

Report on the sanitary condition of the Richmond Barracks, Dublin / by Mr. Rogers Field.

Contributors

Field, Rogers.

Great Britain. War Office.

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Publication/Creation

London : printed at the War Office, by Harrison and Sons, 1889.

Persistent URL

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REPORT

ON

THE SANITARY CONDITION

OF THE

RICHMOND BARRACKS,
DUBLIN.

BY

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

DATED 23RD JULY 1889.

LONDON:
PRINTED AT THE WAR OFFICE,
BY HARRISON AND SONS,
Printers in Ordinary to Her Majesty.

1889.

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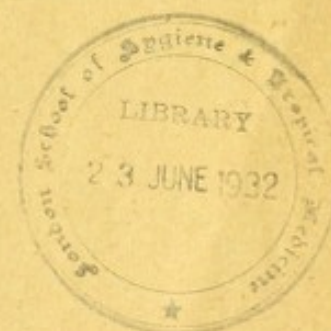
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Report on the Sanitary Condition of the Richmond Barracks, Dublin.

Sir,

In accordance with the instructions I received from you to make a thorough Introductory.
inquiry into the sanitary condition of Richmond Barracks, Dublin, I have paid a number of visits to the barracks myself, and have had a lengthened investigation made of the various details by my assistant, under my direction. I have also studied the numerous papers supplied to me so as to acquaint myself with what has already been done on the question of the sanitary condition of the Richmond Barracks, and now have to report as follows :—

The Richmond Barracks are in the township of Kilmainham, just outside Situation of the barracks.
the City of Dublin. They are situated on a plateau 80 or 90 feet above sea level, which has a valley on the west and north sides through which runs the River Cammock, a tributary of the River Liffey. The position and surroundings of the barracks will be better understood by referring to the small key plan on Plan No. II. The drainage discharges into the River Cammock, and for a long time past there has been a difficulty about the outfall for the drainage of the barracks, which will be explained in the following brief historical summary.

HISTORICAL STATEMENT.

The Richmond Barracks were built about the year 1810, but several of the Date when barracks were built.
houses had to be rebuilt between 1849 and 1859 on account of their unsound condition.

In the General Report presented to Parliament in 1861 from the Com- Recommendations of Barrack and Hospitals Commission, 1861.
missioners for Improving the Condition of the Barracks and Hospitals, a number of recommendations are given as to the improvements required at the Richmond Barracks. These related chiefly to the reduction of men so as to prevent overcrowding, the abolition of cesspits, the reconstruction of privies as water latrines, improvements in the ventilation and lighting of the barrack rooms, and improvements in scavenging.

I know nothing about the history of the barracks for the next 20 years, 1861-1881.
but most of the recommendations of the Commission of 1861 appear to have been carried out. On account, however, of the difficulty about the outfall for the drainage the latrines which were substituted for the privies were not connected with the drains, but arranged so that their contents were emptied into carts and carried away to be used on land in the vicinity of the barracks. Most of the recommendations carried out.

In the year 1881, the Commanding Royal Engineer in Ireland called 1881.
special attention to the offensive arrangement of carrying away the night soil from the latrines at the barracks, and said that it had been reported on several times, but nothing had been done in hopes that the Dublin Corporation would carry out a new system of sewers into which the sewage of the barracks would be discharged. There was, however, very little hope of anything being done at present, and it was therefore suggested that the latrines should be converted into earth-closets. Attention called to offensive latrine arrangements, and earth closets suggested.

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

Lengthy correspondence with Kilmainham Commissioners as to sewer on west side of barracks.

No action appears to have been taken about this, but a long correspondence and negotiations ensued with the Kilmainham Commissioners as to the large masonry culvert on the west side of the barracks, which had been built by the War Department, but was claimed by the Commissioners under the provisions of the Public Health Act. It was suggested that the sewer, which was too large for its purpose and in bad order, should be obliterated, and a new pipe sewer be constructed by the Commissioners to serve as an outfall for the barrack drainage, and also that intercepting sewers should be constructed in the Cammock Valley, with an outlet into the sewer near Kilmainham Bridge (*see key plan*), and that the War Department should contribute towards the cost. The Kilmainham Commissioners objected to this suggestion for various reasons, the chief one being that they were entirely opposed to the introduction of the water-closet system into the barracks, as soil would be discharged into the River Cammock, and the Dublin Corporation would object.

1885.
Serious outbreak of enteric fever. Investigation and report.

In consequence of a serious outbreak of enteric fever, which took place at the barracks in 1885, investigations were made by the Medical Officers and Royal Engineers, and a number of defects were found in the drainage. The Medical Officer reported that he could not detect anything offensive about the fields where the night soil was deposited, but that he had on several occasions experienced a most offensive odour of sulphurated hydrogen which he had traced to adjacent cement factories.

Recommendations in Report of Board of Officers appointed by Lord Clarina.

A Board of Officers was also appointed by Lord Clarina to inquire into the sanitary condition of the barracks, and in their Report of the 4th December 1885, they recommended various works, and stated that the old drains had been imperfectly obliterated, or cut off, and that consequently noxious gases had penetrated into the buildings. They were further of opinion that—

- (a.) Extensive examinations should be made of the entire system of drainage, and all old ones obliterated.
- (b.) Any drains under dwellings should be diverted.
- (c.) Vitrified pipes should be substituted throughout the barracks for stone drains.
- (d.) Pressure should be put on the Kilmainham Commissioners to provide a suitable outfall for the drains.
- (e.) The large masonry drain on the west side of barracks should be done away with, and a large pipe drain substituted.
- (f.) Better flushing should be adopted.
- (g.) Though the system of conservancy was defective it could not under existing circumstances, be improved upon, except by the introduction of a large supply of water in the latrines.
- (h.) Vartry water should be laid on with the least possible delay, and canal water filtered.
- (i.) The accommodation for married soldiers was very insufficient. New married quarters should be erected, or hiring should be resorted to.
- (j.) The stench from decaying vegetable matter in farm adjacent to the barracks could not be conducive to the health of the occupants, but there was nothing injurious to health in the present arrangement for disposing of the night soil.
- (k.) The proximity of the cement factory was not a source of danger to health.

A rider was added by the Principal Medical Officer to the effect that he could not recommend filtering the canal water, as he considered it need not be drunk.

After this report a number of improvements were carried out in the drainage and sanitary arrangements, and, in January 1887, the Commanding Royal Engineer in Ireland recommended, amongst other things, that a careful examination should be made of the condition of the subsoil water. The correspondence was also continued with the Kilmainham Commissioners, and application was made to the Dublin Corporation to allow the City Sewers to be used as an outfall for the Kilmainham township and barrack drainage, but the Corporation declined (in February 1887) on the ground that the sewerage system of that portion of the city was not of sufficient dimensions to admit of receiving the additional drainage. Further negotiations then took place with the Kilmainham Commissioners, who objected to some of the improvements that were being made in the drainage of the barracks on the ground that the connections with the sewer on the west side of the barracks were interfered with, and that fæcal matter would be introduced into the sewers. The question of a general scheme for improving the drainage of Richmond Barracks was raised by the War Office, and, in July 1887, the Commanding Royal Engineer reported that the whole scheme depended on the decision of the Kilmainham Commissioners as to the main sewer they would provide for the locality in order to divert the drainage from the Cammock. He stated that the sewer on the west side of the barracks at present took the subsoil drainage from the cemetery, but that that drainage was not sufficient to provide for sanitary requirements, and that it would be a great advantage to have the subsoil drainage of the cemetery effectively carried out. After this report, further negotiations took place as to the War Department contributing to the cost of re-constructing this sewer, and eventually (in August 1887) the War Department definitely waived all claims to the sewer, but stated that the question of contribution could not be re-considered until the Kilmainham Commissioners were prepared to carry out a complete scheme of sewerage which would provide a proper outfall for the drain from the barracks.

1886-7.
Negotiations continued with the Kilmainham Commissioners, and application to allow outfall into city sewers declined by Corporation.

Question raised as to general scheme for improving the drainage of barracks.

War Department definitely waived all claims to sewer on west side of barracks.

In consequence of the recommendation of the Commanding Royal Engineer in Ireland an investigation was made into the subsoil water and a plan submitted for draining away the subsoil water from immediately around the buildings; but this work was not carried out. A small amount of subsoil drainage was, however, executed to intercept the flow of subsoil water from the cemetery and carry it into the main sewer on the east side of the barracks. (See plan No. II.)

Subsoil water investigated, and a small amount of subsoil drainage carried out.

Subsequently, in December 1887, the Commanding Royal Engineer reported that as there was little prospect of any settlement with the Kilmainham Commissioners, and as the present system of emptying the soldiers' latrines into carts was very objectionable, he would recommend that they be converted into earth closets. The War Office concurred in this and the work was carried out.

Soldiers' latrines converted into earth-closets.

In the beginning of 1888, the question of ventilating the main sewer on the west side of the barracks was brought prominently forward, but objections were raised by the Kilmainham Commissioners, and, after long discussions, the project was, for the time, given up, and a series of "disconnecting" manholes were constructed to cut off the air communication between the sewer in question and the barrack drains.

1888.
Project for ventilation of the main sewer on the west side of the barracks given up and barrack drainage disconnected.

LOCATION OF CASES OF ENTERIC FEVER.

