly constituting the clump of spots shown in and near the Westgate in map D.

There is no record of milk having given rise to other occurrence of fever in Chichester in serious amount during the period 1870-98. In 1896, Dr. Bulstrode made careful investigation in this sense, but found no evidence that milk had had concern with the prevalence of fever in Chichester that year. Like investigation made by us regarding the fever of 1897 and 1898 failed to show any relation between milk and the disease. In both those years the milk supplied to houses invaded by the fever was obtained from some twenty different sources, and in no instance was there special incidence of fever upon houses furnished with milk from any one of these twenty sources.

As regards possible relation between fever and shellfish, the only evidence we have been able to obtain has concern with the outbreak in 1898. In that year 100 cases of enteric fever are known to have



occurred in Chichester. In eighteen of these cases there is history of the attacked persons having consumed cockles, and of this meal having been followed on the same day or on the next day by vomiting and diarrhoea. These symptoms, it is stated, became gradually more marked, and, some ten days after eating the cockles, enteric fever was diagnosed by the medical attendant. But the evidence available, while not inconsistent with the thesis that in some cases the infective material of the fever had been conveyed by cockles, was insufficient to warrant definite conclusion on this subject. It is noteworthy, however, in this connection that many cockles sold in Chichester are derived from mud-flats liable to pollution by sewage; and that the process of cooking to which these shellfish are subjected seldom, if ever, is such as can be trusted to destroy enteric fever bacilli in their interior. Be this as it may, the suggestion of relationship between cockles and enteric fever in 1898 extends to less than one-fifth of the cases known to have occurred in that year.

#### WATER.

At the present time Chichester is furnished with water partly from a public supply, partly from private wells. The analyses, chemical and bacteriological, that have been made of the public supply are consistent with purity of the water, although the circumstances and surroundings of the sources of this supply are not quite satisfactory. The two wells from which the water is pumped are indeed sunk through the Reading Beds to the Chalk, but they are within a few yards of the margin of the Reading Beds, and at this margin the Chalk comes to the surface. Just where the Chalk comes to the surface is a stream polluted by sewage; a condition of things which cannot but be regarded as involving some risk of pollution of the water pumped by the Chichester Corporation from these two wells. The domestic wells that form the remainder of the Chichester supply are sunk in the gravel on which the town stands, and are, by their position and structure, liable, in most instances, to dangerous pollution. Annexed to this report will be found chemical analyses by Sir Edward Frankland, F.R.S., of two samples of well-waters taken by one of us on November 12th, 1898. (*See Appendix A.*) It will be seen that in both instances the analysis indicates a water so polluted as to be unfit for domestic use.

Prior to 1874 the whole of the area comprising the present district of Chichester was supplied with water from domestic wells. In 1874 water began to be furnished from one of the wells constituting the present public supply; water from the other well was first supplied in July, 1898. By 1896 little more than half the houses in Chichester were being furnished with water from the public supply. If, therefore, water has played material part in distribution of fever in Chichester, this part, prior to 1874, had concern, not with the public water supply, which was then non-existent, but with domestic wells only. There was much fever in Chichester for a considerable number of consecutive years after 1874, but there is no evidence as to what proportion of fever cases occurred in houses furnished with the public supply as compared with those having local wells. Evidence of this sort, however, is available for each of the three years, 1896-8. As regards 1896, Dr. Bulstrode notes that 2.6 per cent. of houses furnished with the public water supply were invaded by enteric fever; while 2.9 per cent. of houses with shallow well water were similarly invaded. That is to say, in 1896 the proportional incidence of fever on the two classes of house was practically the same. The following statement indicates what was the incidence of the fever on each of these two classes of house in 1897 and in 1898:—

1897.—Total number of houses in Chichester on July 1st, 1897, 2,540.  
 Number of these houses with public water supply, 1638.  
 Number of these houses supplied by local wells, 902.  
 Number of houses with public water supply invaded by enteric fever, 68, or 4.1 per cent.  
 Number of houses supplied by local wells invaded by enteric fever 33, or 3.6 per cent.

1898.—Total number of houses in Chichester on June 1st, 1898, 2,570.  
 Number of these houses with public water supply, 1705.  
 Number of these houses supplied by local wells, 865.  
 Number of houses with public water supply invaded by enteric fever, 44, or 2.6 per cent.  
 Number of houses supplied by local wells invaded by enteric fever, 32, or 3.7 per cent.



From the foregoing figures it will be seen that in 1897 the proportional incidence of enteric fever on the two classes of house differed but little, and that in 1898, although the resemblance in amount of incidence was not so close, yet the difference was not such as to suggest that one class of water supply had had material concern with dissemination of the fever rather than the other. An hypothesis that in each of these years both the public water supply, and a considerable number of local wells situated widely apart, simultaneously became vehicles for transmission of the infective material of enteric fever, is too remote from probability to require serious consideration. There is not, therefore, ground for belief that water played any notable part as a fever agency in Chichester during the years 1896-8. It is, however, more difficult to arrive at conclusion as to the share water may have had in dissemination of fever in Chichester in years anterior to 1896, and this, because, as already stated, evidence of the sort available for the period 1896-8 is lacking as regards earlier years. It may, indeed, be assumed that for a considerable number of years after 1874, when a public water supply was introduced to the district, most houses continued to derive their water supply from shallow wells, many of them liable to dangerous pollution, a condition of things sufficiently likely to conduce to undue prevalence of enteric fever. It is, however, open to doubt whether, if water had been the main agency of fever dissemination during those earlier years, the very small proportion of deaths from this cause in the area within the line of the old city walls in later years—as for instance during the period 1885-98—was to have been looked for co-incidentally with serious prevalence of fatal fever in other areas in Chichester. For within the old walls, even so recently as 1898, there were no fewer than 120 wells (out of a total of 474 in the whole district), of which the water was the sole supply available to certain premises for domestic purposes; and it may reasonably be supposed that, in years before 1898, the number of such wells within the walls was still greater.

#### SEWERAGE.

Prior to 1895 all houses in Chichester were either undrained or were drained to cesspools. The present sewerage system of the district was commenced in September, 1893, and was not completed until 1895; the first connection of any house to the sewerage system being made in March of the latter year.

So far, therefore, as undue prevalence of fever in Chichester is concerned, the sewerage system as an agency is excluded, unless in the three years 1896-8. If the sewerage system has had material share in propagation of enteric fever in these three years, it may be held that there would be likely to have been a materially greater incidence of the disease on houses connected with the sewers than on those not so connected. As to this the facts are as follows: In regard of fever in 1896, Dr. Bulstrode found that "the percentage incidence on the whole of the undrained houses in the town was slightly in excess of that upon the whole of the drained houses."

As regards fever in 1897 and 1898 the following figures show the relative incidence of the disease on houses draining to the sewers and houses not so drained:—

1897.—Total number of houses in Chichester on July 1st, 1897, 2,540.

Number of these houses drained to sewers, 1,493.

Number of these houses not drained to sewers, 1,047.

Number of houses drained to sewers invaded by enteric fever, 72, or 4·8 per cent.

Number of houses not drained to sewers invaded by enteric fever, 29, or 2·8 per cent.

1898.—Total number of houses in Chichester on June 1st, 1898, 2,570.

Number of these houses drained to sewers, 1,871.

Number of these houses not drained to sewers, 699.

Number of houses drained to sewers invaded by enteric fever, 58, or 3·1 per cent.

Number of houses not drained to sewers invaded by enteric fever, 18, or 2·6 per cent.

In 1898, it will be perceived, the proportion of drained houses invaded by enteric fever was but slightly in excess of the proportion of undrained houses so invaded. In 1897, however, the proportional incidence of the disease was materially heavier on drained than on undrained houses. It was, in fact, nearly twice as heavy on the former class, and in view of this circumstance, it is desirable to consider the relationship of the fever to drained and undrained houses in those particular neighbourhoods where it was most markedly prevalent in Chichester in 1897.

These neighbourhoods, as may be seen from the spot-map for that year (map B), were four in number, viz., Somerstown, Portfield, St.



Pancras and the Hornet, and the vicinity of Orchard Street and Franklin Place. The number of dwellings invaded by the fever in 1897, and the condition of these dwellings as regards drainage, in each of those neighbourhoods, appear in the following table:—

TABLE IV.

SHOWING, for certain areas in CHICHESTER, the total number of Houses in each area (in 1898) together with the number in each instance, of these Houses, invaded by ENTERIC FEVER in 1897.

Neighbourhood.	Total Number of Houses in Neighbourhood (1898)	Number of Dwellings invaded by Enteric Fever.	Number of invaded Dwellings Drained.	Number of invaded Dwellings Undrained.
Somerstown ...	303	36	33	3
Portfield ...	335	26	9	17
St. Pancras and Hornet.	253	12	9	3
Orchard Street and Franklin Place.	180	10	7	3

It appears from this table that the bulk of the incidence of the fever on drained houses in 1897 was in Somerstown, where the number of fever-invaded houses that were drained was eleven times that of fever-invaded houses that were not drained. But it also appears from the table that in Portfield the main incidence of the fever, relative as well as actual, was not on drained houses, but on undrained houses. This contradictory result is not to be looked for if sewerage had been the main agency of fever distribution in 1897. It would, however, be consistent with the operation of some other agency which chanced to display much the same degree of activity in neighbourhoods in which there were unequal proportions of houses drained to sewers; thus bringing about a large number of invasions of drained houses in those districts where connection with the sewers had been generally made, but fewer invasions of drained houses where such connections were scantier. From this point of view the following table is instructive. It gives for each of the three years, 1896, 1897, and 1898, the number of houses connected with the sewers and the number of houses invaded by enteric fever in those years in each of the four neighbourhoods dealt with in Table IV., and also in that part of Chichester which lies within the old walls:—

TABLE V.

SHOWING, for certain areas in CHICHESTER, the total number of houses in each in 1898; and the number of these houses connected with the SEWERS, as also of those invaded by ENTERIC FEVER, in each instance, in each of the three years 1896, 1897, 1898.

Neighbourhood.	Total No. of Houses (1898).	No. of Houses connected with Sewers, June 1, 1896.	No. of Houses invaded by Enteric Fever in 1896.	No. of Houses connected with Sewers, July 1, 1897.	No. of Houses invaded by Enteric Fever, in 1897.	No. of Houses connected with Sewers, June 1, 1898.	No. of Houses invaded by Enteric Fever, in 1898.
Within the old walls.	682	174	4	346	6	425	13
Somerstown...	303	127	18	251	36	285	8
Portfield ...	335	44	13	113	26	178	21
St. Pancras and the Hornet.	253	54	21	114	12	133	9
Orchard Street and Franklin Place.	180	65	11	139	10	154	10

Careful consideration of the figures in this table tends strongly to suggestion that during the three years 1896-8 there has been in Chichester some fever agency acting independently of the sewerage system. As regards that part of Chichester that lies *within the old walls* it will be observed that in 1896 and 1897 the amount of fever was small and practically the same, notwithstanding that in the meanwhile the number of houses within that area connected with the sewers had risen from 174 to 346. In 1898 there was some



increase in the number of houses invaded by the fever in this neighbourhood; not, however, to extent sufficient to render this one of the areas especially affected by the disease in that year.\* As regards *Somerstown*, it is noteworthy that while this district suffered heavily with the fever in 1896 and 1897, yet in 1898 it suffered hardly more in relation to its population than that part of *Chichester* that lies within the old walls. And yet, by 1898, nearly all the houses in *Somerstown* had become connected to the sewers; indeed, of the areas dealt with in the table, *Somerstown*, it will be observed, contains the largest proportion of drained houses. *Portfield*, on the other hand, is a neighbourhood that has been slow to avail itself of the sewerage system, nearly half of the houses in this area still remaining unconnected with sewers on June 1st, 1898. Yet *Portfield* has suffered considerably with the fever in each of the three years 1896-8; more especially in 1897, for which year the incidence of the disease on drained and undrained houses has already been given. *St. Pancras and the Hornet* is another district in which connection of houses with sewers has gone on slowly; at much the same rate, indeed, as in *Portfield*. Here, too, the fever incidence has been considerable; but remarkable in this, that it has declined in amount year by year from 1896 to 1898, notwithstanding that there was going on during these years material addition to the number of houses connected with the sewers. In the neighbourhood of *Orchard Street and Franklin Place* the amount of fever would seem to have remained stationary during the three years, 1896, 1897, and 1898; nevertheless during this period the number of houses connected with the sewers rose from 65 to 154, out of a total of 180 in this area.

The absence of parallelism between the behaviour of the fever in these several neighbourhoods and the sewerage conditions of the areas in question is, in our judgment, not consistent with those conditions having had material concern in dissemination of the disease. Nevertheless we deem it desirable to briefly consider views held in *Chichester*, by persons who maintain that the especial incidence of the fever on certain neighbourhoods is referable to these neighbourhoods being situate on the highest parts of the sewerage system. They contend that sewer air, pressing to the highest parts of the sewerage system, has found outlet there, and has, when charged with the infective material of enteric fever, brought about an outbreak of that disease in those localities where the highest parts of the sewerage system occur. It may very seriously be questioned whether in a system of sewers ventilated as are those of *Chichester*, sewer air would move in the manner claimed; but, however this may be, we have studied the levels of the sewerage system and of the ground in *Chichester* with a view to consideration of how far these levels favour behaviour of the sewer air in the manner suggested. As result we have ascertained the following facts concerning the several neighbourhoods dealt with in Table V.

*Within the old walls.*—In the northern half of this neighbourhood the levels of the sewer-inverts range from 38 to 42 ft. above Ordnance Datum, and the ground surface levels from 45 to 51·5 ft. above Ordnance Datum. In the southern half of this neighbourhood the levels of the sewer-inverts range from 32 to 38 ft., and the ground surface levels from 42 to 48·4 ft. above Ordnance Datum.

*Somerstown.*—The sewer-invert levels range from 36 to 42 ft., and the ground surface levels from 42·8 to 48·5 ft. above Ordnance Datum.

*Portfield.*—The sewer-invert levels range from 38 to 48 ft., and the ground surface levels from 48·3 to 53 ft. above Ordnance Datum.

*St. Pancras and the Hornet.*—The sewer-invert levels range from 37 to 43 ft., and the ground surface levels from 45·4 to 50·9 ft. above Ordnance Datum.

*Orchard Street and Franklin Place.*—The sewer-invert levels range from 28 to 37 ft., and the ground surface levels from 36·5 to 45·7 ft. above Ordnance Datum.

