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COMPLETE REPORT

ON

THE SANITARY CONDITION

OF THE

ROYAL BARRACKS, DUBLIN.

BY

MR. ROGERS FIELD, M. INST. C.E.

DATED 31ST AUGUST 1889.

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Complete Report on the Sanitary Condition of the Royal Barracks, Dublin.

Sir,

In the Interim Report, which at your request I presented on the 25th of February last, I stated that a thorough enquiry into the sanitary condition of the barracks included so many different branches, that it would necessarily take a large amount of time to follow them up. As the enquiry proceeded the task increased in magnitude, so that even more time than I anticipated has been required to complete the investigation. This, and my having made a thorough examination of the sanitary condition of the Richmond Barracks, and furnished you with a full report on the same during the interval, will account for my not having been able to send in this report sooner. Introductory.

I have endeavoured as far as possible to make this report sufficiently intelligible without it being requisite to refer to the Interim Report and accompanying plans, but there are necessarily some points about which a reference must be made to that report in order that the whole subject may be grasped.

There are several additional plans attached to this report, and to avoid confusion I have numbered them so as to follow on after the previous plans. Plans attached to this report.

Location of Cases.

Considerable pains have been taken to compile from the information supplied to me a complete list of the cases of enteric fever for the last 10½ years, in order of date, both at the Royal Barracks and at Arbour Hill, giving the precise locality as far as possible. This list is given in two parts on Plan (IV.), which I have prepared to show the locality of the cases. The numbers on the plan correspond with those on the list. With reference to this list I cannot help thinking that cases may be entered in it which are not fairly attributable to the Royal Barracks, for instance, in Case No. 106, that of Lieutenant McLaughlin, which occurred while I was in Dublin, it is known that he was at Pigeon House Fort (where he stopped for a month) till within three days of the date of his becoming ill. Plan (IV.)

I have also prepared a Plan (V.) showing the number and location of the cases at the Royal Barracks in each separate year. Plan (V.)

The approximate population is as follows:— Approximate population dealt with.

Royal Barracks	1,640
Arbour Hill, including staff at hospital (but not patients)	230
Military prison, warders, and schoolmasters ..	150

In the latter buildings (military prison, &c.) there have been no cases of fever during the last 10½ years.

To the Right Hon. Edward Stanhope, M.P.,
Secretary of State for War.

Points noticeable on studying these plans.

On studying the plans above mentioned there are several points which are particularly noticeable.

In the first place, it appears from Plan (V.) that though the barracks have never been entirely free from fever during the last 10½ years, it was not till the year 1886 that any large number of cases occurred, but that since then the numbers have greatly increased.

In the next place, looking at the whole 10½ years, Horse Square with the north side of Cavalry Square has all along been remarkably free from fever as compared with the rest of the Royal Barracks.

In the third place, looking at the first seven years (up to the year 1885 inclusive), Royal Square, which has recently suffered so severely, was almost entirely free, there being only two cases.

In the last place, during these same seven years, Palatine and Brunswick Squares have generally had one or more cases of fever, there being altogether 10 cases as against two in Royal Square, which, after allowing for the greater population (760 as against 460), is still a much greater proportion.

Points noticeable in lists of cases.

The lists of cases are also very instructive. I will, however, confine myself to mentioning only two points which have particularly struck me. One is the large number of cases there have been among the staff at the Hospital, considering the small number of the staff, viz., 7 cases amongst 23 people, 4 of which occurred in the year 1887. The other point is the number of instances in the Royal Barracks in which there are groups of cases occurring within a few days of one another, which seems to indicate some frequently recurring but temporary cause of disease.

Medical considerations are involved in some points.

It is impossible for me to follow up points like these which involve strictly medical considerations not within my province, and it is therefore much to be regretted that you were unable to act upon the suggestion I made to you as to having a supplementary medical enquiry. In the serious outbreak of enteric fever which has just occurred this grouping of the cases is particulary noticeable, and the medical view as to this and other points will have an important bearing on what action should be taken with regard to further demolitions, as will subsequently be seen.

Scope of Enquiry.

It may be remembered that in my Interim Report I stated that the enquiry resolved itself into at least the following branches:—

Drainage and sanitary appliances.
Nature and stratification of subsoil.
Condition of surface and subsoil as regards pollution.
Crowded arrangement of buildings.
Structure of buildings.
Condition of floors and spaces underneath them.
Ventilation of buildings.
Water supply.
Milk supply.

The two first of these branches I dealt with, as far as I was then able, but I now have a good deal to add to what I said. The remaining branches I have not previously dealt with and they are fully treated herein.

Drainage.

In my Interim Report I stated that, judging by the results given, the drains would, according to all ordinary methods of ascertaining their condition, be pronounced to be generally good and sound, but some analyses of the subsoil water only just completed pointed so strongly to a leakage of sewage into the subsoil that I suspected there might be some defects which had not yet been

discovered. I also stated that in order to ascertain whether there were any undiscovered defects in the drains, I had determined to apply the water test to them.

Analysis of the subsoil water used as a guide to where defects in drains existed.

Considering the great difficulty there would be in applying the water test on account of the large size of most of the drains, and the great quantity of sewage always coming down them, it appeared very desirable to limit the amount of testing, if possible, by using the analysis of the subsoil water as a guide to where the defects were most likely to exist, and for this purpose to have samples of the subsoil water taken from various parts of the barracks.

Samples of subsoil water obtained by borings.

The samples of the subsoil water previously taken had been obtained by excavating down to the water, but this process was tedious, owing to the great depth of the water below the surface, and caused a great deal of obstruction, owing to the large heaps of earth that were thrown up. I, therefore, determined to obtain the additional samples of subsoil water required by sinking tube wells or borings. A great deal of difficulty was experienced on account of the large number of boulders that were met with, but eventually borings were sunk at various places near the lines of the main drains, and a sufficient number of samples were obtained for analysis to give a good general idea of the condition of the subsoil water.

General results of analysis of subsoil water.

The results of the analyses of the subsoil water are given in the Appendix, page 28, and will be fully considered later on. All that need be stated here is, that although they showed that the subsoil water was polluted they did not appear to indicate that the pollution was confined to any particular portion of the barracks, so as to justify the limitation of the drain testing. Under these circumstances there appeared no other course open than to apply the water test to the greater number of the important drains.

Method of testing the drains with water.

The testing of the drains proved to be an exceedingly tedious and troublesome matter, and showed that the difficulties which had been anticipated had not been overestimated. The method of testing differed somewhat according to the class of drain tested. In the case of the branch drains, the drain or portion of drain in question was securely plugged at the lower end, so as to prevent any water passing down it, and water was either passed into the drain, or the natural flow of sewage was allowed to accumulate till the drain was full. The inflow of water was then stopped off, and observations were made as to whether the water remained stationary in the drain or whether it sunk, a subsidence, of course, indicating leakage. In the case of the main drains it was generally not possible with the appliances available to make the plug at the lower end absolutely watertight, but the quantity of water escaping, which could always be seen, was only slight. To compensate for this escape, a continuous flow of water, largely in excess of that escaping, was permitted to take place into the drain after it was full, so that if a subsidence of the water took place it showed unmistakeably that the drain was not sound. In addition to this, a number of the drains were laid bare while under test, so as to watch what took place.

Result of testing the drains with water.

The results of these various tests was that the drains which were tested were found to be almost everywhere leaky, some of them more so than others, but all of them to an appreciable extent. The worst were some branch drains in Brunswick Square and about the Cavalry quarters, and the main drains in the lane west of Cavalry Square (both the main drain from the barracks and that from the Arbour Hill Hospital). The main drain from the barracks was found on being laid bare to have several cracked pipes, and the Royal Engineers at once relaid a portion of it. The principal drain on the east side of the Arbour Hill Hospital was also found to be so leaky that water from a burst pipe near entered the drain in large quantities at a number of joints.

Saddle pipes.

A careful examination of the drains which were laid bare showed that although many of the ordinary joints of the pipes were leaky, especially at the

Hospital, the greater portion of the leakage occurred at the places where "saddle pipes" had been inserted. In the investigations which had been made for my Interim Report a few saddle pipes were met with, but as these were mostly on branch drains, and placed in a haphazard way, no particular importance was attached to them. The subsequent baring of the drains, however, showed that the saddle pipes were used everywhere at more or less frequent intervals, both on the main drains as well as on the branch drains, so that the saddles assumed an importance which I did not then anticipate.

When reporting to you on the sanitary condition of the Richmond Barracks, I dwelt at some length on the objections there were to the introduction of saddle pipes on the lines of the drains, I pointed out that not only is their use founded on the mistaken idea that the drains must sometimes be opened, and that the saddle pipes afford ready access to the drains, but also that they are an inherent source of weakness in a drain, on account of the extreme difficulty of making the joints sound. The leakiness of the saddle pipes on the drains at the Royal Barracks is a direct confirmation of what I stated with regard to them.

Objections to arrangements for carrying waste water from sinks to gullies by long channels.

Another minor matter, which I now find to be of greater importance than I originally thought, is the arrangement which is so generally adopted of conveying the waste water from sinks, &c., to gullies by channels of considerable length. I have pointed out in detail in my Report on the Richmond Barracks the great objections there are to these long channels. In the first place, dirt is blown or washed into the channels, which obstructs the waste water, and causes it to overflow the sides and lie about, and thus give rise to offensive smells in hot weather. In the next place, the channels generally serve a dual purpose, taking surface water from the roads and parades, as well as slop water, and the gullies which are suitable for the one purpose are not suitable for the other, so that the combined arrangement leads to trouble. The result is that if gullies suitable for retaining silt are used they become stinking catchpits, and if gullies suitable for waste water are used they allow silt to pass into the drains and cause a deposit.

General conclusions as to the drainage and sanitary appliances.

In my Interim Report I stated that as my investigation was not completed I was unable to draw any general conclusion, I will, therefore, now briefly state the conclusions I have arrived at as to the drainage and sanitary appliances.

On the whole the system of drains is well designed, and the drains generally have good falls. When first examined, although some serious defects were discovered, the drains to all appearances were well laid.

Subsequently, when considerable lengths of the drains were laid bare further defects were discovered, and the details of construction were found to be in some respects bad. Moreover, on the drains being subjected to the water test they were found to be everywhere leaky, in some places extremely so, notably at the Arbour Hill Hospital.

The manholes and other means of access are too few, and those that there are are not easily accessible. Some other accessories are bad. The ventilation provided for the drains is very inadequate.

The water-closets, sinks, baths, and other sanitary appliances are on the whole good, but there are many defective details which interfere with the general efficiency. The most serious defects are in connection with the Hospital water-closets, the arrangements of which are specially bad.

River Liffey.

Before leaving the question of drainage I had better refer to the River Liffey, the consideration of which certainly ought not to be omitted in any review of the sanitary condition of the Royal Barracks. This river is now practically little else than the common sewer of the City of Dublin, and although in cold and wet weather the nuisance from it is very much less than might be expected, in hot or dry weather the smell is perfectly abominable.

Notwithstanding this, however, I am bound to say that the incidence of the fever at the Royal Barracks does not seem to point to any particular influence of the Liffey. For instance, taking the year 1888, although there were five cases of fever in E and F attics, behind Horse Square, there was only

one case in Horse Square itself, which is nearer to the Liffey than these attics. Again, in the serious outbreak of July and August of the present year, which occurred when the Liffey was exceedingly offensive, although there were nine cases in Palatine Square there were none at all in Horse Square, which is similarly situated as regards the Liffey.

Nature and Stratification of Subsoil.

Borings have confirmed the conclusions arrived at in the Interim Report.

This subject has been fully dealt with in my Interim Report, and the further light that has been thrown on the matter by the series of borings which have been subsequently made fully confirms the conclusions previously arrived at.

None of the trial holes made in the first instance passed through the thick bed of gravel under the barracks into the boulder clay which is known to underlie the gravel, but several of the recent boreholes did reach the boulder clay, and showed that this lay from 16 to 30 feet below the surface.

Boreholes show that subsoil water is even at a greater depth than stated in Interim Report.

The boreholes also show that the subsoil water is even at a greater depth below the surface than stated in the Interim Report, and that this subsoil water does not lie in a continuous bed but is more or less in "pot-holes," so that in some places there is no subsoil water at all between the gravel and the clay.

It will be seen also from Dr. Dupré's analysis of the subsoil water (Appendix, page 28, Conclusion, No. 4), that this incidentally confirms the view that the amount of natural subsoil water is only small.

Condition of Surface and Subsoil as regards Pollution.

Samples of soil taken from a large number of places.

In order to form a reliable opinion as to the condition of the surface and upper portion of the subsoil over the barrack area, samples of soil were taken from a large number of places all over the barracks so chosen as to give a fair representation of the whole area. Two samples were taken from each place, one at 2 inches and other at two 2 feet below the surface, and the whole of them, 44 in number, were analysed by Dr. Dupré, whose report will be found in the Appendix, page 25.

Dr. Dupré's report on samples of surface soil.

From his report it will be seen that 5 only of the 22 samples of surface soil show any signs of pollution.

The pollution of one of these samples (1*a*) is easily explained as the sample was taken from a place at the back of A house, Royal Square, where urine tubs are washed out. As regards two of the others (4*a* and 15*a*) taken at the south front of Royal Square, and back of north side of Palatine Square, respectively, the pollution may be explained by the fact that the soldiers, when they can do so without being observed, throw their slops out of window. The pollution of the remaining two samples, one (8*a*) taken from outside the serjeants' billiard room, Horse Square, and the other (9*a*) from the centre of Cavalry Square, was inexplicable, and fresh samples were therefore taken as nearly as possible from the same spots and analysed. These fresh samples were found to be unpolluted, showing that the pollution indicated in the first set of samples can only have been of an extremely local character.

Dr. Dupré's report on samples of the subsoil 2 ft. below the surface.

In the case of the samples of the subsoil from 2 feet below the surface, 3 only out of the 20 analysed show any distinct indication of pollution.

The pollution of two of these samples, Dr. Dupré says, is probably due to urine. I have no doubt the pollution of the first sample (1*b*) was due to urine, as it was taken where urine tubs are washed out, The pollution of the second sample (11*b*) I cannot so easily account for, as it was taken from the centre of Royal Square. The pollution of the third sample (17*b*), Dr. Dupré says, is probably due to vegetable matter, and this I can quite believe, as the sample was taken from the Esplanade, which is all made-up ground.

Dr. Dupré adds that in no case, except perhaps in that of (1*a*), is there any indication that the purifying power of the soil has been overtaxed.

General conclusion on analysis of surface soil and upper portion of subsoil.

Speaking generally, therefore, and leaving out of account the four samples which gave contradictory results, it may be said that out of 38 samples analysed, 6 only show signs of pollution, and in 5 out of these 6 cases the pollution can be accounted for by special circumstances. The conclusion is inevitable that the surface and upper portion of the subsoil of the barrack area is not polluted.

Subsoil water. Dr. Dupré's report.

As previously stated, a number of analyses were also made of the subsoil water by Dr. Dupré, and his report on them will be found in the Appendix, page 28. The results obtained may be looked at in two different ways—

1. As regards pollution by sewage pointing to leakage from the drains.
2. As regards influence on health.

Results as regards pollution by sewage.

1. As regards pollution by sewage, by far the greater number of the samples show undoubted indications of such pollution. A few samples, however, are of such a character as not to warrant a definite conclusion that they are polluted, some, indeed, being equal in freedom from pollution to many drinking waters. The relative position of the polluted and unpolluted samples is very remarkable. The polluted samples were almost all taken near the drains, whereas the unpolluted samples were taken at the north portion of the barrack area near Arbour Hill, and included a sample of water from the land drain which is supposed to drain Arbour Hill Burial Ground. Taking this in conjunction with the fact that the barrack drains (as we have seen) were found to be leaky, there seems little doubt that the pollution of the subsoil water comes from the drains on the barrack area and not from any passage of polluted water from Arbour Hill.

Results as regards influence on health.

2. As regards influence on health, I cannot do better than quote Dr. Dupré's precise words. He says:—"In most of the samples the sewage matters have been oxidized, and as far as any possible foul emanations from the water are concerned, rendered harmless. In addition to this, the level of the subsoil water is in every case many feet below the surface of the ground. This leaves a considerable layer of dry soil above the water, and in presence of so effective a purifying agent, no fear of any foul emanations reaching the surface need be entertained, even if the condition of the water were much worse than that actually found."

Crowded Arrangement of Buildings.

Demolitions. Suggestions made at various times.

As stated in the historical summary in my Interim Report, there is a remarkable concurrence of opinion that the buildings at the barracks are crowded together, and that demolitions are required to give more light and air. There is also a concurrence of opinion that the Riding School and some other structures to the north of the barracks should be amongst the buildings to be removed, but as to what the other demolitions should be there is a great difference of opinion.

The various suggestions that have been made with reference to the demolitions other than the Riding School, &c., may be divided into two classes—

1. Suggestions involving extensive demolitions.
2. Suggestions involving only minor demolitions.

Suggestions involving extensive demolitions.

1. Among the suggestions involving extensive demolitions may be mentioned that made in 1881 by Sir Thomas Steele, Commander of the Forces in Ireland, who considered that the Cavalry Barracks should be removed altogether. This suggestion, which was brought forward again in 1886, appears, however, to have been made mostly on account of the small space allotted for the horses (only about half the regulation amount.) At the same time it was proposed to reappropriate the space for infantry, so as to allow of

the removal of buildings elsewhere. Sir Charles Cameron's Commission in 1887, recommended that one entire side of three of the squares should be demolished, viz., the east side of Royal Square, the east side of Horse Square, and the east side of Cavalry Square. Subsequently, His Royal Highness, the Commander-in-Chief, suggested that both sides of Royal Square should be demolished.

Suggestions involving minor demolitions.