A list of the cases of enteric fever at the barracks for the last six years has been supplied me, and from this I have compiled a plan (No. I) showing, as far as they are known, the localities where the cases occurred. The plan also contains a copy of the list, the numbers on which correspond with the numbers on the plan, with notes extracted from the reports of the Medical Officer which have been supplied to me.

Enteric fever cases during last six years.

The detailed consideration of the cases would involve medical considerations which are not within my province, but I may call attention to a few

points which are certainly remarkable. In case No. 33, Private Thorlby had left Richmond Barracks and been at the Curragh 25 days before the disease declared itself. If, as I believe, this is longer than what is usually considered the period of incubation, it would seem to show that the disease was not caught at Richmond Barracks.

In cases Nos. 39 and 44, the Officers had been on guard either at the Castle or Mountjoy Prison previous to their illness at periods which would, I believe, fall within the usual limits of incubation. These guard-rooms were at the beginning of the year in a more or less insanitary state.

In cases Nos. 41, 42, and 43, the men had all been at Pigeon House Fort, and two of them at the Bank or Castle guard-rooms within the usual period of incubation of the disease. The Pigeon House Fort has been frequently suspected of being the cause of illness, and the Bank guard-room was at the beginning of the year in an insanitary condition.

Enteric fever cases compared with those at Royal Barracks.

The following is a summary of the cases with those at the Royal Barracks placed opposite them for the purpose of comparison:—

Year.	Number of cases of enteric fever.	
	Richmond Barracks. (Population about 1,130.)	Royal Barracks. (Population 1,300 to 1,450.)
1883	3 cases	2 cases.
1884	7 „	3 „
1885	14 „	1 „
1886	3 „	11 „
1887	2 „	30 „
1888	10 „	40 „
1889 to June inclusive	6 „	2 „
Total	45	89

On reference to this summary, it will be noticed that there is no correspondence in the prevalence of typhoid fever at the Royal Barracks and Richmond Barracks, but just the reverse, the fever being generally prevalent at one barrack when there is comparative immunity at the other.

RESULTS OF PRESENT INQUIRY.

Inquiry divided into branches.

I will now proceed to give the result of my examination of the various matters which, in my opinion, might affect the sanitary condition of the barracks, and, for convenience, I have divided the inquiry into the following branches:—

Drainage and sanitary appliances.

Subsoil and subsoil water.

Structure of buildings.

Air and ventilation of buildings.

Water supply.

Milk supply.

I will deal with these subjects in the order in which I have mentioned them.

DRAINAGE AND SANITARY APPLIANCES.

The plan No II., appended hereto, represents the drainage as found at the time of my investigation (some alterations have been made since). The sewage drains are shown by red lines, and the subsoil drains by dotted green lines. This plan also contains a small key plan.

From this plan it will be seen that the drainage of the barracks discharges into three main sewers outside the barrack area—one on the west side, one on the north side, and one on the east side. The sewer on the west side of the barracks runs down St. Vincent Street, then turns to the west along Emmet Road, and discharges into the River Cammock at Golden Bridge. This is the sewer referred to in the historical statement, as originally belonging to the War Department, and subsequently handed over to the Kilmainham Commissioners. The sewers on the north and the east sides of the barracks join one another at the north-east corner of the barracks, and form an outfall sewer, which likewise discharges into the River Cammock, but at a point considerably below Golden Bridge.

The whole of the sewers and drains were most carefully examined by making a large number of openings (in addition to those afforded by the man-holes). The smoke test was applied to nearly all the drains; and a large number of drains were tested by plugging them, and filling them with water. The drains were also flushed separately with water, and a note made of the speed at which the water travelled, and whether or not it brought any deposit with it. A search was also made for old culverts and drains, as it appeared from the report of the Board of Officers in 1885 that a number of old culverts had then been found to have been left in.

I will deal with the old culverts and drains first. Only two of these were found within the barrack area. One of them was an old brick culvert, part of which was in an especially objectionable position as it passed under K house of the north block of Officers' quarters. This is evidently the culvert which was mentioned at the time of the inquiry by the Board of Officers in 1885, and was stated to have been obliterated. This culvert does not appear now to connect with any existing drains, at the same time an old culvert of this sort is very likely to lead to trouble, as it would harbour rats, and their runs might easily make an air connection with drains in the vicinity, and thus create a means by which foul air could escape into the house.

The other drain was an old stoneware pipe drain passing under F house, soldiers. This also was mentioned at the inquiry by the Board of Officers. The old drain, of which this was a part, was found to have been removed outside the building on each side, and the portion under the building had been stopped up and cemented at the walls. Here, again, there was no connection with any existing drain; but I think it was a great mistake to leave the old drain in, as one never knows what old drains underneath houses may indicate. In the present case, as will be seen further on, there are reasons to think from the analysis of the subsoil water that pollution of some kind exists beneath the house (see page 13).

Proceeding now to the existing drainage, the main sewers, as already stated, are outside the barrack area.

The sewer in St. Vincent Street on the west side of the barrack (about which there has been so much controversy between the War Office Authority and the Kilmainham Commissioners) is constructed of masonry, and for the greater portion of its length is 5 feet high and 3 feet wide, with a rounded brick invert, and with a fair fall for a sewer of this size. The culvert was opened and examined in three places, and found to be structurally in very good condition, but there was a large quantity of deposit at the upper end. This deposit did not, however, extend very far, as the sewer was entered from the manhole near the prison, and traversed the distance measured, to which the

deposit extended downwards, and found to be only 90 feet below the manhole. When I first examined the sewer, it was almost unventilated, and the air within it was very foul. Quite recently, however, additional ventilation in the form of two brick shafts has been provided, which has had a beneficial effect on the air in the sewer.

Sewer on
north side of
barracks.

The sewer on the north side of the barracks is also constructed of masonry, but of much smaller size (15 inches by 12 inches), and has a flat bottom, composed of rough masonry. The sewer has a good fall, but on account of its defective construction, retains deposit throughout its entire length. This sewer is very inefficiently ventilated, there being only one 6-inch ventilating pipe at its upper end.

Sewer on east
side of
barracks.

The sewer on the east side of the barracks is constructed of 9-inch stoneware pipes. The pipes at the lower end are jointed in cement, but judging from what was seen at the openings, which were made further up, many of the pipes have nothing at all in the joints, and are very leaky, so much so that the sewage was found to be running out of the joints at one place, and into them again at another. The fall of this sewer is irregular, and the upper portion of it generally lies half full of deposit, and on more than one occasion it has been found to be blocked up completely. This sewer is well ventilated by gratings at the manholes on its course. When I first examined it, the gratings were placed immediately over the manholes, so that children dropped stones and bits of slate into the manhole, and obstructed the sewer. Recently, however, the ventilators have been put at the side to obviate this objection.

Subsidiary
drains.

As regards the subsidiary drains within the barrack area, it will be seen from the plan that the whole of them are kept outside the buildings, which is a very good feature. Beyond this, however, very little or nothing can be said in their favour.

Arrangements
of drains bad.

The arrangement of the drains is very unmethodical and straggling, and in many cases the natural fall of the land has not been fully taken advantage of, so that the drains have a much flatter inclination than they need have. On the whole, the impression left on one's mind, after an examination of the drains, is that they could never have been laid out on any system, but must have been added to, and altered from time to time as the necessity arose.

Drains badly
laid and leaky.

The drains are all composed of stoneware pipes, and are nominally jointed with cement, but the jointing has been badly done, and in a number of cases there is nothing at all in the joints. As a natural consequence when the drains were tested with water they were found without exception to be leaky, many of them exceedingly so. The majority of the principal drains had more or less deposit in them, partly due to the bad way in which the drains were laid, and partly, no doubt, to the large quantity of silt and other surface washings which get in at the gullies, owing to their faulty construction. The result is that the sewage generally travels very slowly, and in a great measure stagnates in the drains.

Defective
drain at back
of south block
of Officers'
quarters.

One of the most defective drains was that at the back of the south block of Officers' quarters. There was a 9-inch drain passing close to the building, for the most part very badly laid, and with extremely defective joints. At one place (behind C House) where this drain took a double turn instead of curved pipes being used, straight pipes had been used laid at an angle with one another, so that the joints were open to the extent of several inches, and afforded ample opportunity for the sewage to escape into the ground. Further down also behind B House the drain was so badly laid that when the ground was removed from off it, it was possible to see into the drain through the joints. The drain also contained a large amount of deposit. It will be seen from Plan No. I. that two cases of fever have occurred in the houses behind which this drain passed. The drain has now been removed, and a new drain has been laid in a better course.

The means of access provided to the drains is very insufficient. A few of the principal drains are provided with manholes, but these are much too few in number, and instead of being covered with iron doors are, with two or three exceptions, covered with heavy stones placed some distance beneath the ground, so that there is a great deal of trouble in getting at the manholes. In one case near the Clock Tower, instead of a stone being used the manhole is covered by wooden planks below the surface, which are fast rotting, and if not soon removed may lead to a bad accident. In addition to the manholes most of the drains are provided with so-called saddle pipes, which are intended for access to the drains, but are practically useless for this purpose as they are laid at irregular intervals, and no record has been kept of their position, which can consequently only be ascertained by extensive excavations.

Means of access to drains insufficient.

