admitted at all, the probability is that it will be admitted in excess. The report provides overflows for this excess, which will find its way into the natural water-courses. The catchment areas for the rain water being hard impervious surfaces—yards and roofs—water falling thereon will be rapidly passed into the drains and sewers, which will be quickly filled. Sharp and severe storms have in some past years been frequent during the summer season, and a repetition of such may be expected. Therefore, it is reasonable to expect that several times during a like period that sewers will be overcharged, and the diluted sewage passed into the open watercourses and channels. Will such diluted sewage be harmless? A great deal will depend upon the heaviness of the rainfall. A heavy summer thunder shower of short duration will quickly charge the sewers, and no doubt perform the object for which the rainwater is admitted, viz., to scour out the drains and disturb the heavier and lingering matters that the ordinary volume of sewage has not power to remove. A portion of this out-scouring, or washing out of the sewers, is to be turned into the water channels—into the open air—in the summer a course altogether antagonistic to the realisation of that purpose for which sewers should be constructed—perfect sanitation. The calculated dilution at the period of maximum flow of sewage is for the Northern system ·7 of rain water to 1 of sewage, and for the Southern and Western systems, 1·39 of rain water to 1 of sewage. But even if the volume of rain water entering the sewers increases the dilution to the extent of 3 to 1, it is most certain that the first overflow, after a dry period especially, would cause a serious nuisance. There is also this matter to be considered; a heavy thunderstorm may pass over the Northern watershed chiefly, surcharge the sewers and the diluted sewage overflow into the open channels on the Southern watershed where there would be no rain falling to further dilute and wash it away. Those who have paid attention to the range of thunderstorms which travel from west to east, must be well aware how limited the range often is, and how very severe the rainfall is within the limits.

There is another serious objection to the entry of rain water into the sewers. It will render most difficult the treatment of the effluent at the outfall. A regular volume of sewage may easily be provided for, but a sudden rush of storm water will cause complications, and it is quite certain that the maximum volume of storm water estimated for will be exceeded by 25 per cent. at least.

It has now been shown that the admission of rain water is quite unnecessary, and will not improve the sanitary condition of a system of sewerage. All sewers should be so designed as to be self-cleansing when the normal volume of sewage is passing through. The common idea that the admission of rain water to a system of sewers is absolutely necessary to keep them clean, must be relegated to that obscurity which is the fate of so many old notions which the advance of science has driven from their vantage grounds. The exclusion of rain water would necessitate a complete re-arrangement of the whole scheme, and more efficiency would be obtained, and quite possibly at a much reduced cost.

The report adopts the common or English practice for ascertaining the maximum flow of sewage, viz., one half the total daily flow to pass off in six hours, which is based upon the consumption of water from the mains being at a similar rate. Is this rule worthy of universal application? If it be found to be correct for cool climates, where water is used at the rate of 30 gallons per head, will it apply without modification to a community using 72 gallons per head? A very short examination will show that it cannot. The excess of 42 gallons will be due chiefly to two causes—firstly, a more liberal use of water for bathing purposes, and secondly, the use of water for gardens. Water used for the latter purpose will not enter the sewers, and will be drawn from the mains generally after the six-hour period of maximum draught, that is, towards evening—it should not be allowed to be taken during the six-hour period—that is during the forenoon. Therefore a deduction is necessary from the estimated maximum volume of sewage. Bathing will be indulged in chiefly during

the morning, within the six-hour period, and as the waste water will enter the sewers at once, it is quite evident that a large proportion of the excess of 42 gallons before mentioned will pass into the sewers within the six-hour period. This fact should not be lost sight of, and in a properly designed system of sewers could be made a most effectual flush. The common or English rule is not applicable to those conditions as stated in the report, which will prevail on the area included in the design.

The primary object of a system of sewers is the removal of sewage and the sanitary efficiency of such a system depends upon the rapidity and completeness with which the removal is effected. To obtain the most desirable speed of flow for the sewage when at its normal volume is the chief point to be considered in the adjustment of the gradients. When estimating the normal volume of sewage, from an area upon which population is increasing, it is necessary to consider fully the following points in all their bearings. The present population and the probable future population; the time which will elapse before the prospective population is reached; the present rate of consumption of water per head and the future rate; the annual fluctuations in the comsumption of water; the maximum being reached in the summer period, and the minimum in the winter period; the daily fluctuations in the use of water and consequent flow of sewage. The present condition of the western suburbs, considered as above, will require the exercise of the greatest care to ensure the sanitary efficiency of the sewers from the commencement; the use of 72 gallons of water by an estimated maximum population, 20 years hence, is only an assumption and one that may not be realised. It is, therefore, decidedly wrong to base the sanitary efficiency of the sewers on a contingency so very remote. Even without the admission of rain water the difficulties to be contended with will be very great; but with the admission of rain water into the sewers, complications will arise such as to render a sanitary system almost, if not quite, impossible of attainment. It has been shown that the amount of sewage and rain water contributed to the Eastern, Northern, and Western branches of the Western system will be proportionate to the