2. The suggestions involving only minor demolitions are too numerous to be particularized, but it may be stated broadly that the principle generally adopted was to make comparatively small openings at various places through the sides of the squares, and remove cook-houses and other small buildings in the lanes. One of the latest proposals (that of Lieut.-Colonel Slacke) also included the removal of the buildings which formed blocks at the southern ends of the two central lanes, so as to admit a free current of air right through the lanes. As this latter proposal was being carried out at the time of my investigation, I had better give some further particulars about it.

Demolitions and reappropriations in progress, Plan (VI.)

The main feature of the demolitions and alterations in progress are shown on Plan (VI.). From this it will be seen that the greater portion of Royal Square is to be reappropriated for ordnance stores, and that only the two upper floors of the north side are to be used for soldiers' barracks. It will also be noticed that the south end of the lane between Cavalry Square and Royal Square (A on plan) is to be roofed over so as to form a building for stores, and Colonel Slacke informs me that if this is carried out he proposes to divert the main drain which now passes under that lane, and carry it clear of the block of buildings. With reference to this plan I must remark that notwithstanding the fact that the buildings are to be only used for stores, I think it is a mistake to close up the south end of the lane again after the manifest improvement that has been effected by removing the block that previously existed there, and thus admitting a free current of air through the lane to the upper portion of the barracks.

Question of connection between the crowding together of buildings and incidence of cases of fever.

I quite concur in the general opinion that the buildings have been too much crowded together, and that more light and air are required, but I cannot help feeling some doubts as to whether this crowding together has played such an important part in the unhealthiness of the barracks as has been supposed. In order to see whether there was any foundation for my doubts, I have endeavoured to find whether I could trace any connection between the crowding together of the buildings and the incidence of the cases of fever.

On looking at Plan (IV.), which shows the locality of the cases of fever, this would at first sight appear decidedly to support the view that the buildings which have the most light and air are the freest from fever, inasmuch as Horse Square and the north-east portion of Palatine Square have had much fewer cases than the other portions of the buildings which are more crowded together. If, however, we look more closely into the matter it bears a somewhat different complexion. The north side of Palatine Square is not really a case in point, as it is a good deal hemmed in by the high ground, north of it, and the buildings thereon, which are amongst those proposed to be demolished. Again, several portions of the barracks which are as openly situated as Horse Square, have had a great number of cases, for instance E and F attics, north of Horse Square, B[1] and C houses, Royal Square, and N[1] house, Palatine Square.

In order to test the question in another way I have taken separate houses and separate floors, distinguishing those which are sheltered from those which are not sheltered, and have calculated the percentage of cases to population in each, using for this purpose the three years 1886, 1887, and 1888, during which the precise room where each case occurred is known, which it is not for the earlier years. The upshot of this is that if separate floors, separate houses, or even groups of houses are compared, the results are so irregular as to be worthless. If, on the other hand, all or nearly all the houses are included, the results become more regular, and the percentage of cases in the unsheltered houses is slightly less than that in the sheltered ones.

General conclusions arrived at with reference to demolitions.

The general conclusion I have arrived at, after looking at the question from a number of points of view, is that the demolitions shown on Plan (VI.), which are now being carried out, were certainly required, but that whether further demolitions are necessary depends chiefly on other considerations than the crowding together of the buildings. These other considerations I shall refer to under the next head, viz., Structure of Buildings.

Structure of Buildings, including Condition of Floors and Spaces Underneath Them.

The whôle of the buildings of the Royal Barracks are constructed of local stone, partly limestone and partly granite; this latter, however, has only been used for facing some of the buildings, the body of the walls being limestone.

Condition of walls.

When I first visited the barracks I noticed that many of the walls were very much bulged and tied together with iron tie-rods. I subsequently had reason to think that the objectionable stone locally known as "calp" stone was used to a considerable extent in the walls. This stone, as I have explained in my Report on the Richmond Barracks, closely resembles the hard limestone, but is really a shale, which when first quarried is hard, but when exposed to the action of the atmosphere quickly crumbles, and the excessive use of this "calp" stone is one reason why some of the older houses in Dublin are in a rotten and unhealthy condition. Under these circumstances, I determined to make a thorough examination of the structure of the walls.

As already stated, certain demolitions were being effected while I was at the Royal Barracks, and this gave me an excellent opportunity of examining certain portions of the walls. In addition to this I had a number of holes of considerable size cut in the walls in various parts of the barracks, so as to be able thoroughly to examine the interior of the walls. The examination thus made showed that there was considerable difference in the condition of the walls in various parts of the barracks.

In Cavalry Square and Horse Square the walls are good samples of masonry walls, being well built and solid. In Palatine Square the east side appears to be also fairly well built, but the north-west and south sides are not so well built, the centre of the walls being chiefly filled in with small stones without mortar. In Royal Square the walls are worse still; indeed, in such a defective condition that it is not to be wondered at that they are bulged, and that it has been found necessary to tie them with iron rods. All that appears to have been done when these walls were constructed was to build an outer and inner face without any bond between the two, leaving the centre to be filled up with broken stone loosely thrown in, much of this stone being "calp." The result is that the centre of the wall is full of holes, some of which are large enough to admit of one's arm being thrust completely into them. These holes, moreover, abound in cobwebs and dust, with here and there traces of mouse nests, and even a rat's nest was found in the centre of a wall.

In connection with what has been stated as to the walls, it is worth calling attention to the fact that those buildings, which are in the worst condition, are the oldest portion of the barracks, and that the east side of Palatine Square and Horse Square, which are in good condition, were, as will been seen from my Interim Report, not constructed till more than 50 and 100 years, respectively, later than the older portion.

Foundations of buildings.

The foundations of the buildings, as far as could be seen, were good, except in one particular, viz., that there is no damp-proof course. Notwithstanding this omission, however, I did not notice any signs of damp in the walls, except in the ground floor of F house, Palatine Square.

Concrete under floors.

I made a special examination of the floors in all the barrack rooms. On the ground floor the surface of the ground beneath the floor boards is not generally covered with concrete, but merely has a thin layer of lime mortar, and in one case hardly anything at all except dust. In the Officers' quarters, on the other hand, there appears to be a layer of good concrete over the ground. The

boards in a great number of the barrack rooms are much worn and patched, and the interstices are filled in with dirt. One of the worst floors I saw was that in E Cavalry attic, north of Horse Square, where a number of cases of fever had occurred. Here the floor was double, the top boards were worn very thin, and there was a layer of dirt between them and the lower boards. Boards.

It was also noticed that the floors, especially during the winter months, were often very wet for many hours at a time, sometimes all through the night. This I found to be the result of the way in which the floors are washed. In one case, where I myself saw the washing going on, so much water was used that the floor was entirely flooded, and the water was pushed about from place to place, and even ran down the stairs. Dampness of floors.

In this connection I may mention that I also noticed that on the landing outside some of the barrack rooms, where the urine tubs are placed at night, there was an unpleasant smell, which the washing appeared not to remove. My first idea was that it came from urine having got in between the joints of the stone flagging, and I had some of the stones taken up to examine them. I found, however, that the floor was not saturated, but the smell came from the walls in the particular corners where the tubs are placed, and the explanation appears to be that the tubs are rather low, and that the men when using them carelessly foul the walls. Smell on landing where urine tubs are placed at night.

The boards were taken up in a large number of rooms on the upper floors to examine the condition of the joists and the spaces between them. In a few cases dry rot was found in the short joists near the fire-places of the rooms in Royal Square, but with these exceptions the joists were everywhere in good condition. It should also be mentioned that except the floors and joists there is very little woodwork in the barrack rooms, the skirtings being of iron. The spaces underneath the boards had in almost all cases a quantity of dust in them, which is not to be wondered at where the boards are neither tongued or filletted; but the accumulation appeared to be nearly as large where they were tongued or filletted, so that it would appear that the ordinary method of jointing floor boards is not sufficiently secure for a barrack room. Condition of the joists and the spaces between them in rooms on the upper floors.

I have had a large number of samples of dust taken from the floors and walls, and had most of them analysed by Dr. Dupré, and tested bacteriologically by Dr. Klein. In addition to this, for the purposes of comparison, samples of dust were taken and tested from beneath the floors of two houses in Ship Street Barracks, viz., H and I houses, which are of much more recent construction than any in the Royal Barracks, having been rebuilt in 1854. A further comparison was afforded by the tests which had been carried out on the dust from beneath the floors of the Richmond Barracks. The reports on the samples of dust are given in the Appendix, pages 30 and 36. Tests of samples of dust from the floors and walls.

From these reports it will be seen that the chemical examination of the dust taken from beneath the floors does not lead to any decided conclusion, beyond showing that most of the samples contain a very considerable proportion of organic matter, indicating that the dust is chiefly produced inside the building and not blown in through the windows. There is also some evidence to show that the dust in the Royal Barracks contains more organic matter than that in either the Richmond or the Ship Street Barracks. Chemical examination of samples of dust from beneath the floors.

The bacteriological examinations on the other hand lead to some remarkable results. The first thing that strikes one is the enormous number of microbes that exist in the dust. This will be better realized by looking at the matter in a popular way. Dr. Klein gives the results in microbes per milligramme. Now, roughly speaking, there are about 28,000 milligrammes in an ounce. Applying this multiplier to Dr. Klein's results we find that in the case of the samples which had the least number of microbes, an ounce of dust contained more than 8 million microbes, and that in many samples the number of microbes in an ounce of dust was reckoned by thousands of millions. Bacteriological examination of samples of dust from beneath floors.

Dust from Royal Barracks compared with that from Ship Street and Richmond Barracks.

The next noticeable point is that there are decidedly more microbes in the dust from beneath the floors of the Royal Barracks than in that from the Ship Street or Richmond Barracks, which are of more modern date. Averaging the whole of the figures the results are as follows:—

	Microbes in a milligramme.
Royal Barracks	310,077
Ship Street Barracks	57,250
Richmond Barracks	3,825

On looking at the details in the Appendix, however, it may be considered that this is hardly a fair comparison, as one sample (No. III.) in the Royal Barracks contains such an exceptionally large number of microbes as abnormally to affect the average for those barracks. Against this view it should be remarked that there have been included in the case of the other barracks figures which are relatively as high as those for sample No. III. in the Royal Barracks; at the same time, in order to avoid any undue influence of these abnormal figures, I have excluded the highest figure in each of the three barracks, and have recalculated the averages, which are then as follows:—

	Microbes in a milligramme.
Royal Barracks	51,756
Ship Street Barracks	26,666
Richmond Barracks	633

Showing that the average number of microbes at the Royal Barracks when calculated even in this way is still the highest.

Again, if instead of comparing the average numbers we compare the maximum and the minimum in each case we shall find that this leads to the same conclusion, inasmuch as the maximum at the Royal Barracks is much above the maximum at the Ship Street Barracks and Richmond Barracks, and the minimum at the Royal Barracks is much above the minimum at the Ship Street Barracks and Richmond Barracks.

The fact of there being so many more microbes at the Royal Barracks than at either the Ship Street or Richmond Barracks is certainly a remarkable one, but its importance must not be overestimated, inasmuch as according to modern scientific researches it is only the specific or pathogenic germs which produce a specific fever, and it does not follow that because there are an enormous number of micro-organisms present the pathogenic germs exist among them.

Moreover, Dr. Klein has not been able to find any pathogenic germs. At the same time, looking at the matter from a common sense point of view, and considering, as Dr. Klein puts it, that "it would require an extremely lucky chance to come across" the pathogenic germs among the very small proportion of the whole number of microbes which he was able to study, it would certainly seem that the excess in the number of microbes at the Royal Barracks is suggestive.

Examination of dust from centres of walls.

The dust which was taken from the centre of the walls gives even more remarkable results than that taken from below the floors. Two sets of samples were taken from the walls of D house, Royal Square, one set from room No. 3, on the first floor, where there have been several cases of fever, and the other from the room immediately over this, viz., No. 5 on the second floor, where there have never been any cases of fever. The first set of samples had 64,000 microbes per milligramme, the second set only 900. Dr. Klein's remark about this is that the facts are highly suggestive, but to carry the investigation any further would require special search for the typhoid bacillus, for which it would be necessary to examine the whole of the suspected sample of dust by plate cultivation, an examination which would take several weeks if not months to carry out.

Air communications between centres of walls and rooms.

It will be easily understood that the microbes in the dust underneath the floors might gain access to the inhabitants of the rooms, but it is not at first sight clear how the microbes in the centre of the walls could do so. This is, however, perfectly possible, as the following explanation will show. In the first place, the walls in a large number of the buildings are, as already stated, so hollow that they permit the passage of air up through them as shown by the cobwebs in them. In the next place, the joists frequently fit loosely into the walls, so as to leave air communication with the interior of the walls. That this was the case was proved experimentally, as smoke generated in the centre of the walls came out into the rooms at the joist ends. Lastly, there are additional air communications afforded by defects in the ventilating flues, as will be explained under the next heading.

Possibility of dust in the defective walls affecting the healthiness of the barracks.

The above considerations would certainly seem to suggest that the dust in the defective walls may have had something to do with the unhealthiness of the barracks. This view is, moreover, apparently supported by the fact that Horse Square, which has been remarkably free from fever throughout has good sound walls, whereas Royal Square and the west side of Palatine Square, which have suffered most from fever, have very defective walls. It is also a remarkable fact that the serious outbreak of fever which has occurred during July and August of the present year was confined almost entirely to the houses nearest to the recent demolitions, from which clouds of dust were blown about.

Cubic Space and Ventilation of Buildings.

Cubic space per head.

In order to ascertain whether there was any overcrowding of the barrack rooms, I have taken 600 cubic feet as the normal space which ought to be allowed per head (being the figure given in the Official Synopsis of the proposed normal sizes for barracks), and have had the rooms measured, the number of occupants noted, and the figures tabulated, to see whether this amount of space was given. The result is that in Horse Square and Royal Square the normal amount appears generally to be given, but that in Palatine Square the cubic space per man falls rather short of this in a number of rooms.

Mode of ventilation.

The ventilation of the rooms is effected by inlets and outlets arranged according to the directions given in the Official Synopsis. The inlet ventilators consist partly of openings through the walls, provided with "louvres" or "hoppers" on the inside to give the incoming air an upward direction, and partly of Galton ventilating grates. The outlets consist of wooden shafts carried up from the ceilings of the rooms to above the roofs.

Method adopted for ascertaining the real amount of ventilation provided.

My first idea was that the measurements of the ventilating openings inside the rooms would enable an opinion to be formed as to whether the right amount of ventilation had been provided, but on proceeding to examine the details it was found these openings were often misleading, as there were constrictions of different kinds in connection with them. These constrictions therefore had to be taken into account in every case before the real amount of ventilation could be ascertained. For this purpose, it was necessary to examine the details of every ventilating opening, and measure the gratings both inside and outside, the flues, diaphragms, &c. The figures were then tabulated, and the superficial area of inlets and outlets per occupant calculated.

Result.

The result of this was to show that the actual amount of ventilation provided was very different from what at first it appeared to be. The outlet ventilators generally afforded very nearly the amount of superficial area given in the Official Synopsis, viz., 10 square inches per head, but the inlet ventilators were almost everywhere below the standard, and generally very much below, being in many cases less than half the standard. This was due to various causes.

Causes of the deficiency of inlet ventilation.

The principal cause was that the Galton ventilating grates, which, according to the Synopsis, ought to supply 50 per cent. of the total amount of the fresh air required gave, in the majority of cases, only about 3 per cent. in

consequence of there being no proper inlet into the room for the warmed fresh air, but merely a few small holes drilled in the iron frame of the grate. The enormous extent to which the inlet is constricted by this arrangement will be understood when it is stated that the area of the fresh air duct is generally 108 square inches, and the inlet in the room ought to be larger than this, whereas the total area of the small holes is only about 2½ square inches. Moreover, in some cases where proper inlets for warmed fresh air from the Galton grates are provided, the air ducts, instead of being 108 square inches in area, are very much less, indeed, in two cases they consisted of 4-inch rain-water pipes, giving an area of only 12 inches instead of 108 square inches.

Another cause of the deficiency in the inlet ventilation is that all the "hopper" ventilators have diaphragms within them (out of sight), which greatly reduce the apparent amount of inlet. In addition to this a large number of the ventilators have gratings on the outside, which also much restrict the air space of the openings.

I should explain that as a matter of fact the deficiency in the inlet ventilation is often considerably greater than what I have stated, inasmuch as many of the gratings are choked with dirt, which has not been taken into account in the calculation.

Standard of ventilation is taken low, so that deficiency is inadmissible.

In order fully to appreciate the extent to which the inlet ventilation is defective, it should be borne in mind that the figures given in the Official Synopsis are based on the recommendation of the Barrack and Hospital Commission, 1861, and that recent investigations have shown that a larger amount of ventilation is advantageous. Professor de Chaumont gives 24 square inches per head instead of 10 square inches. Under these circumstances any arrangements which reduce the superficial area below 10 square inches per head are evidently inadmissible.

Holes through the walls for ventilation not "rendered."

During the examination of the details of the ventilating openings, a circumstance was discovered which may possibly have an important bearing in view of what has previously been stated about the defective condition of the interior of many of the walls in the barracks. It was found that in a number of cases the holes through the walls for the inlet ventilators had only been roughly cut and not "rendered" with plaster or cement. Consequently there was air communication between the inside of the walls and the rooms through the ventilating openings.

Water Supply.

In an enquiry like the present, one of the subjects which claims perhaps a greater amount of attention than any other is the water supply. In the present case the water is laid on from the public supply to the City of Dublin, and as this supply is well known to be of good quality, it would at first sight appear very improbable that it should in any way be the cause of the unhealthiness of the barracks.

It will have been seen, however, from the historical statement given in my Interim Report, that the water supply has every now and then been under suspicion, and that numerous analyses have been made of samples of the water taken from the Royal Barracks, and also special investigations made to ascertain whether there were any defects in the water-pipes which would account for local contamination. No such defects were, however, discovered.

