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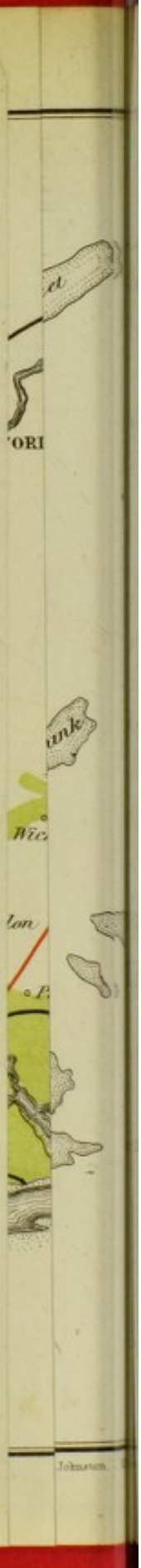
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ON THE

UTILISATION OF SEWAGE:

WITH A DESCRIPTION OF

THE PLAN

OF

MESSRS NAPIER AND HOPE

FOR THE

UTILISATION OF THE SEWAGE OF LONDON.

BY

GEORGE ROBERTSON,

M. INST. C.E. F.R.S.E. ETC.

READ AT THE

ROYAL SCOTTISH SOCIETY OF ARTS, FEBRUARY 27, 1865.

ON THE

UTILISATION OF SEWAGE.

At a recent meeting of the Society, at which our President read a paper in connection with the pollution of rivers by sewage and other matters, allusion was made to the scheme of Messrs Napier and Hope for the Utilisation of the Sewage of London. I then mentioned that Mr G. W. Hemans, the engineer who laid out the scheme, had paid a recent visit to the irrigated meadows near Edinburgh, in company with Professor John Wilson and myself; and, during that visit, had given me such information regarding his London plan as to enable me to give the Society a somewhat detailed and authentic account of it. He has since sent me the large Plan, now on the walls, which will greatly elucidate and simplify my task. I have also been furnished with pamphlets and other documents on the subject. It is one which cannot fail to be interesting to this Society, for the whole subject of the Utilisation of Sewage, taken in connection, as it must ever be, with the pollution of rivers, is one of the most important questions of the day, and will, doubtless, occupy a large share of the attention of Parliament for several sessions to come. The necessity of some legislation about it has become

gradually more and more urgent since the introduction of the water-closet system.

Before describing the plan for the Utilisation of the Metropolitan Sewage, it may be as well to glance generally at the present state of the question. It is now universally admitted that the method tried at Tottenham, Leicester, and elsewhere, of precipitating the solid matters in sewage by lime, or other cheap substances, has not been a commercial success. At least five-sixths of the valuable matters contained in sewage are not capable of being precipitated by any known process, whatever chemistry may do for us in the future. The sewage must therefore be used as a fluid; and, though it might be desirable to obtain it in a more concentrated form, by separating the house drainage from the surface drainage of a town, my own impression is, that we must accept the present state of matters. Civilisation will not permit us to withdraw from the water-closet system, now generally introduced; and it is not likely that we shall ever have our streets complicated with a double system of sewerage, especially after the large sums of money which have been expended in perfecting the present arrangements throughout the whole kingdom.

We must therefore use our sewage in its present liquid and diluted form. Can it be used with advantage to the produce of the land? and can it be used with profit on a reasonable outlay? My firm belief is, that the sewage of almost every town in this country might be more or less used with advantage, for the irrigation at least of meadow grasses and Italian rye grass; and, in most cases, with fair prospect of pecuniary

profit, if *properly* done. There may, however, be instances, especially in towns far from the sea or in deep valleys, where a pecuniary loss will have to be faced as part of the expense of draining the town; for the day cannot be far distant when every town will have to adopt some means, either of interception, or of clarifying its impure water, before permitting it to run into the adjacent stream.

