GOVERNMENT NOTIFICATION.—No. 334.

The following Report on the Water Supply of Hongkong was laid before the Legislative Council on the 4th instant, and is published.

By Command,

F. H. MAY,
Colonial Secretary.

Colonial Secretary's Office, Hongkong, 4th June, 1902.

REPORT

ON THE

WATER-SUPPLY OF HONGKONG.

MAINLY WITH REGARD TO THE FULL DEVELOPMENT OF THE SUPPLY FROM THE TAITAM-TUK VALLEY.

PUBLIC WORKS OFFICE,
HONGKONG, 18*th April*, 1902.

SIR,

1. The reasons which led to the conclusion that the Taitam-tuk Valley is the most suitable one for development, are as follows:— Reasons for developing Taitam gathering ground.

Other gathering-grounds exist, but their areas, above the level which would admit of the delivery of the water, by gravity, into the general system is but small. As far as can be seen from existing maps, no good reservoir-sites exist within them. To get any large quantity of water, the reservoirs must be put low down, and pumping must therefore be resorted to. A long length of conduit or pipe would be required, to bring in the water from them. The conduit from Taitam exists, and is capable of conveying a far larger quantity of water, than it is now called upon to deliver. Therefore, though it will be well to examine other gathering-grounds, and even to reserve them for future use, if any favourable conditions be found to exist, the Taitam Valley should be the scene of immediate operations.*

2. The original project, drawn up by Mr. COOPER was, firstly, to construct two reservoirs, having a joint capacity of 110 millions of gallons, fed by, and placed within, the Taitam gathering-ground, and above the existing reservoir. Then, later on, to construct, lower down the valley, a further reservoir, having a capacity of 100 millions at a level of 180 above O.D., so that the contents thereof would have to be pumped up to the Tunnel. Since this project was submitted, events have occurred, which point to a reversal of the policy. Taitam Reservoir never filled, during the rainy season of 1901, and it is doubtful whether 100 millions escaped collection in 1900, in which year the rainfall was also below the average. Therefore the gathering-ground should be increased, as well as the reservoir-capacity, and this can only be done by going further down the valley, and resorting to pumping, consequently let pumping be resorted to at once. Another great advantage of this arrangement is that the supply could be materially increased, at an early date. During the exceptional drought of 1901-02, the stream, below Taitam, yielded *at least* 45 millions of gallons, in September and October, which would have been a valuable addition to the general water-supply. The reasons for resorting to pumping at first.

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* *Vide* Report on the Sanitation of Hongkong dated 10th April, 1902, 3 page *et seq.*

As to the position of the pumping station.

3. The pumping-station should be placed on the shore, well below the site of any reservoir that may, at any future date, be constructed. It should be on the beach, near to a spot in the neighbourhood, at which there is about one fathom of water, at low tide, to facilitate landing coals. It will be more economical to take the water down to the coal-supply, than to carry coal up to the pumping-station. Bringing the water down to the pumping-station will not involve any appreciable increase of power, the water would be conveyed, down to the engines, in a pipe of appropriate diameter from which the pumps would draw direct. The water will then rise by gravity to the height of the water-level in the reservoir, or reservoirs, and all that the engines will have to do is to lift the water from the level of the new reservoir to the level of the Taitam Tunnel.

As to the size and power of the engines.

4. I propose that the ultimate pumping-plant should consist of three engines, each capable of lifting 1,250,000 gallons in 24 hours. Two would do the daily work, with one in reserve. For the present, I recommend that one only be erected. It will be time enough to erect a second or third, when the reservoirs are finished; and when the actual quantity to be pumped is known by actual observation.

Type of engines.

5. It is premature to discuss the details of the pumping-plant. I will now merely say that the engines should be of the most economical type, triple expansion, fully jacketted. The size of the engine, upwards of 100 horse-power, is such as to justify considerable expenditure on arrangements tending to fuel-economy. As regards fuel-consumption, I would observe that the actual fuel-consumption of the small engines, now in use, must not be taken as the basis of the calculation of the probable fuel-consumption. The large engine will probably consume, per horse-power per hour, at most one-half, and very probably one-third, the coal that the small engines require.