Good opinion of the water expressed by Sir Charles Cameron's Commission.

Sir Charles Cameron's Commission stated in their report that the water "is taken from taps attached to the main pipes and not from cisterns, which might possibly be contaminated with organic matter from the atmosphere, and we are satisfied that the water used in the barracks is a perfectly safe one for all possible purposes."

Several analyses which were made of the water by Dr. Dupré also showed that the water supply to the barracks was as pure as that of the town, and that this latter was slightly peaty, but gave, as a rule, no indications of pollution by sewage.

Dr. Dupré's analysis also showed it to be good.

Notwithstanding such favourable reports from so eminently qualified authorities, I could not exclude from my mind the possibility of occasional local contamination. It is well known that two fruitful sources of local contamination are the direct connection of the water-mains to a water-closet or urinal, and the existence of leaky water-mains laid near leaky drains or other sources of contamination, in which case, if the mains are emptied for repairs or any other purpose, a partial vacuum may be created in them, which will suck polluted matter into the pipes. One of the first objects which attracted my attention when I visited the barracks, was a number of men repairing a fractured water-main in the barrack area. This led me to make enquiries, and I then learned that leakages were not of infrequent occurrence, and that the water was then turned off and the pipes emptied for the necessary repairs.

Occasional local contamination suspected.

Moreover, on tabulating and carefully comparing the numerous analyses which have been made at different times by the Army Medical Department, I noticed certain remarkable discrepancies which did not appear to have been satisfactorily explained, nor indeed to have had any special attention drawn to them at the time.

Remarkable differences noticed in the analyses made by the Army Medical Department.

Under these circumstances, and looking at the extreme gravity of the question, I have felt bound to go more minutely into the matter than might perhaps at first sight seem warranted by the occasion.

Minute investigation undertaken.

The street main from which the branch along the Arbour Hill Road to the Royal Barracks draws its supply, comes directly from one of the arterial mains of the city, and, consequently, the water delivered at the Royal Barracks ought to be exceptionally pure and free from risk of local contamination in the city. The branch main along the Arbour Hill Road besides supplying the Royal Barracks proper, supplies also the schools, the military prison, the married soldiers' quarters and the Hospital, &c., in Arbour Hill, as will be seen by referring to Plan (VII.) appended hereto. There are three subsidiary mains, one to the Royal Barracks, one to the military prison, and one to the Arbour Hill premises, and each of these mains is fitted with a Siemens' water-meter. The supply to the schools is taken off the Royal Barracks system.

Course of the mains supplying the barracks, &c. Plan (VII.).

The first proceeding was to ascertain whether by chance there was any direct connection which had been overlooked between a water-closet or urinal and the water-main, and for this purpose, when the sanitary appliances were examined, special note was taken of the precise method in which the water supply was laid on to each individual water-closet and urinal. It was then found that all the water-closets and almost all the urinals were supplied from cisterns, but that two urinals were supplied directly from the main. Here, therefore, is a possible source of pollution, which ought on no account to be allowed to remain.

Sanitary appliances examined to see if any direct connection with the mains existed.

The next proceeding was to ascertain whether any leakages existed in the water-mains; the difficulty, however, was how to test them, so as to obtain really reliable results.

Method of testing the mains so as to ascertain whether leakages exist.

At the outset my idea was that, by dividing up the water-mains into sections, it might be possible to test them by means of a force pump and pressure gauge, but this method of testing had to be abandoned, as, after a few trials, it was found to be impracticable while the barracks were occupied. It was then determined to resort to the system of water waste detection by means of the Deacon waste water-meter, which has been so successfully adopted in various towns. I therefore obtained the permission of the Commanding Royal Engineer to have a Deacon meter fixed on the water-main where it enters the barracks, without disturbing the Siemens' meter which was left to record the total quantity of water used as hitherto.

Deacon's waste water-meter.

The Deacon meter is a self-recording one, and differs from ordinary meters in not registering the total quantity of water consumed, but the rate at which the water passes at any given time. Moreover, it is so sensitive in its action that very small changes in the rate of the passage of the water are recorded, so that when a test is being made any irregularities in the flow, such as those due to the opening or closing of taps, are at once detected.

Description of method of carrying out the tests.

The system on which the tests were made was as follows:—The operations were carried out at night when the consumption of water was at its lowest, and ought to have been almost nothing if there had been no leakage or waste. A certain section of the mains was selected to be tested, and the sluice cocks on the mains supplying the remainder of the barracks were shut down. A special inspection was then made of all the fittings in connection with the section under test to see if any taps had been left running, and, if so, they were closed, the closing of each tap being clearly recorded on the meter diagram. Things were then left in this condition for a while, and any flow of water recorded on the meter diagram during this period was clearly due to leaky taps or leaky mains. If leaky taps were found these were repaired the following day, and the test was subsequently repeated; and if in the second test water still passed it indicated leakage in the main. Similar tests were carried out on each section throughout the barracks.

In the case of the Arbour Hill premises and the military prison the systems of water-pipes are so much less extensive that the testing of them was a much simpler matter, and was effected without a self-recording meter by reading the Siemens' meter at frequent intervals. The procedure in other respects was similar to that adopted at the Royal Barracks.

First results of tests was to show large waste.

The first result of the various tests was to show that a very large amount of preventable waste was taking place at night in every conceivable way. The automatic flushing tank attached to the trough closets discharged every few minutes. Many of the other water-closets also continued to discharge of their own accord through the siphoning of the flushing cisterns attached to them. The urinals were left continually running all night. The supply taps to horse troughs were left running, bath taps, lavatory taps, and sink taps, were left running.

After these various sources of visible waste were eliminated, it was found that there was still a considerable waste of water in a number of sections which could not be accounted for, except on the assumption that leakages existed in the mains. In order to trace these leakages out the suspected mains were then laid bare at various places, and in all cases but one the suspected leakages were discovered.

Leakage found in main in burial ground.

The first leak discovered was on a lead main in the Soldiers' Burial Ground, to the north-east of the Garrison Chapel, at a point marked A on Plan (VII.). The lead main had burst and a large quantity of water was escaping, but there was no sign of this on the surface as the whole of the water ran down into the ground.

This leak partly accounted for the flow from the land drain of the burial ground.

As soon as this leakage was discovered, I suspected that it might account in a great measure for the water running from the land drains of the burial ground, which are connected with the deep subsoil drain from the south side of the Arbour Hill (KK on Plan (II.) of my Interim Report). I therefore gauged the flow of water from the burial ground drain for several days, and found that the flow rapidly diminished after the leakage was repaired. It will be remembered that Dr. Dupré stated with reference to his analyses of this water that there were no indications that it came from a burial ground. Putting these two facts together, I think there can be little doubt that the supposed subsoil water really consisted, to a great extent, of the water which leaked from the water-main.

Two leakages in main of Arbour Hill Hospital.

The next two leaks discovered were in the iron water-main, on the east side of Arbour Hill Hospital, at points B and C on Plan (VII.). Here two splits

in the pipes were found from 1½ feet to 2 feet long, from which a large quantity of water was escaping with great force. The water-pipe, moreover, was laid along side, and almost touching the main drain which conveys excreta from the Hospital, and the water escaped so strongly that it had driven the surrounding grit against the drain-pipe with sufficient force to wear indentations in the stone-ware pipe. One of these indentations was a very remarkable one, and had penetrated through the whole substance of the pipe with the exception of the interior glaze. On being touched with the finger the glaze at once gave way, thus completing the hole through the pipe.

Another leak on east side of Hospital.

The fourth leakage was also on the east side of the Hospital, at a point marked D. This leakage took place from a lead branch off the main close to a catchpit, into which slops from the Hospital are emptied. The sides of the catchpits were defective and allowed sewage to pollute the ground round the pipe.

Leakage in lane between Royal and Palatine Squares.

The fifth leakage was in the lane between Royal and Palatine Squares where a small lead branch joined the main, at the point E on plan. I am doubtful whether there is not another leakage in connection with this main, but time did not permit of my carrying the search any further, especially as there were difficulties in baring the pipe on account of its being laid underneath a well-finished concrete paving.

Suspected leak in main supplying military prison.

The sixth case is only one of suspected leakage, and was on the system of mains supplying the military prison; but although considerable search had been made, this suspected leak has not yet been discovered. There is an element of uncertainty about the matter, on account of the Siemens' meter being suspected of being out of order, but there must certainly either be a leakage of some kind or the meter must be a most erratic one.

Branch main laid through trap of urinal.

During the search for the leak at the prison, a discovery was made of a condition of things which, had it not been found, might have led to very serious pollution of the water supply. A branch lead water-main was most improperly carried through the trap in the floor of a urinal, and the urine had so corroded the pipe that it was almost eaten through. It was evident that it was only a question of time how soon the pipe would have been completely perforated, and when this occurred, an insuction of urine would certainly have taken place when the main was emptied. Moreover, the leak would not have been discovered, as the water would simply have escaped into the trap and thence into the drain.

Summary of conditions discovered which might cause pollution.

All the leakages which were found have now been repaired, but from what was discovered it is quite clear that the conditions necessary for local contamination of the water supply have been in existence at the Royal Barracks and Arbour Hill. Independently of the urinals in direct connection with the water-mains many leaks have been discovered in the water-mains, and some of these leakages were close to the Hospital drains, which would often be conveying infectious matter. In one case the leaky pipe was actually surrounded with pollution, and in two other cases it was only a question of time as to a direct connection being established between a drain and a water-main.

Experimental proof of insuction into mains causing pollution.

The matter was, however, carried further than this, and it was proved by direct experiment that insuction did take place into the water-mains sufficient to affect the quality of the water. In the case of two of the leakages at the Hospital, samples of water were taken from an adjacent tap before disturbing the water-main. The water-main was then emptied when insuction was heard to take place at the leak. The water was then turned on again and another sample taken from the same tap. These samples were subsequently very carefully analysed by Dr. Dupré (the analyses being repeated in each case) and the results showed that the water drawn from the tap after the main had been recharged was distinctly, though but slightly, polluted (*see* Dr. Dupré's Report, Appendix, page 33).

Water supply cannot be excluded as a possible source of infection.

In considering the possible effect of leaky water-mains on the contamination of the water supply to the Royal Barracks, it might at first sight appear that as all the worst leakages discovered were outside the Royal Barracks' area, insuction through them, though it might affect the supply to Arbour Hill, could not have affected the supply to the Royal Barracks proper. I do not think, however, this conclusion would be warranted, as, if polluting matter once enters water-mains it is almost impossible to say where it will or will not be carried. Independently of this, however, leaks are known to have existed at previous times in the Royal Barracks' area itself, and it is therefore perfectly possible that insuction may have taken place through them in the same way it has been proved to take place through the leaks in Arbour Hill. I therefore fully concur in Dr. Dupré's final conclusion that it would be unsafe to exclude the water supply as a possible source of infection.

Leakages near Arbour Hill Hospital must have been going on for some time.

Before leaving the question of the leakage in the water-mains, I had better mention that the leaks near the Arbour Hill Hospital have evidently been going on for a long time, as shown by two circumstances In the first place it must have taken a considerable time for the water to wear the remarkable indentation in the stoneware drain-pipe which I have before referred to. In the next place, the records of the meters show an abnormally high consumption for a long time past. The average consumption of water from the Arbour Hill main for the two months previous to the discovery of the leakage was about 32,000 gallons a-day. After the leakage had been discovered and remedied the consumption was reduced to about 19,000 gallons a-day. On referring to the table given below as to the consumption of water during the last 10 years, it will be seen that it varied from 30,000 to 64,000 gallons a-day, and that a great rise took place about the year 1883. Comparing these figures with the present consumption of 19,000 gallons a-day it is pretty clear that the leakage has been going on since 1883, and possibly since 1879.

Consumption of water at Royal Barracks, Arbour Hill, and military prison for the last 10 years.

The following is the table above referred to, giving the consumption of water during the last 10 years, with reference to which it should be mentioned that the yearly amounts include sometimes a day or so more or less than the true year.

Consumption of Water.

Year.	Royal Barracks.		Arbour Hill.		Military Prison.	
	Consumption per year.	Consumption per day.	Consumption per year.	Consumption per day.	Consumption per year.	Consumption per day.
1879	41,461,000	113,591	11,091,000	30,386	3,327,000	9,115
1880	34,747,000	94,678	11,356,000	31,027	1,670,000	4,528
1881	37,895,000	103,538	12,818,000	35,021	1,424,000	3,890
1882	37,678,000	103,226	14,133,000	38,721	1,625,000	4,451
1883	42,412,000	116,516	18,926,000	51,994	1,966,000	5,401
1884	41,811,000	113,921	20,782,000	56,626	2,579,000	7,046
1885	40,551,000	111,098	23,392,000	64,090	1,198,000	3,306
1886	25,603,000	69,763	21,732,000	59,215	1,978,000	5,389
1887	22,650,000	62,225	18,331,000	50,360	1,873,000	5,145
1888	27,388,000	74,830	16,074,000	44,038	1,912,000	5,238
Totals ..	352,196,000	..	168,635,000	..	19,552,000	..
Averages ..	..	96,338	..	46,147	..	5,351

If we count horses, as men, the following may be taken as the approximate population and average consumption per head for the 10 years:—

	Population.	Consumption. Gallons per head per day.
Royal Barracks	1,900	50
Arbour Hill (including patients in hospital) ..	360	128
Military Prison	160	33

The consumption in every case is very high, and that at Arbour Hill enormous. Now that the leakages have been remedied the consumption at Arbour Hill has been reduced to about 50 gallons per day per head; but this is much higher than it should be, which is accounted for by the fact that a large amount of preventable waste is taking place here in the same way as at the Royal Barracks, as already explained. Large amount of preventable waste.

From experiments I have made with the Deacon meter, it is clear that the consumption at the Royal Barracks can, with a little care to prevent gross waste, easily be reduced to 25 gallons per head per diem, and might with sufficient care be reduced considerably lower. Taking 25 gallons per head per diem at all three places, it appears that during the last 10 years considerably more than half the water consumed has been leakage or preventable waste, and that the unnecessary expenditure on this account (at 6*d.* per 1,000 gallons, the price paid) has amounted to nearly 8,000*l.* Money value.

Irrespectively, however, of the unnecessary waste of money it causes, there are serious objections to a waste of water from a sanitary point of view. In the first place, it has a tendency to keep the subsoil round the buildings damp, and in the next place, where gross waste is the rule, it is almost impossible to detect any leakages in the water-mains, as any increase in the recorded consumption of water is merely attributed to waste. There could not be a better example of this than the long time that the leakages at Arbour Hill have remained undetected, as if attention had been paid to reduce the consumption of water there within any reasonable limits it must have been found out that something was wrong. It is often thought that waste is a good thing, as it assists in flushing the drains; but this is a mistake, as a constant flow of this kind is practically useless for flushing, as explained in my report on the Richmond Barracks. Waste of water objectionable from a sanitary point of view.

Milk Supply.

The possible influence of a milk supply on an outbreak of enteric fever so essentially involves medical considerations, that I cannot go into the question beyond giving two or three general facts in connection with the milk supply at the Royal Barracks.

In the report of Sir Charles Cameron's Commission it is stated that the milk supply at the Royal Barracks was found to be largely adulterated with water, the amount of added water varying from 13 to 56 per cent. Since that time a very considerable improvement appears to have taken place, as I had the milk tested on several occasions, and found it to be practically unadulterated.

The following seems to bear on the question of whether there is any connection between the milk supply and the incidence of fever.

The 5th Dragoon Guards and the Royal Lancaster Regiment, so far as non-commissioned officers and men are concerned, were supplied with milk by the same purveyor, and the incidence of fever amongst them was as follows :—

	5th Dragoon Guards.	Royal Lancaster.
From 14th July to 31st December 1888 ..	6	3
From 1st January to 16th August 1889 ..	0	17

SUMMARY OF RESULTS OF INVESTIGATION.

Drainage. On the whole, the system of drainage is well designed and the drains, as far as appearances go, well laid, some serious defects were however found, and when the water test was applied all the drains that were tested were found to be leaky, some of them extremely so, especially at the Arbour Hill Hospital. The ventilation is very inadequate and other accessories defective.

Sanitary appliances. The sanitary appliances are on the whole good, but there are many defective details which interfere with the general efficiency, the most serious defects being in connection with the Hospital.

River Liffey. The Liffey is practically the common sewer of Dublin, and the smell from it sometimes is abominable, but it seems to be very doubtful whether any clear connection can be traced between this and the unhealthiness of the barracks.

Site of barracks. The site of the barracks is remarkably dry and affords a good foundation for the buildings. The subsoil water is comparatively small in amount and lies at a great depth below the surface.

Surface and subsoil. The analyses of a large number of samples of the surface and upper portion of the subsoil of the barrack area, show that these are practically not polluted.

Subsoil water. The subsoil water, on the other hand, is polluted probably from the leaky drains in the barrack area. Dr. Dupré states however that the sewage matters have generally been oxidized and rendered harmless as far as any possible emanations from the water are concerned, in addition to which the considerable depth of dry soil above the water is so effective a purifying agent that no fear of any foul emanations reaching the surface need be entertained, even if the condition of the water were much worse than actually found.

Crowding together of buildings. The buildings are too much crowded together, and more light and air are necessary. The demolitions shown on Plan (VI.), which are now being carried out, were certainly required, but whether further demolitions are needful depends on other considerations than the crowding together of the buildings.

Walls of buildings. The structure of the walls differs considerably in different parts of the barracks. In Cavalry Square and Horse Square the walls are well built and solid. In a portion of Palatine Square and in Royal Square they are badly built, especially in the latter, where the centre of the wall is full of holes which abound in dust.

There is no damp proof course, but no signs of damp were noticed in the walls except in one case. The surface of the ground beneath the barrack rooms is not generally covered with concrete, but that in the Officers' quarters appears to be so.

Floors.

