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LECTURE VIII.

SUGGESTIONS FOR THE SANITARY DRAINAGE OF WASHINGTON CITY.

BY
GEORGE E. WARING, Jr.,
OF NEWPORT, R. I.

DELIVERED MAY 26, 1880.

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SPENCER F. BAIRD,
Secretary Smithsonian Institution.

SMITHSONIAN INSTITUTION,
Washington, June, 1880.

LECTURE VIII.

Delivered May 26, 1880.

SUGGESTIONS FOR THE SANITARY DRAINAGE OF WASHINGTON CITY.

By George E. Waring, Jr., of Newport, R. I.

Washington is sometimes called our official metropolis. One who reads the flood of reports which have been made, from time to time, concerning its drainage, must feel inclined to call it the metropolis of sanitary advice. Every one who has had to do with any branch of engineering which has even an indirect bearing upon sanitary improvement, seems to have been called upon at one time or another to express an opinion concerning the intricate problems here presented, until it has come to be a matter of course, that sooner or later, every member of the profession must prepare a thesis on the Washington Sewers and the Kidwell Flats. That duty, or rather that privilege, now falls to my lot, and I ask your attention to a few suggestions which seem to me appropriate.

The essential elements of a healthful condition of soil and surroundings are very simple. Here, as everywhere, a dry and clean soil beneath us, and dry and clean air about us, are the primary conditions of a wholesome life.

Where these have not been provided by Nature, they must be established by Art. Washington, like other places, was adopted as the site for a city for reasons among which sanitary advantages had no conspicuous place. It has grown to be a great capital without reference to these sanitary advantages—indeed largely in

spite of their absence, but to secure them is now, from our point of view, its most important and most pressing duty.

It needs but a casual survey and slight consideration to see that the difficulties to be overcome are quite distinctly marked.

Aside from the heavy rainfall to which the locality is subject, it lies across the outlets of a wide outlying drainage area, whose storm-waters pour upon it in torrents.

Much of the city is level, and its heavy soil at different points retains moisture almost to the point of saturation.

A large part of its area lies so near to the level of tide water as to prevent satisfactory drainage even were the soil more porous.

Incidental to the elevation and to the conformation of its surface, the obstacles to the free and complete removal of its natural waters have served also as obstacles to the removal of its artificial pollution. The waste incident to human life constitutes here as elsewhere, a most dangerous element of a problem whose solution is the sanitary engineer's chief task. There are difficulties in Washington which do not obtain to the same degree in higher-lying towns.

The rivers by which your borders are swept, in addition to the degree to which their shoal shores prevent the requisite drainage of the city, accumulate deposits which, exposed at low tide, maintain in your immediate neighborhood a most prejudicial decomposition of organic matter fouled by the outflow of the sewers. The emanations from this decomposition in such close proximity to the heart of the city are a recognized and palpable source of ill-health which has attracted the attention of all who have discussed the subject.

The first of the difficulties referred to,—the pouring of torrents of storm-water from the outlying country into the city,—is now receiving at the hands of the engineering authorities of the District, such complete and adequate treatment, that it is unnecessary to consider it here. It need no longer be regarded in

discussing the general question. The removal of this water without injury to property and without materially increasing the saturation of the soil is now being perfected in a manner which leaves nothing to be desired.

So far as the remaining elements of the problem come within the domain of engineering art, what we have to consider is a system of improvements which shall, first, turn the pestiferous river flats and swampy shore into dry and wholesome earth; second, dry the soil; and, third, properly remove its foul sewage.

Proper outside conditions being secured, it will remain to give such attention to the defective interior and exterior drainage of houses as will remove the present menace to health and life from that fertile source.

These improvements being completed, Washington, with its generally undulating surface, its most thorough ventilation by wide streets, and its excellent municipal control, would doubtless become the healthiest, as it is already the most beautiful, of the large cities of the country.

While it is easy to formulate the required improvements, their proper execution must involve the most careful consideration, and to perfect the details of a comprehensive scheme adequate to secure them all, is far beyond the limits of an evening lecture. All that I propose is to give an outline of the manner in which I think the desired results may be secured, that you may consider whether or not the most desirable end would justify the necessary means.

In carrying out, and even in suggesting, a project for improvement, there is one obstacle of an artificial character which is more important than at first sight it appears to be. Human nature is alike the world over, and the tendency to make use of existing works, to adopt make-shifts, and to avoid the condemnation of costly improvements is universal.