As I found these saddle pipes were also largely employed at the Royal Barracks, and as their use appears to me to be objectionable and founded on mistaken notions, it will be well to go a little more fully into the matter. The objection to the saddle pipes is that it is very difficult to make the joints of the saddles sound. In the case of the Richmond Barracks the joints of the pipes generally are defective, so that the use of the saddles has probably not made much difference, but in cases where the drains are well laid it would be quite otherwise. Good drains should always admit of being tested by being charged with water, and the presence of saddle pipes greatly interferes with this test, as the joints of the saddles are so liable to give way when it is applied. Moreover, the idea on which the use of saddle pipes appears to be founded is a mistaken one. This idea is that when anything goes wrong with the drains they must be opened, and that it is therefore better to provide places where they can easily be opened, and that saddle pipes will effect this. If, however, the drains are properly laid according to the modern system of straight lines and manholes, it should not be necessary to open the drains at all, as any examination and cleaning that is required can readily be done from the manholes without disturbing the drains.

Saddles pipes objectionable.

The whole of the drains within the barracks are "disconnected" from the sewers outside the barracks by ventilated traps, which is the proper arrangement, but the ventilation is not everywhere adequate, and other details of the disconnection are not arranged in the best manner. The disconnecting traps on the drains from the water-closets at the east block of Officers' quarters are of specially defective form, and during my investigation were two or three times found choked and caused an abominable stench.

Disconnection of drains.

The drains are ventilated by fresh air inlets at the disconnecting traps and by vertical iron pipes erected against the boundary walls and buildings of the barracks to act as outlets. On the west side, where the drains are all comparatively short, these ventilating pipes have a beneficial influence on the air in the drains by creating a current through them. In the other portion of the barracks, however, the ventilating pipes are erected at such long intervals apart, and so far from the fresh air inlets, that they do not create any current of air through the drains, and are thus practically of very little use. The result of this defective ventilation and of the large amount of deposit in the drains was, that when the drains were opened they were almost invariably found to smell badly.

Ventilation of drains.

There are two deep cellars from which drains have been laid. The first is the canteen cellar, under which is laid an agricultural pipe to keep the cellar dry. This drain was disconnected from the sewer by a ventilated trap, but the details of this disconnection were faulty when I examined it. Since then it has been altered. The second cellar is that underneath the mess premises in the north block of Officers' quarters. There is a gully in the floor of the cellar, and a deep drain consisting of cast-iron pipe is laid from this gully to a ventilated trap opposite the east end of the chapel. This trap was found to be partially choked, and on opening up the drain it was found to

Drainage of cellars defective.

have no outlet at all, as though it was carried close to the sewer it stopped short of it. The drain was also blocked with roots. This drain has since been relaid, and a proper disconnecting manhole constructed.

Water-closets. Owing to the objection on the part of the Kilmainham Commissioners to admitting any large amount of excreta into the sewer in St. Vincent Street, the number of water-closets has been limited, at the same time there are a good many. The great majority of these are in detached buildings, and well away from any dwelling-house, which is a good feature, but the apparatus is generally defective in one way or another. The closets in the married quarters, at the prison, for the serjeants, for the women and for the children are iron trough closets, of the identical pattern that has been condemned and discarded at the Royal Barracks. They have no proper flush of water, and for the most part foul. The Officers' and other private closets have separate basins of the "Hopper" type. Many of these are not of a self-cleansing form, and the flushing arrangements of all are either inadequate or defective.

Special defects in Officers' closets. In addition to the general defects in the apparatus, special defects were found in two sets of the Officers' water-closets. At the east block of Officers' quarters ("Rookery") on the smoke test being applied to the drain in the lane the smoke came out under the seats of the water-closet, showing that there was a serious defect in the connection between the closets and the drain. Precisely the same thing occurred in the water-closets opposite the east end of the south block of Officers' quarters. In both these instances, therefore, foul air from the drains must have been continually passing up from under the seats. In the case of the water-closet at the "Rookery" the evil was aggravated by the defective state of the disconnecting trap on the drain already mentioned. These water-closets are used by the Officers occupying the east and south blocks, and it will be seen from Plan No. I. that cases of fever have occurred in both these blocks.

There are a few indoor water-closets in Officers' quarters, and at the hospital. Those in the Officers' quarters are all fairly good, but the floors beneath them are simply of wood, and have no safes or other protection against saturation or spilling of slops, or leakage.

Water-closets at hospital in bad condition. The water-closets at the hospital, on the other hand, are in an exceedingly bad condition. On removing the woodwork it was found that the edges of the basins and the adjoining woodwork were coated with decomposing fæcal matter, and that the floors and woodwork generally were saturated with slops and urine causing the closets to smell badly. At first sight it appeared inexplicable how the fæcal matter got outside the basins, but on inquiry it was found that the bed pans were emptied down the water-closet, as there are no slop sinks, and this will no doubt account for the state of the apparatus. It need hardly be pointed out that such a condition of things in a hospital must be specially prejudicial to health.

Soil pipes. The soil pipes from the water-closets are all fixed, rightly, outside the buildings. They are also all carried up full size above the roofs as they should be. Some of them are directly connected with the drains, and act as drain ventilators, others have a trap at foot with a fresh air inlet. Either of these is a good arrangement.

Urinals. There are a large number of urinals throughout the barracks. The majority of them are placed against occupied buildings, which is not a good position, as if any stoppage occurs in the outlet (not an unusual occurrence) there is danger of the urine soaking into the ground and the adjoining walls. The urinals are all flushed with water, but in many cases the flushing pipes are nearly stopped up. The arrangement of the floors and drainage of the urinals is not as good as it should be, and attention does not seem to be paid to cleaning the urinals. The consequence is they frequently smell badly.

The ablution and bath-rooms are well situated, and with plenty of light and ventilation. The waste water from the baths and basins is conveyed outside the buildings by channels in the floors, and these are properly disconnected from the drains by discharging over gullies. The waste pipes of the sinks also are disconnected from the drains by discharging with open ends outside the building. A great number of the waste pipes, however, are not trapped in themselves, which is a faulty arrangement as air will pass into the buildings through the pipes and become contaminated by contact with the foul interior of the pipe, and thus cause a smell. This objection was particularly noticeable in the case of the sinks which are at the foot of the staircase of the houses in the "Rookery" (L, M, N, on plan). The sinks are nominally only to take the drippings from taps, but as a matter of fact are used for pouring down bedroom slops. The consequence is that the air coming up the waste pipe smells of urine. I particularly noticed this smell in M house.

Ablution
rooms and
sinks.

In a great many cases the waste water, instead of being discharged immediately over a gully, is conveyed to a gully by a channel of considerable length. This arrangement is similar to that at the Royal Barracks, in which case I pointed out that there were certain objections to it. The further opportunities I have had of noting the action of the channels has convinced me that the objections to them are greater than I then thought. 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. As this is rather an important matter I must go a little into details about it.

Objections to
long channels
for waste
water.

In the case of slop water, the object to be effected is to pass it as quickly as possible into the drains, and the gullies ought therefore to be "self-cleansing," and not to retain any foul matter. In the case of surface water, on the other hand, especially where it comes from the roads and parades, a quantity of silt and stones is washed along which ought to be kept out of the drains; and the gullies ought to be of a kind which will cause the silt to be deposited, and only allow the water to pass into the drains. If, therefore, the wrong kind of gully is used (as is necessarily the case when the same kind is used for both purposes), either it will retain matters that it ought not to retain, or pass matters that it ought not to pass. In the case of the Richmond Barracks, although there is a greater retention of foul matter in the gullies than there should be, the chief fault is that there is not a sufficient retention of the silt and stones, so that these are carried into the drains. This will no doubt account to a considerable extent for the large amount of deposit in most of the drains.

For reasons already stated, the greater number of the men's closets are not connected with the drains, but constructed so that their contents can be carted away. Until quite recently they were latrines supplied with a limited amount of water, and the contents were daily discharged into special carts and taken to fields in the vicinity of the barracks, and used as manure. This system of conservancy was found to be very objectionable, and last year the latrines were done away with, and earth closets were substituted. These consist of an ordinary seat with a galvanized iron pail beneath on an impervious floor, and the dry earth is supplied in small boxes fixed at the back of each compartment, and provided with a scoop. The arrangement itself is a good one, and would no doubt prove satisfactory if proper attention were given to it, but this is precisely what is wanting.

Earth-closets.

When I examined these earth-closets, I found that the pails almost invariably contained nothing but faecal matter, without any signs of earth over it, so that the smell was very offensive. As there was generally earth in the boxes, I was at first inclined to attribute the failure to apply the earth to the fact that the scoops were generally missing, but on examination of the

Want of
proper atten-
tion.

closets used by the Guards, I found that in these the scoops were generally attached to the boxes, but that the earth was no better applied. From this it is clear that the cause of the earth not being used was that the men would not take the trouble to apply it.

Disposal of
products of
earth-closets.

The pails from the earth-closets are removed daily in carts to some land on the east side of the barracks; and as there were originally complaints about the disposal of the night soil, I made a special examination of the locality where the contents of the pails are now deposited. I found that the pails were carted by the contractor to a large manure heap, marked A on the key plan, a quarter of a mile from the nearest point of the barracks. The contents of the pails were emptied on the side of the heap furthest from the barracks, were then mixed with spent hop stable manure and ashes, and left to consolidate for a considerable time (the foreman said for six months or more) before they were spread about the field. There was a very offensive smell on the lee side of the heap perceptible quite 200 yards away, but on investigation this smell was found to come entirely from the portion of the heap where the pails had been recently emptied, which was a filthy semi-fluid mass, and that the portion of the heap from which manure was taken to spread on the land was quite inoffensive, in fact, only a black mould. The conclusion I arrived at was that though it was possible that under certain circumstances the smell from the emptying of the pails might reach the barracks, the manure spread about the fields was quite inoffensive.