As to the size and position of the reservoir.

6. The low-level reservoir or reservoirs, should have a capacity, singly or jointly, of at least about 400 millions of gallons. In the absence of surveys, it is impossible to state where the reservoir should be constructed, or whether there should be several. One reservoir, that to be constructed in the first instance, should be formed, by throwing a dam across the Taitam-tuk stream, as near as possible to sea level, so as to collect, directly, or by catch-water channels, all the waters of the streams, flowing into the head of the Taitam-tuk Estuary. If it be impracticable to make a single reservoir of sufficient capacity, at this site, then others might be built higher up. Perhaps that proposed by Mr. COOPER, at site No. 4, might be one of these. It may be even advantageous to construct those proposed, at sites 1 and 2. They, with Taitam, could be filling, the town being supplied, solely by pumping from the low-level reservoir. For the present, suffice it to say that one reservoir, of the greatest capacity practicable, should be constructed, with its dam as near to sea-level as possible. This should be the first to be constructed.

As to the diameter of the rising main.

7. The approximate length of rising-pipe, from the pumping-station to the basin, at the mouth of the Taitam Tunnel is, allowing for the irregularity of the ground, about 9,000 feet, and the lift, including friction, is approximately 400 feet, measured from the bottom of the lowest reservoir. To convey 2,500,000 gallons a day, one pipe of 21″ diameter, or two of 15″ diameter, would be required. Inasmuch as one engine only is to be provided in the first instance, it will be economical to lay one 15″ pipe first; which will amply provide for the water pumped by one engine. The second pipe may be laid later on, when more is known as to the actual yield of the new works. The pump-horse-power of each engine will, therefore, be 105, corresponding to about 124 indicated horse-power.

Coal consumption.

8. An engine, of the proposed type, should not consume more than 2 lbs. of Welsh or 3 lbs of Japanese coal, per I. H. P. per hour, in actual continuous work. So that the daily consumption, going full speed, will be $\frac{124 \times 3 \times 24}{2240} = 4$ tons of coal per day, costing, say, $10 on wharf, or $40 per day, or at the rate of $0.032 per

1,000 gallons pumped, for coal only. The staff, including an European with an allowance for oil and waste, will cost about $25 per day, bringing the total nett cost of pumping to $0.05 per 1,000 gallons. When pumping from a full reservoir, or from one higher up the valley, the lift and consequently the coal consumption, would be reduced, but not in direct proportion, for there is a certain power at which the engine gives its best efficiency.

As to the quantity of water obtainable.

9. The quantity of water that can be obtained from the Taitam-tuk valley will depend a good deal upon the capacity of the reservoirs, whether they be large enough to carry forward a reserve, from one season to the next, as explained in the previous report. A rough approximation to the probable minimum, during a very dry year may be calculated. Taitam, with a gathering-ground of 1,093 acres, including catches and a storage-capacity of 406 millions, maintained, during the water year of 1901-1902, allowing for the broken portion of the current month, a total supply of about two millions per day, on the average of the whole rain-year. The new works will add about 862 acres of gathering-ground which contribute, direct, to the proposed low-level reservoir, and the water from a gathering-ground to the East of the Taitam-tuk Village, having an area of 245 acres, can be brought in, by constructing a small subsidiary reservoir, and a short length of conduit; thus giving a total *additional* area of 1,107 acres, and therefore practically equal, in point of area, to the present gathering-ground of the Taitam Reservoir. Therefore, one may safely assert that with a reservoir or reservoirs, equal in capacity, to the existing Taitam Reservoir, the proposed works will at least *add* as much water as Taitam now affords, or in other words *double* the supply which is now, during a drought, about two millions of gallons per diem. This is on the assumption that the additional storage only bears the same proportion to the added gathering-ground that the existing storage bears to the existing area of gathering-ground. In all probability, by providing more storage, the supply could be materially increased. There is good reason to believe that the estimate of yield which I have given, will be materially exceeded in practice, for the following reasons. The proposed low-level reservoir will receive a larger proportion of its water, direct from its gathering-ground, than Taitam does, and will, moreover, collect any water that escapes from Taitam, or from the catches which feed it. It will also receive any water percolating down through the soil, which now gets away, unperceived, to the sea.