So far as the removal of the household drainage of Washington is concerned, the sewers constructed for this purpose are—perhaps by no means always or generally—but they are very largely, un-

suited to the best performance of this duty. In the recommendations that I shall lay before you, I shall for convenience and for simplicity, and for reasons which will become obvious as we proceed, assume that the larger of the present sewers of Washington are valuable only for the removal of storm-water from the roofs of houses, and from the surface of the ground, and that the system for carrying away house drainage, manufacturing wastes, etc., must be very thoroughly revised and amended. In the development of the details of a working plan, it would rest with the projector to determine to what degree the present sewers could be made useful for this purpose. I imagine that, the question of cost being set aside, they would be much less generally used than would now be supposed; and that the more the subject is studied, the more important, and in the long run the more economical, it will seem to relegate the question of cost to a very secondary position.

Work now being done should have in view the establishment of a perfect sanitary condition throughout the whole city, which will remain effective for all time. When we consider what Washington is, and is always to be, no question of cost is worth consideration as compared with absolute and permanent healthfulness. Economy being regarded in its larger sense, mere cheapness has no place.

To consider, first, the fundamental difficulties of shore and low-level outlets, it seems to me that the example of Holland points the way to their easy and complete solution. Following the example of that remarkable country, we need try no experiments, and we need invent no new processes. We see there executed,—on a scale which makes the Washington work seem insignificant, and with a complete development of all details,—a well formulated system for securing an absolutely good and permanent result. It is not a little remarkable that the Dutch system of artificial drainage, which has been equivalent to filling in the whole low country to a depth of from five to twenty feet; which has been in operation from immemorial time; which has reclaimed from the sea

nearly a million acres; and which has always excited the interest and admiration of the rest of the world, should have remained so exclusively Dutch. The method has crossed the North Sea and invaded the Lincolnshire fens, and it has travelled a little way along the German and Danish coasts; but, with rare exceptions, other countries have adopted it only in an extremely tentative and ineffectual way. The great success of these works in Holland seems to have been ascribed to some mysterious peculiarity of the nature of the Dutch people. But water has the same weight there that it has here, and windmills and steam-engines have the same power here that they have there. Mechanical forces undergo no change by exportation, and there is no other reason than confirmed habit which leads us so generally to adopt the costly wheelbarrow and cart, where the Dutchman would use the cheaper pump.

There is no doubt that the Potomac flats might be rendered healthful and valuable by being filled, in the manner and to the depth that has been suggested, with fresh upland earth; but there is no special advantage in such an elevation of this territory which may not be equally well secured by the sufficient lowering of the ground water of that area, and in one respect there is a disadvantage.

Three hundred years ago all of Holland west of Amsterdam and north of Rotterdam was a series of lakes and swamps, divided by narrow stretches of half-drained land, and protected against the North Sea by the sand dunes along the coast. To-day, in that whole area there is only sufficient water left for interior navigation. Nearly three hundred years ago the Beemster Lake of 16,000 acres was drained to a depth of nearly 20 feet, and it has ever since remained one of the most fertile districts of the earth. Thirty years ago Haarlem Lake, covering 44,000 acres, was brought to the same condition; and it is in contemplation to add to the dry land of the kingdom 480,000 acres now covered by the Zuider Zee. Many of the reclaimed districts lie along the banks of the Rhine, which offers dangers and difficulties with which those of

the Potomac can bear no comparison; while the original cost of the work is vastly greater than would be that of a similar reclamation of the Kidwell Bottoms and the Anacostia Flats. In Holland where the reclamations during this whole century have averaged about 4,000 acres a year, the motive for undertaking these works has been almost solely to secure land for agricultural use; the motive here, where it is necessary to reclaim not more than 2,500 acres, is one compared with which any economical use is insignificant.

The projects of Major Twining, Engineer Commissioner of the District, and of the Board of Survey of 1872, indicate the necessary means for the enclosure of the Potomac Flats, and suggest a similar treatment along the Anacostia, most of the area enclosed to be filled with earth, so that the whole of it, except some lakes and ponds, shall become solid, dry ground, not much below the level of the lower parts of the city.

The Dutch method would be to construct corresponding defences, earth embankments, protected bulk-heads, or otherwise; to leave the enclosed ground at its present level, and to drain it by artificial power to a sufficient depth to secure the same result as to dryness that would be secured by the filling which has been recommended.