Offensive
smell from
cement
factory.

While speaking about the smells which are specially noticed on the eastern side of the barrack, I must not omit to mention the smell from a cement factory, marked B on the small key plan on Plan No. II. The smell from this manufactory is referred to in the historical statement as being most offensive, and I can confirm this from my own experience. On arriving at the barracks one morning, I perceived an offensive smell, which pervaded the whole of the barracks, and might easily have been mistaken for sewage, but which, on closer investigation, was found to be coming from the direction of the cement works. Subsequently I traced the smell up to the cement works, and found that it came from the smoke of one of the kilns, and was only perceptible when standing in the line of the smoke. The smell was undoubtedly that of sulphuretted hydrogen, which I believe is liberated during the process of the manufacture.

Conclusion as
to drainage
and sanitary
appliances.

The conclusion I have arrived at, after careful consideration of all the details, is that the drainage of the barracks is decidedly bad—in fact, so bad that I do not see how anything short of radical alterations, amounting virtually to reconstruction, will suffice to meet the necessity of the case. The sanitary appliances, although not so bad as the drainage, are still far from satisfactory, and require extensive modifications and improvements.

SUBSOIL AND SUBSOIL WATER.

Nature of sub-
soil.

In order to ascertain the nature of the subsoil on which the barracks are built, I had a large number of trial holes dug within the barrack area as well as some outside. These holes showed that the site consisted of boulder clay, which generally came very close to the surface, but that on the west and south sides, soil of a rather freer nature overlies the boulder clay. Water was met with everywhere in considerable quantities.

Analysis of
samples.

I had a number of samples of surface and subsoil taken from different parts of the barracks and submitted them to Dr. Dupré, F.R.S., Chemical Referee to the Local Government Board (England), for analysis. From his report, which is given in the appendix, it will be seen that none of the samples of soil examined show any material degree of pollution, but that they are fairly comparable with ordinary soil.

In sinking the trial holes, as already stated, water was everywhere met with in considerable quantities. This water was so near the surface (only 3 or 4 feet down), and so universally prevalent, that I at once saw that it was a matter of very serious importance from a sanitary point of view, and one which required to be thoroughly investigated.

The levels of the subsoil water in the different holes were carefully taken and laid down on a plan, and then "contour lines" were drawn to show the level of the subsoil water. A study of these water contours showed that underneath the main portion of the barracks the water was almost level and very near the surface, whereas at the north-east corner of the barracks the water had a marked fall away from the barracks. The land also has a fall away from the barracks in this locality, but the water falls more rapidly than the land, so that it lies at a greater depth beneath the surface.

This peculiar backing up, as it were, of the water underneath the barracks led me to think that the water might possibly be due to some local leakage, either from the drains or from the water mains, or from the canal, which, as will be seen from Plan No. II., is close to the barracks. I therefore investigated each of these points.

As regards the drains, there was no doubt that considerable leakage took place from them, but the subsoil water was to all appearances so clear and sweet that it seemed very improbable that it came from the drains. To set this matter at rest, I had a number of samples analysed by Dr. Dupré. From his report, which will be found in the appendix, it will be seen that several samples show undoubted signs of pollution by sewage, but that this sewage is to a very great extent oxidised in its passage through the soil, and is generally mixed with a considerable proportion of subsoil water. Some of the samples he states to be ordinary subsoil water, and equal in purity to many waters used for drinking. From the above, it is evident that the water in the land must come largely from other sources than from the leaky drains.

Before leaving the question of the analysis of the subsoil water, one of the samples requires special mention, viz., that taken from below F house (soldiers'). Dr. Dupré states that this is of somewhat an exceptional character; it has evidently been very largely polluted with sewage and is not much mixed with subsoil water. This is the analysis mentioned on page 7 as indicating the existence of pollution of some kind beneath the house.

As regards the question of the water in the land being due to leaky water mains, it will be seen from what I state later on, under the head of water supply, that though some leakage was detected from the mains, it was not of any great amount.

As regards the canal, it was not possible to arrive at any positive conclusion, but the opinion I formed, after having holes dug near the canal and studying all the available data, was that there was no evidence to show that the subsoil water came from the canal.

The above investigation seems to leave little doubt that though the subsoil water is augmented by local leakage, the greater portion of it is the natural underground water of the district. The question still, however, remains why the water should be held up in such a peculiar way underneath the barracks. To investigate this, additional trial holes were dug on the south and west portion of the barracks, where, as already stated, soil of rather a freer nature overlies the boulder clay. These trial holes confirmed the existence of a greater depth of freer soil on this side of the barracks, and showed that although the junction between the freer soil and the clay was not clearly defined, the surface of the clay was certainly very flat beneath the barracks, if not hollowed out, towards the south-west, so as to form a sort of basin. Such a formation of the surface of the clay would undoubtedly have the effect of holding up the water beneath the barracks, and this is probably the cause of the peculiar level bed of water beneath them.

The proper remedy for such a condition of things is subsoil drainage. The necessity for this has been recognized for some time, but all that has been

done is the laying of some land drains to intercept the flow of subsoil water from the cemetery.

These drains, which consist of agricultural pipes, are shown in green lines on Plan No. II.; and the greater portion of them are outside the barrack area, in a lane between the barracks and cemetery. The main drain, along the north side of the lane, is from 6 to 9 feet deep, and connected with it there are numerous minor drains. Three feet above the main drain, and in the same trench is laid another similar drain. Both of these discharge into a chamber within the barrack area, whence a cemented drain passes to the sewer on the east side of the barracks, being "disconnected" on its course. On examining the chamber above referred to, I found that it was only the deepest of the main drains that had any water (and this only a little) coming down it, showing what might have been anticipated, viz., that the laying of a shallow drain above a deep one is practically useless, as the water that falls on the land passes the shallow drain and finds its way to the deeper one.

Analysis of
water from
subsoil drains
at cemetery.

The chief idea in intercepting the water passing from the cemetery was that it was of a foul nature, likely to be injurious to the health of the barracks. I therefore had a sample of the water from the intercepting subsoil drains analysed by Dr. Dupré, and from his report it will be seen that it shows no special characteristics of having come from a cemetery, and has also been fairly oxidized. From this it would at first sight seem that the idea of the subsoil water from the cemetery being prejudicial to the health of the barracks is a mistaken one. I do not, however, think that the data are sufficient altogether to justify this conclusion, as the depths at which the intercepting drains are laid are not great enough properly to intercept the subsoil water from the cemetery.

Recent pro-
posals for
complete
scheme of sub-
soil drainage.

Quite recently, the Commanding Royal Engineer has prepared a scheme for a complete system of subsoil drains over the whole of the barracks, and has shown it to me. This is a great improvement on the previous proposals merely to lay drains round the buildings, but I think that it errs too much on the side of uniformity. Over a considerable portion of the barrack area the drains ought, no doubt, to be laid at nearly uniform depths and distances apart, but in other portions where the land is freer, and the water at a great depth below the surface, the drains should be deeper and further apart.

STRUCTURE OF BUILDINGS.

Character of
the stone
used.

The buildings are mostly constructed of local stone, but in some cases where the houses have been rebuilt, a lining of brick has been inserted. This stone is chiefly very hard black limestone, but there is also used with it another black stone resembling the hard limestone very closely, and constantly mistaken for it, but which is a very treacherous material. This stone, locally known as "calp," is really a shale, which, when first quarried, is hard, but after exposure to the atmosphere, sooner or later crumbles away. In consequence of the use of this calpstone, portions of some of the buildings have, from time to time, given way, and had to be rebuilt—in fact, only a year or two ago part of the hospital walls had to be rebuilt, and other portions are crumbling away.

As the excessive use of this calpstone is known to be one cause of the rotten and unhealthy condition of some of the older houses in Dublin, I thought it advisable to make a special investigation into the condition of the walls of the soldiers' quarters. For this purpose I had a number of holes cut in the walls large enough to admit of an examination being made of how the inside of the walls was built, and how much, if any of the calpstone had been used. The examination thus made showed that the walls were generally well built, and flashed in with mortar, and that although some calp had been used in the construction of the walls, there was very little sign of crumbling. This is probably due to the walls being sufficiently well built to protect the calp from air and moisture, as in other places, where the calp is exposed, it is visibly crumbling.

I also made a special examination of the foundations of the buildings, and for this purpose had them opened up and cut into in several places. In the soldiers' quarters the foundations were generally shallow and ragged, while in the Officers' quarters the foundations are deeper and better built. In none of the walls was there any "damp-proof course." Notwithstanding this there are no signs of damp rising in the walls, which must, I suppose, be explained by the hardest kind of stone having been used in the foundations. Foundations of buildings.

The boards of many of the ground floor barrack-rooms were taken up that I might examine the condition of the woodwork and spaces beneath, and also the state of the ground. In every case the joists and sleeper wall-plates proved to be in good condition and free from either dry or wet rot. The spaces also were ventilated by air gratings in the front and back walls. The surface of the ground proved to be covered by a great quantity of dust and dirt which had fallen through the joints of the floor boards (which were generally neither tongued nor filleted), and beneath this dust and dirt was a thin layer of inferior lime concrete, forming a sort of skin over the ground. In some cases this skin of concrete had broken up and intermingled with the dust and dirt. Condition of ground beneath lower floors.