It appears from these data that in *Portfield*, where there has been considerable fever prevalence, the levels of sewer-inverts and of ground surface are decidedly higher than in the other neighbourhoods dealt with. But, on the other hand, *Somerstown*, which suffered so severely with the fever in 1896 and 1897, is on a part of the sewerage system which is no higher than that of the northern half of the area within the

\* It may be observed that of the 13 houses invaded in 1898 in this neighbourhood, four were among those in which the fever was locally referred to consumption of cockles.



old walls, where there has been but little fever; while the ground surface levels of the northern half of the latter area are somewhat higher than those at Somerstown. The neighbourhood of Orchard Street and Franklin Place is, as regards levels of sewers and ground surface, the lowest of all the areas in Table V., and yet this is an area that suffered markedly from fever in 1896, 1897, and 1898. These facts are in direct contradiction to belief that the fever has displayed preference for those neighbourhoods that lie more highly, whether as regards levels of sewer-inverts or of ground surface. And we may cite, as further contradiction of such belief, the small amount of fever during 1896-8 from the upper parts of Broyle Road (north of Infirmary Terrace), where there is (exclusive of the barracks) a population of some 150 persons, and which is the highest part of Chichester, the sewer-invert levels reaching nearly 100 ft. above Ordnance Datum, and the ground surface reaching 105 ft. above Ordnance Datum.

There remains to be dealt with a further local suggestion in this connection; namely, that the sewerage system, while not acting as a direct fever agency, may have brought about the outbreaks of enteric fever in Chichester in 1896, 1897, and 1898, by causing, as result of the necessary excavations, disturbance of soil containing infective material. A hypothesis of this sort, be it observed, does not require a greater proportion of invaded houses among those drained than among those undrained, and to a corresponding extent is difficult either of support or of refutation. If, however, the disturbance of soil caused by laying trenches for sewers had the suggested relationship with fever prevalence, it is difficult to comprehend why outbreak of the disease did not come about sooner. For the sewerage works were commenced in September, 1893, at the sewage outfall works, whence trenching was carried on towards the town, which was reached in January, 1894; and trenching continued in the populous parts of Chichester during 1894 and early in 1895. Nevertheless, only one case of fever is known to have occurred in Chichester in 1894, and two in 1895. By the middle of 1896, when the fever assumed serious proportions, the sewerage system had been completed about a year.

#### RAINFALL AND SUBSOIL WATER.

*Rainfall.*—Appended to this report will be found a record of the daily rainfall in the neighbourhood of Chichester during each of the three years 1896, 1897, and 1898, while the number of notified cases of enteric fever will appear, in weekly periods, from the annexed charts (Charts II. C., D., E.). On these charts are also shown the amounts of weekly rainfall in these years.

In 1896, after three widely separated cases earlier in the year, fever began to be seriously prevalent in Chichester towards the end of May, four cases being notified on May 24th-26th. (See Chart II. C.) These were followed by several more cases, notified on June 5th and days following. If, after infection, some eighteen days be allowed for incubation, diagnosis, and notification of the disease, time-relation between these cases in May and previous rainfall does not appear. For in May, 1896, there was no rainfall, save on the 20th-22nd, when 0.55 inch is recorded as having fallen. It may, however, be contended that time-relation existed between this rainfall and the series of cases in early June referred to, which were notified sixteen to eighteen days after its occurrence. Continuously heavy amount of fever in Chichester in 1896 did not set in until July 7th, and time-relation between this increased activity of fever and occurrence of rainfall during June is not indicated by the chart.

In 1897, after notification of four cases in April and May, fever began to manifest serious tendency to increase on June 12th, between which date and June 25th seven cases were notified. (See Chart II. D.) Continued prevalence of fever in serious amount ensued at the end of June and in early July. Time-relation, however, between these occurrences of fever and preceding rainfall does not appear in the chart; unless the period of incubation of the disease had been unusually short, in which case connection in the above sense may be claimed between these fever occurrences and the rainfall in the last week of May, and on June 17th-19th.

In 1898, after occurrence of a considerable number of scattered cases, fever became and continued seriously prevalent in the commencement of the second week of June. (See Chart II. E.) On May 19th and 20th, some twenty days prior to commencement of this continued prevalence of fever, there had fallen in the neighbourhood of Chichester 0.74 inch of rain. As regards the antecedent fever



cases, these, it may be noted, commenced as early as January 3rd, and are known to have amounted, between that date and June 7th, to no fewer than twenty. Between these earlier cases and occurrence of rainfall no trustworthy time-relation can be traced.

These data as to occurrences of rainfall and of fever in Chichester in 1896, 1897, and 1898, are not, therefore, such as to support inference that in these years there has been sustained association of these conditions in the sense of cause and effect. The evidence, however, does not preclude possibility of there having been occasional relationship of the sort.

*Subsoil water.*—On Charts II., A., B., C., D., E., the weekly variations of level of subsoil water in Chichester are shown for the period June, 1894, to December, 1898. These variations are shown for weekly, not daily, periods, for the reason that the observations on which the chart is based had been made only once a week. The record, therefore, shown in diagrammatic form on the series of charts, is to be taken as showing, not all the oscillations of level of the subsoil water, but merely its general curve of rise and fall throughout the period dealt with. Comparison of this curve with the weekly occurrences of fever exhibited upon the chart shows that the outbreaks of enteric fever in 1896 and 1897 commenced in each instance when the level of the subsoil water was falling with some rapidity: but that in 1898 the serious prevalence of fever occurred at a time when the level of the subsoil water was indeed falling, though its fall was very slight.

As regards the actual level of the subsoil water at the times of occurrences of fever, 1898 differs materially from 1897 and 1896, as is seen in the series of charts. For, in 1898, when fever became seriously prevalent, the level of the subsoil water was not quite 28 ft. above Ordnance Datum, whereas, at the times of like occurrences in 1896 and 1897, it was 32 ft. and 32.5 ft., respectively, above Ordnance Datum. Furthermore, it is worthy of note that while there was in 1895 and 1896 considerable resemblance between the general lines of rise and fall of subsoil water, there were, in 1895, but two known cases of enteric fever in Chichester, whereas in 1896 there were 116 such cases. These data are not such as to encourage belief that there has been definite relation between the general rise and fall of subsoil water in Chichester and the occurrence of enteric fever there in 1896, 1897, and 1898.

In this connection it may be noted that there is some local belief in Chichester that enteric fever is apt to appear in this district when the subsoil water, after having submerged the sewers, falls again below their level. With a view to ascertaining if relation of this sort could be made out, the variations of level of subsoil water in the Portfield district, as recorded by weekly gaugings of a well there, have been considered in connection with sewer levels in that neighbourhood. The record in question extends from the latter part of June, 1894, to the end of May, 1898, and it shows that the subsoil water was above the level of the sewer invert on the following dates:—

November 26 and December 3; 1894.

January 7, 14, 21, 28; 1895.

February 4, 11, 18, 25; 1895.

January 25; 1897.

February 1, 8, 15, 22; 1897.

March 1, 8, 15, 22, 29; 1897.

April 5, 12, 19, 26; 1897.

It appears from this record that the Portfield sewers were submerged by the subsoil water in certain weeks in the end of 1894 and the beginning of 1895, the water falling below their level subsequent to February of the latter year. In 1895 two cases of enteric fever are known to have occurred in Chichester, one in September, the other in October; of these, the September case was in Portfield. So far as can be gathered from the weekly gaugings, the subsoil water had been three or four feet below the sewer-invert levels for some four months before this case occurred. In 1896, when thirteen houses in Portfield were invaded by enteric fever, the subsoil water is not recorded by these gaugings as having submerged the sewers in that neighbourhood at any time. In 1897 the Portfield sewers seem to have been submerged during February, March, and April; and in that year a case of fever occurred in Portfield on April 12, followed by two more in May. In later months several more cases occurred; twenty-six houses in all being invaded. In 1898, up to the end of May, when the record of weekly gaugings of the Portfield well ceases, the subsoil water is not recorded as having risen to within six feet of the sewer-inverts. Nevertheless in this year twenty-one houses in Portfield were invaded by enteric fever.



The subsoil water levels shown on the series of charts were obtained from gaugings of a well situated near the Chichester Cattle Market. This well was selected as being more centrally situated than any other in Chichester of which gaugings were available. Near this well the level of sewer-inverts is about 34 ft. above O.D., and there, as may be observed by reference to the series of charts, the subsoil water is recorded as having been above the level of sewer-inverts one week in January, 1895, and during most weeks of February and March, 1897, but not in either 1896 or 1898.

These facts do not afford support to the hypothesis that occurrence of enteric fever in Chichester has had relation with the submergence of sewers by the subsoil water.

The relations of subsoil water levels to ground surface levels also require brief reference. The well, from the gaugings of which the subsoil water levels shown in Charts II., A., B., C., D., E. were derived, is situated near Chichester Cattle Market, on the south-eastern border of the area described in this report as *within the line of the old walls*. The ground surface level at the mouth of the well is 45.48 ft. above Ordnance Datum. From consideration of the subsoil water levels shown on the series of charts, it accordingly appears that these levels ranged between 11 and 19 ft. below the ground surface level. Weekly gaugings of a well in the *Somerstown* neighbourhood indicated that there the subsoil water levels ranged between 3 and 11 ft. below the ground surface level. As, however, the record of gaugings from this well ceases in October, 1895, the lower limit of subsoil water level there is not strictly comparable with the lower limit indicated in the Cattle Market well; since the subsoil water levels in Chichester in 1897 and 1898 touched a lower point than in 1894, 1895, or 1896. Weekly gaugings of a well in *St. Pancras* indicated that the subsoil water levels ranged from 6 to 18 ft. below the level of the ground surface. Similar observations of a well in *Portfield* showed the subsoil water levels there as having ranged between 11 and 20 ft. below the ground surface level. The gaugings of a well in one of the areas in Chichester (*Whyke*) which has in recent years been characterized by comparative immunity from the fever, indicated that the levels of the subsoil water below the ground surface ranged from 8 to 16 ft. These comparative figures as to subsoil water levels in reference to the ground surface in different parts of Chichester do not appear to indicate relation between these conditions and fever prevalence.

#### OTHER FEVER AGENCIES.

From the foregoing facts and considerations it does not appear that sufficient explanation of the continued recurrence of serious prevalence of enteric fever in Chichester is to be found in relation with any of the fever agencies hitherto discussed.

Neither milk nor shellfish can be regarded as having been associated in any notable degree with the recurrent outbreaks of enteric fever in the district.

The evidence is not consistent with water having been a main factor in dissemination of the disease in recent years; while, as regards occurrences of fever in former years, the available data do not afford ground for definite conclusion on the subject.

For fever in those earlier years, the sewerage system, then not existent, cannot be held responsible, while the evidence furnished as regards recent outbreaks does not point to material concern, direct or indirect, of the sewerage system with these occurrences of fever.

Sustained relation between rainfall and fever prevalence is not suggested by the evidence, although there may have occurred from time to time direct association of one with the other.

The weekly records of the fluctuation in level of subsoil water do not indicate connection between these fluctuations and outbreaks of the fever, although it has to be borne in mind that more exact data such as would have been afforded by record of daily variations in the levels of subsoil water might have supplied indications not apparent in the weekly curves. Be this, however, as it may, indication of correlation between either rainfall or subsoil water fluctuations and occurrences of fever, would be but one step towards complete explanation of the frequently recurrent activity of the infective material of enteric fever in Chichester. The reason for the presence of this material in this district in the amount or in the quality sufficing for repeated manifestation of fever there, would still be to seek.

Of the known agencies of enteric fever other than those already discussed, but one remains for consideration: and to that one, or failing it, to some causative condition as yet unrecognised, we are driven by a process of exclusion. This agency, yet remaining for consideration, is soil. It may be that the conditions of the soil upon which Chichester, or some



portions of Chichester, stand, are such as to foster in a higher degree than do those obtaining in most soils, the vitality and morbid power of the infective material of enteric fever. Present knowledge as to what may be the particular soil conditions favourable or unfavourable to this infective material is somewhat scanty. The researches of Dr. Sidney Martin and Dr. Robertson seem to indicate that soils rich in organic matter are more favourable to the vitality and growth of the bacillus of enteric fever than are soils in which there is little or no organic matter; and they afford also some information as to the influence of temperature, moisture, and the presence of other bacteria on the growth of this bacillus in soil. As regards the first of these conditions, that, namely, concerned with the presence of organic matter in the soil, there would seem to be good reason for belief that the ground on which the more populous parts of Chichester stand is fouled, and has long been fouled, to considerable extent in this way. For, in addition to the soakage of surface filth into the soil, usual in populous neighbourhoods, Chichester suffers from an additional source of soil pollution in the leaky cesspools and cesspit-privies which, until some three years ago, formed the sole methods of disposal of all its excrementitious matters; and which, even now, remain in the district in considerable amount. In so far, therefore, as the amount of organic matter in soil may reliably be gauged by the potential sources of pollution of that soil, Chichester may be regarded as presenting this condition more markedly than do many other town districts. It is, however, necessary not only to consider Chichester in this aspect as compared with other places, but also to compare several areas in the city, one with another, as regards degree of liability of the soil to fouling; and this because of the manner of distribution of fever in Chichester in recent and in former years, and also because of the periods of comparative quiescence of fever in this district, alluded to earlier in this report.

This comparison cannot, with our present means of knowledge, be made with accuracy. But consideration of the relative amount of poverty in several areas in Chichester may cast some light on this matter; since, as a rough guide to the amount of potential soil pollution in urban communities, it may be generally accepted that the poorer the neighbourhood the greater will these potentialities be. In Chichester, the poorest neighbourhood is St. Pancras, while Somerstown and Portfield are of somewhat better class. The area that lies within the old walls comprises, on the whole, fairly good class dwellings; with, however, the exception of one or two streets which are of no better quality than those in St. Pancras. The Orchard Street and Franklin Place area is, at the Orchard Street end, much like Portfield; while houses in the neighbourhood of Franklin Place are of better class. As regards fever prevalence in recent years, the areas in Chichester that have suffered most have been Somerstown, Portfield, St. Pancras and the Hornet, and Orchard Street and Franklin Place; while within the old walls there has been but little fever. The four first-mentioned areas have been set down in the order which, as regards proportional amount of fever, they suffered; there is, however, but little difference in this respect between one and another of these areas. In the main, therefore, the distribution of fever in Chichester in recent years would seem to have been such that the poorer neighbourhoods, in which fouling of the soil is likely to be greater than elsewhere, suffered most heavily. But it is noteworthy that, as regards fever in Chichester in earlier years, a like distribution is not observable during the period 1870-84. During this period the area that lies within the line of the old walls suffered with fever in nearly the same proportion as the rest of the district, and this, notwithstanding that at that time the character of the population in each of the several areas under consideration would seem to have been much the same as in recent years. Nor does the fever seem to have exhibited preference, during this period, for the poorest neighbourhoods in the area within the line of the old walls.