I have no hesitation in suggesting the adoption of the latter method. The soil of the Kidwell Bottoms needs only to be drained to become, under atmospheric action, in all respects as good for any use to which it may be desirable to put it, as any other dry and solid ground. For all practical purposes, the difference of level is not of the least consequence, especially as the whole area would probably be devoted to the uses of a public park. The effect would be simply to substitute a dry and pleasant meadow for the present noisome mud flats.

The project might include a channel along the Potomac water front of the city below the public grounds, as at present; and a rectification of the main channel of the Potomac and of the channel of the Anacostia. The improvement of the latter stream should

include the canalization of the whole river to a point at least three-fourths of a mile above Benning's bridge, or, better still, to the limits of the District. The canalization should provide an ample outlet for flood-waters, but the wide stretch of flats and marshes along both sides of the river should be thoroughly drained by artificial means. Tributary streams from either side, and the outlets of storm-water sewers, should be carried to the water-way at its natural elevation,—the current, especially in the case of the new Boundary Avenue sewer, being checked by a sufficient ponding of its outflow. So far as practicable, all upland water should be made to flow to the channel without descending into the drained lands. As in Holland, so here, the deep drainage of the reclaimed territory should be by open canals or ditches, which, in the case of the Kidwell Flats, might well be made of an ornamental character. The water in these canals would be kept pure by the introduction of a sufficient flow from the river. Except during violent storms, the pumping need be done only at low water, when but a slight lift would be required. It would be easy to connect nearly if not quite all of the drainage streams of the reclaimed land at one point for removal, at a single pumping station.

Aside from the economy and simplicity of this system, it would secure the very great advantage of affording easy deep drainage to those large areas of the city which now lie but slightly above tide level. This means of outlet being secured, there will be no difficulty in rapidly reducing the ground-water level by natural or artificial drainage sufficiently below the present grade for all sanitary purposes. In short, the carrying out of this improvement would be practically equivalent to raising the whole city six or eight feet above its present level, and giving it high and dry ground to the shore of a clear running stream on each side.

The reclamation of the flats east of the channel of the Anacostia is by all means to be recommended, as these flats must in time become, if they are not already, sources of malaria too near the city to be disregarded. Such of the reclaimed land as is not needed

for municipal purposes, would, from its fertility and its nearness to the market, have an agricultural value fully compensating for the original and permanent cost of its improvement.

The flats about the city being brought to a proper condition, the next object that claims our attention is the drying of the soil of those parts which are now conspicuously subject to saturation.

There are two leading objections to the saturation of the soil of an occupied site: The first and most clearly defined is the now recognized influence which soil saturation has in the production or aggravation of diseases of the lungs. It has been clearly shown by Dr. Bowditch, and confirmed by other observers, that there is a direct relation between consumption and a wet soil in the vicinity of the dwelling. It is known, too, that the condition of the atmosphere caused by excessive wetness of the ground is unfavorable as regards other diseases of the respiratory apparatus. In Washington in 1879, out of a total death list of 4,309, 1,341 deaths —being over thirty per cent. of the total mortality—were due to consumption and pneumonia. It would be too much to say that these diseases are to be completely eradicated by a thorough drainage of the soil; for constitutional taint, exposure in other places, and various other causes must still have their influence. But these diseases, which for years past have invariably stood as the first two of the mortality list, may certainly be enormously reduced in their fatal effect.

The other disadvantage of a wet soil is less clearly defined, and its effects are less readily separated from those of other causes of ill-health and of death. Precisely what processes are going on under the surface of the ground—what is the kind, extent, and character of the decomposition of organic matter there taking place—has not yet been determined with scientific accuracy. We have theories only, but they are well founded and reasonable, and they command the confidence of those whose business it is to consider such matters. Whatever the processes, it is undoubtedly

true that a deleterious condition of the contained air of the soil is due to the character of the decomposition within that soil of the organic matter which may have been added to it by vegetation, or which may have reached it from the off-scourings of human life. We know that the oxygen of the atmosphere is the great scavenger on which we must depend to destroy these injurious matters in the ground; we know that its penetration into the soil is impossible when this is filled with water, and that its entrance is more and more free, and its action more and more effective, in proportion as the interior spaces of the earth are rapidly emptied of the water which they may receive from rains. We know, too, that the downward movement of water through the soil carries with it to the drainage outlets below, whether natural or artificial, the oxidized products of decomposition, and that as the water descends the spaces which it had occupied are filled with fresh volumes of air. We know, too, that the good effects which attend such descent of water in the soil, are substituted for the bad effects of a rising from below of the water of saturation, which fills the pores of the earth, and prevents or impedes the necessary work of atmospheric destruction.