Considering the nearness to the surface of the subsoil water under the part of the barracks over which the soldiers' quarters are built, it is certainly most important that the ground should be covered with concrete, but the material which has been used is altogether insufficient for the purpose, in fact, it can hardly be called concrete at all. Inferior concrete used.

The presence of so much dust and dirt underneath the ground floors led me to examine the upstairs floors. A general inspection showed that in a large number of cases the boards were much worn and patched, so that there had been ample opportunity for the passage of dust and dirt, and on taking up the boards in several rooms a large accumulation was found. Even in the case of the rooms in F house, where the floors had been recently entirely renewed after the recurrence of enteric fever, there was a quantity of rubbish left beneath, showing that when the new floor had been relaid the joists and spaces had not been properly cleaned. Condition of upstairs floors.

I had several samples of the dust beneath the floors analysed by Dr. Dupré, and tested for micro-organisms by Dr. Klein, F.R.S. From their reports it appears that although there is a considerable amount of organic matter and numerous micro-organisms in the dust there is nothing sufficiently remarkable about it to make it necessary for me to give the details. Analysis of samples of dust beneath floors.

I cannot think it conducive to the healthiness of the barrack-rooms that there should be this large accumulation of dust and dirt under the floors, and that no sufficient means should be taken to prevent its accumulation, or to remove it when met with in the course of repairing the floors. Up to quite lately, moreover, even when disinfecting rooms after cases of illness it has not been the practice to go further than to fumigate the room and limewhite the walls; so that the process of disinfection and cleaning did not extend to the dirty spaces beneath the floors. The disinfection itself was also quite inadequate as the most recent investigations have shown that the fumigating and lime-whiting cannot be relied on to kill micro-organisms, particularly those producing infectious diseases. Accumulation of dust and dirt under floors objectionable.

As bearing on the question of cleaning and disinfection, I cannot do better than refer you to the joint report of Dr. Dupré and Dr. Klein, which I obtained at your request early in the present year, and which is given in the appendix. From this it will be seen how the disinfection should be effected, and what great care should be exercised in removing and destroying all rubbish and dust. Cleaning and disinfection.

AIR AND VENTILATION OF BUILDINGS.

The buildings are very well situated for light and air, and are not in any way crowded together.

Cubic space per head ascertained by measurement. In order to ascertain whether there was any overcrowding amongst the men I had all the barrack-rooms measured, the number of occupants noted, the results tabulated, and the cubic space per head calculated. The following are the general results, taking 600 cubic feet per head as the normal amount, being that given in the official synopsis of proposed normal sizes for barracks.

In the barrack-rooms proper the normal amount of cubic space per head has been provided with very few exceptions.

In the huts the space is under 450 cubic feet per head.

Insufficiency of accommodation in married soldiers' quarters. In the married soldiers' quarters there are a considerable number of rooms in which the cubic space is below the normal amount per head (even when reckoning that children only require half the space that an adult does), and several rooms in which it is very greatly below. These latter are small inner rooms, all of which are overcrowded, and with inadequate ventilation. As a sample I may mention one (and this is not the worst) that is only 8 ft. 9 in. by 7 ft. by 10 ft. 8 in., with three persons sleeping in it (two adults and one child).

The insufficiency of the accommodation at the married soldiers' quarters was called attention to by the Board of Officers in 1885, as before mentioned.

Ventilation of rooms. How effected. The ventilation is generally effected by inlets and outlets, constructed according to the official synopsis of proposed normal sizes for barracks. The inlets consist of openings through the walls at high level with louvres or hoppers on the inside to direct the current upwards. The rooms are also generally provided with Galton ventilating grates which act as inlets. The outlets consist partly of brick flues and partly of wooden shafts carried up above the roof.

Amount of ventilation ascertained by measurement. The amount of ventilation provided was ascertained in the same way as that in which the cubic space was ascertained, viz., by measuring the inlets and outlets in every barrack-room, noting the number of inmates, tabulating the results, and calculating the superficial area of inlets and outlets per occupant.

The following are the general results, taking 10 square inches per head as the normal amount of superficial area for inlet ventilators, and the same for outlet ventilators, being that given in the official synopsis of proposed normal sizes for barracks.

In the barrack-rooms proper and huts the amount of ventilation provided is generally more than the normal amounts, especially as regards outlet ventilation, but in one or two cases the amounts is decidedly less.

Ventilation in married soldiers' quarters deficient. In the married soldiers' quarters the ventilation is deficient in a considerable number of rooms, including the inner rooms, which on account of their smallness require ventilation more than any other rooms. These inner rooms have no outlet ventilators at all, and the inlet ventilators being controllable are as a matter of fact generally shut.

Larger amount of ventilation than that in synopsis preferable. It should be explained that the figures given in the official synopsis of proposed normal sizes for barracks are based on the recommendations of the Barracks and Hospital Commission, and that investigations which have been made since that date have led to the conclusion that a somewhat larger amount of ventilation would be advantageous. The late Professor de Chaumont, F.R.S., in his treatise on Practical Hygiene, says that "a size of 24 square inches per head" (as against 10 square inches) "for inlet and the same for outlet seems calculated to meet the common conditions, but arrangements should be made for enabling this to be lessened or closed in very cold weather."

Ventilation of gas burners. One of the recommendations of the Barracks and Hospital Commission, 1861, was that the gas burners should be ventilated presumably by extract tubes fixed over them, but this has not been done.

WATER SUPPLY.

The water used at the Richmond Barracks is derived from two sources—(1) from the Vartry water mains; (2) from the Grand Canal, and there are two separate systems of distributing pipes throughout the barracks. It appears that in former years the taps from which water for drinking and culinary purposes was drawn were supplied partly from the Vartry mains and partly from canal mains, but recently this has been altered, and now all the taps are supplied from the Vartry mains except the taps in the ablution rooms, lavatories, and wash-houses, and two taps attached to stand pipes. These two latter, moreover, are labelled "unfit for drinking purposes." The canal water, in addition to being used for the ablution rooms, wash-houses, &c., is also used for the closets and urinals.

Two sources of supply.

The Vartry water is the public water supply of the City of Dublin, which is well known to be of good quality. I have had an analysis made by Dr. Dupré of the Vartry water as it comes to the barracks, and from his report, which is appended hereto, it will be seen that he considers it to be a good drinking water.

Vartry water a good drinking water.

Such a statement as this might appear at first sight to settle the question of the water supply and render any further investigation unnecessary, but this is not so, as many cases are on record where a water supply which is naturally good has been subject to serious pollution from local conditions which only occasionally come into play. I refer more particularly to the direct connection of the water closets or urinals with the mains and to leaky pipes laid through polluted ground, in which case, if the mains are emptied for repairs or any other purpose, a partial vacuum may be created in them and suck polluted matter into the pipes. When the water is turned on again this polluted matter will be distributed for consumption. I therefore considered it necessary to investigate this question very closely.

Possibility of pollution from local conditions investigated.

The water-closets and urinals are, as already stated, generally supplied by canal water, but a few of them are supplied with Vartry water. The closets, which are supplied with Vartry water, have intercepting cisterns, but two urinals are supplied direct from the Vartry mains. This, therefore, is a source of possible pollution which ought on no account to be allowed to exist.

Two urinals directly connected with main.

In order to ascertain whether the pipes were sound, a special series of tests were made which had to be carried out at night as being the only time when it was possible to stop the use of water at the various taps, &c., connected with the mains. The test was carried out as follows:—A special midnight inspection was made of all the taps supplying Vartry water to see that no water was running away. The meter on the main was then read at frequent intervals, when it was found that it was practically motionless. As the pressure in the pipes at night is about 50 lbs. on the square inch (more than double what it is in the day time), any appreciable leakage would readily show itself, and, therefore, the above test may be considered as proving that the Vartry water mains are practically sound.

Tests carried out to ascertain soundness of pipes.

The canal water supply is drawn from the canal at a point more than a half-a-mile west of the barracks, above a series of locks, which raise the water to a sufficient height to supply the barracks by gravitation. The water passes from the intake into settling tanks, and thence by a 6-in. iron main to the barracks. It will have been seen from the historical statement that the Board of Officers in 1885 recommended that the canal water should be filtered, but, as a matter of fact, no filters appear to have been constructed.

Canal water.

As the canal water is supplied to taps from which water for drinking could be drawn, I thought it important to have the water analysed by Dr. Dupré. From his report, it will be seen that he considers the canal water to be unfit for drinking, at which I am not surprised, considering the great liability there is of this water being polluted. I, myself, when I inspected the intake, saw two

Analysis of canal water shows that it is unfit for drinking.

dead animals floating in the canal, and nothing would be easier than for a carcase of this kind to lodge close to, or even against, the intake, in which case gross pollution of the supply would at once take place.

No security that canal water is not used for drinking purposes.

This is rather a serious matter, as I think there is no security at all that the canal water may not have been frequently drunk by the men. Even in the case of the two stand pipes labelled "unfit for drinking purposes," the label may very likely have been disregarded; and in the case of the ablution rooms and washhouses, there is nothing to show that the water ought not to be used for drinking, and therefore a probability that it will be so used if it is convenient to do so. The only safe rule in dealing with a duplicate water supply, where one of the waters is impure, is to make it impossible for the impure water to be used for drinking, by not supplying it to any tap from which water by any possibility can be drawn for drinking.

A similar test to that applied to the Vartry water-pipes was applied to the canal water-pipes, and though they were found not to be as sound as the Vartry pipes, there is no great amount of leakage from them.