I believe that, almost without exception, every town which can use its sewage for irrigation, by means of gravitation alone, would find the necessary outlay to be amply repaid. Where gravitation is impossible, many towns might make use of water power for pumping; and even where steam has to be employed, this need not necessarily discourage; for pumping by steam, as I shall show, is not such an alarmingly expensive thing, and its cost is well known.

There are two main points in the sewage question, as it stands at present, upon which there is a great difference of opinion—the quantity to be applied per acre,—and the value of the sewage per ton. In giving my opinion, therefore, on these points, I do so with some diffidence, considering the eminent authorities who take contrary views. From my own observation, however, and after consideration of the whole subject, and elimination of whatever is obviously too sanguine on the one hand, and too damping on the other, I have been enabled, as an engineer, to form some definite views, which may contribute towards a practical solution of the problem.

Without reference either to the value of the sewage, or the quantity used per acre of land, and applying

equally to every town, there are two very important points in the consideration of the utilisation of sewage, both in a commercial and an engineering point of view. One is, the area of land which can possibly be irrigated during the course of the sewer; and the other is, the outfall for the sewage, at times when, either from wet weather, frost, or other reasons, the whole of it cannot be used on the land through which the conduit passes. The most perfect system attainable would be, to sell or utilise all that was possible on the way to the outfall, but to have the outfall itself on worthless barren land, belonging to the corporation or company to whom the sewage has been conceded. During the time when there is no market for the sewage *in transitu*, it can then be used for the fertilisation and benefit of the land at the outfall. If it should be found to pay better *not* to sell any on the way, then the whole can be used on the promoter's own land. But my impression is, that when the farmers find the sewage absolutely brought past their doors, and that by using it they may, without doubt, double or treble the amount of grass grown on their meadows, they will be glad to buy it, and most probably will use all they can get. In this case, the whole can be sold for the greater part of the year, and only used on the barren lands at the outfall, when not wanted above. It is the want of a constant and certain outfall which is one of the greatest objections to some of the schemes proposed for London, especially to the one favoured by the corporation, of pumping the sewage to heights near the town, and then distributing it by hose and jet over the surrounding fields. What is to become of this mighty stream of filth when there is

no market for it? It must fall back into the Thames, and render useless the present great expenditure for the purification of that river.

With regard to the *quantity* of sewage to be applied per acre; one party of authorities advocates the application of large quantities to the land; the other of small dressings, not exceeding 500 tons, or the sewage of about ten people per annum. When we consider that this latter quantity represents a total depth in the year of only five *inches* over the surface, and that at Craigentinny the depth applied must be at least eight *feet*, the difference between the two systems is very striking. There can be no doubt, however, that the sewage at Craigentinny, being had for nothing, is most lavishly used, and might be greatly economised, with the same result to the land. While we have no exact data at present as to the *minimum* quantity which may be used with advantage or profit, I think we have clear evidence as to the *maximum*. Upon looking over the evidence before the special committee in 1864, of Mr J. B. Lawes, who has been conducting the systematic experiments at Rugby, I find he states (in answer to question 4,351) that, where the unmanured land produced 9 tons of grass per acre, he obtained 22 tons of grass by using 3,000 tons of sewage, 30 tons of grass by using 6,000 tons of sewage, 32 tons of grass by using 9,000 tons of sewage.

The first 3,000 tons, therefore, gave an increase of 144 per cent. on the unmanured field; the second 3,000 tons gave an addition of only 36 per cent. on the result of the first quantity; while the third 3,000 tons gave only an extra 7 per cent. on the result of the

second. Here we see that by far the greatest comparative result was given by the first 3,000 tons of sewage; and that, while it might be a question whether it would be worth while to pay for a second 3,000 tons, it would clearly be most unprofitable to pay for a third 3,000. Of course, where the sewage can be had for nothing, the full 9,000 tons per acre may be applied; but even then, it probably does more harm than good, by making the grasses too rank.