There are parts of your city, some low-lying and some high-lying, which have so little inclination of the surface that rain-water does not readily flow away, but remains to soak slowly into the ground, which is of so nearly an impervious texture that the underground escape is extremely slow, if it is not practically absent. In many districts much of the water by which the earth is wetted, lies clogging its pores, until removed by a chilling evaporation, accompanied by the escape of unwholesome gases from the unclean earth.

So far as this defective drainage exists in Washington, and it is by no means exceptional, the best or even tolerably good sanitary surroundings cannot be hoped for. In so far as the atmosphere of the city is insalubrious, it is not to be doubted that its insalubrity is directly or indirectly due more largely to the saturated condition

of wide areas of its soil, than to the more offensive emanations of the sewer catch-basins and the odorous nuisances which still exist.

As a rule, in my judgment, the damp lands of the city should be drained by an independent system of pipes entirely disconnected, except at their outlets, with the sewer system. It is usual, I know, to leave, purposely or accidentally, sufficient openings to secure the admission of soil-water into the sewer, and so to effect a rude and incomplete, but still valuable, drainage of the ground. Efficient drainage of the whole area cannot be secured by this means, even were it not, as it certainly is, extremely objectionable, for the reason, among others, that a sewer which will let ground-water into the conduit in wet weather, will let sewage matter into the ground in dry weather, adding an important and foul contribution to the organic matter which the earth is already charged with destroying; and adding to the danger of tainting the ground-air, with which the atmosphere about our houses, and especially the atmosphere of our cellars, is in free communication.

No scheme for the sanitary improvement of Washington can be considered even tolerably complete unless this very simple matter of the thorough drainage of the soil is duly and skilfully provided for.

In the construction of new work much may be accomplished by laying agricultural draining tiles in the same trenches with the sewers, but ordinarily more than this will be necessary, and it is always especially important to establish such a relation between the subsoil drains and the sewers, where the latter must serve as outlets for the former, as shall fully protect the drains against any inflow or regurgitation of sewage matters, as these might readily escape from the tiles into the ground.

We come now to the question of the sewerage of the city—that is to the means by which the twenty-odd million gallons of water poured into it daily by the water-works, much of which serves as a carrier for household and manufacturing wastes, is to be got

out of the city and removed to a point where it will do no harm. It has been assumed in the construction of work hitherto executed, that the drainage of the streets and the drainage of the houses is to pass off through the same channels. Whatever the objections to this, there are undoubtedly practical reasons why this existing system ought not to be, or at least why it certainly will not be entirely abandoned, but it is an objectionable system, and it surely should not be extended. It seems to me that its objections are so simple and palpable that they must convince all who will consider them. They are largely as follows: Any sewer, as sewers are ordinarily constructed, with the rate of inclination required by the usual slope of the ground, depending upon the simple constant flow of the unassisted household wastes, and having the roughness and irregularity unavoidable in such work, must inevitable retain a deposit along its course, especially toward its upper end, where the amount of flow is slight, and where the solid matters are sure to be stranded for want of sufficient stream to move them forward. This condition is pretty nearly constant while house-drainage alone flows into a channel too wide for it to wash clean. It is aggravated whenever a light rain or a short heavy shower carries into the sewer horse-droppings, papers, and all manner of nameless rubbish from the surface of the street. Now and then there comes a heavy down-pour, or a long and strong rain, which gives every sewer a thorough scouring out from end to end, but the gradual flow at the end of every such a storm too often leaves behind it a deposit of earthy matters which its waning volume and velocity have been insufficient to carry along. Even where this does not happen, the storm once over and its flow subsided, the houses along the route begin again their work of deposit, and we must wait until another heavy rain for the thorough removal of the accumulations. It is during this waiting that the mischief occurs.

It will surely be accepted by all sanitary engineers as very desirable that all waste organic matter should be delivered at the mouth of the sewer at least within twenty-four hours after its production.