The floor boards in the barrack rooms are much worn and patched, and the method of washing them objectionable. The spaces beneath the floors have a large quantity of dust in them.

Dust from beneath floors.

The chemical examinations show that this dust contains a considerable amount of organic matter, and the bacteriological examinations show that it contains an immense number of microbes. The dust from beneath the floors of the Royal Barracks contains considerably more microbes than either that from the newer houses in the Ship Street Barracks or that from the Richmond Barracks.

Dust from walls.

The dust taken from the centre of the wall of a room in Royal Square, where there have been several cases of fever, contained 70 times as many microbes as that from the centre of the wall of the room immediately over it, where there have never been any cases of fever.

There are air passages through which the dust in the centre of the defective walls could pass to the barrack rooms.

The above facts seem to suggest that the dust may have something to do with the unhealthiness of the barracks, and certain coincidences between the condition of the buildings and incidence of fever appears to support this view.

Ventilation.

The ventilation of the barrack rooms is almost everywhere deficient. The outlet ventilation is generally equal to the prescribed amount, but the inlet ventilation is much below it, owing to the improper construction of the ventilators, especially of the Galton ventilating grates.

Water supply.

The water supply is Vartry water, obtained from the public supply to the City of Dublin, which is known to be generally good, and special analyses of the water actually supplied to the Royal Barracks confirm this view.

Certain circumstances, however, led me to suspect that occasional local contamination of the water might have taken place, and, consequently, to undertake a very close examination and systematic testing of the water-mains. The result was the discovery of several leakages in the mains.

Three of these leakages were situated close to the Arbour Hill Hospital drain, and had, probably, been going on for several years. It was proved by actual experiment that insuction took place when the mains were emptied, and that the water was thereby distinctly, though but slightly, polluted.

In addition to this, two urinals were found directly connected with the mains, and other matters which were likely to lead to local pollution of the water supply.

The experiments that were necessary to test the water-mains showed incidentally that a very large amount of preventable waste of water was taking place from the various fittings, and an examination of the records of consumption for the last 10 years showed that this waste had been going on for that time. Besides having caused (together with the leakage) a large money loss, amounting to nearly 8,000*l.* in the 10 years, this waste is objectionable from a sanitary point of view.

Milk.

The quality of the milk supplied to the troops in the Royal Barracks seems to have very much improved since the date of the Report of Sir Charles Cameron's Commission.

RECOMMENDATIONS.

1. I have already, in my Interim Report, given a number of recommendations as regards the drainage and sanitary appliances, and these should be carried out. The leaky condition of the drains, which has been discovered by the further tests which have been carried out, renders a number of additional alterations necessary.

Drainage.

2. As the drains are, on the whole, fairly well laid, I think the defects in a number of them can be remedied without the necessity of taking them up.

It is impossible, in general recommendations like these, to give detailed instructions as to which drain should be taken up and which only repaired, but certain leading points can be pointed out. In the first place, all the drains hitherto not tested by water should be subjected to the test. In the next place, the principle that should determine what should be done in each case is that all drains close to occupied buildings should be made absolutely watertight, so as to stand the water test, but that those which are at a distance from occupied buildings, so long as they have no decided defects, need not be made absolutely watertight.

3. The defective branch drains, which are comparatively shallow, can be so easily taken up and relaid, that this, no doubt, will generally be the best thing to do with reference to them. As regards the main drains, those round the Hospital must certainly be relaid, others, no doubt, may be partly relaid and partly repaired. One or more of the main drains might perhaps be diverted with advantage, especially if the proposed reappropriations are to be carried out. Wherever any new drains are laid they should be constructed without saddle pipes.

4. The sinks, baths, &c., should no longer be allowed to discharge into long channels, but self-cleansing gullies should be provided at the foot of the waste pipes to receive the discharge. Properly constructed silt pits also should be provided to receive the surface water and washings.

5. In every case a raised dais should be made on which to place the urine tubs on the landings outside the barrack rooms, and the walls on each side should be "rendered" with Portland cement so as to prevent their being polluted.

River Liffey.

6. It is very desirable that the War Office should do everything in their power in furtherance of any steps that may be taken by the Dublin Corporation for the purification of the River Liffey.

7. The further investigations into the nature and stratification of the subsoil having tended only to confirm the opinion I expressed with regard to it in my Interim Report, I have nothing to add to the recommendations therein contained.

Surface and subsoil.

8. As regards the surface and subsoil, I am of opinion that it would be expedient to abolish the use of the cobble stone paving (which is not only uncomfortable but very apt to retain polluted matter among the crevices), and to substitute instead serrated brick paving, or some other impervious material, which would not become slippery. Steps should also be taken effectually to prevent the throwing of slops out of window by the soldiers.

Demolitions.

9. The demolitions which are shown on Plan (VI.), and which are now in progress, should be completed. Whether any further demolitions or reappropriations are required depends not so much on the crowded arrangement of the buildings as on what view is taken of the possible influence of the dust from the defective walls on the health of the occupants.

10. If the medical view taken of the matter is that the dust may have a serious influence on the health of the occupants, I can hardly see how the demolition and reconstruction of all the defective buildings can be avoided if they are to be occupied by troops. Even if it is proposed that they should not be occupied by troops but be used as stores, it is a question whether this would be a safe expedient, as there must be men in charge of the stores. Should this serious view of the matter be taken and the defective buildings be pulled down, special precautions should be taken under medical advice as to the disinfection of the interior of the walls before they are pulled down, by drenching them with a solution of perchloride of mercury, so as to prevent any possible injury

which might arise from the dust. The details of the method of disinfection which should be employed will be found in the Joint Report of Dr. Dupré and Dr. Klein, appended to my Report on the Richmond Barracks. Of course when the buildings are reconstructed they should be laid out so as not to be so crowded together.

11. On the other hand, if the medical view taken is that the question of the dust has no serious bearing on the health of the occupants, I am of opinion that further demolitions beyond those shown on Plan (VI.) are not absolutely necessary. As already stated, however, I think that notwithstanding the buildings are to be reappropriated with stores, it would be much better not to close up the south end of the lane between Royal Square and Cavalry Square by the block marked A, after the manifest improvement that has been effected by opening the end of this lane.

Air communications between centre of walls and rooms to be stopped.

12. If the view in the last paragraph is adopted, I still think that effective measures should be taken to prevent any air communication between the centre of the walls and the rooms by making good the walls where the joists enter, cementing the defective ventilating openings and carrying out other precautionary works. All floors having dust and dirt beneath them, especially those where illness has occurred, should be taken up, and the spaces underneath should be cleaned and disinfected in the way recommended in the Joint Report of Dr. Dupré and Dr. Klein.

Floors.

13. Whenever any new floors are laid they should either be tongued or filletted, or a double floor should be laid (similar to those lately constructed in E and F Cavalry attics), having the upper layer of narrow strips of pitch pine. It would be well to try the method of rendering the boards impervious with a solution of wax in paraffin, recommended in the Report of Sir Charles Cameron's Commission. Under any circumstances the excessive flooding of the floors when washing them should be avoided.

14. Where the concrete below the ground floors is of an inferior nature it should be removed, and Portland cement concrete, not less than 6 inches in thickness, should be laid over the surface of the ground under all ground floors. The system of dry areas round the foundations of the buildings may be extended with advantage, and where any new buildings are built they should be provided with a damp-proof course, and care should be taken that no calp stone is used.

Ventilation.

15. All Galton grates in barrack rooms which ventilate only by holes in their framework, should have proper air shafts of suitable dimensions constructed to conduct the warmed fresh air into the room through a louvred opening near the ceiling, the clear area through the louvres being much larger than through the shaft.

16 All hopper inlet ventilators should be removed and be replaced by the more modern louvred ventilators. All gratings to ventilating flues which constrict the air passages should be removed and be replaced by gratings which shall give the full air way, and the gratings should be periodically cleaned.

17. Where gas burners have not been provided with ventilating tubes to carry off the products of combustion, tubes should be fixed.

Water supply.

18. The direct connection of the water-mains with two urinals should be cut off and the urinals supplied from a cistern.

19. The water-main in the lane between Royal Square and Palatine Square should be retested at night, in the manner explained on page 16, and if any leakage is still found to take place the main should be laid bare and the leakage found and repaired.

27 20. The Siemens' meter on the main to the military prison should be changed, and after a new one is fixed, special tests of the main should again be
28 made at night in the manner explained on page 16, and if any leakage is indicated it should be found out.

29 21. The iron water-main immediately alongside the drain on the east side of the Hospital should be removed, and relaid at some distance from it.

22. A minute examination should be made of the localities of the water-mains generally, both at the Royal Barracks and Arbour Hill, and wherever
30 there seems to be a chance of the mains passing close to drains, traps, or other sources of pollution they should be laid bare, and if found to be wrongly laid altered.

23. The whole of the water-mains should be periodically tested (say every half-year) in the manner previously described, and wherever the tests indicate
31 a leakage the indications must be followed up, and either the leakage be found, or the escape of water accounted for. Water-mains should be laid so as to be accessible.

24. The flushing cisterns of all water-closets, including the trough closets,
32 should be supplied from a cistern, and not from the main direct, as the pressure in the main is too great for the fittings.

25. It should be considered whether it would not be advantageous to fix a
33 pressure reducing valve on the three subsidiary mains, as the existing pressure at night (namely, about 72 lb. on the square inch) is too great for ordinary ball valves and fittings, and this causes additional waste.

26. Steps should be taken to prevent the gross misuse of water which now takes place. For this purpose an intelligent man should be appointed to shut off the urinals and automatic flushing cisterns to trough closets, to make a
34 nightly inspection of all washhouses, bathrooms and ablution rooms, and water-closets, and to report any leakage, apparatus out of order, or waste of water from neglect, and generally to supervise the water supply.

27. Tests should also be made periodically by the Royal Engineers to
35 check the consumption of water. This can be done at the Royal Barracks by the Deacon meter, and at Arbour Hill and the military prison by taking hourly readings of the Siemens' meter throughout the day and night.

I have the honour to be,
Sir,
Your obedient Servant,

ROGERS FIELD,
M. Inst. C.E.

7, Victoria Street, S.W.,
31*st August* 1889.

APPENDIX I.

REPORT by Dr. Dupré, F.R.S., on his Analysis of Soil and Subsoil at the Royal Barracks.

Four only out of the 22 samples of surface soil examined, viz., 4*a*, 8*a*, 9*a* and 15*a* show a greater proportion of organic matter than is frequently found in unpolluted and uncultivated soil; hence these are most probably polluted. In two cases out of these four, viz., 8*a* and 9*a*, fresh samples were taken as near as possible from the same spot, the analyses of which are given under Nos. 22*a* and 21*a*. These analyses show the soil to be unpolluted, and prove that the pollution indicated in the first set of samples can only have been of an extremely local character.

In one other case, viz., 1*a*, although the proportion of organic matter is but moderate, the percentage of nitrogen contained in this organic matter is high; and this sample is, no doubt, polluted.

Of the 20 samples of subsoil examined (taken 2 feet below the surface) three only show any distinct indications of pollution, viz., 1*b*, 11*b* and 17*b*. In two of these the proportion of organic matter is moderate, but both contain a somewhat high proportion of nitric acid in the form of nitrates, which is probably due to the passage of urine through the soil. The percentage of nitrogen in 1*b* also is high. The third of these samples (17*b*) shows a very high proportion of organic matter, coupled with a moderate proportion of nitrogen, and here the pollution is probably chiefly vegetable.

Taken generally, the surface soil shows pollution in three places, the subsoil in three places also; and in no case, except perhaps in that of Sample 1*a*, is there any indication that the purifying power of the soil has been overtaxed.

In addition to the foregoing, six samples of soil were taken purposely close to drains. Four of these are practically unpolluted, while two, viz., 27 and 28, are undoubtedly polluted.

(Signed) A. DUPRÉ.

ROYAL BARRACKS.

Soil and Subsoil.

No.	Description of sample.	Chlorine, per cent.	Nitric acid, per cent.	Organic matter, per cent.	Inorganic matter, per cent.	Total nitrogen, per cent.	Nitrogen in organic matter, per cent.
1*a*	2 ins. below pebble paving, between Royal Square and Horse Square, where urine tubs were emptied ..	·012	·007	4·73	95·27	·252	5·32
1*b*	2 ft. " " " " " ..	·018	·017	3·30	96·70	·056	1·70
2*a*	2 ins. " north-east corner, B house, Cavalry Square	·004	·002	2·70	97·30	..	..
2*b*	2 ft. " " " "	..	..	..	..	..	..
3*a*	2 ins. " cook-house, No. 3	·012	·002	13·45	86·55	3·22	2·39
3*b*	2 ft. " "	·014	·002	4·14	95·86	..	..
4*a*	2 ins. " south front, Royal Square	·002	·002	15·15	84·85	2·87	1·89
4*b*	2 ft. " " "	·006	·002	4·04	95·96	..	..
5*a*	2 ins. below surface at ladder shed, Royal Engineers Offices	·002	·002	5·85	94·15	..	..
5*b*	2 ft. " "	..	..	..	..	..	..
6*a*	From testhole 24, 2 ft. deep..	..	..	2·81	97·19	..	..
6*b*	" 24, 12 "	..	..	1·33	98·67	..	..
7*a*	" 9, 2 "	..	..	4·40	95·60	..	..
7*b*	" 9, 10 "	..	..	2·32	97·68	..	..
8*a*	2 ins. below surface, outside serjeants' billiard room, Horse Square	·003	·001	9·75	90·25	·119	1·22
8*b*	2 ft. " " "	·004	·002	3·45	96·55	..	..
9*a*	2 ins. " centre Cavalry Square	·003	·001	11·55	88·45	·074	0·64
9*b*	2 ft. " " "	·004	·004	5·60	96·40	..	..
10*a*	2 ins. below pebble paving, South-East Field Officers' Quarters, Royal Square	..	..	5·30	94·70	..	..
10*b*	2 ft. " " " "	..	..	2·80	97·20	..	..
11*a*	2 ins. below surface, centre, Royal Square	·005	·006	2·24	97·76	..	..
11*b*	2 ft. " "	·010	·024	4·02	95·98	..	..
12*a*	2 ins. below pebble paving, south-east corner, Assistant Quarter-Master-General's Quarters, Brunswick Square	..	..	4·40	95·60	..	..
12*b*	2 ft. " " " " " " ..	..	..	2·90	97·10	..	..
13*a*	2 ins. below surface at canteen entrance steps	..	..	3·80	96·20	..	..
13*b*	2 ft. " " "	..	..	2·80	97·20	..	..
14*a*	2 ins. " at back of stable	..	..	3·90	96·10	..	..
14*b*	2 ft. " " "	..	..	2·35	97·65	..	..

ROYAL BARRACKS—Soil and Subsoil—*continued.*

No.	Description of sample.	Chlorine, per cent.	Nitric acid, per cent.	Organic matter, per cent.	Inorganic matter, per cent.	Total nitrogen, per cent.	Nitrogen in organic matter, per cent.
15a	2 ins. below pebble paving, north side, Palatine Square	..	..	8·19	91·81	·140	1·71
15b	2 ft. „ „ „ „	..	..	5·08	94·92	..	..
16a	2 ins. below surface in centre of Palatine Square	..	..	3·39	96·61	..	..
16b	2 ft. „ „ „	..	..	4·38	95·62	..	..
17a	2 ins. „ at testhole 9 in Esplanade	..	..	5·24	94·76	..	..
17b	2 ft. „ „	..	..	21·44	78·56	·35	1·63
18a	2 ins. „ at back of stables 8 „	..	..	6·31	93·69	..	..
18b	2 ft. „ „ „	..	..	3·00	97·00	..	..
19a	2 ins. „ in Riding School passage	..	..	3·81	96·19	..	..
19b	2 ft. „ „ „	..	..	4·15	95·85	..	..
20a	2 ins. „ in centre of Horse Square	..	..	5·24	96·76	..	..
20b	2 ft. „ „ „	..	..	3·07	96·93	..	..
21a	2 ins. „ „ Cavalry Square	..	..	2·80	97·20	..	..
21b	2 ft. „ „ „	..	..	3·16	96·84	..	..
22a	2 ins. „ outside serjeants' billiard room, Horse Square	..	..	4·41	95·59	..	..
22b	2 ft. „ „ „	..	..	3·31	96·69	..	..
23	Beside main drain, No. 3, at end of lane, 6 ft. 6 ins. below surface	..	..	3·20	96·80	..	..
24	5 ft. below surface hospital main drain, and alongside main drain in lane 1, at back of B house, Cavalry Square	..	..	2·03	97·97	..	..
25	Below main drain, alongside saddle at south-west corner of A house, Cavalry Square	..	..	4·42	95·58	..	..
26	Below main drain, No. 2, opposite centre of E house, Royal Cavalry Square	..	..	3·90	96·10	..	..
27	Alongside main drain at pack store, on west side of D[1] at hospital	..	..	7·29	92·71	..	..
28	Below main drain, No. 1, opposite Royal Engineers Store, No. 1	..	..	11·22	88·78	..	..

(Signed) A. DUPRE.

APPENDIX II.

REPORT by Dr. Dupré, F.R.S., on his Analyses of Subsoil Water at the Royal Barracks.

The actual condition of a subsoil water liable to pollution depends on a variety of conditions, such as the actual amount of polluting matter discharged into it, the amount of pure water passing simultaneously through the soil, the nature of the soil, &c. A certain amount of polluting matter will obviously have the greater effect the less the amount of pure water into which it passes and the less the purifying influence of the soil.

In comparing or contrasting the condition of the subsoil water with that of the subsoil itself, it must also be borne in mind that whereas the analysis of a sample of subsoil gives only more or less local information, the analysis of a water averages (so to speak) the condition of things over a greater or less area. Any indication of pollution it furnishes may therefore point either to a strictly local or to a more distant source.