Quantity of water consumed.

Before leaving the question of the water supply, I will refer briefly to the amount of water consumed. The following table shows the consumption for the last four years:—

Year.	Consumption.			Average Daily Consumption.		
	Vartry.	Canal.	Total.	Vartry.	Canal.	Total.
1885..	1,731,000	10,725,600	12,456,600	4,742	29,383	34,125
1886..	1,977,000	9,540,000	11,517,000	5,416	26,137	31,553
1887..	3,603,000	9,340,000	12,943,000	9,781	25,588	35,459
1888..	4,131,000	7,920,000	12,051,000	11,287	21,639	32,926

Consumption shows that water is wasted.

The first thing that strikes one in the above table is the large increase which took place in the consumption of Vartry water in the year 1887, and the gradual decrease in the consumption of canal water. This may probably be accounted for by the Vartry water being laid on to taps which were previously supplied by canal water. As regards the total quantity consumed, this is about equivalent to 30 gallons per head per diem (taking the population at 1,130). This is a much larger quantity than ought to be used, and from my examination I know that a large amount of preventable waste takes place. Even in the case of the Vartry water there is a good deal of waste, and in the case of the canal water, presumably on account of the cheap rate at which it is obtained, hardly any attention appears to be paid to the prevention of waste.

Wasted water does not flush drains.

It might be thought that this waste was a good thing from a sanitary point of view, as it would assist in flushing the drains. This is, however, a mistaken notion, as the constant dribble of water from half open taps, or even the flow from urinals, which are left running all night, is useless for flushing the drains. What is required for this purpose is a large body of water suddenly admitted to the drains at intervals.

MILK SUPPLY.

Whether a milk supply has had anything to do with an outbreak of enteric fever is really a medical question, and I therefore cannot go further into the matter than to give a few facts bearing upon the milk supply at the Richmond Barracks.

Two battalions occupy the Richmond Barracks at the same time. One a Line battalion and the other a Guards battalion. These battalions have recently (so far as the non-commissioned officers and men are concerned) been supplied by different purveyors whose milk, when tested in June last, was of very different quality.

The milk supplied to the Line battalion was practically unadulterated, but that supplied to the Guards battalion was, on analysis, found to be adulterated with 72 per cent. of water.

Since September 1887, there has been no change in the purveyors of milk (although two different battalions of Guards have occupied the barracks), and the incidence of the fever on the non-commissioned officers has been as follows:—

Line battalion	6 cases
Guards battalion.. .. .	8 „

The Guards battalion is stronger than the Line battalion, so that practically the incidence on the two has been the same, though the milk has been supplied by different purveyors.

As regards the great adulteration of the milk supplied to the Guards, it may be mentioned that it was stated incidentally in the report of Sir Charles Cameron's Commission on the Royal Barracks, that the milk supplied to the 2nd Bn. Grenadier Guards at the Richmond Barracks, in August 1887, was found to be adulterated with 21 per cent. of water.

BRIEF SUMMARY OF RESULTS OF INVESTIGATION.

There has been, and still is, a difficulty about the outfall for the drainage Drainage. which greatly complicates matters, and prevents the general adoption of the water-carriage system.

In addition to this, the drainage proper of the barracks is decidedly faulty. The drains are badly laid, leaky, and many of them more or less blocked with deposit. The ventilation and other accessories are defective.

The sanitary appliances are also more or less defective, especially those in the hospital, and some used by the Officers.

The earth-closet system which has been introduced for the men in lieu Earth-closet system of the old latrines is a decided improvement, but proper attention is not given to it.

The surface soil of the barracks is not appreciably polluted.

Surface soil.

There is a great accumulation of subsoil water under the barrack area Subsoil water standing generally within 3 or 4 feet of the surface. This accumulation of subsoil water is partly due to artificial causes, such as local leakage from the drains and water mains, but chiefly to natural causes.

Analysis of this subsoil water shows distinct signs of sewage pollution, but the sewage has been, to a very great extent, oxidized in its passage through the soil. The sample, which shows signs of the greatest pollution, was taken from underneath a house in the soldiers' quarters, where there had been several cases of enteric fever.

The walls of the buildings have been very defective in places, and several Buildings. of them have had to be rebuilt at various times, but now they are on the whole sound, and though there is no damp-proof course, this omission does not seem to have had any bad effect on the lower part of the walls.

The ground underneath the ground floor barrack-room is not covered with a proper bed of concrete; and there is a large accumulation of rubbish and dirt in the space underneath the floor boards, both on the ground and upper floors. Even where floors are removed, and rooms cleaned and disinfected after occurrence of fever, sufficient care is not taken in cleaning and disinfecting the spaces under the floors.

Ventilation.

The buildings are well situated for light and air, and the barrack-rooms generally well ventilated, but in the married soldiers' quarters the accommodation is very insufficient, and the ventilation defective.

Water supply.

There is a duplicate water supply, viz., Vartry water, used for drinking and cooking, and canal water, used for washing and closets.

The Vartry water is a good drinking water, and the main pipes are sound, so that there is no liability of pollution from the in-suction of filth through leaks, but two urinals are directly connected with the Vartry mains, which is a possible source of pollution, and a very improper arrangement.

The canal water is unfit for drinking, and liable to gross pollution. It is supplied to many taps, from which the men could draw water for drinking, though it is not intended they should do so.

There is a large preventable waste of water which produces no useful result.

Milk supply.

The milk supply of one of the battalions, when tested, was found to be grossly adulterated with water.

RECOMMENDATIONS.

Outfall
sewers.

1. With regard to the sewers and drains, I am of opinion, as previously stated, that very radical alterations, amounting virtually to reconstruction, should be effected in them; and the first question is the one of outfall. It has always been assumed that the sewer in St. Vincent Street must be reconstructed, but I think that this is by no means necessary. I quite agree that this sewer is much larger than is required for the purposes it has to fulfil, and that in its present condition it is objectionable, but I think that a great deal too much has been made of its defects. It would be a comparatively easy matter to construct a smaller invert of stoneware channels in the bottom of the culvert, which would make it practically as good as a stoneware drain; and, even short of this, if it were properly cleaned out, and automatic flushing provided at its upper end, it would probably answer its purpose.

2. Looking, however, at the difficulty there has been with the Kilmainham Commissioners about the sewer in St. Vincent Street, I think it well worth the consideration of the War Department whether it would not be advantageous to give up the use of this sewer altogether and connect the drainage of the west side of the barracks with a new pipe sewer on their own property. This new sewer could be laid under the west side of the parade and made to discharge into another new pipe sewer to be constructed on the north side of the barracks in lieu of the present defective culvert. This plan would have the advantage of bringing the whole of the sewage of the barracks to a point where it would be comparatively easy to make a connection with the Dublin Corporation sewers, should an arrangement about this be come to with the Corporation.

3. Under any circumstances the existing defective culvert on the north side of the barracks must be abolished and a new pipe sewer constructed. The sewer on the east side of the barracks must also be taken up and relaid at the best available fall.

Drains inside
the barrack
area.

4. As regards the drains inside the barrack area, if the sewer in St. Vincent Street is still used, it may be possible to retain some of the drains discharging into it, as they are mostly of short lengths forming portions of small systems complete in themselves. All of them which are unsound must, however, be relaid, and if the use of the St. Vincent Street sewer is given up, the whole of them will have to be reversed in direction. In the remainder of the barracks, the whole of the drains should be taken up, and a new, carefully-devised system of drains laid. All disused drains and culverts should be followed up and removed, and the other defects, which have been pointed out, remedied.

5. All sewers and drains should be watertight and laid out in straight lines, with manholes or lampholes at the changes of direction or inclination, and at all the principal junctions. The manholes and lampholes should be covered by iron doors so as readily to admit of the inspection of the drains. Saddle pipes should not be used. Ventilators should be provided to the drains at frequent and convenient intervals, and the details of the "disconnecting" traps should be improved. Flushing arrangements should be provided where necessary.

6. The existing trough closets should be removed, and, either combined closets of improved design, or separate water-closets, should be provided instead. The Officers' water-closets, and other private ones, which are not of a self-cleansing form, should be replaced by those of approved pattern. Sanitary appliances.

7. All indoor water-closets should be provided with lead trays beneath them, or impervious floors should be constructed of concrete or tiles. The seats of all closets should be hinged to admit of easy access to the space beneath, and the underside of the seats should be painted. All "risers" should be made movable, and all saturated woodwork should be removed.

8. At the hospital, proper slop sinks should be provided to receive bedroom slops, instead of their being poured down the water-closets as at present. These sinks could be fixed in the water-closet apartments, where there is ample room for them, and should be suitable for washing bed-pans. Probably, porcelain sinks, with flushing rims, would be the best.

9. The position of the soldiers' urinals should be taken into consideration, with a view to removing them away from the walls of inhabited buildings wherever possible. The details of the traps, channels, and floors of the urinals should be improved, so that the urine may pass away more rapidly, and the floors be kept cleaner and dryer.

10. The sinks at the foot of the stairs in each of the houses in the east block of Officers' quarters (houses L, M, N) should be entirely removed, together with the waste pipes. It would be better to remove the taps as well; but if it is considered necessary to retain these, a movable tray could be provided to catch the drip. The waste pipes of all sinks, fixed lavatory basins, and similar appliances at present untrapped should be provided with syphon traps with cleaning caps.