I believe, and I think that I am supported in the belief by the opinion of the best sanitarians of the world, that this condition is absolutely indispensable to proper sewerage. Household wastes retained longer than this enter into a decomposition, extremely foul on account of their original character, and made still worse by the conditions under which they are decomposing. It is in the decomposition of such material in soil-pipes and in sewers, alone, that we are to find the seat of the enemy of which we hear so much under the name of "sewer-gas." This much decried and insidious sewer-gas is probably entitled to most of the blame it receives for its own direct action, and to as much more from the fact that it so often acts as a vehicle for the germs, or causative particles of specific diseases. There is no safety in sewerage or in house-drainage until we prevent the production of these gases, and there are no means of accomplishing this, short of the entire cleanliness of every pipe, drain, and sewer which serves for the removal of foul organic matter. To secure this condition is within the power of the engineer. There may still be a very slight sliming of the walls of the best sewer, and a feeble decomposition of matters so adhering will be inevitable; but its amount is so slight that it is easily within the reach of simple measures of ventilation to prevent it from causing injury or perceptible odor. It is true that there are very few sewers now existing which are in this condition, but it is equally true that the construction of such sewers would be materially cheaper than that of those which are more liable to become offensive.

I think it may be set down as an indisputable proposition, that before the city of Washington can be considered to be as well drained as it should be, every foot of the sewers with which its houses are connected must be so improved as to be at all times entirely free from deposits of organic matter.

This end is to be secured by the following provisions: (1.) Every sewer should be of such size that its regular flow, except near its upper end, shall be sufficient to carry forward all matters of what-

ever character that come to it, no halting by the way being possible. Incidentally to this, no matters should be admitted to the sewer which its ordinary flow is not capable of removing. (2.) At the head of each sewer,—technically called "the dead end,"—there should be placed a flush-tank, discharging, at least once in twenty-four hours, a sufficient volume of water to sweep out all material deposited higher up the stream than the point where the efficient natural scouring begins, and to increase the depth of flow throughout the lower portion of the line beyond that, at any time, reached by the natural current, so that the matters adhering to the walls of the sewer may be washed away. (3.) The material and the jointing of the sewer should be such as to retain absolutely all of the liquid portion of its contents; the water of the sewage is all needed as a vehicle for its heavier materials, and its escape into the soil must produce the deleterious effect upon the "ground-air" before referred to.

The popular idea as to the size of drain required to receive the outflow of a single house, or of a number of houses, is strangely in error. A pipe 6 inches in diameter, having an inclination of 4 inches in 100 feet, has a capacity of discharge of nearly 200 gallons per minute,—say 12,000 gallons per hour, or between 8 and 11 in the morning, 36,000 gallons. It is usual to estimate that during these three hours about one-quarter of the daily flow is discharged. Such a pipe then, at such an inclination, would be adequate to the removal of nearly 150,000 gallons per day. If each household averages six persons, and if the daily consumption of water is even 50 gallons per head, the service would be sufficient for 500 houses; or, supposing the sewer to run only one-half full during the hours of greatest use, for 250 houses. It is to be considered also that it is rarely necessary to lay a lateral sewer with so slight a fall as four inches in 100 feet, and that an increase of fall secures, of course, an increase of discharge. During the past year, under the direction of the National Board of Health, I have made a number of gaugings in different parts of the country to deter-

mine the actual, practical dry-weather flow of public sewers during the hours of greatest use. The results of these gaugings fully sustain the estimate just given. Generally, where from 50 to 100 houses contributed to the sewer, the discharge filled a six-inch pipe from less than one to two and one-half inches deep.

A sewer in Milwaukee draining an area of about 70 acres, and serving a population of over 3,000, had the whole of its flow delivered through a six-inch pipe, which it did not entirely fill. A sewer in St. Louis, draining a district having a population of over 11,000, had its entire flow delivered through a twelve-inch pipe which it only about one-half filled.

The belief is very general that if a given flow of sewage can be discharged through a small pipe, it can surely be discharged through a large one. This is not true. The whole sewage, solid matters and all, will be completely removed by a small sewer, while only the liquid portions and the smaller solids will be removed by a large one. The solid matters, beyond the capacity of the broad and flat stream to remove them, remain as a deposit in the large sewer, always subject to decomposition, and often liable to obstruct the water-way, to lessen the already slight scouring capacity of the flow, and to invite further deposit. This action proceeds without interruption, unless occasional storm-flow washes away the accumulations. In aggravated cases, where the sewer is very large, and where the storm-flow is slight, the whole sewer becomes filled with the deposit until there is left under its crown only the small channel needed for the ordinary flow.