Indication as to the degree of potential soil pollution in these areas may also be hoped for from consideration of the methods of excrement disposal in them: and, accordingly a statement of the proportion of houses in each area still draining to cesspools or served by cesspit-privies, at the end of 1898, here follows:—

—	Proportion of Houses Draining to Cesspools.	Proportion of Houses with Cesspit Privies.
	Per cent.	Per cent.
Within the Old Walls ... ..	4·8	22
Somerstown ... ..	0·3	4·3
Portfield ... ..	3	14
St. Pancras and the Hornet ... ..	none	23
Orchard Street and Franklin Place ...	none	6



It appears, therefore, that at the end of 1898, the area within the old city walls had somewhat the largest proportion of houses either drained to cesspools or served by cesspit-privies, while St. Pancras and Portfield came next in this respect. Obviously, however, this state of matters at the end of 1898, in a town such as Chichester, with a recently introduced sewerage system, cannot be taken as a guide to what existed even a few years ago. Prior to the introduction of the sewerage system in 1895, houses were served either by water-closets drained to cesspools which would seem to have allowed most part of their contents to escape into the surrounding soil, or by cesspit-privies, also of leaky sort. By which of these two methods of excrement disposal the greater amount of soil pollution would be brought about is difficult to say; nevertheless, the degree to which one or other method formerly obtained in the several neighbourhoods under consideration, may here be stated. From information furnished on this subject it would seem that, prior to the introduction of the sewerage system in Chichester, houses in the area within the line of the old walls either drained to cesspools or had cesspit-privies, with, however, a majority of the former class. Somerstown, Portfield, St. Pancras, Orchard Street and Franklin Place, were almost entirely cesspit-privy districts. The Hornet, however (comprised in the area of St. Pancras and the Hornet), had about as many houses furnished with water-closets draining to cesspools as with cesspit-privies. It appears, therefore, that in recent years the fever has, in the main, chiefly affected those of the areas under consideration that may be termed cesspit-privy neighbourhoods, appearing in less degree in the area within the walls where cesspools, as well as cesspit-privies, abounded. But this apparent preference of the fever for cesspit-privy neighbourhoods does not extend to those parts of Chichester not included in the several areas selected for special consideration. Those other parts, which were mainly cesspit-privy neighbourhoods, have had but little fever in recent years. An illustration of this is afforded by the neighbourhood of *Whyke*; an area with some 420 houses, lying to the south-east of the central portion of Chichester. This area was formerly served almost entirely by cesspit-privies. Nevertheless in the three years 1896-7-8, but 15 houses in *Whyke* are known to have been invaded by the fever. It has also to be borne in mind that during the earlier period 1870-84, cesspool and cesspit-privy neighbourhoods seem to have suffered from fatal fever in much the same degree.

These considerations as to the degree of potential soil pollution in Chichester, and in several particular areas in Chichester, regarded in relation with the varying preference of enteric fever now for one and now for another area, together with occasional periods of comparative immunity of the whole district from this disease, do not favour belief that these potentialities as to soil pollution are in themselves sufficient explanation of the long continuance of this fever in serious amount in Chichester. And, indeed, although these potentialities have been and still are, in Chichester, greater than they should be, and although they are greater than in many other urban communities, yet it is difficult of belief that there are not still other towns in this country where these potentialities are as great as in Chichester, but where, nevertheless, fever has not prevailed to so serious an extent. Further knowledge, therefore, would seem necessary for discovery of the causation of the serious prevalence of enteric fever in Chichester. Thus, it does not necessarily ensue that two soils subject to the same degree of potential pollution, do, in effect, become and continue equally polluted. It may well be, and is, indeed, even to be anticipated, that polluting matters disappear more readily from some soils than from others; so that the latter, even when subject to the same degree of pollution, nevertheless are in a habitually fouler condition than the former. But how this may be in Chichester we know not. It is known that for the most part Chichester stands on surface mould and gravel overlying the London and Reading Beds; but it is not known what is the thickness of this sheet of gravel save at one or two points, nor what, if any, variation there may be in the character of this gravel. There is like want of knowledge as to variations in quantity and quality of the surface mould covering the gravel. Nor is it known what may be the influence, as compared with that exercised by other soils, of such a soil as that underlying Chichester upon organic matter reaching it, in the way of bringing about conditions more or less favourable to the viability and morbid power of the infective material of enteric fever.

The above, however, constitute but a small part of the total conditions appertaining to soil, regarding which there is no adequate knowledge, but which may count for much in determining its suitability or otherwise as a medium for the life and growth of the enteric fever bacillus. Thus there is some knowledge, as already stated, concerning the degree of moisture of



soil and the degree of soil temperature best adapted to this organism; but as to the qualities of Chichester soil in these respects no information is available. Again, the relations between the enteric fever bacillus and other micro-organisms in soil may conceivably have important bearing on the life and activity of the former. Some soils may contain organisms obnoxious to the enteric fever bacillus, others may contain organisms that encourage the growth or intensify the virulence of that bacillus. Yet of this aspect of the matter all but nothing is known.\*

In our judgment, hypothesis that the prevalence of enteric fever in serious amount in Chichester is referable to the existence there of soil conditions especially favourable to the viability and growth of the infective material of this disease, is not inconsistent with the facts ascertained by us and set out by us in this report. But, on the other hand, such hypothesis, while not inconsistent with these facts, does not at present afford adequate explanation of features that have characterised the fever in its distribution in time and place in Chichester. Fuller knowledge of soil conditions in their relations with fever prevalence may account for these features; without that knowledge it is not possible to arrive at definite conclusion.

The likelihood of acquiring such knowledge would be materially enhanced by widening the scope of inquiry directed to this end. Investigation, in this connection, of the circumstances of certain places other than Chichester, may be looked to as not unlikely to afford helpful information on this subject. As instance, careful comparison of the similarities and dissimilarities in local conditions obtaining in places exceptionally prone to enteric fever with those obtaining in places that suffer but little from enteric fever, would seem to be indicated. Such investigations would need to be supplemented by skilled research on the part of the statistician, the geologist, the chemist, and the bacteriologist, and would entail prolonged and arduous labour in all their aspects. They are, nevertheless, in our judgment, urgently called for in the interests not only of Chichester but also of not a few other localities in this country where enteric fever is endemically prevalent in such amount as to take, year after year, a toll of deaths greatly in excess of the proportion claimed by this disease in England and Wales as a whole.

We desire to express our thanks to the following persons for information furnished by them to us in relation to matters concerned with our inquiry:—Mr. Arnold, Town Clerk of Chichester\*; Sir Robert Raper, Superintendent Registrar of certain districts near Chichester; Dr. Jones, the Medical Officer of Health for Chichester. Our thanks are also due to Mr. Baldwin Latham, M.Inst.C.E., for the valuable information regarding fluctuations in the level of subsoil water at Chichester, quoted in this report. We would also especially record our sense of obligation to Mr. Saunders, the City Surveyor, to whom we are indebted not only for much statistical and other information, but also for work done by him in connection with the maps contained in this report, and for sustained assistance throughout the course of our inquiry.

THEODORE THOMSON.  
J. T. MARSH.

June 12th, 1899.

#### POSTSCRIPT ON ENTERIC FEVER IN CHICHESTER IN 1899; BY DR. THEODORE THOMSON.

THE year 1899 has been, like the three years immediately preceding it, marked by recurrence of enteric fever in Chichester in notable amount. By the end of September, 76 cases of this disease had been notified to the local authority as having occurred within their district—exclusive of cases imported into public institutions in Chichester from other districts. Six of these cases occurred

\* Account of interesting researches on this subject by Dr. Sidney Martin will be found in the forthcoming Report of the Medical Officer to the Local Government Board, 1898-99.

\* While this report is passing through the press, we regret to learn that Mr. Arnold has unhappily died.



during March and April; the remainder as shown in the following weekly periods.

During the week ending May	6	...	...	3
" " "	13	...	...	4
" " "	20	...	...	7
" " "	27	...	...	4
" " "	June 3	...	...	11
" " "	10	...	...	7
" " "	17	...	...	7
" " "	24	...	...	6
" " "	July 1	...	...	1
" " "	8	...	...	1
" " "	15	...	...	2
" " "	22	...	...	7
" " "	29	...	...	1
" " "	August 5	...	...	1
" " "	12	...	...	1
" " "	19	...	...	-
" " "	26	...	...	-
" " "	September 2	...	...	2
" " "	9	...	...	2
" " "	16	...	...	3
" " "	23	...	...	-
" " "	30	...	...	-

The majority of the cases, it will be seen, occurred during the months of May and June.

During these nine months of 1899, eleven deaths were referred to enteric fever in Chichester: a fatality rate of 14·5 per cent.

The most noteworthy feature of the fever of 1899 has concern with its distribution in place; which was remarkable in this, that the comparative immunity of the area within the line of the old walls from the disease, noted as having obtained in recent years, is no longer evident.\*

The following short tabular statement indicates the incidence of the fever of 1899 on houses in the whole of Chichester, as well as in certain areas, already specially referred to in the foregoing Report.

SHOWING for the whole of CHICHESTER, and for each of certain areas in CHICHESTER, the total number of houses and the number of such houses known to have been invaded by ENTERIC FEVER during the nine months January to September, 1899.

Area.	Total Number of Houses.	Number of Houses known to have been invaded by Enteric Fever, January to September, 1899.
Within the Old Walls ... ..	682	16
Somerstown ... ..	303	6
Portfield ... ..	335	6
St. Pancras and the Hornet ...	253	13
Orchard Street and Franklin Place	...	5
Other Areas ... ..	827	12
The whole of Chichester ... ..	2,580	58

It will be seen from the above table that the area within the old walls not only suffered proportionally as much from the fever as the whole of Chichester; but also relatively more than some of the other areas for which the disease has in recent years manifested a marked preference. The area which continues to show a comparatively high incidence of the fever is St. Pancras; which is, it will be remembered, the poorest neighbourhood in Chichester. It may be noted that in the neighbourhood of Whyke, an area referred to in the body of the Report, only 5 houses out of a total of some 420 houses in that area, were invaded by the fever in 1899.

Of the total number of houses in Chichester, 1,971 were receiving the public water supply on May 1st, 1899; while 609 derived their water from private wells. Of the former class of house 41, or 2·1 per cent., were invaded by the fever; of the latter class 17, or 2·8 per cent. were invaded. There was, therefore, a somewhat greater

\* It is noteworthy that the incidence of fever in 1899 has been greater in the north-western quarter of the area *within the line of the old walls* than on other portions of this area. Also that the fever, in this year, exhibited marked preference for the poorer neighbourhoods in this area.



incidence of the disease on houses deriving their water from private wells than on houses supplied from the public service.

The number of houses in Chichester drained to sewers on May 1st, 1899, was 2,133: the number of houses not so drained was 447. Of houses drained to sewers, 49, or 2·3 per cent., were invaded by the fever; while of houses not so drained, 9, or 2 per cent., were invaded. The relative incidence of the disease, therefore, on these two classes of houses was almost the same.

Investigation failed to reveal relation of causative sort between milk supply and the fever.

During May and June, when the fever prevalence was at its height in Chichester, there was considerable suspicion locally that the consumption of cockles, infected with the specific contagium of enteric fever, was responsible for the occurrence of no small number of cases of the disease. As result of careful inquiry it appeared probable that certain persons had actually contracted the fever in this way. Investigations on this subject were made locally in late July and early August, by which time nearly 70 cases of enteric fever had been reported to the local authority. As regards these cases it appeared that in 20 instances cockles had been partaken of within a month of the onset of illness: the remainder of the persons attacked by the fever had not partaken of cockles within that period. Of the 20 referred to, 18 had eaten of cockles within 3 weeks of attack. In some instances, however, this relation in time between consumption of cockles and occurrences of the fever constituted the only apparent ground for attributing the latter to the former. But, as regards 13 of these 20 persons, probability of causal connection was indicated by other evidence; such as nearly simultaneous onset of symptoms of the fever in two or more persons who had partaken together of cockles some ten or fourteen days previously; or the occurrence, within 24 hours of consumption of cockles by several persons, of sickness, followed, a week or two later, by development of enteric fever in one or more of the consumers. In most instances it proved impossible to ascertain whence the cockles had been derived: but, as noted in the body of the Report, many cockles known to be obtained from mud-flats liable to pollution by sewage, are sold in Chichester. The share of the fever, however, which can reasonably be referred to consumption of cockles, is but small. The 13 cases referred to occurred in 4 houses: the remaining 7 cases, regarding which evidence of causal connection between the fever and consumption of cockles is less trustworthy, involved other 4 houses.

THEODORE THOMSON.

October 2nd, 1899.



## APPENDIX A.

### DRINKING-WATER.

#### *Memorandum No. 3.—Previous Sewage or Animal Contamination.*

THERE is reason to believe that the excrementitious matters which exist in sewage are often possessed of intensely infectious properties; and that sewage mixing with water, even in the minutest proportion, is likely, by such properties, to spread particular diseases among populations which drink the water.

Thus is explained the peculiar power which impure waters have been shown to exercise on many occasions, in promoting great epidemics of typhoid fever and cholera.

The existence of an infectious property in water cannot be proved by chemical analysis, and is only learnt, too late, from the effects which the water produces on man. But though chemistry cannot prove any existing infectious property, it can prove, if existing, certain degrees of sewage-contamination. And every sewage-contamination which chemistry can trace ought, *prima facie*, to be held to include the possibility of infectious properties.

Nearly the whole of the animal matter which gains access to drinking-water consists of sewage, that is,—solid and liquid excrement.

The column headed "Previous Sewage or Animal Contamination," in the accompanying analytical table, expresses in terms of average London sewage, the amount of animal matter with which 100,000 lbs. of each water was, at one time or other, contaminated. Thus 100,000 lbs. of the water of Well B at Chichester had been polluted with an amount of animal matter equal to that contained in 18,958 lbs. of average London sewage. So far as chemical analysis can show, nearly the whole of this animal matter had been oxidized and converted into mineral and innocuous compounds at the time the analysis was made: there is, however, always a risk lest some portion (not detectable by chemical or microscopical analysis) of the noxious constituents of the original animal matters should have escaped that decomposition which has resolved the remainder into innocuous mineral compounds. But this evidence of previous contamination implies much more risk, when it occurs in water from rivers and shallow wells, than when it is met with in the water of deep wells, or of deep-seated springs. In the case of river water there is great probability that the morbid matter sometimes present in animal excreta will be carried rapidly down the stream, escape decomposition, and produce disease in those persons who drink the water; as the organic matter of sewage undergoes decomposition very slowly when it is present in running water. In the case of shallow-well-water, also, the decomposition and oxidation of the organic matter are liable to be incomplete during the rapid passage of polluted surface water into shallow wells. In the case of deep-well and spring water, however, if the proportion of previous contamination do not exceed 10,000 parts in 100,000 parts of water, this risk is very inconsiderable, and may be regarded as *nil* if the direct access of water from the upper strata be rigidly excluded; because the excessive filtration to which such water has been subjected in passing downwards through so great a thickness of soil or rock, and the rapid oxidation of the organic matters contained in water when the latter percolates through a porous and aerated soil, afford a considerable guarantee that all noxious constituents have been removed.