Lastly, by means of catch-water channels, water may be collected from the slopes of the hills, surrounding Taitam bay, from Cape D'Aguilar on the East to near Stanley Village on the West.

As to the capacity of proposed plant.

10. The size of proposed engine was mainly determined, in the first instance, with regard to the fact that the flow of Taitam in a very dry year, 1901-02, was for a month on end at least, at the rate of one million gallons in 24 hours. The proposed engine could raise this quantity without any appreciable storage, only a small collecting-pond, as proposed by Mr. COOPER. I feel certain that with adequate storage, a permanent additional supply of 2,000,000 gallons per day, could be maintained, at the very least, in a dry water year. The proposed engine, therefore, will not be too large. If future experience shews that less, say for example only one million gallons a day can be obtained, then all that has to be done is to erect a second engine, of the same size, as a reserve. If, on the other hand, it is found that an additional supply of two millions or more can be maintained, then a second and third can be added, two to do the work, and with one in reserve. Or, on the other hand, if still more be obtainable, then even a fourth engine may be provided. I find that, during water-year 1901-02, an average daily supply was given from Taitam, from April to October inclusive, at the rate of 2,400,000 gallons a day, under constant supply, for the remainder of the year, the average rate of supply was 1,500,000 gallons a day, so that about one million of gallons extra per day would have maintained the constant supply, for the whole year.

Deficiency of data for precise calculation of flow-off.

11. I regret that I am unable to form a more precise estimate of the probable yields of the increased gathering-ground. I have been carefully through the data which have been collected, during the past 12 years, and I shall give, in an Appendix, an abstract of the results which I have obtained, with regard to the percentage of the rainfall which is available under various conditions of rainfall. The value of the data, which has been collected, is however greatly diminished by the fact that it is not practicable to estimate, with even approximate accuracy, the quantity of water which escapes through the waste-weir, during heavy rain. The only plan is to confine one's self to the investigation of periods, during which there was no overflow, thus materially reducing the number of available observations. Again, the methods of measurement, now available, are not sufficiently accurate to give precise results. I shall offer later on some suggestions as to improvement in this matter.

Preliminary expenditure to be sanctioned, $20,000.

12. I shall not attempt to give any estimate of the probable cost of the works which I have recommended. The data before me, in the form of plans, are not sufficient to permit of the preparation of even a rough estimate. The submission of estimates, based on insufficient data, is a most objectionable practice and one apt to mislead. I therefore recommend that the sum of $20,000 be sanctioned for preliminary work, such as surveys, gaugings of streams and the like.

Programme of operations.

13. The first thing to be done, is to commence a survey of the Taitam Valley, extending from sea-level to about 300 feet above it. This survey should be made with the utmost accuracy, so that it may be available as a portion of the new survey of the Island, a work, so much needed, as I have frequently pointed out. Whilst surveying, it would also be well to include the whole gathering ground of Taitam, including areas utilised, by means of catch-water drains. I would here observe that sections 21 and 22, of Ordinance 16 of 1890, Demarcation and Reservation of gathering-grounds, do not appear to have been complied with. The Taitam gathering-ground should therefore be carefully surveyed and delineated with *permanent* Boundary Stones. Whenever convenient, for example those at the summits of hills, should serve as trigonometrical points, and their positions should be referred by means of rectangular co-ordinates, to some one fixed point, such as the Kowloon Observatory. I cannot too strongly insist upon the necessity for recording, permanently, leading survey-points; so that they may be available for future work. It is greatly to be regretted that this was not done, in the case of the Collinson Survey of 1845. I, and many others, have invariably failed to find on the ground, the trigonometrical points, on which this survey was based. Therefore, all the valuable information, which is contained in the field-books and computation sheets, which exist or did exist, in the R. E. Office, are practically valueless. Had the trigonometrical points been permanently marked, by means of substantial pillars or otherwise, much of the work of 1845 would still be available, for purposes, such as the present.