All this, I think, points to a profitable maximum of about 5,000 tons, or fully *four feet* deep of sewage during the year. Some soils will, no doubt, require a little less, and others a little more, according to circumstances.

On the question of *value* per ton, we must also accept Mr Lawes' evidence of what he would give, as a farmer, for sewage, as the best guide at present on this important point, more especially when we find that, practically, it lies between the scientific values of two eminent authorities on chemistry—Dr Hoffman and Professor Anderson. Mr Lawes says he would rather give 2d. a-ton for it, if allowed to take it in such quantities, and at such times as he liked, than ½d. a-ton if he had to take it regularly at all times.

Now, in the case of a corporation, or company, having an outfall on land of their own, upon which to put the sewage when it was not wanted by the farmers on the way, the average value of the entire sewage might, I think, be fairly and safely taken at *one penny per ton*. This value, while only about one-half of that assigned to sewage by Dr Hoffman and Baron

Leibeg, is double what Professor Anderson thinks is the extreme value—viz., ½d. a-ton.

The plan proposed by Messrs Napier and Hope for the Utilisation of the Sewage of London is not altogether novel in its main features. In 1856 Mr M'Clean, the present President of the Institution of Civil Engineers, suggested a somewhat similar idea, which was supported also by Sir Morton Peto. He proposed to conduct the whole sewage of London, through the county of Essex, to a point on the coast between the rivers Blackwater and Crouch, using it on the way to irrigate whatever land could be reached by gravitation. Seventy-three of the occupiers of lands in the southern division of Essex memorialised the Board of Works to adopt this project; and I am not sure but what the scheme got so far as the preparation of Parliamentary plans.

Some years after, the Board of Works advertised for plans and tenders for the sewage; and, after some delay, the proposal of Messrs Napier and Hope has been accepted, and a concession granted to them on certain terms. Several changes and modifications of the scheme have taken place during the negotiations; but I have the authority of Mr Hemans, with whom Mr Bateman has lately been associated, as to the information about to be given. I may here mention that Mr Hemans is also engineer for the Utilisation of the Sewage of Dublin, which it is intended to discharge upon the North Bull Sands in Dublin Bay.

When we examine the contour of the county of Essex, through which the London sewage is to be

taken, we find it peculiarly adapted for the purpose. There is also no county in England in which the proportion of waste land is so small; and, from being wholly agricultural, the people are found in moderate sized, and not in large towns. The part which lies in the southern portion, on the banks of the Thames and on the sea-shore, is of moderate elevation, and is a rich alluvial soil, on a subsoil of very tenacious clay. Under cultivation, this produces very abundant crops of wheat, beans, and clover; indeed, the best wheat in the London market is that from the "Essex Hundreds." Most of the farms in South Essex have, more or less, a proportion of rich marsh land; the edges of the coast towards the Thames and sea being flat, and broken into creeks and islands, with great breadths of sands drying at low water. On these fringes of flat land oxen are fed, and hay grown for winter consumption. In some parts the scarcity of water is severely felt; and throughout the county generally there is a small rainfall, perhaps ten inches less than in more western counties of England. The great mass of land is arable at present; but meadow grasses could easily be grown, if the rainfall were to be supplemented by a supply of sewage.

Through this favourably situated county, therefore, it is proposed to take the sewage of London on its way to the outfall on the coast; and the contour of the land is indeed so favourable that at least 80,000 acres can be commanded, by gravitation alone, from the main culvert and its branches. The promoters will irrigate a few fields for themselves here and there, as advertisements to show what can be done by sewage; and I think it cannot be doubted but that the farmers will soon find

out its advantage, and be ready to give a good price for this stream of wealth flowing past their doors—more especially when we consider that it is daily becoming more difficult to grow corn in this country with profit, and that stock and dairy farms are found to be more remunerative.