It follows from what has been already stated that chemical analysis cannot discover the noxious ingredient or ingredients in water polluted by infected sewage or animal excreta; and as it cannot thus distinguish between infected and non-infected sewage, the only perfectly safe course is to avoid altogether the use, for domestic purposes, of water which has been polluted with excrementitious matters.

This is the more to be desired because there is no practical process known, whereby water, once contaminated by infected sewage, can be so purified as to render its domestic use entirely free from risk.

Nevertheless, as it is very difficult in some localities to obtain water which has not been more or less polluted by excrementitious matters, it is desirable to divide such previous contaminated drinking waters into three classes, viz.:—

1. Reasonably safe water.
2. Suspicious or doubtful water.
3. Dangerous water.

*Reasonably Safe Water.*—Water, although it exhibits previous sewage or animal contamination, may be regarded as reasonably safe when it is derived either from deep wells (say 100 feet deep), or from



deep-seated springs; provided that surface-water be carefully excluded from the well or spring, and that the proportion of previous contamination do not exceed 10,000 parts in 100,000 parts of water.

*Suspicious or doubtful water* is, 1st, shallow-well, river, or flowing water which exhibits any proportion, however small, of previous sewage or animal contamination; and, 2nd, deep-well or spring water containing from 10,000 to 20,000 parts of previous contamination in 100,000 parts of water.

*Dangerous water* is, 1st, shallow-well, river, or flowing water which exhibits more than 20,000 parts of previous animal contamination, is 100,000; 2nd, shallow-well, river, or flowing water containing less than 20,000 part of previous contamination in 100,000 parts, but which is known from an actual inspection of the well, river, or stream, to receive sewage, either discharged into it directly, or mingling with it as surface drainage. 3rd. As the risk attending the use of all previously contaminated water increases in direct proportion to the amount of such contamination, deep-well or deep-seated spring water exhibiting more than 20,000 parts of previous contamination in 100,000 must be regarded as dangerous. River or running water should only be placed in the second-class provisionally, pending an inspection of the banks of the river and tributaries; which inspection will obviously transfer it either to the class of reasonably safe water if the previous contamination be derived exclusively from spring water, or to the class of dangerous water if any part of the previous contamination be traced to the direct admission of sewage or excrementitious matters.

E. FRANKLAND,  
Analytical Laboratory,  
The Yews,  
Reigate, Surrey.

#### Water-Analysis Laboratory,

The Yews, Reigate,  
November 19, 1898.

SIR,

Herewith I enclose results of analysis of the two samples of shallow well water which you sent here for examination from Chichester.

Both these waters contain only a small proportion of organic matter, but they are derived from very impure sources, and the organic matter is of animal origin. Well B. is the worst. Nearly one-fifth of the water of this well has been in the condition of average London sewage.

The water of both wells is dangerous to health, and therefore unfit for domestic use. Both wells ought to be closed.

I am, Sir,  
Your obedient servant,  
E. FRANKLAND.

Col. J. T. Marsh, R.E.

#### RESULTS OF ANALYSIS EXPRESSED IN PARTS PER 100,000. Collected by COL. MARSH, 12th November, 1898.

Number of Sample.	Description.	Total solid Matters.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Total Combined Nitrogen.	Previous Sewage or Animal Contamination.	Chlorine.	Hardness.			Remarks.
										Tempor-ary.	Perman-ent.	Total.	
11,023	A. Well in Chichester.	33.12	0.32	0.03	0	7.28	7.36	7,248	2.4	15.3	5.3	23.6	Turbid.
11,024	B. Do. do.	52.80	0.65	0.12	0	1.887	1.899	18,053	4.6	28.8	5.6	31.4	{ Slightly turbid.

E. FRANKLAND,  
The Yews,  
Reigate.



## APPENDIX B.

RAINFALL FOR 1896 ; IN INCHES.  
Recorded at Chichester Sewage Works.

Date.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	·04	...	·05	...	...	...	...	...	·71	...	·02	·15
2	...	...	·05	...	...	...	·13	...	·44	...	·02	·66
3	...	...	·21	...	...	...	·04	...	·34	·20	...	·23
4	...	...	·26	...	...	·29	...	...	·92	·07	...	·80
5	...	·02	...	...	...	...	...	...	·06	·31	...	·32
6	...	...	·03	...	...	...	...	...	...	·76	...	·18
7	...	...	·16	...	...	·26	...	...	...	·14	·25	...
8	...	·05	·16	...	...	·10	...	·04	·38	·10	·05	·16
9	...	...	·01	...	...	...	...	·07	·02	·03	...	...
10	...	...	...	...	...	1·40	...	...	·72	...	...	·12
11	...	...	·08	·02	...	...	...	...	·31	...	...	·06
12	·05	·02	·08	·05	...	...	...	...	·95	·15	...	·17
13	·10	...	...	·08	...	...	...	...	·28	·06	·04	·81
14	·05	...	...	·15	...	...	...	...	·01	·08	·32	·01
15	·01	...	·06	...	...	...	...	...	·25	·03	·18	...
16	...	...	·03	·06	...	...	·02	...	...	·33	...	...
17	...	...	·20	...	...	·11	...	...	·36	·10	...	...
18	·03	...	·22	·03	...	...	...	·11	·05	·30	·05	...
19	...	·05	Nil	...	...	...	...	·05	...	·09	·06	...
20	·02	·37	1·06	...	·11	...	...	...	...	...	...	...
21	...	·04	·02	...	·32	...	...	...	·42	...	...	...
22	·02	...	...	...	·12	...	...	...	·35	...	...	...
23	...	...	...	...	...	...	...	...	...	...	...	...
24	·15	...	...	...	...	·03	...	·20	·84	·19	...	·28
25	·40	...	...	...	...	...	...	·34	·03	·10	...	·02
26	...	...	·15	...	...	...	·80	·05	·20	·31	...	·05
27	·13	·03	...	...	...	...	...	...	·09	...	...	·09
28	...	...	1·23	...	...	...	...	...	·02	...	...	·09
29	...	·03	·08	...	...	...	·16	...	·11	·03	...	·06
30	...	...	Nil	...	...	...	·04	·38	...	...	...	·06
31	...	...	...	...	...	...	·11	·22	...	...	...	·09
	1·00	·61	4·14	·39	·55	2·19	1·33	1·46	7·86	3·40	·99	4·41

E. L. SHERA.

RAINFALL FOR 1897 ; IN INCHES.  
Recorded at Chichester Sewage Works.

Date.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	...	·74	·71	·07	...	·08	...	...	·45	...	...	...
2	...	·40	·60	·11	·04	·02	...	...	·16	·14	...	...
3	...	·05	...	·16	...	...	...	...	·03	...	...	...
4	·11	·90	·06	...	·12	·06	...	...	·30	...	...	...
5	·10	·15	...	...	·05	...	·06	...	·50	...	...	·08
6	·28	·05	...	·21	·01	...	·01	...	·02	...	...	·10
7	·45	...	...	·02	...	...	...	...	...	...	·38	·52
8	·72	·15	...	...	...	·71	...	·45	·20	...	·05	·06
9	·03	·02	·25	·05	...	·92	...	...	·06	...	...	...
10	·18	·32	·03	...	·02	...	...	...	...	...	...	·40
11	...	·10	·45	·02	...	...	...	...	...	...	·01	·30
12	...	...	·05	·09	...	...	...	...	...	...	...	·25
13	·02	·05	...	·02	...	...	...	·02	...	·11	...	·14
14	...	...	·51	...	...	...	...	...	...	·03	·36	·18
15	...	...	·18	·19	...	...	...	...	...	·08	...	·02
16	...	...	·22	·25	...	...	...	...	·15	...	·05	...
17	...	...	·25	·20	...	·16	...	·08	·42	...	...	...
18	...	·02	·07	...	...	·05	...	·06	...	·03	...	...
19	·13	·16	...	·19	...	·28	·03	·11	·07	·01	...	...
20	...	·07	...	·03	...	...	...	·12	...	...	...	...
21	·04	...	·07	·09	...	...	·52	·02	...	...	...	...
22	·03	...	...	...	...	...	...	...	·09	...	...	...
23	...	...	...	...	...	...	...	·01	·02	...	...	...
24	...	...	...	...	...	...	...	·26	·02	...	·13	...
25	...	...	...	...	...	...	...	·17	·02	·12	...	...
26	...	...	...	...	·07	·62	...	·28	...	...	·03	...
27	...	...	...	...	·07	...	...	...	·25	...	·45	·25
28	...	·14	·07	...	·06	·45	...	·03	...	...	·07	·17
29	·14	...	...	...	·20	...	...	·07	·12	...	·03	·20
30	·06	...	...	·15	·27	...	...	·36	...	...	·42	·08
31	·44	...	·40	...	·23	...	...	·32	...	...	...	·30
	2·73	3·21	3·92	1·85	1·14	3·35	·62	2·36	2·88	·52	1·98	3·05

E. L. SHERA.



RAINFALL FOR 1898; IN INCHES.  
Recorded at Chichester Sewage Works.

Date.	Jan.	Feb.	Mar.	April.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	.16	.07	.11	...	.20	.03	.10	...	...	...	.13	...
2	...	...	...	...	.02	...	...	...	...	...	.27	...
3	.01	.06	.17	...	.42	...	...	.07	...	...	.10	...
4	...	.05	...	...	.02	...	...	...	...	...	...	...
5	.37	.21	.04	...	.46	...	...	.01	...	...	.07	...
6	.10	.01	...	...	...	.45	...	.05	...	...	...	...
7	...	...	...	...	...	...	...	.60	...	...	...	...
8	...	...	...	...	.09	.52	...	...	...	...	...	...
9	.01	...	...	...	...	...	...	.04	...	.05	...	...
10	...	...	...	.10	.22	...	...	...	...	...	...	...
11	...	...	...	.06	.18	...	...	...	...	...	...	...
12	...	...	...	...	...	...	...	...	...	...	.10	...
13	...	.07	...	.04	.53	...	.04	...	.01	...	...	...
14	...	...	.06	.15	.26	...	...	...	...	.20	...	...
15	...	...	.03	...	...	...	...	...	...	.15	.03	...
16	...	...	...	...	...	...	...	...	...	.40	...	...
17	...	.16	...	...	...	...	...	...	...	.59	...	...
18	...	.25	...	...	...	.02	...	.33	.14	.30	...	...
19	...	...	.03	...	.18	...	.01	...	...	.25	...	...
20	.03	.07	...	...	.56	...	...	...	...	.42	.30	...
21	...	.60	...	...	...	...	...	...	...	.02	.55	...
22	...	...	...	...	.07	...	.18	...	...	.08	.42	...
23	...	...	...	...	...	...	...	...	...	...	1.05	...
24	...	...	...	...	...	.18	...	...	...	.20	.30	...
25	...	.06	.11	...	.07	...	...	...	...	...	.18	...
26	...	...	.05	.14	...	.45	...	...	...	...	...	...
27	...	.05	...	.21	...	.08	.32	.18	.07	...	.03	...
28	...	.01	...	.11	...	...	.05	.04	...	...	...	...
29	.02	...	...	.11	.01	.05	...	.09	.85	.53	...	...
30	...	...	.08	.12	.01	...	...	...	...	.50	...	...
31	...	...	...	...	.09	...	...	...	...	.02	...	...
	.70	1.67	.68	1.04	3.39	1.79	.70	1.14	1.07	3.71	3.53	...

E. L. SHERA.



## APPENDIX C.

## EXTRACTS from Dr. BULSTRODE'S REPORT to the LOCAL GOVERNMENT BOARD upon PREVALENCE of ENTERIC FEVER in the CITY of CHICHESTER.

The chief industries of the district are those connected with agriculture, brewing and tanning. The city is the market town of the surrounding districts; a cattle market, the largest in the south of England, is held here fortnightly, and the Cathedral attracts numerous visitors.

The main streets of the city, which are wide and well-constructed, run directly north, south, east, and west, and in the centre of the city stands the old market cross. The town is traversed by the Lavant and by branches of this river, some of them artificial. In winter the river and its branches give passage to a good deal of upland water, but in summer all these channels tend to become dry or to contain more or less elongated pools of stagnant water.

In former times the Lavant received much slop-water and not a little sewage, but these sources of pollution are now far fewer than formerly; drains are being rapidly cut off from the river, and made to discharge into the recently constructed sewer system. There were, however, at the time of my visit, sundry privies, the contents of which oozed through the bank into the channel at St. Pancras, and slop-water was here and there being cast into the bed of the stream. This state of affairs was exceptionally well marked behind some cottages, Nos. 90-94, in St. Pancras, the inmates of all of which got rid of their slop-water into the channel, and obtained their drinking water from a well hard by; on the opposite bank was an offensive privy used by the tenants of the cottages referred to. In addition to sundry sources of pollution in St. Pancras, slop-water enters the channel at intervals at other parts, and at one place, near Southgate, a house drain discharges into it. In Orchard Street there are also sundry sources of pollution. The culvert running from near Eastgate to just beyond Southgate is brick-bottomed, and by this means is kept clearer from deposit than would otherwise be the case; but beneath Orchard Street and thereabouts, where the bed of the river is unbricked and irregular, there is a thick deposit in its bed of offensive matter.

As a general rule, there is in Chichester but little overcrowding of houses upon area; usually a curtilage of some size is attached to each house or group of houses. There are, however, exceptions to this rule; notably, in some of the poorer parts of St. Pancras, where some few houses have practically no curtilage whatever, while others abut upon the Lavant, and, as has been said, dispose of their slop-water and other refuse in the river. In spite, however, of the fact that houses, even of the poorer sort, are generally provided with curtilage, it can rarely happen, that sufficient space obtains to safely allow of excrement and slop-water being deposited into one or more holes in the pervious soil, and of pure water being obtained from another. In certain of the premises which I visited the conditions of the yards was extremely unwholesome; and although in some cases the houses had recently been drained, the work had been now and again done in such a careless manner that the present state of the yard surface was probably no better than before. It may, too, be remarked in regard of several houses that I visited, and which had been recently drained, that the privy vaults had, together with their contents, perhaps the accumulation of some years, been simply filled in, and not, as they should have been, carefully emptied, their bricks removed, and their sites carefully cleansed. In one case which was brought prominently to my notice, and where enteric fever was prevailing, the buried privy contents still at times made themselves manifest on the adjoining wall; and in other instances complaints of a somewhat similar nature were heard of.