As an example of the importance of permanently marking survey-points, not only on the ground, but by records also in the office, I may site the Survey of Malta, with which I was formerly connected. The trigonometrical points were well marked on the ground, and the co-ordinates of each recorded in the office. Government surveys, for any purpose, whatsoever, were all connected to two or more points. The result was that, in the course of not very many years, a nearly complete cadastral plan has been produced, at trifling expense. Whereas here, surveys have been made of the City, of the Peak district, of Taitam and other places, but there is nothing to link them together.

Levelling-operations need not in the first instance be carried higher than is required, for the immediate necessities of the case.

Two gauge-weirs should be erected, on the main Taitam-tuk stream, at sites which have been selected. One of these, which should be at least 40 feet in width, is intended to measure moderate floods, up to 4 inches per day. The other, a V

gauge, is intended to measure smaller flows, with greater precision than the large flood-gauge is capable of doing. Each of these gauge-weirs should be provided with a self-recording instrument, with clock-work, giving a continuous record of the depth of water passing over each gauge. The object now is to obtain an estimate of the total water, flowing off from the whole area; including moderate floods. Now, during floods, the rate of flow varies from hour to hour, so much so that daily measurements are most misleading. A continuous record is, therefore, essential to accuracy.

Steps should at once be taken to obtain proposals and quotations for the first pumping-engine. The best procedure in such cases is to draw up a Preliminary Specification, setting forth merely the work which the engine is to do, and the general conditions under which it is to be performed. Then call upon a number of Firms, who make a speciality of such work, to make proposals. Having obtained proposals, let the best design be selected on its general merits, and not merely with regard to cost. Having selected the design, then let details be arranged, and a final plan and specification be drawn up.

I have already furnished the Director of Public Works with the necessary specification. If this be transmitted to the Crown Agents for the Colonies, the proposals will be ready for my consideration, on my return, and I shall then be able to report, finally, as to cost.

At or about the same time, the surveys will have made sufficient progress, to, enable the Director of Public Works to submit a preliminary Design and Estimate of cost.

At the same time, let pipes be ordered. As the pressure, in parts at least, is somewhat great (400 feet), and as the ground over which they have to be laid is rugged, I am under the impression that steel or wrought-iron piping will be suitable, on account of its lightness, and of the ease with which it can be jointed. The best plan, however, will be to obtain preliminary tenders both for steel and cast-iron piping.

First instalment of work.

14. The Pumping-plant and piping being procured, let them be erected and laid forthwith. The large reservoir will doubtless take at least two years to construct. To realize some benefit, at the earliest date, let a small temporary dam be constructed, at some convenient spot, and from it to the permanent pumping-station, let a temporary conduit be laid.

If these operations be carried out with expedition, it will be possible to obtain some additional water, during the dry season of 1903-4.

General remarks on the proposed scheme.

15. It is evident that the Water-question is pressing. It is one which should take precedence of all other sanitary improvements, such as those of sewerage and drainage. The defects, which I have mentioned in connection with the latter are productive of nuisances, but are not menaces to health, certainly not in comparison with the present water-famine—cholera is at present in our midst. May this not be due to the fact that, owing to the scarcity of water-works water, people are collecting water from all sorts of places, such as nullahs and streams, obviously open to contamination? The actual scarcity of water is not the only, indeed, the principal menace to the public health. The intermittent system, under which the mains are emptied, for a considerable portion of each day, makes it possible for contamination to find its way into the mains. If, by any mischance, the bacillus of cholera were to find its way into the mains, the consequences might be grave. An incident, similar to that which occurred at Maidstone, might occur. Consequently every effort should be made to obviate the necessity for the intermittent system: and, as this cannot be done at once, steps should be taken to render the intermittent system as little objectionable as possible, in the manner suggested in a previous report.