density of population on each drainage area, and that the present population is most dense on the Eastern and decreasing towards the Western area, therefore the volume of sewage and rain water which will pass down the eastern branch will most nearly approach the estimated maximum, the volume which will pass down the Northern branch will come next while the volume in the Western branch will bear the least proportion to the estimated maximum. This variation in the volumes will cause a corresponding variation in the flow line of the three sewers at the point where they join. The flow line at the point of intersection of the three sewers has been designed to be at one level, when the maximum volumes of combined rain and sewage are passing; but such will be an abnormal condition of the sewers. If the flow line in each branch sewer be ascertained for the maximum volume of sewage only, it will be found that the flow line of the Northern sewer stands at the highest level, and the flow line of the Western at the lowest. The flow line of the Eastern will occupy an intermediate position. These levels, however, are for volumes of sewage, which may be expected 20 years hence, when the prospective population has reached the estimated density. In the meantime, the daily sewage flow line in the Western branch will be considerably below the flow line in the other sewers, the result of which will be that the Western sewer will be backwatered, to a considerable extent; the velocity of the flow in the Western branch has been shown to be very inferior, the backwatering will make it very much worse. Considerable deposits of offensive matter may be expected to take place. This is another illustration of the complications which will attend the admission of rain water to the sewers, and taking as the basis for the hydraulic calculations the abnormal instead of the normal or legitimate duty.

The scheme proposed is partly a gravitation and partly a pumping one; the area from which sewage and a proportion of rainfall will have to be raised (leaving out the Canterbury Branch) is 29 per cent. of the whole area. This will require a considerable outlay for pumping plant. If rain water be excluded, and the grades very much improved, the first will tend to reduce the

volume of liquid to be raised in the proportion of 2.39 to 1, but the second will increase the pumping area, and the height of lift. It would require a careful calculation to ascertain whether any more expense would be incurred for pumping by this modification, but even if there were, the superior efficiency of the system would amply repay the outlay.

On page 12 of the Report will be found the following statement:—"The primary object to be attained in devising the proposed scheme is to provide for the removal of as much of the sewage as practicable by gravitation, or in other words to reduce the amount of pumping to a minimum." No doubt calculations have been made, with due regard to economy, to arrive at the recommendations contained in the report; but if the calculations for arriving at the engine power necessary for raising sewage as given on page 18 be accepted as the system adopted throughout, the report should be amended. On page 18 will be seen the following words:—"To provide steam power for raising the combined flow of 1,879 cubic feet per minute direct from the sewers, without storage, would necessitate pumping engines equivalent to 120 horse-power." The lift is 34 feet. The calculation has been worked out for clean water, without any allowance for slip or friction. Making these allowances for sewage, the horse-power required will be practically nearly double, or 223·2 instead of 120. For a similar reason, instead of a 38 horse-power engine described lower down, being "sufficient to perform the actual duty required," one of about 70 horse-power would be necessary. The "Worthington" type of pumping engine is recommended for adoption; the duty of this class of engine is given at 100,000,000 foot pounds per cwt. of coal. Such a duty may be obtained when working on a constant volume of clear water, but pumping a fluctuating volume of sewage is a vastly different matter—the volume fluctuating from the surcharge of a thunderstorm at one hour to the minimum flow of sewage during the next. The circumstances surrounding the design for pumping the sewage at Marrickville will render economy difficult of attainment with the ordinary direct acting steam pumps.