*The Water Supply of Chichester.*

The city of Chichester is supplied with water partly by private wells, partly by the Chichester Waterworks Company. The wells are of that kind known as "shallow"; i.e., they are not sunk through any impermeable stratum, but consist of excavations sunk in the gravel overlying clay. These wells are dry-stained, and thus are but imperfectly protected against filth soaking through the soil. In the majority of instances the water is raised from these wells by means of pumps; but in some cases, especially in that part of the town which is rural in character, water is often raised by means of a windlass, and wells are covered over with wooden lids, which frequently are not so



fitted as to protect them from the influx of surface water. The position of these wells was, in the great majority of cases which I inspected, a dangerous one. Frequently wells were found but a little distance removed from non-watertight privies and cesspools, to which reference will shortly be made; and it was obvious that the water contained in them was in danger of becoming fouled by infiltration of cesspool or privy contents. In numerous instances the exact position of the well was a matter of surmise only, the present tenant of the dwelling having had no occasion to ascertain its whereabouts. A large number of these shallow wells in Chichester have been made to furnish water for chemical examination, and many have been pronounced highly polluted. It is clear, however, whatever may be the finding of the chemist or of the bacteriologist as regards any given sample, that a very large number of the Chichester wells are in very dangerous positions.

The Chichester Waterworks Company obtain their supply from a well which was constructed in 1874, and which is situated on the Portsmouth Road at a point distance some  $1\frac{1}{2}$  miles west of the centre of the city. The well has a total depth of 47 feet from the floor of the engine house, the first 17 feet being lined with 9-inch brickwork, the remaining 30 feet with wrought iron cylinders. In reference to the geological strata through which the well is sunk, it may be recorded that after passing through the superficial soil and gravel, the combined thickness of which, I am informed by Mr. Shelford, the Engineer, is but a few inches, a stiff clay was encountered which continued to a depth of  $23\frac{1}{2}$  feet. At this point chalk marl was reached, and after penetrating this for some  $2\frac{1}{2}$  feet, water entered the well in large quantities. The remainder of the well shaft penetrates chalk marl and Chalk.

The water is raised by means of two engines, each capable of throwing 10,000 gallons per hour; but the total maximum average yield of the present well is, it appears, not more than some 15,000 gallons per hour. By working both engines at full speed the water may be quickly reduced to its lowest point, *i.e.*, 29 feet below the engine floor. If the engines are now stopped the well will fill up to the level of the overflow in 23 minutes, and to within 10 feet 6 inches of the floor in 12 minutes. At the present time the consumption of water in the city necessitates constant pumping, and it is contemplated, therefore, that additional borings for water will shortly be necessary. The water is pumped up into a main passing through Chichester, which it supplies on its way to reservoirs situated on the north of the city. One of these reservoirs is at the ground level, the other some 40 feet higher. The storage capacity is at present 200,000 gallons, each of the above-mentioned reservoirs holding some 100,000 gallons. The higher reservoir is for the supply of the barracks and all parts of the town that are situated above the level of the Infirmary.

The draft on the ground level reservoir (capacity 100,000 gallons), when no water is being pumped into it, is found to be about 8,000 gallons per hour, so that the capacity of the reservoir is only about 12 hours' supply.

The water from this well has been analysed on several occasions. On March 10th, 1879, Dr. J. Muter, F.C.S., pronounced the water to be "a water of very excellent quality indeed."

In April, 1893, Dr. Frankland reported that "the water possesses a very high degree of organic purity, and it is in every way well fitted for dietetic use. It is of most excellent quality. It is slightly harder than Thames water, but will soften down to less than two degrees of hardness upon Clarke's scale, or 2.6 per 100,000."

#### *Excrement and Refuse Disposal.*

Excrement is disposed of partly by means of a recently constructed sewer system, partly by means of privy cesspits and cesspools. Use in the above sense of the public sewer system is an increasing one.

The privy cesspits are capacious receptacles situated in the curtilage of the houses; they are lined mostly with brick, but not in such a manner as to render them water tight. Over the cesspits are erected commonplace privy structures, and, in numerous instances which I saw, these edifices were much dilapidated, while their floors which covered part of the pits were, not unfrequently, found unsafe. The cesspits in a very large number of instances are in situations which must be regarded as unduly near the houses which they serve. They, too, are often within a few feet of the well from which the drinking water of households is derived, in circumstances which cannot fail to seriously endanger the wholesomeness of the well water. Even where the cesspits have been done away with, and the houses connected with the sewers, I found, as I have said, that, in not a few instances, the cesspit had been simply filled up, and not, as it should have been, carefully



dug out and cleansed. The cesspools are, like the privy pits, not watertight; they are, as a rule, covered over in such a manner as to conceal their whereabouts, and in many cases the occupier had only a very vague notion as to the locality of his cesspool. In only a few instances are they properly disconnected from drains, and some of them appear to ventilate directly into the sculleries or kitchens of the houses. Everywhere cesspit and cesspools are numerous; in fact, it would seem that the whole of the gravel upon which Chichester is built is riddled with them. Some that had been covered over and forgotten were brought to light during recent operations connected with the drainage.

The emptying of the cesspools and cesspits is left to occupiers, who exercise their own discretion in the matter. As regards some of the premises which I visited, the dates, or, even the fact, of the last emptying of the cesspool could not be called to mind. It is certain, too, from the infrequency with which cesspools require to be emptied, that the greatest part of their fluid contents must find its way into the gravel underlying Chichester.

Although the Town Council do not undertake the removal of excrement, they lend their assistance by letting out "tuns" for the purpose. Doubtless the fact that a charge is made for these tuns discourages frequent emptying of cesspits and of cesspools.

*House Refuse* is removed twice weekly by the Town Council, and deposited upon an open space near the cemetery to the east of the town.

#### *Isolation Accommodation.*

In 1888 the Local Government Board after local inquiry sanctioned a loan for the purposes of an isolation hospital. The hospital is situated in the Spitalfields Road, to the north-east of the city, on a site consisting of some 3 acres of land. The present buildings consist of what is practically a slight modification of the Board's plan B., i.e., of a block of six compartments, three of which face in one and three in an opposite direction. Each group of three consists of a large ward  $24' \times 18' \times 13'$ , a nurses' ante-room  $14' \times 14' \times 13'$ , and a small ward for one bed  $12' \times 12' \times 13'$ . There is thus, upon a basis of 2,000 cubic feet per bed, accommodation for, say, at most eight patients in all. If, however, two diseases are being treated in hospital at the same time, there is obviously at most accommodation for but four cases of each disease, i.e., three of one sex and one of the other. Clearly the accommodation is insufficient for the population of the now extended district. There is also an administrative block, consisting of a kitchen, sitting-room, and scullery on the ground floor, and three bedrooms on the first floor. In addition, there is a block of outhouses, comprising a laundry, disinfecting room, mortuary, ambulance house, fuel house, tool shed, and w.c. The ambulance is a converted brougham; but it has not been so modified as to enable a patient to be introduced into the vehicle in a recumbent position, a point of considerable importance in some instances.

#### *Disinfecting Apparatus.*

The Town Council have not provided proper disinfecting apparatus; instead, fumigation with sulphur of clothing and bedding is practised in one of the outhouses at the hospital. It is to be regretted that the Authority possess no apparatus such as would serve for satisfactory disinfection of such articles. Possibly one of the outhouses in question might be dealt with so as to afford proper housing accommodation for a modern "disinfecter," one room being used for infected, the other for disinfected, articles.

#### *Byelaws.*

At the time of the outbreak the Town Council had no byelaws in force. Byelaws, however, relating to new streets and buildings, and to other sanitary matters, have been submitted to the Local Government Board, with a view to their being put in force in the district.

#### *Adoptive Acts.*

The Infectious Disease (Notification) Act, 1889, is in force in this district, as also is Part III. of the Public Health Acts Amendment Act, 1890, and the Private Streets Works Act.

#### *Regulations.*

The Town Council have made regulations under the Dairies, Cowsheds, and Milkshops Orders, 1885 and 1886. The cubic space required for each cow is 800 feet.

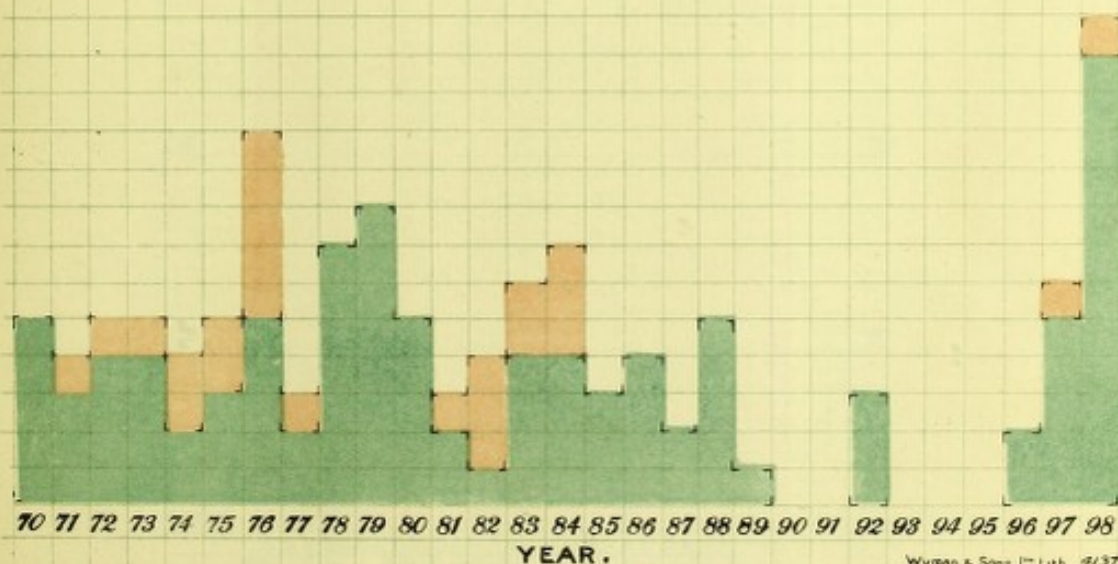


# CHART I.

*Shewing the deaths referred to "Fever" within the area comprised in the present City of Chichester year by year during the period 1870-98.*

*Each red square represents a death from this cause in the area within the line of the old walls.*

*Each blue square represents a death from this cause in the total area exclusive of the area within the line of the old walls.*









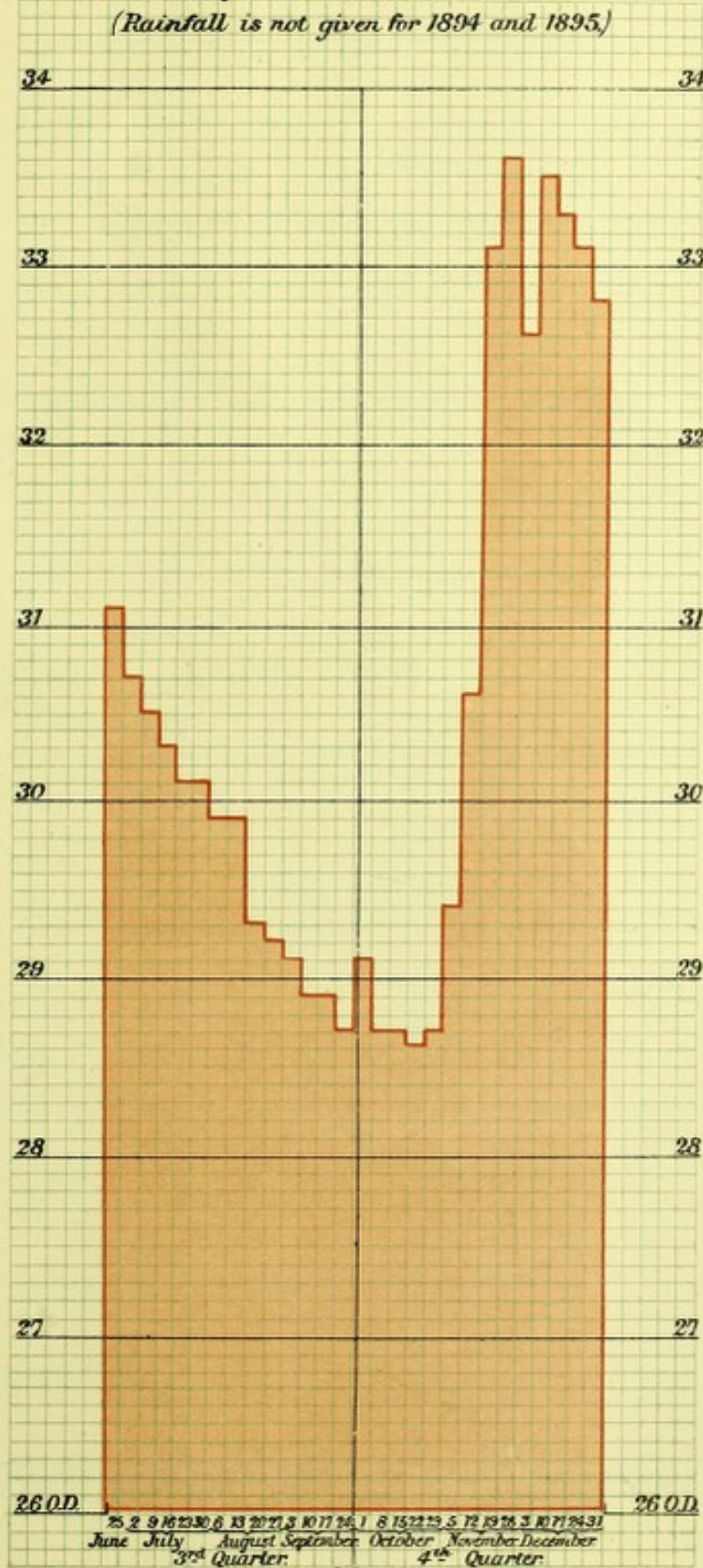
## CHART II. A.

*In these Charts A. B. C. D and E.  
each red square -  $\frac{1}{10}$  foot, subsoil water, rise or fall.  
" blue " -  $\frac{1}{10}$  inch rainfall.  
" black " - case of Enteric Fever.*

*Rainfall, variations in subsoil water, and cases of  
Enteric Fever, are all given in weekly periods.*

*In 1894 there was only one case of Enteric Fever viz, on April 26<sup>th</sup>*

*(Rainfall is not given for 1894 and 1895.)*



1894.