Applying these general considerations to the waters under examination, we find—

1. That as regards pollution by sewage, the following numbers show undoubted indications of such pollution:—3, 4, 5, 6, 8, 10, 11, 12, 13, 14, 15, 16, 17, 19 and 23.

2. The character of waters No. 1 (2, 7), (9, 18, 20) 22 is such as not to warrant a definite conclusion that they are polluted. Some, indeed, are equal in freedom from pollution to many drinking waters. Sample 22 is stated to come from a drain from a burial ground, but the analysis shows no indications of this.

3. One sample of No. 21 is of somewhat doubtful character. The proportions of chlorine and nitric acid are low, but on the other hand the proportions of ammonia, albuminoid ammonia, and of oxygen absorbed are high.

4. Judging from the high proportion of chlorine and of nitric acid found in many of these samples, the amount of natural subsoil water can be but small.

As regards the influence on health, excluding the question of drinking, the condition of a subsoil water should be judged mainly by the amount of unoxidized organic matter which it still contains, and not by the proportion of mineral matter derived from sewage.

Taking the oxygen absorbed from permanganate as a guide for estimating the proportion of the former class of matters, it will be seen that in eight out of the 19 samples examined in this respect the proportion of oxygen absorbed does not exceed that of ordinary drinking waters, viz., Nos. 1, 2, 3, 6, 7, 14, 20 and 22, while in the three others it but slightly exceeds this, viz., Nos. 4, 8, and 12. In the remaining eight the proportion is high. In three (Nos. 11, 16 and 21) it is very high, although even in these cases it falls very short of the amount absorbed by ordinary sewage.

Turning now to two of the characteristic mineral matters derived from sewage, viz., chlorine and nitric acid, many of the samples (as previously stated) show undoubted indications of pollution by sewage. In most of the samples the sewage matters have, however, been oxidized, and, as far as any possible foul emanations from the water are concerned, rendered harmless.

In addition to this, the level of the subsoil water is in every case many feet below the surface of the ground. This leaves a considerable layer of dry soil above the water; and, in presence of so effective a purifying agent, no fear of any foul emanations reaching the surface need be entertained, even if the condition of the water were much worse than that actually found.

(Signed) A. DUPRÉ.

SUBSOIL WATER FROM ROYAL BARRACKS, DUBLIN.

Grains per Gallon.

No.	Description of sample.	Oxygen absorbed from permanganate in few minutes.	Oxygen absorbed in four hours.	Chlorine.	Nitric acid.	Ammonia.	Albuminoid ammonia.	Total dry residue.	Phosphoric acid.	Behaviour of residue on ignition.
1	Testhole 17, at back of stable 30, 26th January 1889	..	·021	4·55	·022	·0465	·0056	90·72	Strong trace ..	Does not blacken perceptibly.
2	From well at back of north side of Palatine Square, 2nd February 1889	..	·053	1·96	3·248	·0098	·0120	35·84	Trace	Blackens slightly; burns off readily.
7	„ on north side of Palatine Square, depth of well about 53 ft., 15th February 1889.	..	·038	2·10	4·280	·0000	..	40·88	Slight trace ..	Blackens scarcely perceptibly.
3	From testhole 9, Esplanade, 2nd February 1889	..	·100	7·84	3·276	·2240	·0070	57·40	Trace	Blackens markedly; burns off readily.
4	Testhole 24, opposite cook-house No. 5, 2nd February 1889	..	·605	5·60	13·580	·4200	·0700	69·72	.. ..	„ „ „
5	From testhole 9, Esplanade (2nd sample), 12th February 1889	..	·202	5·53	0·360	..	..	65·80	Very strong trace..	Smells uriniferous; blackens very strongly; burns off with much difficulty.
6	Testhole 24, west side of Palatine Square (2nd sample), 12th February 1889	..	·140	3·68	12·620	..	..	63·00	Excessive amount .	Blackens markedly; no smell of urine.
8	„ 90 on Esplanade, 25 ft. east of testhole 9, depth 10 ft. 6 in., 19th February 1889.	..	·251	10·05	3·160	..	..	67·48	.. ..	.. ..
9	Sample from testhole 32, 19th March 1889	..	..	2·66	1·650	..	..	..	.. ..	.. ..
10	Testhole 24 (3rd sample), at 16 ft. deep, 21st March 1889	..	..	3·64	6·580	..	..	..	.. ..	.. ..
11	„ 20 in General's garden	0·700	1·130	4·97	7·000	..	..	..	.. ..	.. ..
12	„ 3A in Cavalry Square, 30th March 1889	0·140	0·204	14·56	14·000	..	..	..	.. ..	.. ..
13	„ 4, near cook-house No. 1, 30th March 1889	0·350	0·770	4·83	7·200	..	..	..	.. ..	.. ..
14	„ 1 in Esplanade, 2nd April 1889	0·025	0·069	7·56	11·200	..	..	..	.. ..	.. ..
15	„ 19 in Esplanade, 4th April 1889	0·350	0·603	4·69	1·120	..	..	..	.. ..	.. ..
16	„ 10, 24 ft. from surface	0·700	1·09	4·80	0·185	..	..	45·25	.. ..	.. ..
17	„ 13 in lane 2, 13th April 1889	..	..	7·56	0·147	..	..	48·20	.. ..	.. ..
18	„ 32 (2nd sample), 15th April 1889	..	0·419	2·35	0·258	·0140	·0112	56·70	.. ..	.. ..
19	„ 9 (4th sample), 23rd April 1889	0·508	0·722	2·10	5·600	·0168	·0168	68·60	.. ..	.. ..
20	„ 32 (3rd sample), 23rd April 1889	0·077	0·174	2·52	3·750	·0372	·0073	47·60	.. ..	.. ..
21	„ 21 in lane 3, 34 ft. deep, 3rd May 1889	..	0·924	1·08	0·014	·0224	·0476	21·70	.. ..	.. ..
22	Drain from burial ground at Chamber, near coal yard, 4th May 1889	..	0·045	1·96	3·050	·0028	·0028	36·80	.. ..	.. ..
23	From testhole 2, 14th May 1889	..	·45	5·39	9·63	·0560	·0196	74·20	.. ..	.. ..

(Signed) A. DUPRÉ.

APPENDIX III.

REPORT by Dr. Dupré, F.R.S., on his Analysis of Dust at the Royal Barracks.

The chemical examination of the samples of dust taken from beneath the floors of various rooms in the Royal Barracks does not lead to any decided conclusions, even when coupled with the results yielded by the analyses of similar samples taken from the Richmond and Ship Street Barracks. Most of the samples show, however, a very considerable proportion of organic matter, and with one or two exceptions, a somewhat high proportion of nitrogen. This shows that most of the dust is produced inside the building, and is not dust blown in through the windows from the grounds outside; as a comparison of these dusts and the surface soil of the barracks clearly indicates.

In the case of the Royal Barracks 71·4 per cent. of the samples examined (10 out of 14) contain more than 20 per cent. of organic matter. In the case of the Richmond Barracks, 28·6 per cent. only of the samples examined (2 out of 7) contain that amount of organic matter; and in the case of the Ship Street Barracks 25 per cent. of the samples (1 out of 4) exceeded that amount. In this respect, therefore, the dust from the Royal Barracks appears to be decidedly the worst.

A little more light is apparently thrown on the nature of the results contained by comparing them with the remarkable results recorded by Dr. Klein.

Taken as a whole there seems to be a certain parallelism between the percentage of nitrogen and the number of microbes found in the dust. There are certainly some very striking exceptions, but on the whole the tendency is decidedly one of agreement.

It would, however, require a far greater number of analyses and examinations to warrant the drawing of any general conclusion.

(Signed) A. DUPRÉ.

Dust.

No.	Description of sample.	Organic matter, per cent.	Inorganic matter, per cent.	Total nitrogen, per cent.	Nitrogen in organic matter, per cent.
I.	From under floor at Moore's bed, E attic, Cavalry soldiers' quarters, 1st December 1888	18·84	74·56	·644	3·42
II.	„ „ centre of E block, Cavalry soldiers' quarters, No. 3, opposite Coate's bed, 1st December 1888	13·71	86·29	·462	3·37
III.	„ Horse Square, B attic, room 7, over stable No. 8, 19th December 1888	18·29	81·71	·805	4·39
IV.	„ „ C „ „ 8, „ No. 16, 19th December 1888	22·85	77·15	..	..
V.	„ Palatine Square, 3rd floor, room 47, where case No. 78 occurred, 21st December 1888	21·60	78·40	..	..
VI.	„ „ 1st „ room where case No. 82 occurred, 22nd December 1888	20·95	79·05	·770	3·67
VII.	E attic, east end, at Bennet's bed, 1st February 1889	22·70	78·30	·854	3·76
VIII.	L house, Palatine Square, 1st floor, 2nd February 1889..	29·00	71·00	1·120	3·90
IX.	F „ Palatine Square, 3rd floor, „ „	25·60	74·40	·490	1·91
X.	D „ Royal Square, 1st floor, 2nd February 1889	23·50	76·50	..	..
XI.	C[1] „ „ 2nd „ „ „	19·05	80·95	..	..
XII.	C „ „ 1st „ „ „	20·50	79·50	..	..
XIII.	B „ „ 2nd „ „ „	20·50	79·50	..	..
XVIII.	O[1] „ Palatine Square, room 61, 21st May 1889	21·40	78·60	·789	3·68

RICHMOND BARRACKS.

Dust.

No.	Description of sample.	Organic matter, per cent.	Inorganic matter, per cent.	Total nitrogen, per cent.	Nitrogen in organic matter, per cent.
I.	Dust under floor, west side of F soldiers', No. 5	12·9	87·1	..	..
II.	„ „ east „ „	6·0	94·0	..	..
III.	„ „ M soldiers', No. 5	18·0	82·0	·976	5·37
IV.	„ „ „ No. 1, north-east corner	8·4	91·6	..	..
V.	„ „ L „ room 5	17·5	82·5	·805	4·60
VI.	„ „ M house, Rookery, room 8 (Scott's)	20·8	79·2	·868	4·17
VII.	Captain Every's drawing-room floor, D house, Officers'	25·23	74·77	·812	3·21

SHIP STREET BARRACKS.

XIV.	H house, No. 7 room, 1st floor, centre of north end of room, 4th February 1889	17·65	82·35	·658	3·79
XV.	I „ centre of room, 2nd floor, 4th February 1889..	19·35	80·65	·630	3·25
XVI.	Under floor, H house, room 11, in centre 2nd floor, 15th March 1889..	18·94	81·96	·700	3·80
XVII.	„ I „ 1st floor, north centre of room, 15th March 1889	26·70	73·30	·756	2·83
XVII.	(Duplicate) „ „ „ „	21·35	78·65	·707	3·31

(Signed) A. DUPRÉ.

APPENDIX IV.

REPORT by Dr. Dupré on his Analysis of the Vartry Water supplied to the Royal Barracks.

The drinking water used in the Royal Barracks is the same as that supplied to the City of Dublin. It is a slightly peaty water, but gives, as a rule, no indications of pollution by sewage. In this respect, therefore, the inhabitants of the barracks stand in the same position as the inhabitants of Dublin generally.

The analyses specially made for this enquiry, as a rule, bear out this supposition, viz., that the water supply of the barracks is as pure as that of the town.

In the course of the enquiry it was, however, found that leaks in the water-pipes were by no means of very rare occurrence, and if such a leak should happen to be near to a faulty drain-pipe serious pollution of the drinking water might take place, more especially when the pipe was emptied in order to be repaired.

In two cases we were able to put this supposition to the test, and in both cases it was found that the first portions of water drawn from the pipe after the leak had been repaired were distinctly though but slightly polluted.

Here then a very serious danger is indicated. Every leaky water-pipe, particularly if any infectious disease happened to be in the barracks at the time, might be a means of spreading infection.

In connection with this it may be well to refer briefly to some analyses of Vartry water taken at these barracks, made by the Army Medical Department. A glance at these analyses shows that during the years 1886 and 1887 the water was remarkably uniform in character. They correspond well with my own analyses of the same water made in the early part of 1889. The two analyses made in January 1888, show, however, a striking difference. In these most of the characteristics indicating sewage pollution show a decided increase, as, for example, chlorine, nitric acid, phosphoric acid, and ammonia.

It is to be regretted that more marked attention was not at that time drawn to this alteration, with a view of having the cause or causes thoroughly investigated. Taking this in connection with my own results on waters taken from pipes that had leaked, it would be unsafe to exclude the water supply as a possible source of infection.

(Signed) A. DUPRÉ.

VARTRY WATER, ROYAL BARRACKS.

Grains Per Gallon.

No.	Description of sample.	Oxygen absorbed in 15 minutes.	Oxygen absorbed in 4 hours.	Chlorine.	Nitric acid.	Ammonia.	Albuminoid ammonia.	Total dry residue.	Phosphoric acid.	Behaviour of residue on ignition.
A	From tap, west side Palatine Square, 14th January 1889	..	·139	·91	·146	·0014	·0047	3·92	Trace	Blackens strongly, burns off with difficulty.
B	„ at south end of C attic, Horse Square, at same time as A, on different mains, 14th January 1889.	..	·124	·91	·131	·0007	·0058	..	.. ..	.. ..
C	From tap in F house, Palatine Square, 19th January 1889	..	·127	·84	·176	·0000	·0039	..	.. ..	.. ..
D	„ at south-west corner, Palatine Square, 19th January 1889	..	·124	·84	·176	·0028	·0039	..	.. ..	.. ..
E	Dublin Corporation main hydrant, near Arbour Hill Gate, before any large quantity had been run off, 19th January 1889.	..	·130	·84	·098	·0000	·0039	..	.. ..	.. ..
F	Dublin Corporation hydrant, Arbour Hill Prison Gate, after large quantity had been run off, 19th January 1889.	..	·132	·84	·176	·0000	·0045	..	.. ..	.. ..
G	Dublin Corporation hydrant, near Arbour Hill Gate of barracks, 19th March 1889.	·041	·101	·91	·114	·0159	·0031	4·20	Slight trace ..	Blackens markedly, burns off very readily.
H	From tap at south-west corner of Palatine Square, 19th March 1889	·048	·094	·91	·123	·0000	·0032	4·48	Slight trace ..	„ „
J	„ west side corner of Palatine Square, 19th March 1889	·041	·096	·91	·132	·0000	·0032	4·48	Very slight trace ..	„ „
K	„ south end of C attic, Horse Square, „ „	·042	·098	·91	·088	·0000	·0028	4·48	Very slight trace ..	„ „
L	Leak in 2¼-in. main, at back of Arbour Hill Hospital, 1st June 1889	..	·101	·81	·100	·0000	·0048	..	.. ..	.. ..
M	From tap nearest to leak in water-main, Arbour Hill Hospital, after main had been emptied, 1st June 1889.	..	·104	·82	·100	·0000	·0031	..	.. ..	.. ..
N	From tap in ablution room, C[1] House Hospital, before main was emptied on discovery of 2nd leak outside, 12 ft. north of last, 7th June 1889.	..	·094	·727	Trace	·0000	·00359	3·92	.. ..	Blackens strongly, burns off fairly readily.

Vartry Water, Royal Barracks—Grains Per Gallon—*continued.*

No.	Description of sample.	Oxygen absorbed in 15 minutes.	Oxygen absorbed in 4 hours.	Chlorine.	Nitric acid.	Ammonia.	Albuminoid ammonia.	Total dry residue.	Phosphoric acid.	Behaviour of residue on ignition.
O	From tap after water had been turned on again, 7th June 1889	..	·103	·744	Trace	·0000	·00396	4·20	.. ..	Blackens strongly, burns off fairly readily.
N	Details of the two check analyses, of which the above is the mean	..	·094	·730	Trace	·0000	·0034	..	.. ..	.. ..
			·095	·725	Trace	·0000	·00378	..	.. ..	.. ..
O	Details of the two check analyses, of which the above is the mean	..	·101	·750	Trace	·0000	·00372	..	.. ..	.. ..
			·105	·738	Trace	·0000	·0042	..	.. ..	.. ..
P	From tap at back of A^2 and B^1 Hospital, before water was turned off on discovery of leak, 28th June 1889 (mean of two experiments).	..	·0983	·7455	·095	·0000	·0043	·4106	Slight trace ..	Blackens markedly, burns off readily.
Q	From tap at back of A^2 and B^1 Hospital, after water had been turned on again, 28th June 1889 (mean of two experiments).	..	·1036	·7577	·095	·0000	·00625	·4984	Trace	Blackens markedly, burns off readily.
P	Details of analyses in duplicate of sample P, of which the above is the mean .	..	·0997	·7455	·095	·0000	·0040	..	.. ..	.. ..
			·0969	·7455	·095	·0000	·0046	..	.. ..	.. ..
Q	„ „ „ Q, „ „ .	..	·1050	·7560	·095	·0000	·0064	..	.. ..	.. ..
			·1022	·7595	·095	·0000	·0061	..	.. ..	.. ..
	Percentage of aeration left at end of 10 days { P, 100 per cent. .. .. / Q, 75 per cent. .. .. }	..	..	..	..	..	..	..	.. ..	.. ..

(Signed) A. DUPRÉ.

APPENDIX V.

Report of Dr. Klein, F.R.S., on his Bacteriological Examination of the Samples of Dust from Floors and Walls.

Sir,

I beg to report upon the result of the bacteriological examination of the various samples of dust submitted to me between December 1888 and 20th July 1889.

The samples were contained in sealed bottles, and were labelled as mentioned below.

Method of Examination.

The examination was in all instances carried out in this way:—One gramme of the dust was carefully weighed, it was then placed in 1,000 cubic centimetres of sterile warm distilled water, contained in a sterile flask plugged with sterile cotton wool. By shaking the fluid for about 10 minutes to a quarter of an hour the material was well mixed, and the dust thoroughly and uniformly distributed. The fluid was then allowed to stand for a quarter of an hour, and it was then again well agitated for five to 10 minutes. After standing then for about a further quarter of an hour the fluid was shaken up and a small quantity, about 2 to 3 cubic centimetres, was poured out into a sterile glass dish covered with sterile cover. The object of the repeated shaking up of the dust in warm water was to free the micro-organisms as much as possible from the dust and to distribute them uniformly in the water.