11. A radical change should be made in the method of dealing with the slop water after it is discharged from the waste pipes, so as to keep it separate from the surface water. In every case a gully trap of self-cleansing form should be fixed close to the open end of each waste pipe to receive the waste water, instead of allowing it to run down the surface water channels. The gullies receiving the surface water, on the other hand, should be reconstructed so as to form silt pits, which will intercept sand, stone, &c., from passing into the drains. These silt pits must be so arranged as to be readily cleaned out.

12. The equipments of the soldiers' earth-closets, such as earth boxes and scoops, should be made thoroughly complete, so that there may be no excuse for the men not applying the earth. In addition to this, a man should be appointed to see that the proper amount of dry earth is supplied, and to go round the whole of the earth-closets regularly two or three times a day to apply the earth where needed, and generally keep the closets in order. This same man should also look after the urinals, and water-closets, as has been arranged at the Royal Barracks, with beneficial effects. The earth-closets in the North Block of Officers' quarters should be put in working order. Soldiers' earth closets.

13. As regards the disposal of the products of the earth-closets, the contractor should be instructed always to cover over the contents of the pails

with earth or ashes immediately the pails are emptied. The manure heap should be periodically inspected to see that this method of procedure is properly carried out.

Subsoil
drainage.

14. A complete system of subsoil drainage should be carried out over the whole area of the barracks. As previously stated, the depths and distances apart of the drains must vary according to the levels of the subsoil water and nature of the land; and the main subsoil drains must be laid out with due regard to the maximum depth required in each portion of the barracks.

15. The greatest depth will be required on the south-west of the barracks; and it would probably be best for the main subsoil drain for this portion to discharge either into the St. Vincent Street sewer, or into the new sewer on the north side of the barracks. The remainder of the drainage could probably discharge into the sewer at the north-east corner of the barracks. Of course these main drains should be properly "disconnected" from the sewers, and occasional means of access should be provided.

16. The depths and distances apart of the minor drains will be best decided upon after the main drains have been cut, as these will give the most complete information as to the nature of the subsoil, and how far the influence of the drains will be felt. To ascertain this latter point, test holes should be dug, and the level of the water in them watched.

Structure.

17. When any new walls are built, or old walls renewed, care should be taken that no "calp" stone is used, and that a damp-proof course is provided.

18. The dirt, rubbish, and inferior concrete beneath the buildings (including the huts) should be removed and the ground covered with a layer of Portland cement concrete. This should be at least 6 inches thick, be rammed solid, and the surface be floated over with cement.

19. In the case of house F (soldiers'), the ground beneath the floor should be excavated for at least a couple of feet, and a thorough search made for old drains, or other sources of pollution, which of course should be removed. The excavation should then be filled up with clean dry earth, and covered with a layer of concrete, as in the other cases. The walls below the floor, the joists, and other woodwork should be disinfected with perchloride of mercury, according to the instructions given in the joint report of Dr. Dupré and Dr. Klein.

20. The spaces beneath the boards on the upper floors should all be thoroughly cleaned, and in the cases where there has been illness they should be disinfected.

21. Whenever any new floors are laid, they should either be tongued or filleted, or a double floor should be laid (similar to those lately constructed in E and F attics at the Royal Barracks), 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 C. Cameron's Commission.

Cubic space.

22. The number of men in the huts, and in two or three barrack-rooms, should be reduced so as to give the normal amount of cubic space per head.

23. More accommodation should be provided for married soldiers so as to prevent overcrowding.

Ventilation.

24. Increased ventilation should be provided in the married soldiers' quarters, and in one or two barrack-rooms, so that there shall be nowhere less than the normal amount.

Water.

25. The direct connection of the Vartry mains to two urinals should be cut off, and the urinals supplied from a cistern.

26. The canal water should be cut off from all taps from which there is any possibility of water being drawn for drinking, and the Vartry water should be laid on to the taps instead of the canal water.

27. Steps should be taken to prevent the existing waste of water at the barracks. This can best be done by taking hourly readings of the meters at night, and making night inspections in order to ascertain where the waste is taking place. The fittings which cause the waste should then be altered or repaired, and a subsequent nightly reading taken to see that the waste is stopped. This proceeding should be carried out periodically. All urinals should be shut off at night.

28. The milk supply should be periodically tested. An easy way of detecting gross adulteration with water, such as that which has recently taken place, would be to provide the Quartermasters with lactometers, and give them instructions how to use them. In doubtful cases, the milk should be analysed.

In conclusion, I must express my regret at not having been able to let you have this report before, but the large amount of detailed information that was required for it has taken a very long time to obtain and to work into shape.

I have the honour to be, Sir,

Your obedient Servant,

ROGERS FIELD.

M. Inst. C.E.

Westminster Chambers,
7, Victoria Street, London, S.W.,
23rd July 1889.

APPENDIX.

REPORTS BY DR. DUPRÉ, F.R.S., ON ANALYSIS OF VARIOUS SAMPLES OF SOIL AND WATER AT THE RICHMOND BARRACKS.

Samples of Surface and Subsoil.

None of the samples of soil examined show any material degree of pollution, but on the contrary, they are fairly comparable with ordinary soil. This is shown both by the small proportions of volatile matter, as well as by the low proportions of nitrogen in such of the soils as have been examined in this respect. This character of the subsoil fairly corresponds with the general character of the subsoil waters, all of which show that the soil through which they have passed cannot be surcharged, or even charged, to any notable degree, with unoxidized animal matter.

(Signed) A. DUPRÉ.

SAMPLES OF SURFACE AND SUBSOIL, 1889.

Analytical Details.

Description of Sample.		Organic matter, per cent.	Inorganic mat- ter, per cent.	Nitrogen in total soil, per cent.	Nitrogen in or- ganic matter, per cent.
1a	6 in. below surface, M house, "Rookery"	3.25	96.75	0.070	2.15
1b	2 ft. " " " "	5.09	94.91	0.133	2.61
2	Back of Staff Officers' quarters	2.40	97.60	..	..
3	2 ft. below parade, opposite F passage	2.32	97.68	..	..
4a	2 ft. below surface, back of B house, Staff Officers' quarters	2.22	97.78	..	..
4b	2 ft. below surface, back of B house, Staff Officers' quarters	2.27	97.73	..	..
5a	2 in. below surface, back of M house, soldiers' quarters	2.53	96.47	..	..
5b	2 ft. below surface, back of M house, soldiers' quarters	2.55	97.45	..	..
6a	2 ft. below surface, back of F house, soldiers' quarters	2.10	97.90	..	..
6b	2 ft. below surface, back of F house, soldiers' quarters	2.97	97.03	..	..
7a	2 ft. below surface, between huts Nos. 3 and 4 ..	6.24	93.76	..	..
7b	2 ft. " " " " " " ..	5.14	94.86	0.042	0.81

(Signed) A. DUPRÉ.

Samples of Subsoil Water.

R 1, I am informed by Mr. Field, is supposed to be drainage from the cemetery, but it shows no special characteristics of being such, and it has also been fairly oxidized.

Samples R 3 and R 7 are undoubtedly polluted by sewage which, however, is mixed with a considerable proportion of subsoil water, and has been effectively oxidized in its passage through the soil, as proved by the relatively small proportion of oxygen absorbed from permanganate.

Sample R 8, on the other hand, is somewhat of an exceptional character. It has evidently been very largely polluted by sewage, and is not mixed with much subsoil water, as shown by the very high proportion of nitric acid and of chlorine present. But even in this case the organic matters have, to a very great extent, been oxidized.

The other samples, viz., R 2, R 4, R 5, R 6, show but little pollution, but are ordinary subsoil waters, and have been, in almost every case, very completely oxidized, as shown by the remarkably small proportions of oxygen absorbed from permanganate. They are, indeed, quite equal in purity to many waters used for drinking.

(Signed) A. DUPRÉ.

SAMPLES OF SUBSOIL WATER.

Analytical Details.

	Description of Sample.	Oxygen absorbed in a few minutes.	Oxygen absorbed in 4 hours.	Chlorine.	Nitric Acid.	Ammonia.	Albuminoid Ammonia.	Total dry residue.	Behaviour of residue on ignition.
R 1	Inspection pit on land drains, 17th April 1889.	Very little.	·054	3·71	6·79	·0084	·0084	87·5	Blackens markedly; burns off readily.
R 2	Test hole R, 17th April 1889	Very little.	·068	2·24	0·93	·0140	·0062	44·1	Chars scarcely perceptibly.
R 3	Test hole S, 17th April 1889	Very little.	·091	3·22	6·15	·0185	·0148	58·8	Blackens strongly; burns off with difficulty.
R 4	Test hole G, 17th April 1889	Very little.	·029	1·96	1·06	·0050	·0034	25·2	Very slight blackening.
R 5	Test hole M, near "Rookery," 17th April 1889	Very little.	·018	1·75	3·39	·0308	·0034	40·6	Very slight blackening.
R 6	Test hole N, near huts, 17th April 1889 ..	Very little.	·011	1·68	0·29	·0151	·0042	26·6	Chars strongly; burns off with difficulty.
R 7	From hole under passage of M house in "Rookery," 23rd April 1889.	Very little.	·171	2·10	5·32	·0406	0143	32·1	Blackens very strongly; burns off very readily.
R 8	From hole in passage of F, soldiers' quarters, 2nd May 1889.	Very little.	·082	8·12	19·18	·0420	·0138	119·0	

All quantities are given in grains per gallon.