No reference has yet been made to the syphons proposed to be introduced at various places on some of the main lines of sewer. One on the eastern branch of the Western system is 870 feet long and 33 inches diameter; its capacity will be about 5,100 cubic feet. Whatever be the volume of sewage flowing the syphon will always be full. Applying the same method of reasoning as used previously for estimating the sanitary condition of the sewers, it will be found that, leaving the rain water out of consideration, and taking the volume of sewage from the present population, there will be neither sufficient volume nor velocity to thoroughly cleanse the syphon out, or prevent undesirable stagnation, which will be most pronounced in its results during the period of daily minimum flow. During this period, lasting over 12 hours, the heavier putrescible organic matters will gravitate to the bottom, and not be given out until the maximum flow during the morning, and possibly not then. It is a fundamental principle of sanitation that no sewage be allowed to stagnate. It should be ever on the move at quick march. Stagnation means decomposition, and this in populous centres, such as the syphon, will be located in will prove injurious to health. There will always be a leaven of decomposition remaining in the syphon. The contents will decompose under pressure. In the morning the increased flow will cause a portion of the contents to be moved on into the ventilated sewers; the gas will be liberated in volumes, and pollute the air in all the drains to which it may gain access. One syphon is bad enough, but four are proposed on the main line of sewer of the Northern system—one at George Street West, one at Johnston's Creek, one at White Creek, and one at the north end of Balmain. These syphons will always be full of sewage in a greater or less degree of decomposition depending upon the volume of sewage contributed to them. It is a most unfortunate circumstance that these syphons are at the head of the main Bondi sewer. If the decomposition prove serious, as may be expected in warm weather, the sanitary efficiency of the whole system below it will be endangered, and this system lies in the midst of the thickly populated city and Eastern suburbs. Just before reaching the syphon

at George Street West, an overflow is to be provided, which will pass off 400 cubic feet per minute during rain storms. This overflow will not always be harmless. What would be the result of a sharp thunderstorm occurring about six o'clock on a summer morning after a few weeks of dry weather? Would the overflow resulting from the rain-water, mixed with the scourings of the sewers and syphons be harmless? And it must be remembered that a less volume of rain-water is admitted to the sewers of the Northern system than to those of the Eastern and Western systems. There will for this reason be less dilution of the sewage.

The remarks hitherto made had reference chiefly to the sanitary efficiency of the proposed scheme; a reference must be made to the estimated cost of the scheme. The estimate given in the report does not include the cost of constructing the subsidiary or minor branch sewers. This will be considerable, and the estimate is not complete without it. No revenue will be derived from the main sewers until the branches for facilitating house connections are laid. Therefore, some estimate should have been furnished of this work.

A very brief reference is made in the report to the Shone Ejector system of sewerage, and none at all to the Hydraulic Ejector system. A full consideration of either system would scarcely have failed to have indicated a course which would have considerably reduced the estimated cost of the scheme, increasing at the same time its efficiency. There are many other matters which, if time had permitted, would have repaid examination. Only one can now be referred to. The report assumes that seventy-two gallons of water per head in the summer will be used by the prospective population twenty years hence. If the present rate of increase be maintained, the population over the whole Metropolitan area will at that time be about 900,000. These 900,000 will, at the rate of seventy-two gallons per head, require a daily supply of 64,800,000 gallons. This will have to be supplied at the rate of one-half in six hours, which is equal to a rate of 129,600,000 gallons per day. To convey this volume into the metropolis would require six additional main pipes, each equal

to the 48-inch main recently laid from Potts' Hill to Sydney. At the above rate of 64,800,000 gallons per day, Prospect Reservoir would only hold 110 days' supply. If seventy-two gallons per head be a correct assumption, then long before the population has reached 900,000 it will be necessary to provide extra storage, which will entail extra cost for water supply. If the assumption of seventy-two gallons be incorrect, then the data upon which the dimensions and inclinations of the sewers have been calculated must be modified. It will be interesting here to note what Mr. E. O. Moriarty, the originator of the Nepean scheme, has said in relation to the time when additional reservoir room will be required. In an appendix to the late W. Clark's report on Sydney water supply will be found the following statement:—"When the time arrives that the population of Sydney equals that of Glasgow (540,000), it may be necessary to consider the expediency of constructing new reservoirs." In an earlier paragraph of the appendix the rate of supply to Glasgow, a manufacturing city, is stated to be thirty million gallons per day.

According to a report just to hand, the population of Sydney and suburbs is given at 357,856. Seventy-two gallons per head for this number will nearly equal the total Glasgow supply.

Seventy-two gallons per head is a lavish supply, and it should be seriously considered whether it may be possible to curtail it or not. If the meter system be introduced there will no doubt be economy of consumption. What it will amount to it will be difficult to say; but if it fall much below 72 gallons per head, the standard adopted in calculating the efficiency of the sewers, the sewers will suffer.

The whole question of the sewerage and drainage of the Western suburbs is one of vital importance; and as the object desired is the conservation of the health of the inhabitants, the most perfect application of the water carriage system should be sought. It will not be safe to trust too much to English practice. Local conditions must be considered and provided for in any design. The design proposed is not sufficiently perfect.