Of the above mixture a definite small quantity was measured out with sterile measure, and added to solid nutrient gelatine contained in sterile test tube. This was then placed in warm water, till all the gelatine was lignefied, well shaken up and then poured out into a flat sterile glass dish covered with sterile glass cover. The gelatine formed herein a thin layer at the bottom of the dish and, after it had set, the dish was placed in the incubator and kept there at 20 degrees centigrade. The dish was inspected from day to day, the number of colonies that made their appearance in and on the gelatine carefully noted, and when their number remained stationary for two or three days this number was taken as indicating the number of micro-organisms originally present in the quantity of the water used for the plate.

In all instances, two, three or even four plates were simultaneously established from the same sample. The quantity used for each plate varied, half a cubic centimetre was the maximum, 10 cubic millimetres was the minimum used for one plate; as a rule the several plates made of the same sample of dust received 0·5 cubic centimetres, 0·1 cubic centimetre, 20 cubic millimetres or 10 cubic millimetres, respectively. In several instances when the plates received 0·5 cubic centimetres or 0·1 cubic centimetre, the number of colonies developing was so great that the counting could be carried out only with great difficulty. In such cases the whole experiment had to be repeated from the beginning, and then a much smaller quantity (of the mixture of the dust and water) was measured out for the new plate.

The number of micro-organisms, which will be mentioned, of the several samples in the following are the averages of the examination of several plates, calculated per 1 milligramme of dust; but I may state that the difference in the number of colonies in the different plates was comparatively small, so that the averages here given may be taken as fairly accurately representing the number of micro-organisms present in the dust.

Number of Microbes.

Before entering upon the question of the nature of the micro-organisms, I will give the numbers present in the different samples.

According to the labels attached to the samples received, they were derived from three different sources: A from Richmond Barracks, B from Ship Street Barracks, and C from Royal Barracks.

A.—*Richmond Barracks.*

	Number of microbes calculated per 1 milligramme of dust.
No. III.—Under floor, M Sol, No. 5, 18th May 1889	13,400
No. V.—Under floor, L Sol, room 5, 21st May 1889	1,000
No. VI.—M house, rookery room 8 (Scott's), 21st May 1889	600
No. VII.—Below Captain Every's drawing room floor, D house, Officers' quarters, 25th May 1889.	300

B.—*Ship Street Barracks.*

No. XIV.—From H house, No. 7 room, 1st floor, centre of N end of room, 4th February 1889.	1,500
No. XV.—I house, centre of room, 2nd floor, 4th February 1889	500
No. XVI.—Under floor, H house, No. 11 room, N centre of room, 2nd floor, 15th March 1889.	78,000
No. XVII.—From below floor, I house, No. 1 room, N centre of room, 1st floor, 18th March 1889.	149,000

C.—*Royal Barracks.*

No. I.—From under floor of E attic at Moore's bed, 1st December 1888 ..	48,500
No. II.—Centre of E attic, No. 3, opposite Coate's bed, 1st December 1888.	4,340
No. III.—Horse Square, B attic, room 7, over stable No. 8, 21st December 1888.	1,860,000
No. VI.—Palatine Square, 1st floor room, where case No. 83 occurred, 22nd December 1888.	217,000
No. VII.—From E attic, east end at Bennett's bed, 1st February 1889 ..	34,000
No. VIII.—From L house, Palatine Square, 1st floor, 2nd February 1889..	5,200
No. XVIII.—Palatine Square, O[1] house, room 61, 25th April 1889 ..	1,500
No. XXI.—Dust from wall, room 3, D house, Royal Square, hole No. 2 ..	A 64,000
No. XXII.—Dust from wall, room 3, D house, Royal Square, hole No. 3 ..	
No. XXIII.—Dust from wall, room 5, D house, Royal Square, hole No. 5..	B 900
No. XXIV.—Dust from wall, room 5, D house, Royal Square, hole No. 7..	

Character of the Microbes.

In examining the colonies as they made their appearance, attention was paid (as is customary in studying plate cultivations) to the following characters:—(1) the rapidity of the appearance and of the progress; (2) the general aspect of the colonies as to outline, colour, size and thickness; (3) the presence or absence of the power of lignifying the gelatine (in the former, the rapidity with which it lignified and the character of the lignified gelatine), viz., whether clear or turbid; (4) the character of the individual organisms constituting a colony, as seen under the microscope when examined fresh and after the customary methods of staining.

Now as to these characters, the microbes and their colonies did not differ from those one obtains by similar methods from the ordinary dust and filling of dwelling rooms; and although I have devoted a good deal of time in studying them, by very

numerous subcultures on gelatine, in agar mixture, and in broth, the result has been so far devoid of practical interest; and I do not think it necessary to give a minute and detailed description of these very numerous species of microbes thus isolated from the plate cultivations. My attention was particularly directed to detect any indication of the presence of that microbe which is known to be constantly present in human typhoid fever, that is the organism known as the typhoid bacillus of Eberth and Gaffky. Whenever, in the plate cultivations, I noticed a colony which bore a resemblance to the colonies of that typhoid bacillus, I have specially studied such a colony, in order to see, by microscopic examination and by subcultures in the various media (notably by gelatine and potato cultures), whether or not it was the same as the typhoid bacillus. Only in two samples did I come across colonies which, by their general characters and by the microscopic appearance of the microbes constituting them, bore a certain resemblance to the typhoid bacillus, but on further study in gelatine, and particularly on potato cultures, proved to be different. These two samples were Sample No. XVIII. and Sample No. XXI. and XXII. In the plate cultivations of the mixture of these last two samples I found in one plate two colonies which, when watched in their growth and in their aspect, as also when examined under the microscope fresh and after standing, bore a marked resemblance to the typhoid bacillus, but in the subcultures in gelatine at once showed a distinct difference from this latter, inasmuch as our bacillus grew much more rapidly in this medium, and was more filamentous, and on potato at 37 degrees centegrade did not grow at all.

On comparing Samples XXI. and XXII. (A) with Samples XXIII. and XXIV. (B) a striking difference will be noticed. Both sets came from the same building, but from different rooms; one set (A) contained a large number of microbes, viz., 64,000 per milligramme, while the other (B) contained, comparatively speaking, few, viz., 900 per milligramme. Now the room from whose wall Sample A was derived had cases of typhoid fever, whereas Sample B came from the wall of a room in which there had not been any fever cases, and the fact of such a striking difference existing between the two samples seems to be, at any rate, highly suggestive. It must be clear that if even a few typhoid fever microbes* be present amongst the 64,000 microbes contained in a milligramme of dust, there would be sufficient of them to make such a room extremely dangerous. True, in the plate cultivations which I made I have not found any indication of them; but then it must be borne in mind that, supposing few of them be present per milligramme, it would require an extremely lucky chance to come across them in plate cultivations, containing altogether not more than 100 or 200 microbes.

I think the above facts are very suggestive, but to carry the investigation any further would require a special search, for which it would be necessary to examine the whole of the Sample XXI. and XXII. (several grammes of dust) by plate cultivations, an examination which would require several weeks, if not months, to carry out.

Your obedient Servant,
E. KLEIN.

To Rogers Field, Esq.

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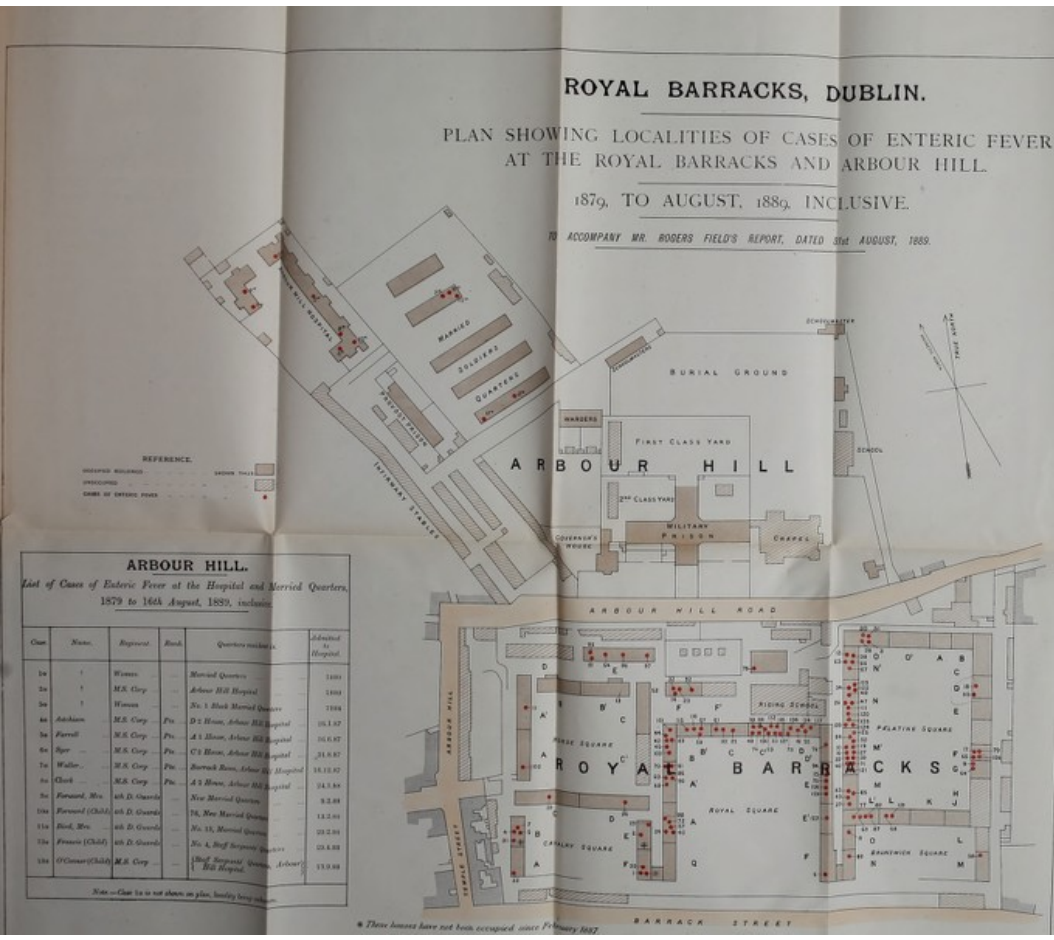
* I must not be understood to say the Eberth-Gaffky bacillus has been satisfactorily proved to be the real typhoid fever bacillus; but if in a certain material the Eberth-Gaffky bacillus can be shown to be present, the probability is very great indeed that such material is tainted with the evacuation of a case of typhoid fever, and therefore most probably contains the typhoid fever germ.

ROYAL BARRACKS, DUBLIN.

PLAN SHOWING LOCALITIES OF CASES OF ENTERIC FEVER AT THE ROYAL BARRACKS AND ARBOUR HILL.

1879, TO AUGUST, 1889, INCLUSIVE.

TO ACCOMPANY MR. ROGERS FIELD'S REPORT, DATED 31st AUGUST, 1889.



ARBOUR HILL.

List of Cases of Enteric Fever at the Hospital and Married Quarters, 1879 to 16th August, 1889, inclusive.

Case	Name.	Regiment.	Rank.	Quarters resident in.	Admitted to Hospital.
1a	?	Women	...	Married Quarters ...	1880
2a	?	M.S. Corp	...	Arbour Hill Hospital	1880
3a	?	Women	...	No. 1 Block Married Quarters	1884
4a	Aitchison	M.S. Corp.	Pte.	D 2 House, Arbour Hill Hospital	15.1.87
5a	Farrell	M.S. Corp.	Pte.	A 1 House, Arbour Hill Hospital	16.6.87
6a	Iyer ...	M.S. Corp.	Pte.	C 1 House, Arbour Hill Hospital	31.8.87
7a	Waller ...	M.S. Corp.	Pte.	Barrack Room, Arbour Hill Hospital	16.12.87
8a	Clark ...	M.S. Corp.	Pte.	A 2 House, Arbour Hill Hospital	24.5.88
9a	Forward, Mrs.	4th D. Guards	...	New Married Quarters	8.2.88
10a	Forward (Child)	4th D. Guards	...	78, New Married Quarters	13.2.88
11a	Bird, Mrs.	4th D. Guards	...	No. 13, Married Quarters	23.2.88
12a	Francis (Child)	4th D. Guards	...	No. 4, Staff Sergeants' Quarters	23.4.88
13a	O'Connor (Child)	M.S. Corp.	...	Staff Sergeants' Quarters, Arbour Hill Hospital.	17.9.88

Note.—Case 1a is not shown on plan, locality being unknown.

* These houses have not been occupied since February 1887.

Plans I., II. and III. ARE IN THE INTERIM REPORT.

ROYAL BARRACKS

List of Cases of Enteric Fever, from 1879 to 16th August, 1889, in

No.	Name.	Regiment.	Rank.	Quarters resident in. Square.	House.	Floor.	No. of Room.	Date of Admission to Hospital.
1	(Female Servant of Maj.r Kelly.)	2nd D.G.	...	Cav.	F	2nd	...	1879
2	Lambert	2nd D.G.	Lieut.	do.	K	2nd	1	31.1.79
3	G. Reed	17th Reg.	Pte.	Fld.	O	...	...	14.1.79
4	Hibbert	Scots Greys	Lieut.	Cav.	B	1st	3	23.1.79
5	Mabel Barry	do.	do.	do.	B	1st	3	23.1.79
6	(Daughter of General Glyn.)	...	...	Reg.	F	...	...	23.1.79
7	Hamilton	Scots Greys	Lieut.	Cav.	B	2nd	4	23.1.79
8	Cook	D.A.A.G.	Capt.	Bonus	O	...	...	1.2.79
9	Harris	2nd D.G.	Lieut.	Fld.	Q	...	...	23.1.79
10	Bourke	46th Reg.	Pte.	do.	M	...	...	4.2.79
11	Rouse	2nd D.G.	do.	Horse	A	Attic	...	6.2.79
12	T. Jones	1st Slengs.	do.	Fld.	N	...	...	23.1.79
13	E. Dove	do.	do.	Horse	B	Attic	6	23.1.79
14	E. Tower	21st Hussars	do.	N.W. of Reg.	F	...	...	23.1.79
15	Goodlad	1st Devon.	do.	Reg.	E	Ground	...	24.1.79
16	Webb	I.S.H.B.	do.	Fld.	M	2nd	47	4.2.79
17	Redmond	21st Hus.	Lieut.	do.	F	...	...	1.2.79
18	Thistlethwaite	46th Reg.	do.	do.	D	...	...	11.2.79
19	Gaudin	I.S.H.B.	L.-Corp.	do.	M	2nd	41	28.2.79
20	Child (of Nurse)	...	...	...	...	...	...	1.3.79
21	Colonel Idle	18th Hus.	...	Cav.	F	...	...	6.3.79
22	Bailey	do.	Pte.	Fld.	M	3rd	47	23.3.79
23	Brown	do.	do.	N of Reg.	F	Attic	4	4.3.79
24	Walsh	2nd Battle	do.	Reg.	A	2nd	5	22.3.79
25	Cripps	do.	do.	do.	C	1st	5	25.3.79
26	Jones	do.	do.	Fld.	N	1st	60	25.3.79
27	Gill	Lincoln	do.	do.	M	2nd	44	14.4.79
28	Farr	21st K.O. Bordered.	do.	do.	O	2nd	23	21.3.79
29	Bailey	4th D.G.	Lieut.	Cav.	E	2nd	8	6.11.79
30	Robertson	Lincoln	L.-Corp.	Fld.	O	2nd	55	8.11.79
31	Smith	4th D.G.	Capt.	Cav.	B	2nd	4	13.11.79
32	Bentley	do.	Pte.	N of Reg.	F	Attic	...	10.11.79
33	Watkins	do.	do.	Cav.	A	2nd	Mess Waiters Room.	9.11.79
34	Taylor	Lincoln	Sergt.	Fld.	N	2nd	40	7.12.79
35	Walt. Mrs.	4th D.G.	...	Cav.	C	1st	...	8.3.80
36	Gosford, Mrs.	do.	...	do.	D	1st	...	10.3.80
37	Lilly, C.	Lincoln	Pte.	Fld.	H	1st	17	7.3.80
38	Barry, H. C.	do.	do.	do.	N	1st	36	11.3.80
39	Cripps ...	do.	do.	do.	M	2nd	44	6.3.80
40	Edwards ...	2nd Bn. Hrs	do.	Barr.	A	2nd	5	14.7.80
41	Tait ...	do.	do.	do.	D	1st	5	14.7.80
42	Neil ...	do.	do.	do.	B	1st	5	13.7.80
43	Gee ...	Lincoln	do.	Fld.	M	1st	37	13.7.80
44	Mahr ...	2nd Bn. Hrs	Corp.	Barr.	B	1st	3	17.7.80
45	Robertson ...	do.	Pte.	do.	B	1st	3	17.7.80
46	Cockle ...	Lincoln	do.	Fld.	M	2nd	44	19.7.80
47	Sutton ...	do.	do.	do.	N	1st	43	20.7.80
48	Francis ...	do.	do.	do.	N	1st	60	30.7.80
49	Hickey ...	2nd Bn. Hrs	L.-Corp.	Reg.	C	Ground	8	2.8.80
50	Baker ...	Lincoln	Pte.	Fld.	M	1st	61	6.8.80
51	Sullivan ...	do.	do.	do.	O	2nd	52	26.8.80
52	Wish ...	4th D.G.	do.	Mar.	Attic	1st	9	19.8.80
53	Boyd ...	2nd Bn. Hrs	do.	Reg.	A	2nd	6	15.8.80
54	Bourke ...	4th D.G.	do.	Horse	E Attic	1st	1 Attic	16.8.80
55	Nunn ...	2nd Bn. Hrs	do.	Reg.	D	1st	3	19.10.80
56	Cowan ...	do.	L.-Corp.	do.	C	2nd	4	11.10.80
57	Scott ...	do.	Pte.	do.	A	1st	3	13.10.80