The present dry weather sewage of the north side of London, with a population of 1,800,000, is 10,000,000 cubic feet a-day; but the prospective sewage may be taken at 11,495,000 cubic feet. Besides this, the Metropolitan Board of Works provides for an extra $\frac{1}{4}$ of an inch of rainfall; but the promoters only propose to take the dry weather sewage—10,000,000 cubic feet a-day, or about 100,000,000 tons per annum—at present.

The main culvert is to tap the northern main outfall sewer of the Metropolitan Board of Works at Abbey Mills, three miles from London, receiving the sewage there considerably above the level of high water. The culvert then runs for a distance of six miles, when it is joined by a branch conduit from the Barking outfall reservoir; it then passes on for a further distance of twenty-two miles, sometimes in cutting, sometimes on embankments, until it reaches the head of the navigation of the river Crouch, at Battle's Bridge, in Essex, twenty-eight miles from the commencement at Abbey Mills. Up to this point the sewer consists of a circular brick culvert, ten feet in diameter, as much as possible half in, and half out of, the ground. The culvert will take 9,500 cubic feet per minute: but with the present dry weather sewage it will only have 7,000, and only be three-quarters full. The reason for starting the

main culvert at Abbey Mills, and not at the Barking outfall, is to take advantage of the higher level of the sewage at the former place. The level of the bottom of the culvert at Abbey Mills is six feet above Trinity high water mark, and from thence it falls gently for more than three miles. The level of the ground then requires that the sewage be lifted up twenty feet by pumps; and, between the ninth and tenth mile, it has again to be pumped up for twelve feet. Previous to this last lift, however, the main culvert is joined, near the sixth mile, by a five feet branch from Barking outfall reservoir, the sewage from which has to be raised a sufficient height to enable it to join the main culvert. If the prospective sewage be taken at 11,495,000 cubic feet per diem, the main culvert at Abbey Mills will accommodate 10,294,500 cubic feet, leaving 1,200,500 cubic feet for the Barking branch.

From the ninth mile, the sewage will flow by gravitation to the sea, with a fall of about one foot per mile. This, it is calculated, will give sufficient velocity to prevent deposit, considering the light nature of the suspended matters in sewage, after having been churned up by repeated pumpings. The bottom of the culvert at the sea will discharge at such a depth below high water level as to command the whole area of sands to be reclaimed.

At the twenty-eighth mile, where the conduit reaches the river Crouch, it branches off into two culverts—one of 8 feet 3 inches in diameter, leading to the Maplin or Foulness Sands, on the south of the Crouch: and the other, of 6 feet 9 inches in diameter, leading to the Dengie Flats, on the north of the

Crouch—the lengths being 16¼ and 18 miles respectively. Should it be determined to give up, or postpone, the Dengie position of the scheme (the flats there being almost *too* rich in alluvial deposit), and increase the area to be reclaimed on the Maplin Sands, then the culvert will be taken there with the full diameter of ten feet. The total distance from Abbey Mills to the Maplin Sands is forty-four miles. The Dengie Flats and Maplin Sands are extensive foreshores on the east coast of Essex, dry at low water, and several miles in width by about twenty of aggregate length. Portions of these vast plains of sand, mixed with alluvial deposit, are to be reclaimed from the sea by embankments (similar to those which are common in Lincolnshire, Holland, and other countries), to the extent of about 7,500 acres of the Maplin Sands, and 4,500 acres of the Dengie Flats—12,000 acres in all at first. The sewage will be discharged over these areas by gravitation; and the effect will undoubtedly be, that the salt and barren sands in a couple of years will be freshened, and soon after capable of growing as rich grass as that grown at Craigentinny. The only hand labour required will be the mere keeping in order and cleansing the water channels—a very trifling expense, indeed, compared with the labour in the hose and jet system, favoured by the Corporation of London. If the whole sewage be put on the 12,000 acres, it would give upwards of 8,000 tons per acre; one-half more than is required as a maximum. So that the Company can either sell their surplus on the way, or use it on an additional enclosure of the sands, and yet do ample justice to their property at the outfall.