# CHART II.B.





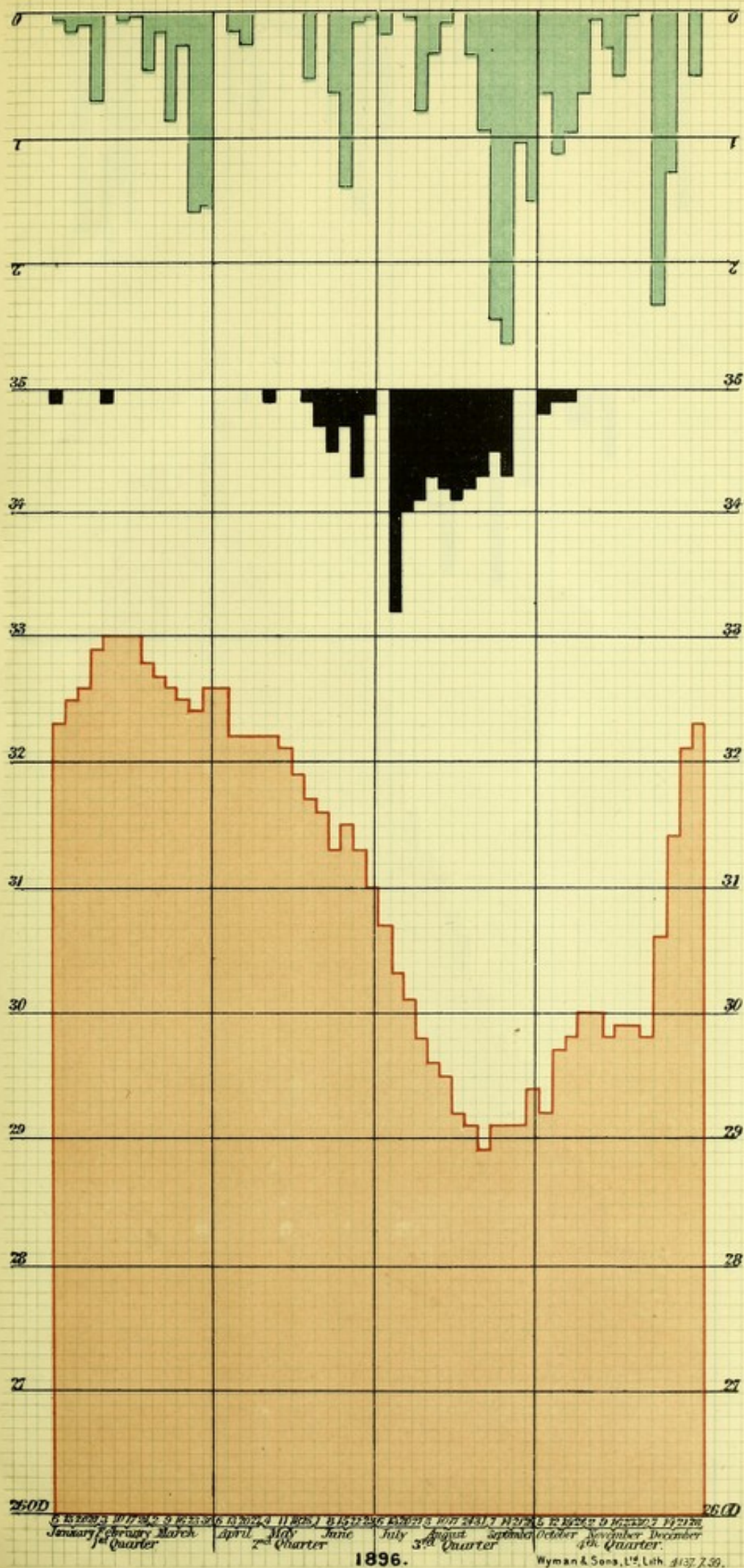
CHART II B



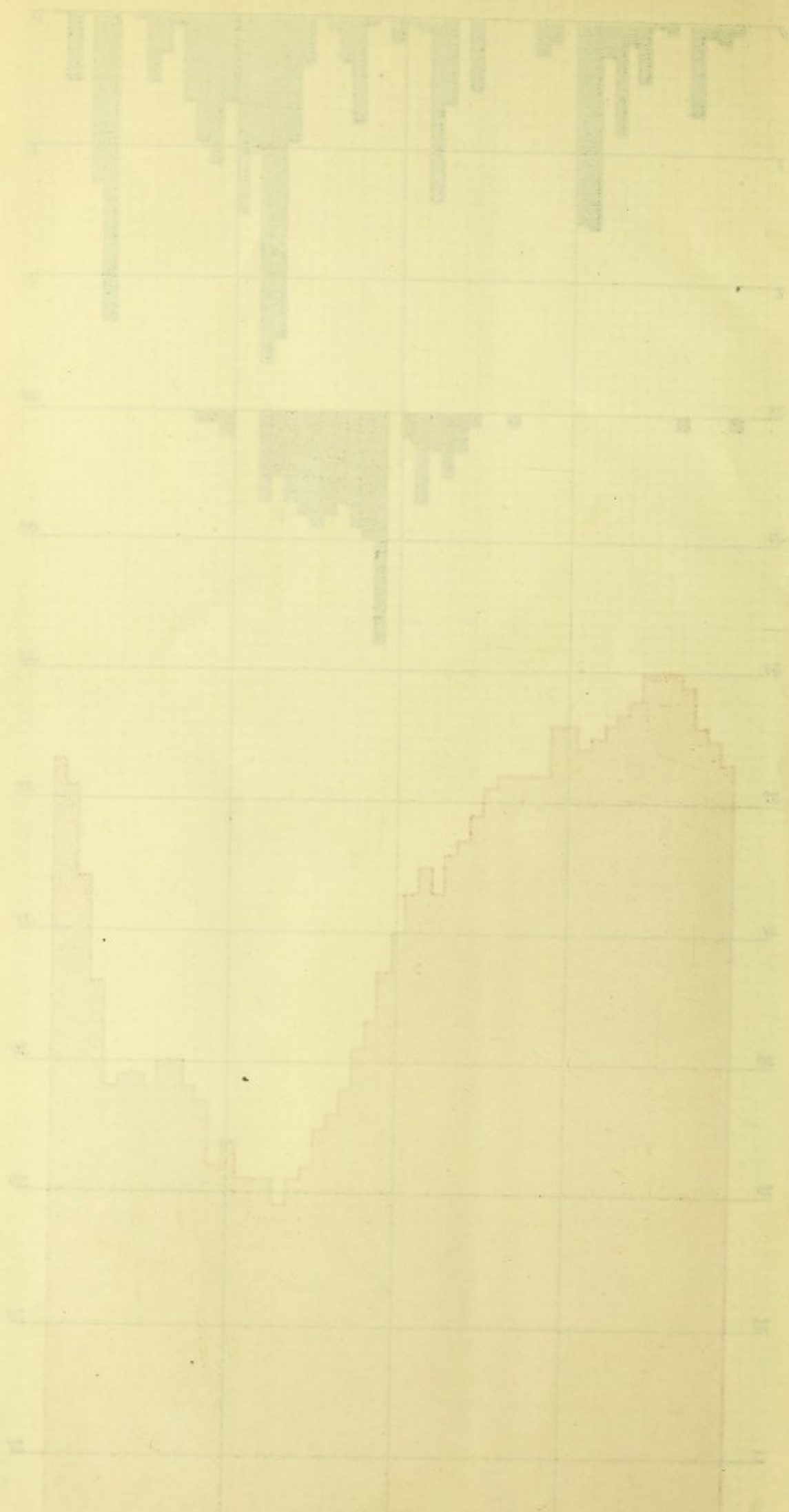
1900 1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920



# CHART II. C.









# CHART II. D.

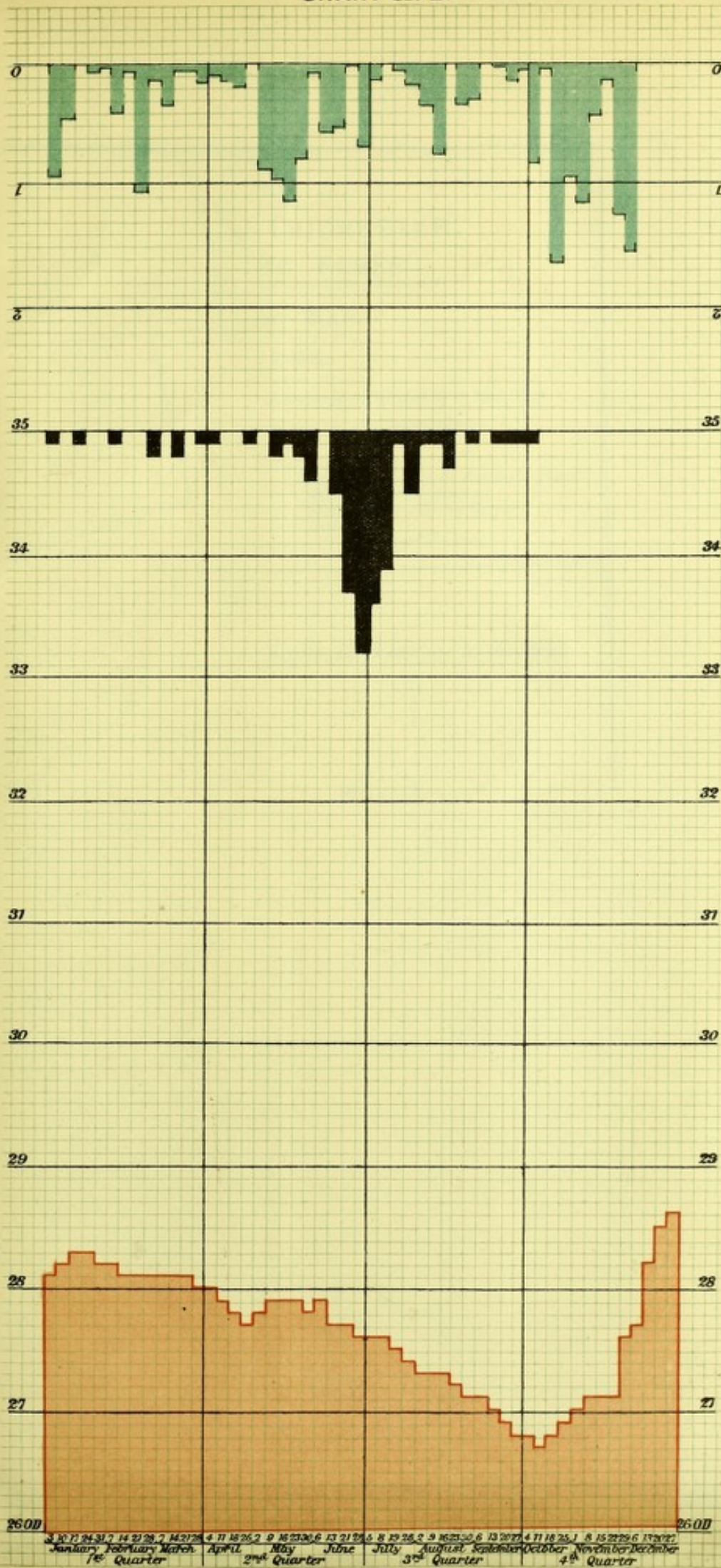








# CHART II. E.





Handwritten text at the top of the page, possibly a title or header, written in a cursive script.

Handwritten text in the middle of the page, appearing as a single line or a short paragraph.

Handwritten text at the bottom of the page, possibly a signature or footer, written in a cursive script.



Map A.  
CITY OF CHICHESTER.  
ENTERIC FEVER.

SPOT MAP.  
1898.

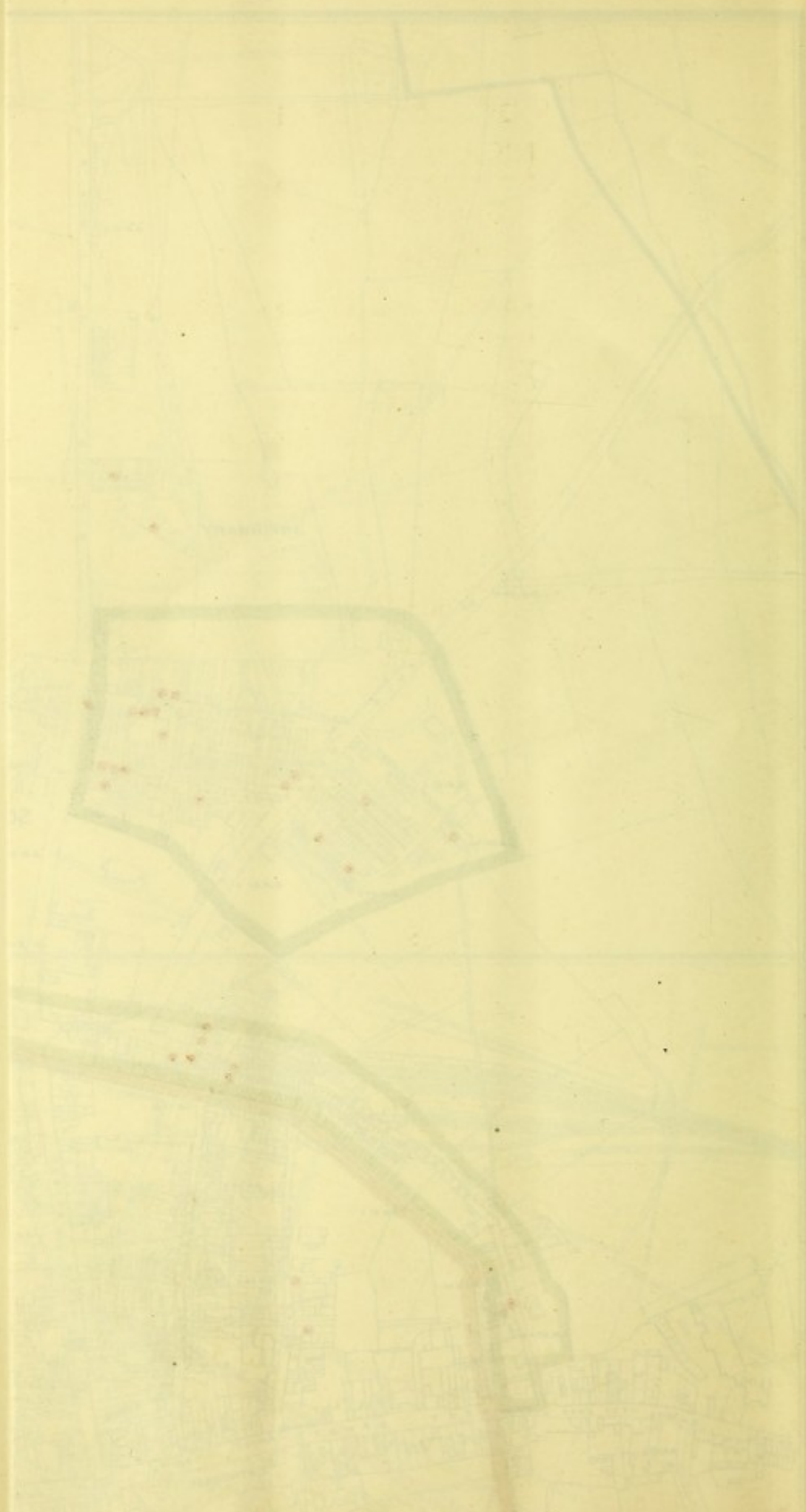
Each house invaded by Enteric Fever is indicated by a Red Spot.