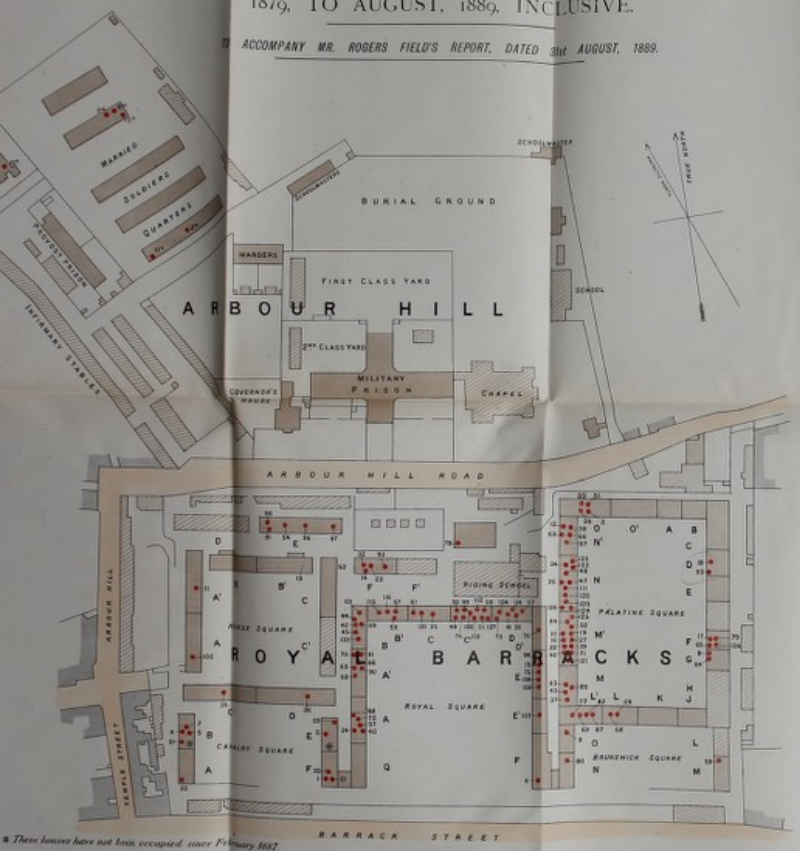
No.	Name.	Regiment.	Rank.	Quarters resident in. Square.	House.	Floor.	No. of Room.
58	Murrell ...	Lincoln	Pte.	...	F	2nd	...
59	Fopp ...	do.	do.	...	K	2nd	...
60	Wicker ...	do.	do.	...	B	1st	...
61	Hazelwood ...	do.	do.	...	B	1st	...
62	Giddie ...	2nd Bn. Hrs	L.-Corp.	Reg.	...	...	...
63	Sheard ...	Lincoln	Pte.	Fld.	...	...	...
64	Dargin ...	2nd Bn. Hrs	do.	Reg.	...	...	...
65	Pedan ...	do.	do.	do.	...	...	...
66	Smith, H. ...	do.	do.	do.	...	...	...
67	Livingstone ...	do.	do.	do.	...	...	...
68	Forrester ...	do.	do.	do.	...	...	...
69	Taylor ...	do.	do.	Fld.	...	...	...
70	Wiltshire, Mrs.	Bt. Lancaster	...	Governor's Quarters	...	...	...
71	Bird, W. D.	W. Surrey	Lieut.	Fld.	...	...	...
72	Speid, T. E.	2nd Bt. Hrs	Capt.	Bonus	...	...	...
73	Fergus, J. ...	W. Surrey	Pte.	Reg.	...	...	...
74	Campbell ...	2nd Bt. Hrs	do.	Fld.	...	...	...
75	Moor ...	do.	do.	do.	...	...	...
76	Hobbs ...	Bt. Lancas.	do.	do.	...	...	...
77	Ellis ...	2nd Bt. Hrs	do.	do.	...	...	...
78	Bailey ...	W. Surrey	Drum.	Reg.	...	...	...
79	Wright ...	Bt. Lancaster	Pte.	Fld.	...	...	...
80	Mortimer ...	W. Surrey	do.	Reg.	...	...	...
81	Riordan ...	do.	do.	do.	...	...	...
82	Mahony ...	do.	do.	do.	...	...	...
83	Hobbs ...	Bt. Lancas.	do.	Hor.	...	...	...
84	Bailey ...	W. Surrey	Drum.	Reg.	...	...	...
85	Connell ...	W. Surrey	do.	Reg.	...	...	...
86	Penny ...	do.	do.	do.	...	...	...
87	Wilkins, H. St. C.	do.	Lieut.	Fld.	...	...	...
88	Webb, H. ...	4th D.G.	Pte.	Hor.	...	...	...
89	Bennett, H. J.	do.	do.	do.	...	...	...
90	Cottle, W.	do.	do.	do.	...	...	...
91	Billinda ...	W. Surrey	L.-Corp.	Reg.	...	...	...
92	Harris ...	do.	do.	do.	...	...	...
93	Davis, G. ...	do.	Pte.	do.	...	...	...
94	Leppard, R.	4th D.G.	do.	Hor.	...	...	...
95	Olsh, G. ...	W. Surrey	do.	Reg.	...	...	...
96	Herbert, J.	do.	do.	do.	...	...	...
97	Atherton ...	Leicester	do.	Fld.	...	...	...
98	McLaughlin ...	do.	Lieut.	do.	...	...	...
99	Mullaney ...	do.	Pte.	Reg.	...	...	...
100	Johnstone ...	W. Surrey	Corp.	do.	...	...	...
101	Holt ...	do.	do.	do.	...	...	...
102	Bourne ...	do.	Pte.	do.	...	...	...
103	Roberts ...	Lancaster	do.	Fld.	...	...	...
104	Gill ...	do.	do.	do.	...	...	...
105	Whitehaker ...	do.	do.	Reg.	...	...	...
106	Jones ...	do.	do.	do.	...	...	...
107	Murphy ...	do.	do.	do.	...	...	...
108	Pocknedge ...	W. Surrey	Drum.	do.	...	...	...
109	Thornton ...	Leicester	Pte.	do.	...	...	...
110	Beaumont ...	do.	do.	do.	...	...	...
111	Bell ...	W. Surrey	do.	Fld.	...	...	...
112	Fairclough ...	Leicester	do.	do.	...	...	...
113	Nicholson ...	do.	do.	do.	...	...	...
114	Cyrus ...	do.	do.	do.	...	...	...
115	Lloyd ...	do.	L.-Corp.	do.	...	...	...
116	Billingham ...	do.	Pte.	do.	...	...	...
117	Holland ...	do.	do.	do.	...	...	...

ROYAL BARRACKS, DUBLIN.

PLAN SHOWING LOCALITIES OF CASES OF ENTERIC FEVER AT THE ROYAL BARRACKS AND ARBOUR HILL.

1879, TO AUGUST, 1889, INCLUSIVE.

TO ACCOMPANY MR. ROGERS FIELD'S REPORT, DATED 31st AUGUST, 1889.



* These houses have not been occupied since February 1887

Plans I., II. and III. ARE IN THE INTERIM REPORT.

IV

ROYAL BARRACKS

List of Cases of Enteric Fever, from **1879** *to* **16th** *August,* **1889.** *inclusive.*

No.	Name.	Regiment.	Rank.	Quarters resided in: Square.	House.	Floor.	No. of Room.	Date of Admission to Hospital
1	{Female Servant of Mess Butler.}	2nd D.G.	...	Cav.	F	2nd	...	1879
2	Lambert	2nd D.G.	Lieu.	do.	E	2nd	1	21/10/79
3	G. Bird	57th Reg.	Pte.	Fol.	O	...	...	14/11/79
4	Hibbert	Scots Greys	Lieu.	Cav.	B	1st	2	23/1/80
5	Mabel, Mary (Daughter of General Gipps)	do.	do.	do.	B	1st	2	18/3/80
6	...	...	Reg.	F	...	...	...	31/10/80
7	Hamilton	Scots Greys	Lieu.	Cav.	H	2nd	4	18/10/80
8	Creek	D.A.A.G.	Capt.	Brass.	O	...	...	14/2/81
9	Harris	2nd D.G.	Lieu.	Fol.	G	...	...	22/3/81
10	Beere	90th Reg.	Pte.	do.	M'	...	...	8/4/81
11	Breen	2nd D.G.	do.	Horse	A'	Attic	...	8/4/81
12	T. Jones	1st Sergt.	do.	Fol.	N'	...	...	20/5/82
13	R. Dunn	do.	do.	Horse	B	Attic	6	23/4/82
14	E. Tuson	21st Hussars	do.	N. W. of Reg.	F	...	...	29/4/82
15	Goddard	1st Devon	do.	Reg.	E	Ground	...	14/11/82
16	Webb	I.R.R.E.	do.	Fol.	M'	3rd	47	4/12/82
17	Richmond	21st Hus.	Lieu.	do.	F	...	...	82
18	Thistlewaite	60th Reg.	do.	do.	D	...	...	13/11/83
19	Gardiner	I.R.E.R.	L.-Corp.	do.	M'	2nd	41	20/12/83
20	Child and Nurse	18th Hus.	...	Cav.	F	...	...	83/84
21	Cahow-Wild	...	...	...	...	...	...	...
22	Bailey	do.	Pte.	Fol.	M'	3rd	47	23/1/84
23	Brown	do.	do.	N of Reg.	F	Attic	4	4/8/85
24	Walsh	2nd Border	do.	Reg.	A	2nd	3	22/3/86
25	Chaplin	do.	do.	do.	C	1st	3	31/3/86
26	Jones	do.	do.	Fol.	N	1st	49	26/3/86
27	Gilpin	Lincoln	do.	do.	M'	2nd	44	10/6/86
28	Parry	{2/24 R.G. Borderers}	do.	do.	O	3rd	55	23/5/86
29	Brinley	6th D.G.	Lieu.	Cav.	E	2nd	6	6/10/86
30	Richardson	Lincoln	L.-Corp.	Fol.	O	3rd	55	8/10/86
31	Sankey	6th D.G.	Capt.	Cav.	B	2nd	4	10/86
32	Herridge	do.	Pte.	N of Reg.	F	Attic	...	10/10/86
33	Washam	do.	do.	Cav.	A	2nd	Mess Waiters Room.	9/11/86
34	Tailby	Lincoln	Sergt.	Fol.	N	3rd	46	7/12/86
35	Walsh, Mrs.	4th D.G.	...	Cav.	C	1st	...	6/3/87
36	Greenlish, Mrs.	do.	...	do.	D	1st	...	10/3/87
37	Ashley, G.	Lincoln	Pte.	Fol.	M	1st	27	7/5/87
38	Barrett, H. C.	do.	do.	do.	N'	1st	50	11/5/87
39	Clayton	do.	do.	do.	N'	2nd	44	6/7/87
40	McKenzie	2nd Bl. Hrs.	do.	Reg.	A	2nd	5	14/7/87
41	Todd	do.	do.	do.	D	1st	3	14/7/87
42	Slater	do.	do.	do.	B	1st	3	15/7/87
43	Gee	Lincoln	do.	Fol.	M	1st	27	15/7/87
44	Michie	2nd Bl. Hrs.	Corp.	Reg.	B	1st	3	17/7/87
45	Robertson	do.	Pte.	do.	B	1st	3	17/7/87
46	Carlisle	Lincoln	do.	Fol.	M'	2nd	44	18/7/87
47	Norton	do.	do.	do.	N'	1st	49	20/7/87
48	Fraser	do.	do.	do.	N'	1st	49	20/7/87
49	Morfett	2nd Bl. Hrs.	L.-Corp.	Reg.	C	Ground	2	2/8/87
50	Dolan	Lincoln	Pte.	Fol.	M'	1st	41	6/8/87
51	Woodhouse	do.	do.	do.	O	2nd	52	26/8/87
52	Wash	4th D.G.	do.	Hor.	C Attic	1st	8	29/8/87
53	Byrd	2nd Bl. Hrs.	do.	Reg.	A'	2nd	6	13/9/87
54	Dennis	4th D.G.	do.	Hor.	E Attic	1st	3 Attic	16/9/87
55	Nevin	do.	L.-Corp.	do.	C	2nd	5	24/11/87
56	Cameron	2nd Bl. Hrs.	do.	Reg.	D	1st	3	30/11/87
57	Carter	do.	L.-Corp.	do.	C	2nd	6	11/12/87
58	Sexter	do.	Pte.	do.	A	1st	2	13/12/87
59	Wainwright	4th D.G.	Lieu.	Brass.	M	2nd	...	24/12/87
60	Sexter	2nd Bl. Hrs.	Pte.	Reg.	B	Ground	2	3/1/87
61	Farrowday	do.	do.	do.	A'	1st	4	14/1/87
62	Young	do.	L.-Corp.	do.	C	2nd	5	24/1/87
63	Nixon	2nd Bl. Hrs.	Pte.	do.	B'	Ground	2	1/2/87
64	Gregory	Lincoln	do.	Fol.	N'	3rd	58	17/2/87
65	Campbell	2nd Bl. Hrs.	Lieu.	do.	G	2nd	7	27/2/87
66	Murrell	Lincoln	Pte.	Fol.	N'	2nd	53	28/1/88
67	Fogg	do.	do.	do.	N'	3rd	56	28/1/88
68	Winker	do.	do.	do.	L	3rd	28	1/2/88
69	Hawkwell	do.	do.	do.	U	2nd	36	8/2/88
70	Goldie	2nd Bl. Hrs.	L.-Corp.	Reg.	A'	2nd	6	10/3/88
71	Sherril	Lincoln	Pte.	Fol.	M'	1st	41	13/3/88
72	Dwyer	2nd Bl. Hrs.	do.	Reg.	A	2nd	5	14/3/88
73	Peden	do.	do.	do.	D	1st	3	6/4/88
74	Smith, H.	do.	do.	do.	C	1st	4	6/7/88
75	Livingstone	do.	do.	do.	E	Ground	1	13/7/88
76	Forrester	do.	do.	do.	D	1st	4	16/7/88
77	Taylor	do.	do.	do.	D	1st	28	23/7/88
78	Wilshire, Mrs.	30. Lancaster	...	Garrison Canteen	...	Ground	...	27/7/88
79	Bird, W. D	W. Surrey	Lieut.	Fol.	F	do.	4	28/8/88
80	Speid, T. L.	2nd Bl. Hrs.	Capt.	Brass.	N	1st	4	5/10/88
81	Turpin, J.	W. Surrey	Pte.	Reg.	A'	2nd	6	10/88
82	Campbell	2nd Bl. Hrs.	do.	Fol.	D'	3rd	36	5/10/88
83	Moor	do.	do.	do.	M	1st	27	5/10/88
84	Holden	30. Lancas.	do.	do.	M'	3rd	47	6/10/88
85	Ellis	2nd Bl. Hrs.	do.	do.	M	3rd	35	15/10/88
86	Buckley	W. Surrey	Drmr.	Reg.	A'	Ground	5	15/10/88
87	Wright	30. Lancaster	Pte.	Fol.	D'	1st	28	19/10/88
88	Montour	W. Surrey	do.	Reg.	A	2nd	5	31/10/88
89	Riordan	do.	do.	do.	B	1st	3	31/10/88
90	Molony	do.	do.	do.	A'	1st	4	3/11/88
91	Moore	5th D.G.	do.	Hor.	E Attic	1st	3	5/11/88
92	Stewart	do.	do.	N of Reg.	F Attic	1st	3	6/11/88
93	Cassell	W. Surrey	do.	Reg.	C	2nd	6	9/11/88
94	Parsey	do.	do.	do.	E	2nd	5	12/11/88
95	Wilkins, H. St. C.	do.	Lieut.	Fol.	D	3rd	14	16/11/88
96	Webb, H.	5th D.G.	Pte.	Hor.	A Attic	...	...	18/11/88
97	Bennett, H. J.	do.	do.	do.	do.	1st	3	18/11/88
98	Coates, W.	do.	do.	do.	do.	...	...	18/11/88
99	Silleeks	W. Surrey	L.-Corp.	Reg.	C'	1st	4	28/11/88
100	Harris	do.	do.	do.	C'	2nd	6	21/12/88
101	Davis, G.	do.	Pte.	do.	B	2nd	3	25/11/88
102	Leyzard, R.	4th D.G.	do.	Hor.	A Attic	1st	...	1/12/88
103	Glew, G.	W. Surrey	do.	Reg.	B	2nd	3	16/12/88
104	Herbert, J.	do.	do.	do.	D	1st	3	26/12/88
105	Atherton	Lancaster	do.	Fol.	N	1st	39	31/1/89
106	Meiaughlin	do.	Lieut.	do.	F	2nd	10	3/3/89
107	Halliday	do.	Pte.	Reg.	E'	Ground	2	9/7/89
108	Johnstone	W. Surrey	Corp.	do.	E	2nd	5	9/7/89
109	Holt	do.	do.	do.	E	2nd	5	8/7/89
110	Banister	do.	Pte.	do.	C	Ground	1	8/7/89
111	Roberts	Lancaster	do.	Fol.	N	3rd	46	8/7/89
112	Gill	do.	do.	Reg.	C'	1st	4	13/7/89
113	Whitehaker	do.	do.	do.	C'	1st	4	16/7/89
114	Jones	do.	do.	do.	D	1st	3	17/7/89
115	Murphy	do.	do.	do.	B'	1st	4	18/7/89
116	Tonbridge	W. Surrey	Drmr.	do.	B'	2nd	6	22/7/89
117	Thurston	Lancaster	Pte.	do.	D	1st	3	25/7/89
118	Beaumont	do.	do.	do.	C'	1st	4	26/7/89
119	Bell	W. Surrey	do.	Fol.	L	1st	22	26/7/89
120	Fairclough	Lancaster	do.	do.	N	2nd	46	28/7/89
121	Nicholson	do.	do.	do.	M'	1st	41	31/7/89
122	Upton	do.	do.	do.	N	2nd	45	8/8/89
123	Lloyd	do.	L.-Corp.	do.	N	3rd	46	7/8/89
124	Billingham	do.	Pte.	do.	N	1st	49	7/8/89
125	Hillard	do.	do.	do.	M'	2nd	44	8/8/89
126	McCorie	do.	do.	do.	N	1st	49	9/8/89
127	Murray	do.	do.	Reg.	C'	1st	4	16/8/89

ROYAL BARRACKS, DUBLIN.