When we consider that 80,000 acres can be commanded by gravitation alone from the main culvert and its branches, there can be little doubt of a constant and profitable market for the surplus.

Though grasses are the most profitable crops yet discovered to which to apply liquid sewage, additional experience may prove, and probably will prove, that it can likewise be profitably used for cereals and roots. But, in the latter case, there must be times during which the application would manifestly be injurious; and we must therefore look to grass meadows, if we wish to have a constant and steady demand for liquid manure.

Where the branch culvert crosses Barking Creek, and at the river Roach, which is an arm of the Crouch, syphons will be necessary; and they will be laid double, so that one may be cleansed while the other is in use. The sewage can always likewise be turned into the Thames, for short periods, when repairs are requ ired.

The estates to be reclaimed are to become the property of the company, and will be entirely under Italian rye grass and meadow grasses, for dairy purposes and for fattening cattle.

It is to be noticed, that, in this scheme, *every kind of theory* may be tried; large quantities applied to sandy soils, or small quantities to clayey and arable land; or any other plan which may, by experience, be found to pay best. By intermediate lifts on the clay lands, small dressings by hose and jet may be applied. There is also the advantage of a thinly populated country, for the sewage to flow through in its covered channels, and a most out-of-the-way part of the coast for it to be discharged upon. Arrangements will be

made by reservoirs, or otherwise, for supplying the farmers who require either a constant, or an occasional supply of manure; those who may consider it worth while to lay out their land as sewage farms; and those who may desire to take a more limited quantity of liquid in times of drought, or to start a hay crop after a first cutting, or for transplantation of cabbage and mangold, or any other market garden purpose.

Mr Hemans estimates the cost of the culverts at £1,600,000; the pumping stations at £72,000; and the embankments and contingencies at £428,000—total estimate, £2,100,000. Should the Dengie branch be abandoned, the saving will be £450,000; culverts being £350,000, and embankments £100,000.

The annual cost of pumping he estimates at £10,000, with £300 per annum for every additional foot it may be found desirable to lift the sewage. This is only $2\frac{1}{2}$ per cent. on the value of the sewage at 1d. a-ton, or 5 per cent. at $\frac{1}{2}$d. a-ton. So that pumping on a large scale, is not so very expensive as I said before. The power required is 490 H. P. for the main line, and 60 H. P. for the branch from the reservoir.

The total expense of carrying the sewage from Abbey Mills to the sea, including 5 per cent. on the cost of the culverts, but exclusive of the sea embankments, is estimated not to exceed one-fifth of a penny per ton.

With regard to the financial prospects of the scheme; I am not quite sure as to the exact nature of the last arrangement with the Board of Works, or of the revenue calculated upon by the promoters; but it is evident

that, if the sewage be practically worth 1d. per ton, then the gross yearly value of the sewage of North London is £417,000. If 5 per cent. on the outlay be first deducted from this, there remains £312,000 for working expenses and profit. The working expenses are calculated at £30,000 per annum; leaving the very considerable sum of £282,000 for division between the promoters and the Metropolitan Board of Works, when the scheme becomes fully developed. Even on the supposition that the sewage is worth only ½d. a-ton, the scheme will still be profitable to both parties, if it be carried out at the estimated expense.

Such, then, is an outline of the plan proposed by Messrs Napier and Hope for the Utilisation of the Sewage of London. When we consider the importance of the experiment to the country at large (and that it *is* an experiment must be at once admitted), as well as its benefit towards the purification of the Thames, we cannot but wish that it may pass successfully through Parliament. It has been well digested; the engineering details worked out carefully by eminent professional men; and it appears to offer a fair prospect of pecuniary success. The worst fault which its opponents, the Corporation of London, have to find with it is, that it is founded upon *too low* an estimate of the value of the sewage of London, which they estimate at £4,081,430 per annum. In this I can only hope that its opponents may turn out to be correct; for not only the promoters, but also the Metropolitan ratepayers, will equally reap the benefit.

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