The areas enclosed by a blue line is "Somerstown."  
 "green" "Arched Street and Franklin Place."  
 "pink" "Within the Old Walls."  
 "brown" "St. Nicolas and the Street."  
 "purple" "Portfield."

Scale, 1/2-5 inches to the Mile.









Map B.  
CITY OF CHICHESTER.  
ENTERIC FEVER.

SPOT MAP.  
1898.

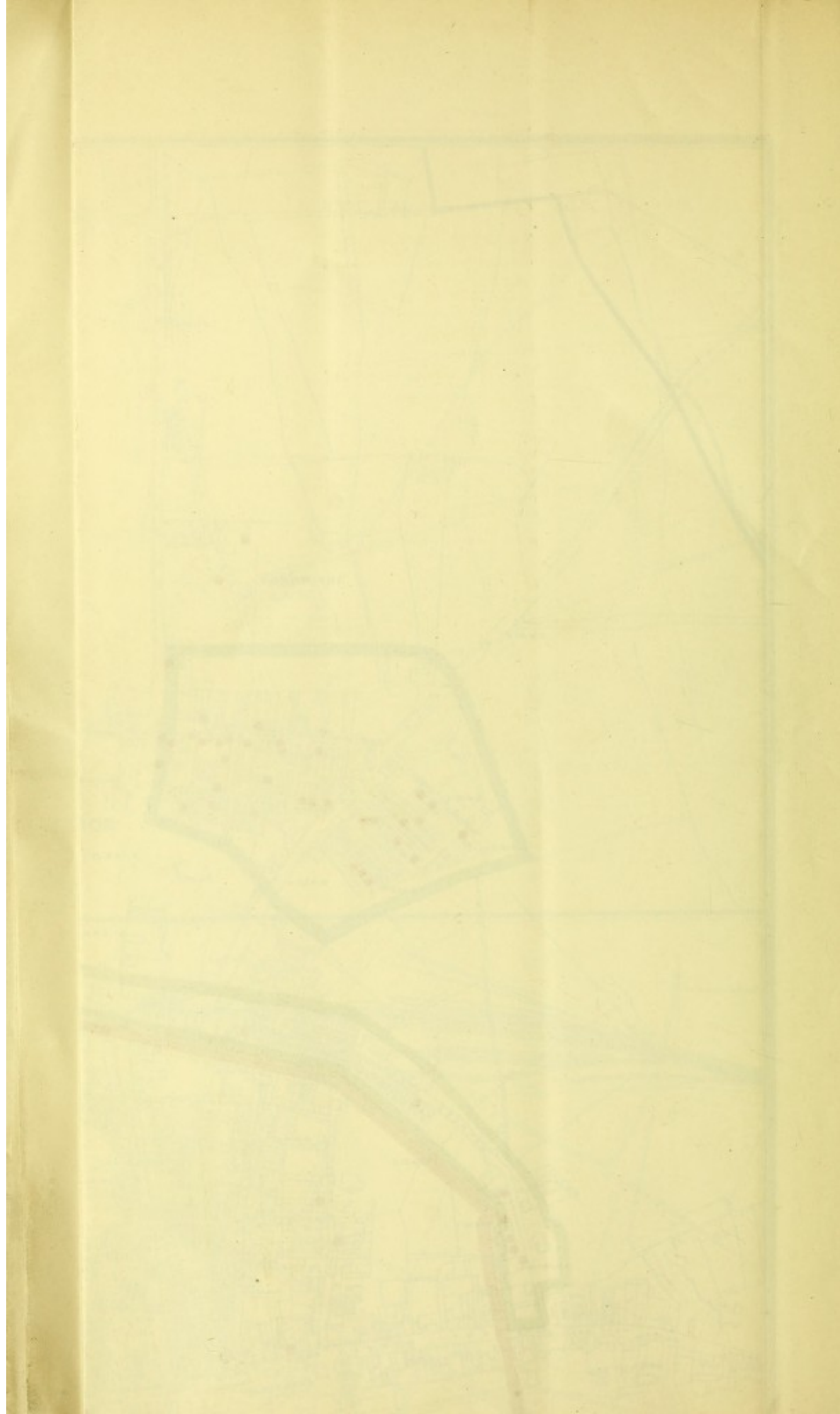
Each house invaded by Enteric Fever is indicated by a Red Spot.

The areas enclosed by a blue line is "Somerstown,"  
green, "Archebald Street and Franklin Place,"  
pink, "Within the Old Walls,"  
brown, "St. Nicholas and the River,"  
purple, "Devfield."

Scale, 12.5 inches to the Mile.









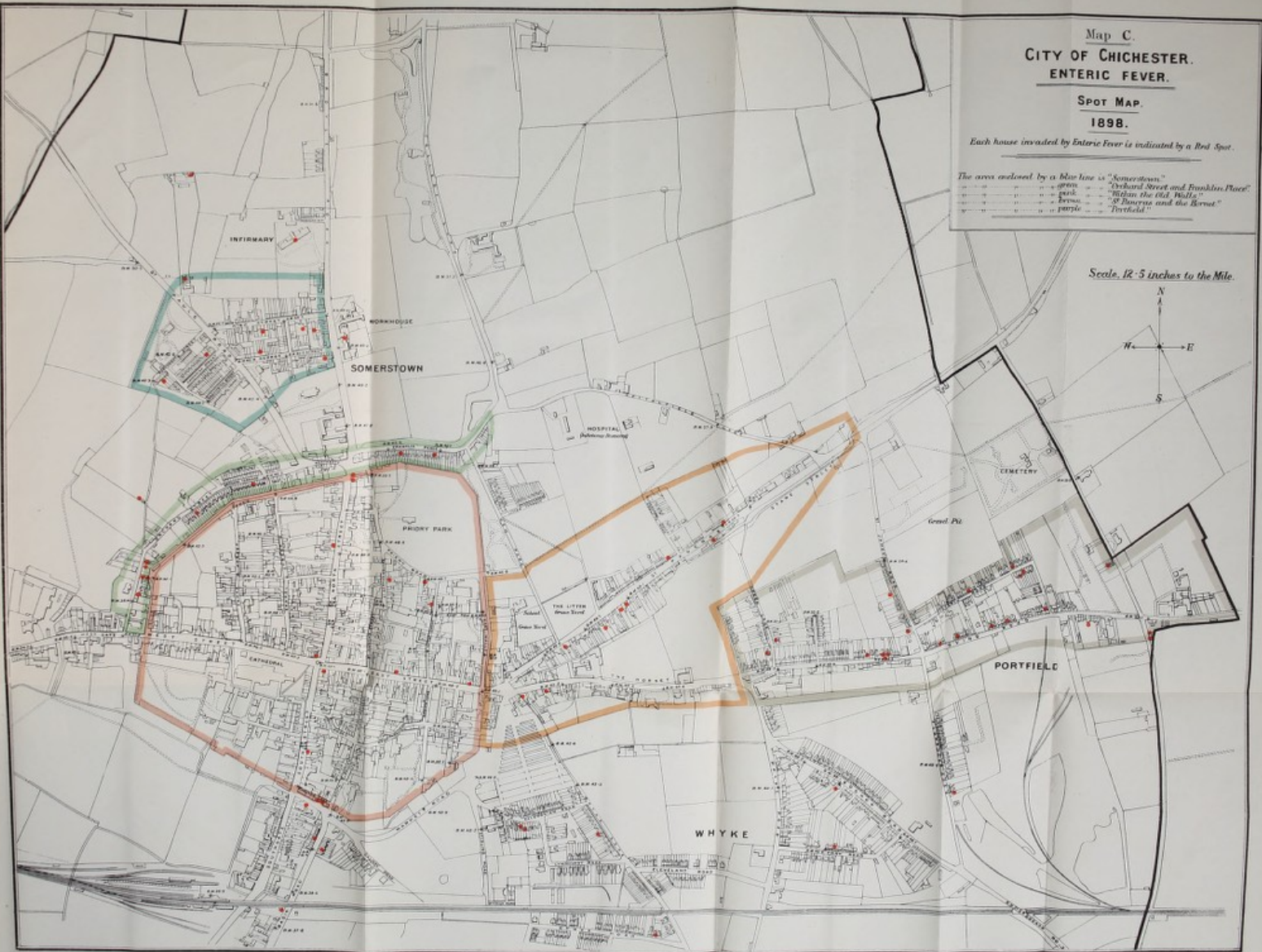
Map C.  
CITY OF CHICHESTER.  
ENTERIC FEVER.

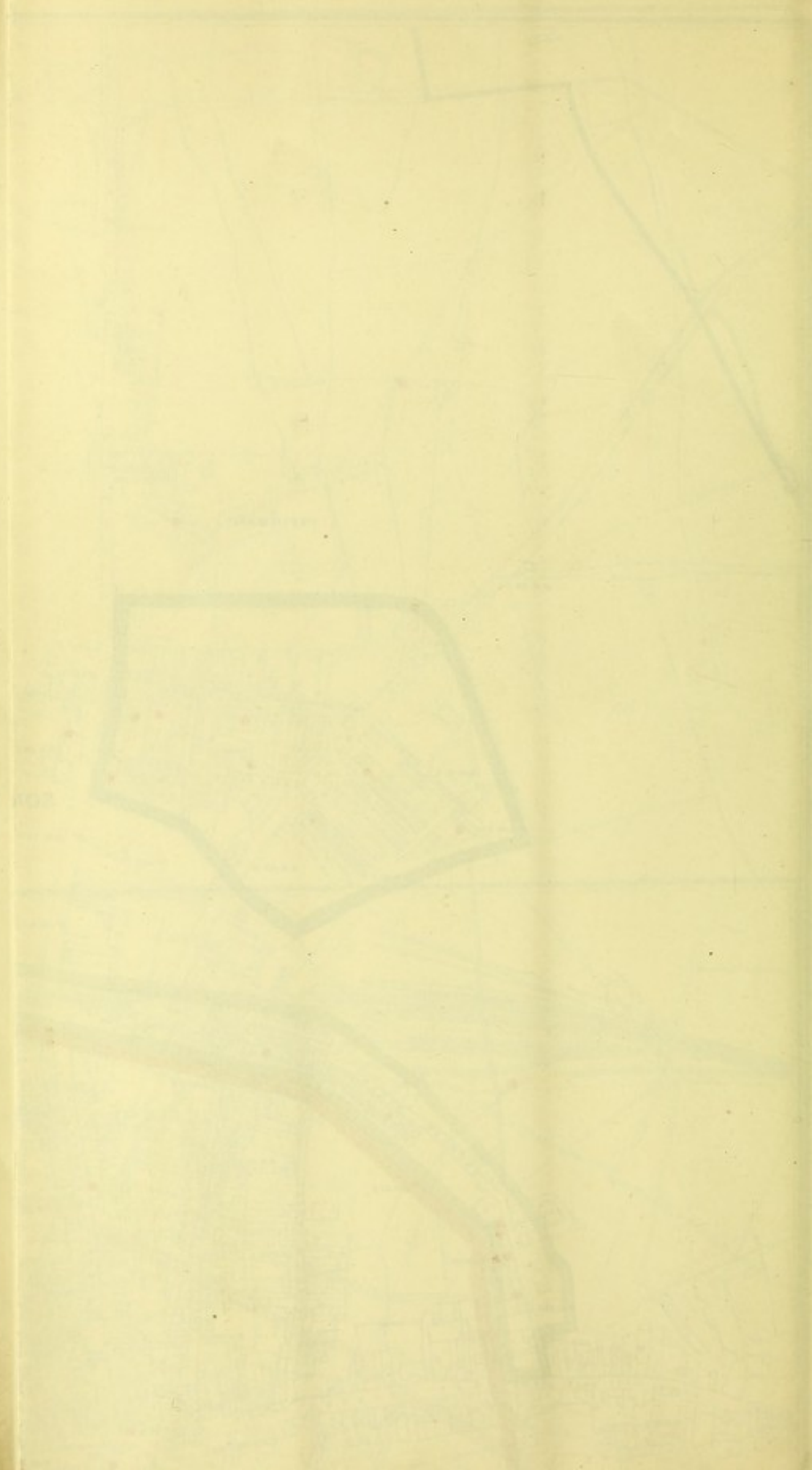
SPOT MAP.  
1898.

Each house invaded by Enteric Fever is indicated by a Red Spot.

The area enclosed by a blue line is "Somerstown".  
Orchard Street and Franklin Place.  
Within the Old Walls.  
St Bonny and the River.  
Portfield.

Scale, 1/2 inch to the Mile.







Map D.  
CITY OF CHICHESTER.

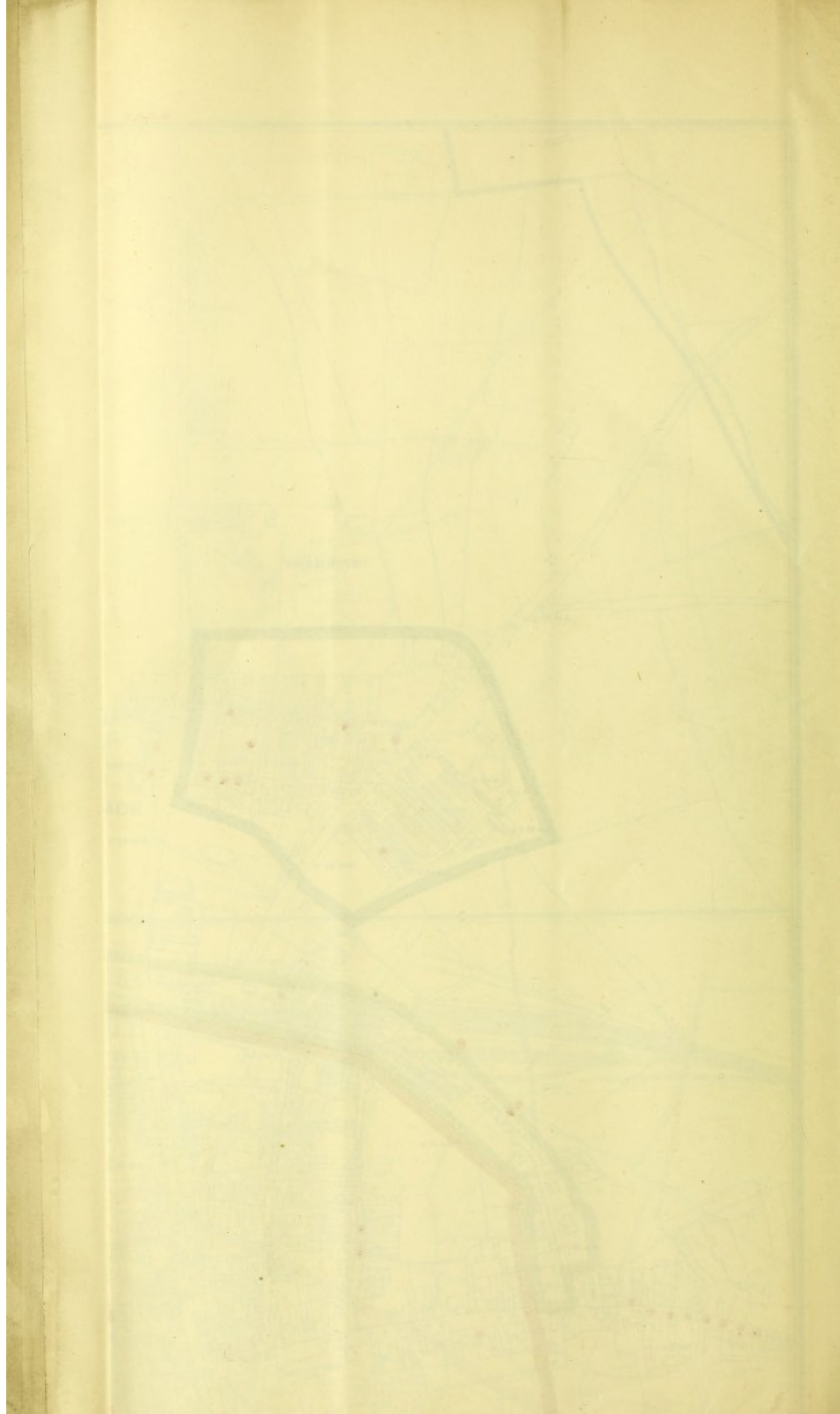
SPOT MAP  
Showing Deaths from  
ENTERIC AND CONTINUED FEVERS,  
during the period  
1870-84.