PLANS SHOWING LOCATION OF CASES OF ENTERIC FEVER

IN EACH SEPARATE YEAR,
1879, TO AUGUST, 1889, INCLUSIVE.

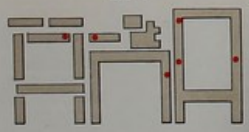
(V)

1879.

1880

1881

1882



1883

1884.

1885.

1886

1887

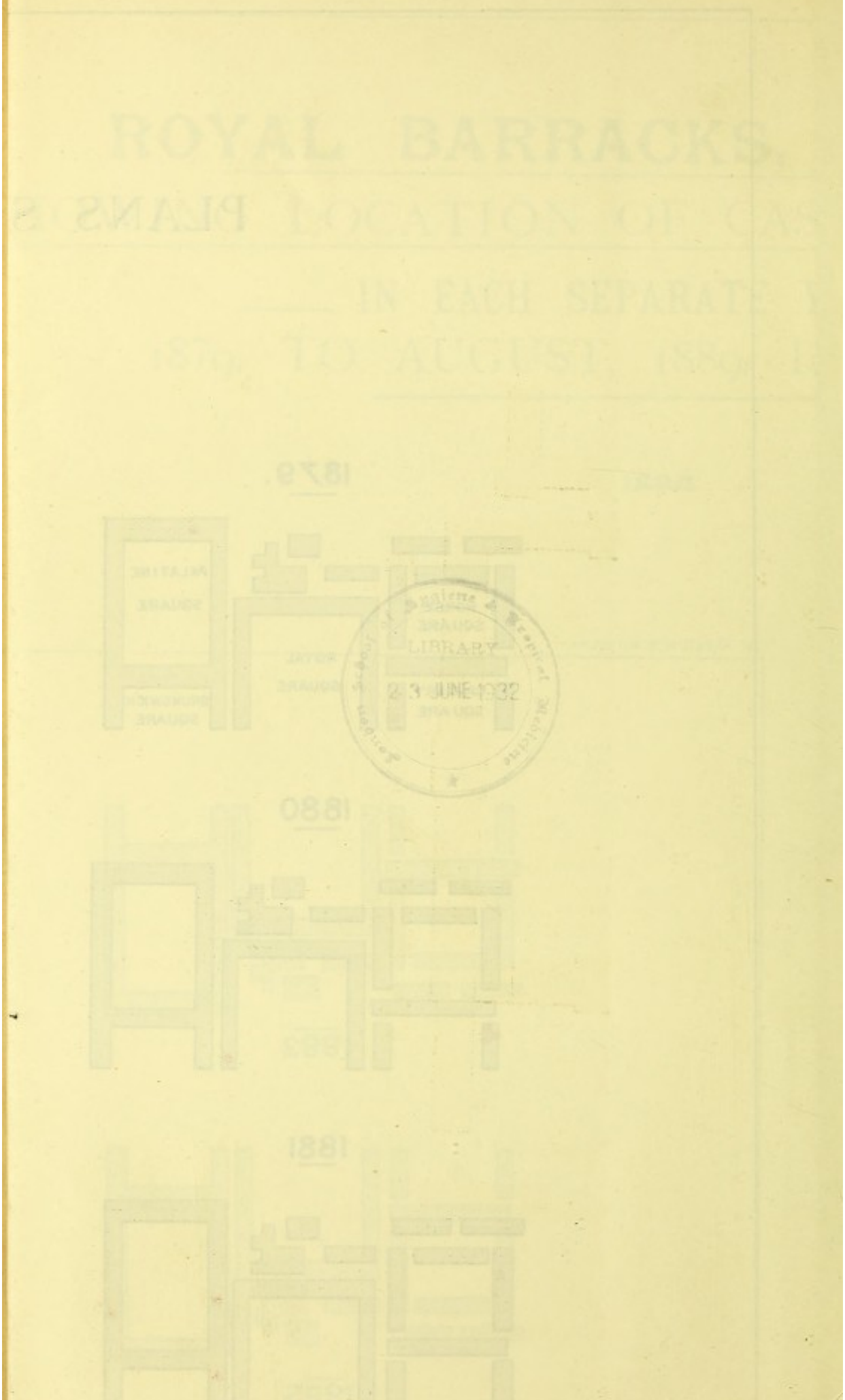
1888

1889 To Aug. 16th

REFERENCE.

Cases of Enteric Fever ——— shown thus ●

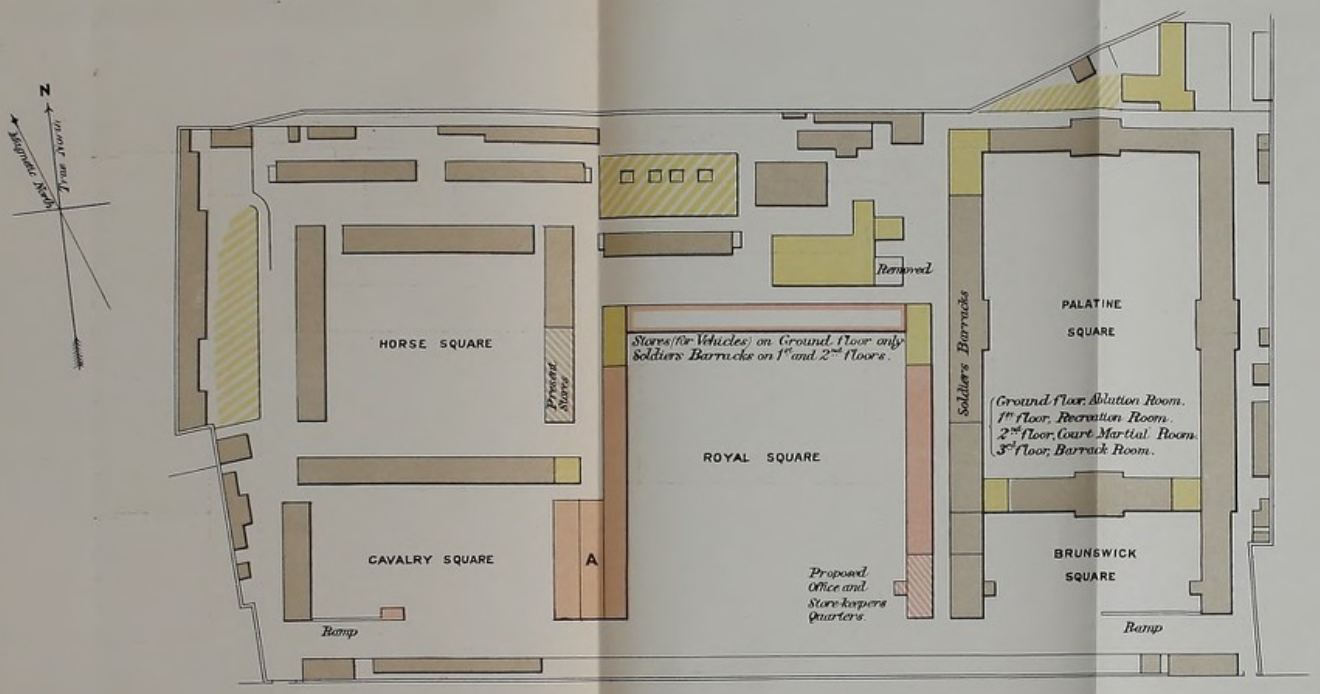
Demolitions recently carried out ,, ,, ▬



VI

ROYAL BARRACKS, DUBLIN.

PLAN SHOWING PROPOSED DEMOLITIONS AND RE-APPROPRIATIONS IN PROGRESS



REFERENCES.

PROPOSED DEMOLITIONS ... ... COLOURED YELLOW

PROPOSED RE-APPROPRIATIONS ... ... LAKE

GROUND TO BE SLOPED OFF ... ... SHOWN THUS

Scale, — 100 feet to one inch.

100 0 100 200 300 feet.

Harrison & Sons Lith. 59 Martins Lane W.C.

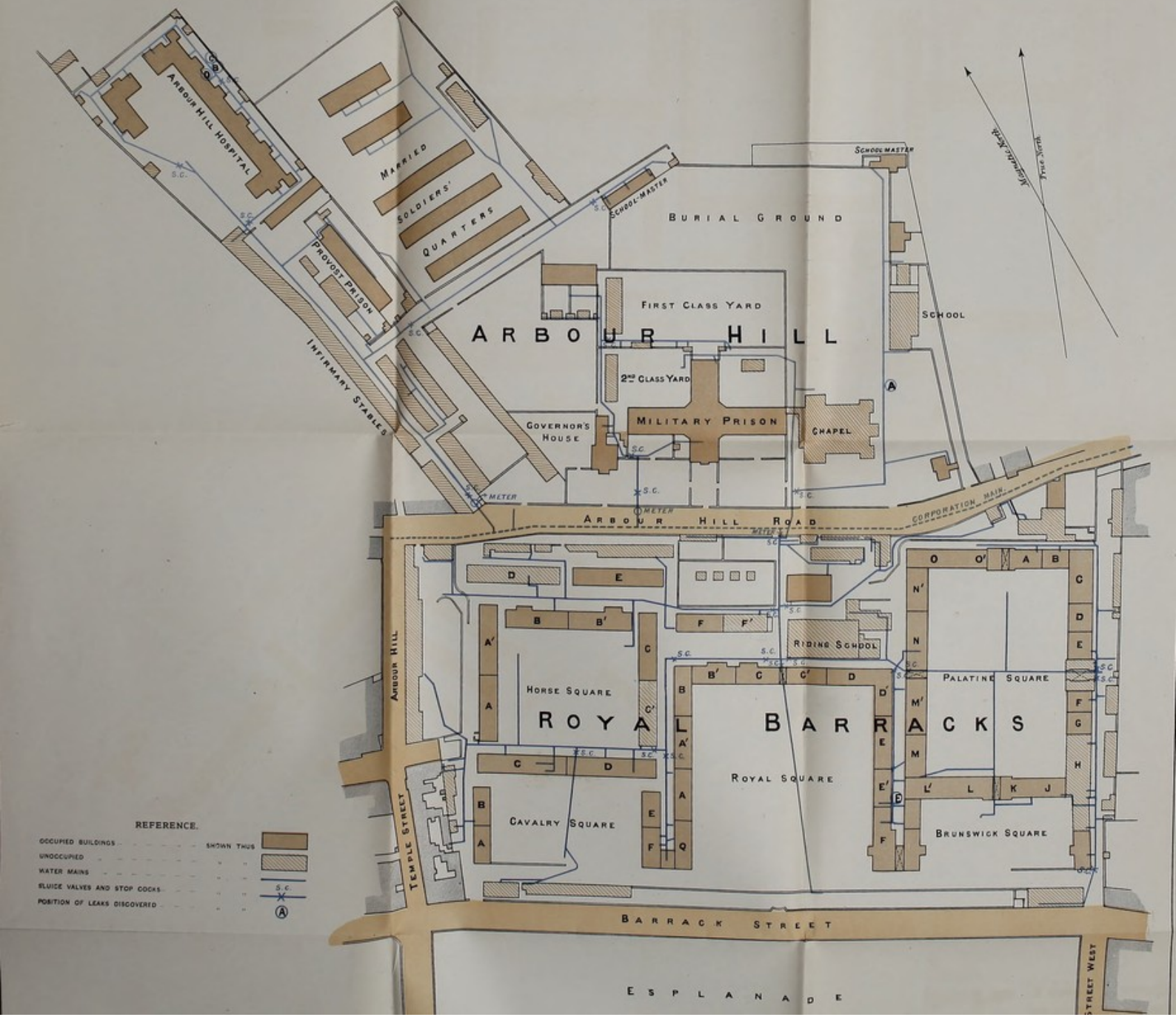
ROYAL BARRACKS, DUBLIN.

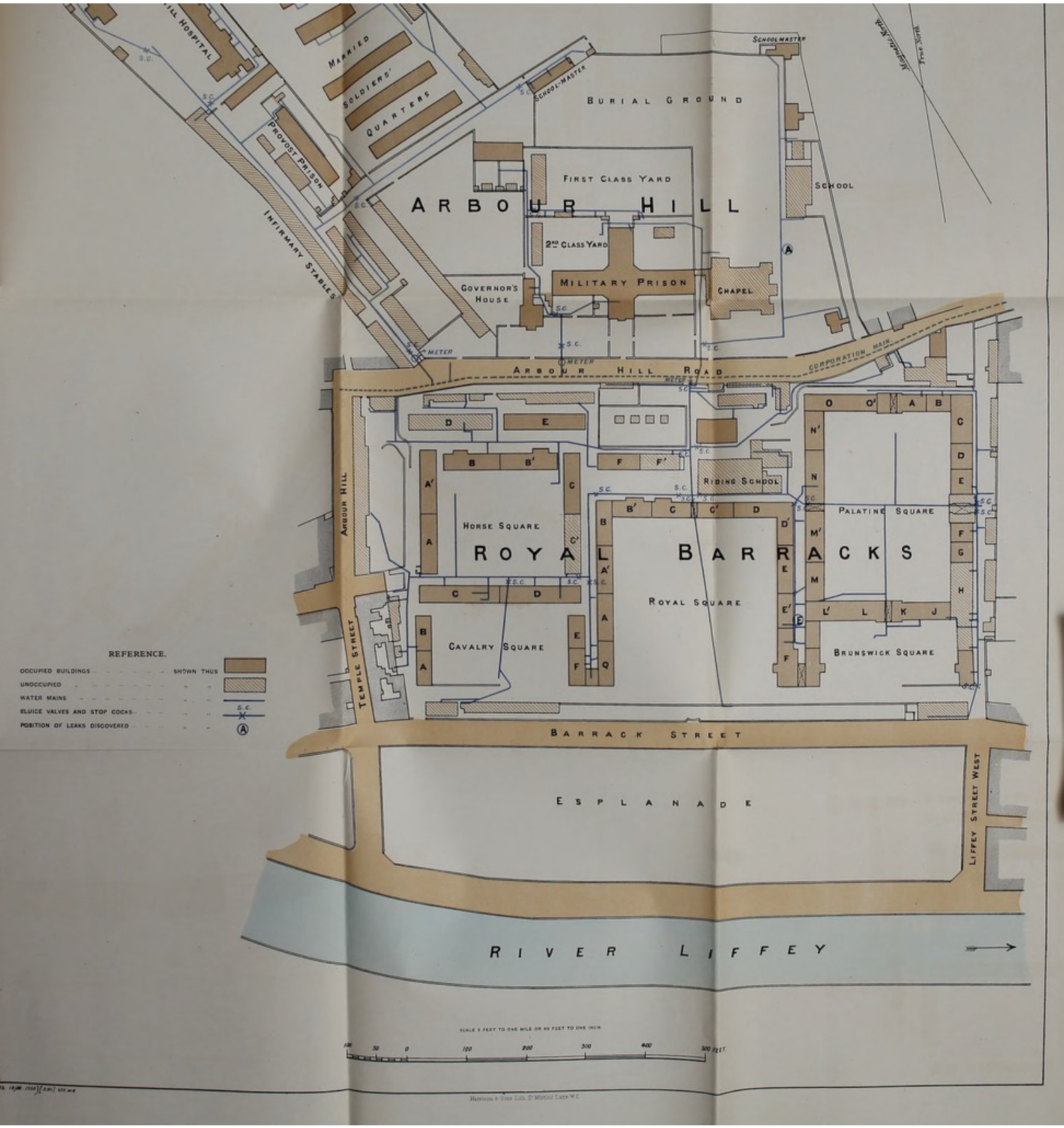
VII

PLAN SHOWING THE WATER MAINS

AT THE ROYAL BARRACKS AND ARBOUR HILL.

TO ACCOMPANY MR. ROGERS FIELD'S REPORT, DATED 31st AUGUST, 1889.




ARBOUR HILL
BURIAL GROUND
FIRST CLASS YARD
2ND CLASS YARD
SCHOOL
MILITARY PRISON
CHAPEL
GOVERNOR'S HOUSE
SCHOOL-MASTER
MARRIED SOLDIERS' QUARTERS
PROVOST PRISON
INFIRMARY STABLES
ARBOUR HILL ROAD
CORPORATION MAIN
ARBOUR HILL
TEMPLE STREET
HORSE SQUARE
ROYAL BARRACKS
RIDING SCHOOL
PALATINE SQUARE
ROYAL SQUARE
CAVALRY SQUARE
BRUNSWICK SQUARE
BARRACK STREET
ESPLANADE
LIFFEY STREET WEST
RIVER LIFFEY
REFERENCE.
OCCUPIED BUILDINGS SHOWN THUS
UNOCCUPIED
WATER MAINS
SLUICE VALVES AND STOP COCKS S.C.
POSITION OF LEAKS DISCOVERED A
SCALE 5 FEET TO ONE MILE OR 88 FEET TO ONE INCH.
100 50 0 100 200 300 400 500 FEET.