It is the invariable tendency of large sewers to accumulate deposits in this manner, which constitutes the chief but by no means the only argument in favor of their abolition, *as house sewers.* I have very carefully considered the general features of the existing sewers of Washington, and I believe that these can never be made satisfactory until the larger ones are generally restricted to the removal of storm-water only; their place being

supplied, where they are so abandoned, by smaller pipes for house-drainage.

Assuming this belief to be well founded, the problem to be considered is, in what way best to make use of such of the sewers of Washington as are suitable for the purpose; and in what way to introduce new works so that the system by which the houses are to be drained shall conform to the best requirements; and in what way best to dispose of the outflow, to the end that no house in the city may be connected with a sewer which at any time or under any circumstances may retain organic matter in a state of decomposition; and that no house may discharge into a sewer whose usefulness is ever, even temporarily, interfered with by storm-water or by back-flow. In short, to give to every house a clean and well-ventilated channel to carry its waste matter to a point whence no ill effect may return.

To determine to what extent and precisely in what manner the present sewers can be made useful as a part of this system, would require more detailed knowledge concerning them than I now possess. One important question would be the extent to which it would be cheaper to construct at the heads of the sewers flush-tanks large enough to keep them clean, than to substitute for them smaller pipes which would be more cheaply flushed. Another would be to determine the cost of making the present sewers absolutely tight. Even pipe-sewers, as ordinarily laid, are very apt to leak at the joints to such a degree as to rob the sewage of its water, and to contaminate the soil.

So far as the present sewers cannot be made to conform to the requirements which I have indicated, they should undoubtedly be reserved for street use only, and new small ones with absolutely tight joints should be furnished to take their place as an outlet for house drainage.

Let us for the moment assume that all of the existing sewers of the higher parts of the city can be made suitable for the work, and that it will be cheaper to flush them, large though they are, than

to build others to supplement them. In this case it would be an easy matter for all sewers lying above a certain level—all, in fact, except those which drain the lower and flatter parts of the city—to have their *dry-weather flow* intercepted, so that the ordinary foul sewage may be led by gravitation directly to a suitable point for its discharge. This may be done by building an intercepting sewer adjusted in its size to this work only, at a level below the present sewers at the points of interception, connecting the latter with the intercepting sewer by such channels of communication as will admit all of the foul sewage and the water used for flushing. Channels large enough for this purpose would carry into an intercepting sewer the flow of *light* rains. The waters of heavy storms would pass on through the present extensions of the sewers beyond the intercepting line, and find their outlet into the B-street sewer or other large outlet mains of the storm-water system. Wherever it became necessary within this high district to build independent smaller sewers for house drainage only, these might be made to discharge directly into the intercepting sewer. It is of but little importance that during heavy storms sewage matter would be carried into and through the storm-water sewers, for the reason that at such times the sewage is enormously diluted, and is discharged into a torrent in the main sewers which is quite sure to remove it inoffensively. At the termination of a storm the flow of the laterals would be reduced to the capacity of the intercepting inlets long before there would cease to be a considerable flow in the storm-water sewers.

For those parts of the city which lie too low for interception by a sewer delivering above high water at a distant point, it would, unquestionably, be cheaper and better to abandon all communication with the present large sewers, and to construct an entirely independent system for house drainage, depending for this solely on a pumping outlet, at least during the higher stages of the tide.

I see no other way in which the drainage of this lower district can be made satisfactory. For the carrying out of a plan requir-

ing the pumping of sewage, we have the conspicuous example of the Surrey side of London, where not only house drainage, but a large part of the storm-water as well, is lifted above the level of high tide, the lift varying from 28 to 48 feet. The adoption of this plan here would immediately relieve the whole problem of its difficulties. Surface water being left to take care of itself, as at present, drainage to any desired depth could easily be given to the houses of even the lowest parts of the city.

This would involve, it is true, the complete re-sewerage of all of the lower district, but it is, I think, easily demonstrable that no other device would be free from grave sanitary objections; and if the new sewers are adjusted to the work of foul drainage only, as are those of Memphis, now nearly completed, the cost would be incomparably less than that of the original storm-water system.