The area enclosed by a blue line is "Somerstown."  
"Green" — "Orchard Street and Franklin Place."  
"Pink" — "High the Old Walls."  
"Brown" — "St. Pancras and the Bazaar."  
"Purple" — "Twitford."

Each red spot indicates a death from Enteric or continued fever.  
Where the precise position of the house in which death occurred is unknown,  
the spot is placed in the centre of the street or neighbourhood where the  
house was situated.

Scale, 1/2.5 inches to the Mile.







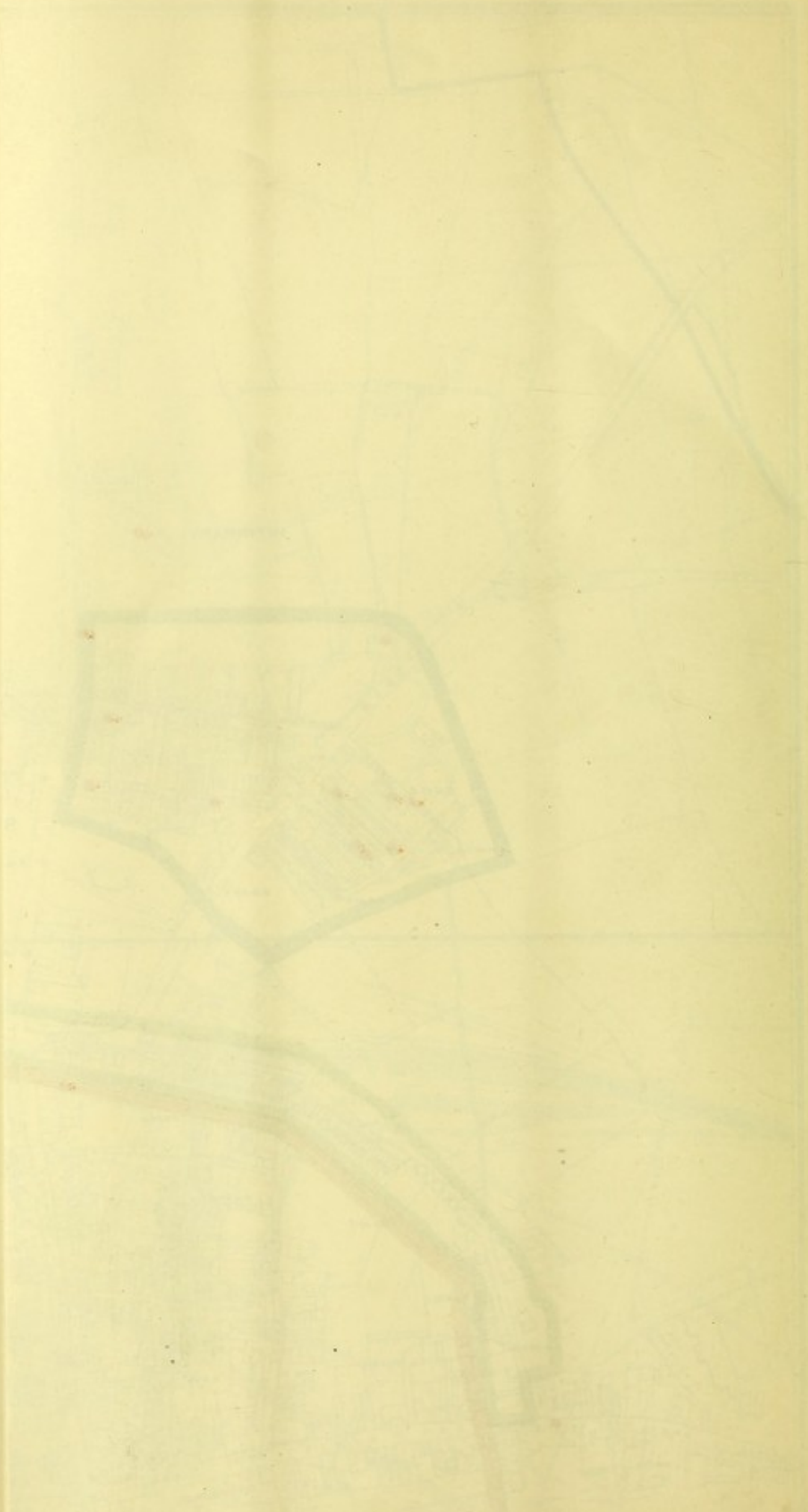
Map E.  
CITY OF CHICHESTER.  
SPOT MAP  
Showing deaths from  
ENTERIC FEVER.  
1885 TO 1898.

The area enclosed by a blue line is "Somerstown."  
green "Orchard Street and Franklin Place"  
pink "Within the Old Walls."  
brown "St. Pancras and the Bazaar."  
purple "Bemfield."

Each red spot indicates a death from Enteric Fever.  
Where the precise position of the house in which death occurred  
is unknown, the spot is placed in the centre of the street or neigh-  
bourhood where the house was situated.

Scale, 12.5 inches to the Mile.





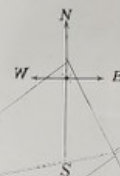


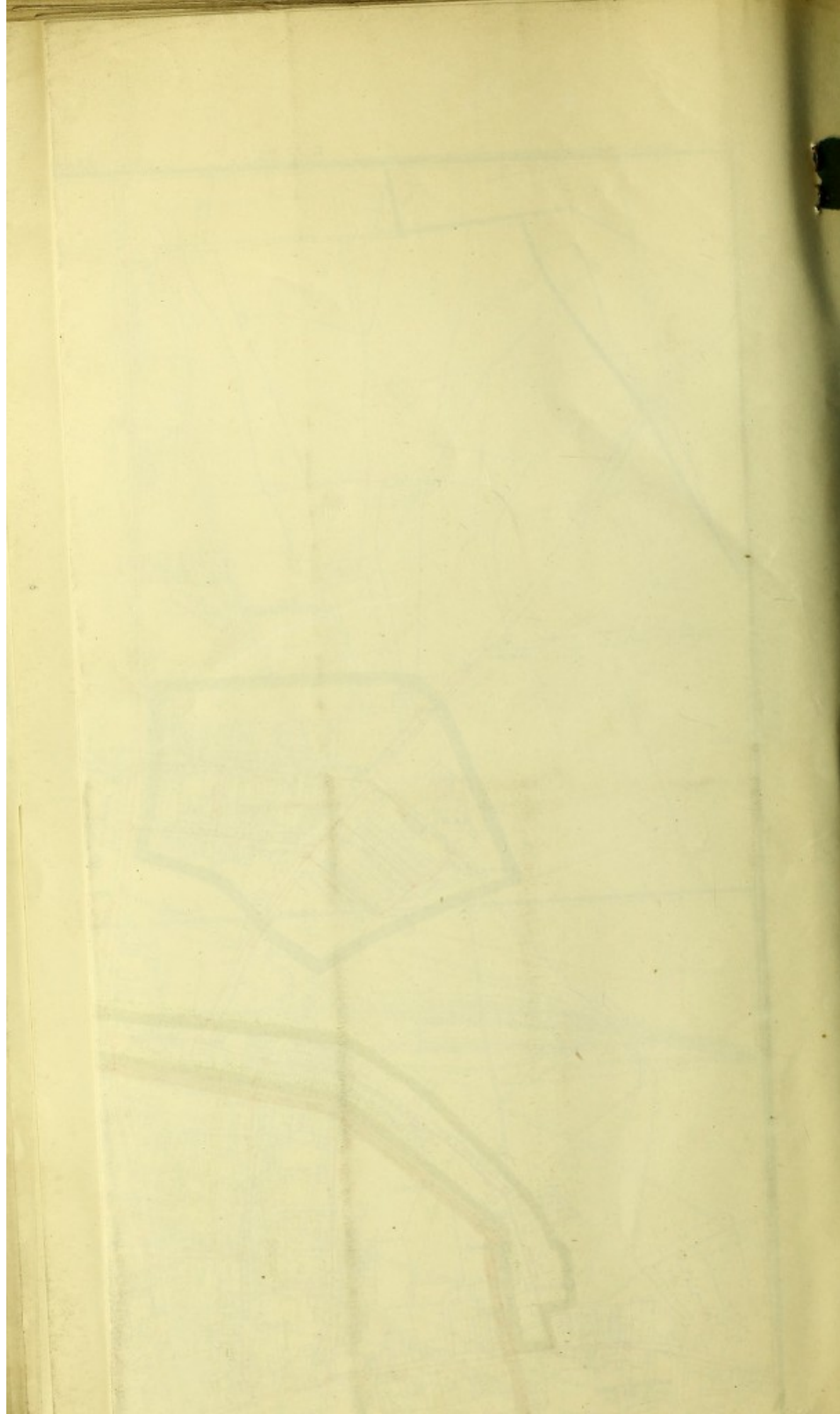
Map F.  
CITY OF CHICHESTER.  
PLAN OF DRAINAGE OF CITY  
1898

The Sewers are indicated by red lines.

The area enclosed by a blue line is "Somerstown."  
green "Orchard Street and Franklin Place."  
pink "Within the Old Walls."  
brown "St. Pancras and the Bazaar."  
purple "Portfield."

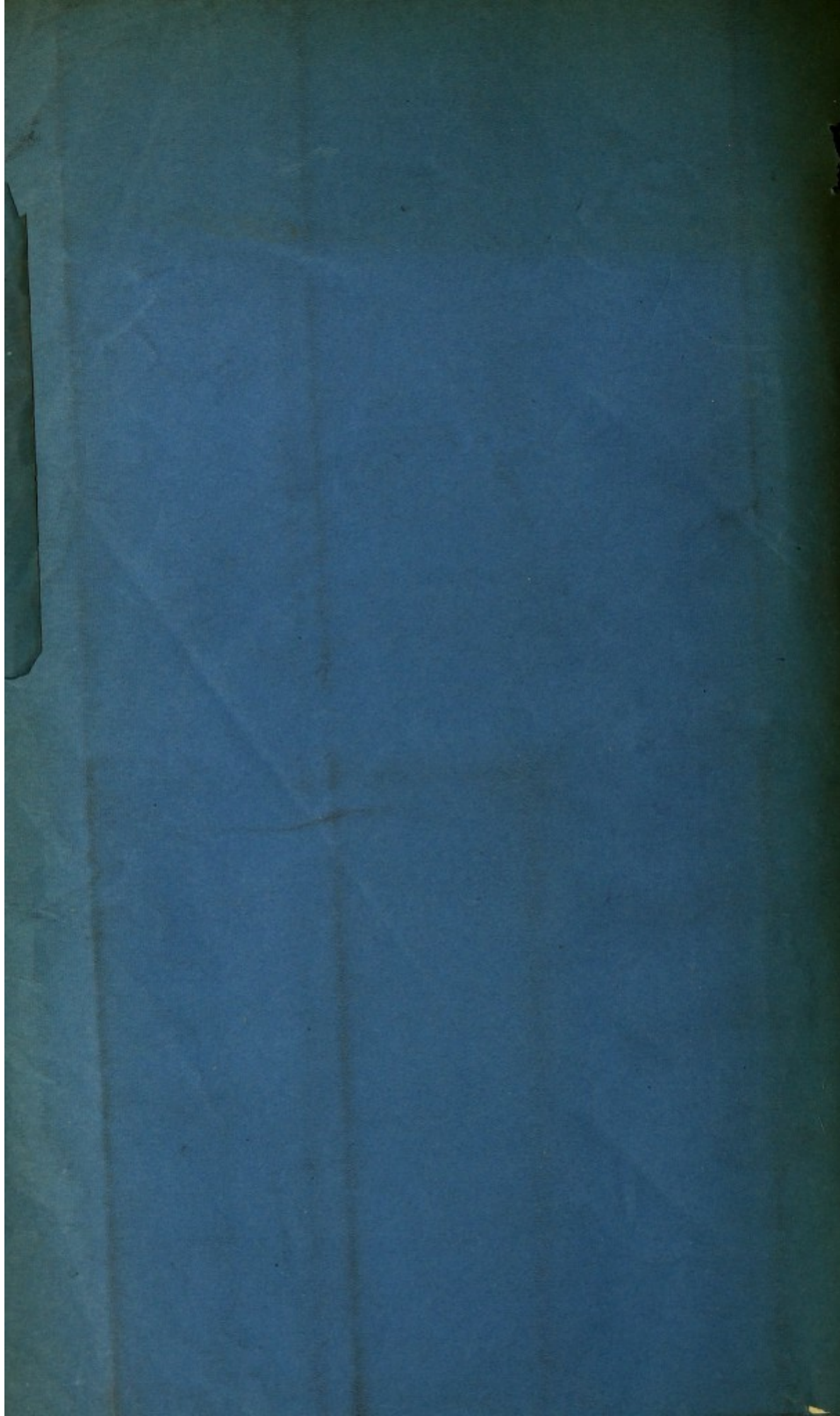
Scale, 12.5 inches to the Mile.















TE LLOW (EVER