(Signed) A. DUPRÉ.

Samples of Water.

Three samples of water were examined, marked A, B, and C respectively in the table. A and B are evidently alike—sample C differs materially from them.

Sample A shows rather an excessive amount of albuminoid ammonia, and also absorbs much oxygen from permanganate, and must be considered as unfit for drinking. Sample B is somewhat better than A, and is no worse than many samples of drinking water I have examined.

Sample C is undoubtedly Vartry water, as a comparison with a number of samples of this water which I have examined in connection with the Royal Barracks conclusively proves. The water absorbs somewhat oxygen from permanganate, but this is due to a small proportion of peaty matter which it contains, and not to sewage or other animal pollution. The water is a good drinking water.

(Signed)

A. DUPRÉ.

SAMPLES OF WATER TAKEN 23RD APRIL 1889.

Analytical Details.

	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 intake in canal, half mile up ..	·0388	0·1050	0·98	Trace	·00546	·01288	22·40	Trace	Blackens slightly, burns off not readily.
B	From canal tap in married quarters ..	·0280	0·0705	0·98	Trace	·00364	·00588	21·84	Trace	Blackens slightly, burns off readily.
C	From tap in M house of the "Rookeries" ..	·0389	0·0863	0·875	Trace	·0000	·00380	3·64	Minute trace	Blackens strongly, burns off very readily.

All the quantities are given in grains per gallon.

(Signed) A. DUPRÉ.

JOINT REPORT of Dr. A. Dupré, F.R.S., and Dr. E. Klein, F.R.S., on the best Method of Disinfecting the Rooms where Enteric Fever has occurred.

Sir,

In accordance with your request, conveyed to us by Mr. Rogers Field, we have considered the question of the best method of disinfecting the rooms at the Royal Barracks where enteric fever has occurred, and after conferring with Mr. Rogers Field, and obtaining full explanations as to the conditions of the case, we beg to report as follows :—

Recent investigations have shown that gaseous substances, such as sulphurous acid gas, and chlorine gas, which have been often used for the purpose of disinfecting rooms and similar localities, cannot be relied on, and that the only disinfectant that can be depended upon to kill micro-organisms, particularly those capable of producing the infectious diseases, is a free application of a solution of perchloride of mercury. It is well to have this solution slightly acid, coloured also in such a way that it shall not readily be confused with drinks or medicines; and proper caution should be given to avoid accidents in its use. The solution is made by dissolving $\frac{1}{2}$ ounce corrosive sublimate and one fluid-ounce of hydrochloric acid in three gallons of common water, with five grains of commercial anilins blue, or ordinary violet ink, to give the fluid a conspicuously distinguishing character. Proper cautions should be given to avoid accidents as the solution is a deadly poison.

The solution is easily made, keeps well, is very inexpensive, and should not be further diluted, and is easily applied. The use of non-metallic vessels (wooden or earthenware house tubs or buckets) should be enjoined on those who use it.

The method of applying the disinfectant will, no doubt, vary under different conditions, but the following may be taken as an outline of the procedure which should be usually adopted.

The walls should be thoroughly stripped of all paper or other covering, and scraped. All skirting should be removed. The floor boards should be taken up, and all rubbish and dust found in the space under the joists should be removed, care being taken that the scrapings, rubbish, and dust are not thrown away, but are burnt, as they may contain infectious germs.

After a thorough clearance has been made as described above, the whole of the ceilings, walls, joists, architraves, and window linings, and any other fixed woodwork in the rooms, together with the spaces below the floors, should be carefully washed with the solution of perchloride, prepared as above directed. The solution should be applied with a whitewasher's brush. A syringe should be used to squirt the solution into any nooks and interstices which the whitewasher's brush will not properly reach. Wherever used, the solution should be liberally applied, and should be allowed to remain over night.

Any dilapidated flooring and other woodwork should be burnt, and only the thoroughly sound portions should be refixed, and these, before being fixed, should be thoroughly washed with the solution, allowed to remain over night, and afterwards washed with warm water, in order to remove the mercury.

Ceilings and walls should be limewashed, and all fixed woodwork should also be washed with warm water in order to remove the mercury.

(Signed)

A. DUPRÉ.
E. KLEIN.

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

21st February 1889.

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TO ACCOMPANY MR. ROGERS FIELD'S REPORT, DATED 23rd JULY, 1880

Note Casts 1, 2, 3, 5, 6, 7, 9, 10, 11, 12, 25 and 26.

are not shown as *Plas.*, locality being unknown.

Row	House	Room	Name, &c.	Admission to Hospital	Remarks.
1	Not known	Not known	With, L., Private, 1st East Kent Regiment	21.6.83	
2	"	"	Bartholomew, W., Private, 1st East Kent Regiment	18.6.83	
3	"	"	Harrison, J., Drummer	24.12.83	
4	No. 7 Hut	"	Travis, J., " 2nd Scots Guards	23.2.83	
5	Not known	Not known	Cook, G., Private, 1st East Kent Regiment	14.3.83	
6	"	"	Milprie, S., " "	23.3.83	
7	"	"	Clum, J., " "	29.4.83	
8	Soldiers' Quarters, A House	"	Thompson, J., Private, 2nd Scots Guards	23.6.83	
9	Not known	Not known	Crooks, W., Private, Duke of Cornwall's Light Infantry	Not known	
10	"	"	Hagel, W., " 1st East Kent Regiment	28.5.84	
11	"	"	Mills, Corporal J., 1st Grenadier Guards	24.1.85	
12	"	"	Cleary, Corporal R., " "	26.6.85	
13	H House, Officers' Quarters	Top Landing	Lieutenant J. H. Bell, 1st Grenadier Guards	30.7.85	
14	Soldiers' Quarters, A House	Not known	Gold, B., Sergeant, 1st Grenadier Guards	4.8.85	
15	Soldiers' Quarters, B House	"	Lee, A., Private, 1st Scots Guards	13.9.85	
16	"	"	Davis, H., " "	14.8.85	
17	"	"	Lambert, A., Private, 1st Scots Guards	22.9.85	
18	"	"	Sheppard, " "	22.9.85	
19	I House	No. 8 Room	Lygfoot, W., " Duke of Cornwall's Light Infantry	10.11.85	
20	H House, Officers' Quarters	Top Landing	Sergeant R. F. Connolly, 1st Scots Guards	4.10.85	
21	F House, Officers' Quarters	Top Landing	Lieutenant W. P. Falvey, " "	25.11.85	
22	Soldiers' Quarters, F House	Not known	Bulley, G., Private, " "	28.11.85	
23	Hospital	Cook's Room	Brund, G. M., Private, Medical Staff Corps	4.12.85	
24	F House, Officers' Quarters	Not known	Wilson, S., Private, 1st Scots Guards	15.12.85	
25	Married Quarters, F House	No. 8 Room	Child	28.1.86	
26	Married Quarters	No. 5 Room	O'Neil, A., Private, 2nd Welsh Regiment	3.8.86	
27	Not known	Not known	Hampson, C., Private, 2nd Welsh Regiment	14.1.86	On Paraph at Dublin.
28	Married Quarters, B House	No. 8 Room	Thomas, W., Private, 2nd Welsh Guards	14.10.86	
29	Married Quarters, C House	No. 1 Room	Vaughan, G., Sergeant, 1st South Wales Borderers	10.12.87	
30	Soldiers' Quarters, F House	No. 3 Room	Cleary, G., Private, 2nd Coldstream Guards	10.1.88	
31	"	"	Gordon, J., " "	11.2.88	
32	Married Quarters, E House	No. 5 Room	Griffiths, B., Sergeant, 1st South Wales Borderers	22.2.88	
33	Soldiers' Quarters, E House	No. 5 Room	Cadogan, F., Private, 2nd Coldstream Guards	18.5.88	
34	Soldiers' Quarters, F House	"	Curry, W. H., " "	31.5.88	At the Curragh from 3.6.88.
35	No. 4 Hut	"	Corcoran, A., " "	0.7.88	At the Curragh from 20.08.
36	Soldiers' Quarters, F House	No. 5 Room	Erwood, J., Private, 1st South Wales Borderers	27.8.88	
37	"	"	MacDonnell, W., Lance-Corporal, 2nd Scots Guards	25.9.88	
38	No. 7 Hut	"	Topple, J., Private, 2nd Scots Guards	25.12.88	
39	Max Bell, B House	Left-hand Quarters, Top Landing	Lieutenant B. W. Watts, 1st South Wales Borderers	5.1.89	
40	Officers' Quarters, M House	Room, Top Floor	Lieutenant C. A. R. Scott, " "	11.3.89	At Castle Guard, 26.3.89. At Mourning Guard, 3.2.89.
41	F.O. Quarters	Second Floor	Captain H. E. Eury	4.5.89	
42	Soldiers' Quarters, M House	No. 3 Room	W. Edwards, Private	6.5.89	At Pipes House Fort, 4.4.89 to 27.4.89. At Dead Guard, 28.4.89.
43	H House, Soldiers' Quarters	No. 8 Room	Jones, " "	7.5.89	
44	H House, Soldiers' Quarters	No. 0 Room	Griffith, " "	10.5.89	At Pipes House Fort, 4.4.89 to 18.4.89. At Castle Guard, 24.4.89.
45	M House, Officers' Quarters	"	Lieut. Hamilton Jones	7.8.89	At Mourning Prison Guard, 23.8.89. At Castle Guard, 2.9.89.