Aside from storm-water removal, the carrying away of foul sewage, and the drainage of the flats about the city, attention is urgently demanded to a radical and almost universal improvement of the interior drainage of houses. Dr. Townshend, the Health Officer of the District, in his report for 1879, says: "I think it is safe to say that of the thousands of houses in the District of Columbia which have house-sewer connections, scarcely one hundred can be found which have any vent for these sewers outside the house-rooms." He also says, in speaking of the escape of the gases of the sewers into dwellings: "What remains for the sanitarian, however, is to warn an indolent public against resting in the fancied security of contrivances for the repulse of this arch enemy, which recent research and a better insight have proved to be worthless in the fulfilment of the purpose desired. A few years ago it was considered all-sufficient upon constructing a water-closet in a house to place under the bowl a piece of bent pipe made to hold half an inch or so of water, which was to act as a barrier against all gas, no matter what the pressure under which it was held in the sewers. Numbers and numbers of water-closets erected

after this manner were put in houses in this city, and some of them are doubtless still remaining, the occupants resting easy in the belief that their sewers are 'trapped.'"

I learn from his report also that out-of-door privies are still largely used in this modern Capital. It seems almost an insult to the intelligence of such an audience as this to call renewed attention to the fact that under no circumstances should a privy vault, a cess-pool, or any other device for retaining within the limits of the city the fæcal matters and other wastes of the household be permitted to exist a day longer than is required for its destruction, and for the connection of the house with a public sewer.

The palpable public nuisance of the old-fashioned privy vault, has been vastly alleviated by the use of the odorless excavator, and I think it is fair to say that, for this reason, the invention of the odorless excavator was a public calamity. Even supposing that it were practicable to make any considerable proportion of privy vaults tight—which it is not—or supposing even that the Charleston earthenware receptacle should be adopted, the difficulty would be only slightly mitigated; it would be by no means removed. However effectually such work might prevent the contamination of the soil, its inevitable contamination of the atmosphere condemns it totally. During the limited time required for the entire abolition of these nuisances, the odorless excavating apparatus may render a most useful public service, but its continued existence can only be a continued advertisement of the fact that the community employing it has a greater regard for outward decency than for radical purity. That such nuisances should still exist in Washington is a disgrace to the country.

Hardly more are you to be complimented upon the condition of the alleys of the city. Dr. Townshend describes the populated alleys as follows: "Drainage is generally effected by the placing of a sewer-trap, or drop, at the mouth or entrance, to which all wash-water, etc., is directed by a surface-drain having but a slight fall. Into this drain all slops, wash-water, etc., must go, and into

such waste material a considerable quantity of animal and vegetable matter is apt to find its way.

"The license to deposit waste-water becomes an incentive to throw refuse, garbage, etc., and often, twenty-four hours after cleaning, we find these alleys again in a filthy condition. The drains become obstructed by small deposits, and the waste-water, etc., soon accumulates and becomes offensive."

He, of course, suggests the obvious and satisfactory remedy,—the construction of sewers for the whole length of the alleys.

There are other points in your Health Officer's report which it would be worth while to consider here, did time suffice. I commend the original document to your careful attention, and will return now to the question of house drainage.

I have long held to the opinion that defective house drains are a far more important factor in the production of disease than defective sewers, and that more of the sewer gas, to which so many of our ills are ascribed, is produced by decomposition in pipes inside the house than by decomposition in sewers outside the house. Defective sewers are common enough in all conscience, though their construction has been much improved within the past ten or twenty years, but defective soil-pipes and water-closets and traps are almost universal. The beginning of their improvement dates from a very recent time. Nominally our houses are often built under the direction of architects, but in reality this most important part of the work is generally left to the unrestricted control of mechanics who, however intelligent and faithful they may be in their manner of working, have had no training, and at least no sufficient instruction as to the whole effect of what they attempt to do. The journeyman plumber does the work that he learned to do when he was an apprentice; the apprentice learned what his boss taught him; and his boss learned it when he was an apprentice. There are many praiseworthy exceptions of course, and their number is rapidly increasing, but I am speaking now of existing work, done five, ten, twenty years ago, at a time when the architect

rarely thought of anything further than getting rid of drainage-water, and when the plumber knew nothing better than the use of sound material and the execution of sound work, and often avoided these. Whether the plumber or the architect or the house owner is to blame for the present condition of the house drainage of this city, and of all other cities, is of no consequence. The fact exists that through the ignorance of one or all of them, work has been put into dwelling houses, almost universally, which had much better be taken out and replaced, and which ought imperatively to be thoroughly overhauled.

Pray do not think that I say this without a thought as to the enormous tax that such a reform must impose upon the community, or that I say it lightly because of the slight responsibility attaching to a public lecture—I say it in all earnestness and advisedly.

By the official statement, the deaths in the District in 1879 from diseases which are believed to be very materially affected by bad drainage,—either by soil-moisture or by filth,—amounted to just about one-half of the total mortality. I believe that one-fourth of the lives thus sacrificed might have been saved by putting every house into perfect condition as to the dryness of the soil on which it stands and by which it is surrounded, and as to the appliances by which its filth is removed. I believe, that is, that five hundred persons annually die within this District because of the defective condition of the houses in which they live. This belief, and not by any means the desire to offer a striking proposition, is my motive in saying what I do on this subject. Were I to attempt to treat it adequately, I should be obliged to make a fresh start and to deliver a tediously long lecture on house drainage only. I will content myself on this occasion with the remark that leaky drains discharging their contents into or under cellars and foundation walls, leaky soil-pipes discharging foul gases into living rooms, unventilated drains and soil-pipes wherein the foulest decomposition is incessant, pan water-closets which are as abominable as they are universal, and defective traps, or too often the absence of traps,

constitute together a source of disease and death compared with which your sewers and your river bottoms are insignificant. The improvement of these is very essential to the welfare of the city, but however complete it may be made, you will be in far from a good sanitary condition until your houses are put into proper plight.

It is no part of my purpose to criticise the many recommendations of those who have preceded me in the discussion of the Washington problems, but I must make an exception in the case of one recommendation of the Board of Survey of 1872, which is of radical importance. That Board advises, with reference to the sewage of the region discharging through the Rock Creek valley and to the discharge of the B-street sewer, that these be allowed to flow into an outlet, presumably a sewer, in which the tide will rise and fall; the theory being that the volume of the tidal flow will be so great as to nullify any bad effect otherwise to be apprehended.

This conclusion is not in accordance with the opinion of the best engineers in England, where the question of tidal outlets has always been prominent. It is found that the checking of the current by the set-back of tide-water causes deposits which are a fruitful source of trouble.

With the great constant flow from the Upper Potomac it would probably be safe, at least for a long time to come, to discharge the sewage in a fresh state into the open river, after its channel shall have been rectified as proposed; though sooner or later the deposit on the flats at Gravelly Point would doubtless make it necessary to reclaim them also, carrying the rectified main channel farther down. It is not impossible that it will be found necessary, in time, to dispose of the dry-weather flow of the sewers by agricultural irrigation, at a safe distance below the city.

I have now sketched in a rapid manner the main features of a comprehensive scheme which seems to me adequate to the improvement required. Let me, in closing, restate its essential points:

(1.) The Potomac Flats or Kidwell Bottoms, and the flats and marshes along the Anacostia, to be reclaimed after the Dutch practice, by embanking and pumping. The embankment or permanent defences to be so placed as to leave the necessary channels for commerce and for the safe discharge of the greatest flow of water.

(2.) The discharge of the lateral streams and of storm-water sewers to be carried beyond these defences and delivered into the main channels of the river, with such precautions in the case of the Anacostia as will prevent injury to the works by the rapidity and volume of the flow.

(3.) The complete under-draining or subsoil drainage of the site of the city.

(4.) The separate removal of the foul drainage. That from the higher portions to be discharged by intercepting sewers into the Potomac, or at a safe point for treatment by irrigation. The intercepting sewers to receive the whole flow of new house-drain sewers, and the *dry-weather* flow of such sewers as may be retained for the double use of carrying surface-water and house drainage. The foul drainage of the lower parts of the city to be thrown into the high-level intercepting sewer by pumping.

(5.) The abolition of privy vaults and cess-pools, and the complete reformation of the interior drainage of houses.

It will not, I am sure, be doubted that the complete execution of these works would make Washington a perfectly healthy city. No one who is qualified to form a judgment on the subject will doubt that the entire cost of the improvement will be more than offset by the increased value of real estate now suffering from a bad sanitary reputation, and by the value for ornamental or economic purposes of the land to be reclaimed along the rivers.

I am sure some will agree with me that the special means proposed will effect these desirable ends not only more economically, but also more cheaply than it could be done by other plans that have been suggested. A constant free outlet for the natural land drainage several feet below the surface of the drained flats is in itself a most important object.