At the present moment, it is not practicable to present well-considered reports, plans and estimates. Yet it is necessary to act with promptitude. I have, therefore, endeavoured to devise a programme of work that is certain to produce a benefit, proportional to the expenditure, while leaving ample margin for modifications in future design, should further investigations render it desirable so to do.

The expenditure which I have recommended is, I feel convinced, certain to effect, at an early date, a material improvement; and, most probably, will be a first step towards further advances.

As to the finite character of the water-supply of Hongkong.

16. It must not be supposed that the works which have herein been suggested, will provide Hongkong with a "practically unlimited supply of water," a phrase but too often used at the opening of new water-works, and one which was current in 1889, when the Taitam Water-works were opened. Its fallacy was fully demonstrated during the following year; when, but for some welcome rain, during the dry-season, the stock in the reservoir would have been nearly exhausted, before the commencement of the rainy season.

Further, I assert that all the supply that can be obtained, within the Island of Hongkong, is finite. Speaking somewhat at random, I doubt the possibility of much more than doubling the present supply, from *all* sources, by works within the island, of practicable character. There are certain remaining gathering-grounds, notably that draining to Saiwan, whose waters might be utilised. By all means, therefore, let such gathering-grounds be surveyed, and reserved for future use. Again, there are some valuable sources, which may someday, have to be abandoned. I find that, during an ordinary water-year, about one-sixth of the annual supply is derived from streams intercepted, along the courses of the two conduits. If the northern slopes of the hills, above the conduits, are built over, then these streams may have to be abandoned. Again, many now advocate the abandonment of Pokfoolum, some urging this step, on account of the excellent building-sites which would be liberated, others on sanitary grounds. I do not, of course, advocate such a step, though I am decidedly of opinion that works at Taitam, should take precedence of any at Pokfoolum.

Deductions to be drawn from the above mentioned consideration.

17. From the preceding considerations, the following deductions may, logically, be drawn. The Island of Hongkong can only provide water for a finite population, the exact number of which I am not prepared to state. The population, therefore, must be kept within bounds. Now there is no serious difficulty in so doing. In Hongkong the population does not increase, by the excess of births over deaths. It grows in proportion to the number of dwellings. Each new house is promptly filled to overcrowding. The measures which have been recommended, for the prevention of overcrowding and the construction of insanitary dwellings, tend in the right direction. As the land belongs to the Crown, it is easy to restrict the number of leases granted. I understand that it is proposed to undertake Reclamation to the Eastward of the Naval Yard. If this Reclamation be occupied by insanitary monstrosities, like the dwellings recently erected on the Praya Reclamation, then the population will increase largely, under extremely insanitary conditions. All future industrial establishments, involving the use of large quantities of water, such as Sugar Refineries, Paper-works, Dye-works and the like, should only be permitted on the mainland. Pressure should be brought to bear, on minor establishments of this character, which do not possess independent supplies, to remove to the mainland, by increasing the price of water, supplied by meter. In short, Hongkong should be, as far as possible, reserved for commerce, properly so called, whilst Kowloon and the New Territory, should be the industrial centre.

Lastly, Waste of Water must be strictly prevented. Though the present water-consumption, per head and per day, is reasonable, it can, certainly, and must be reduced. If the consumption had been reduced to within the amount which has

been shown to be practicable, then it is hardly an exaggeration to say that the present water famine would not have occurred. I will again repeat that the Universal Use of Meters coupled with an appropriate price for water, over and above a certain quantity, is the only efficient means of checking waste. Therefore, I recommend that the existing Water Ordinance be amended, in the sense of the original Draft Ordinance of 1890.

Water-supply of Kowloon.

18. I have nothing to add to what I have already stated, with regard to the practicability of obtaining a supply of water for Hongkong, from the New Territory. From any information obtained, since writing that report, it seems to me that, within the New Territory, water will not be an over-abundant commodity. I hope to make a more complete examination of the New Territory shortly, and will embody any further remarks in a special report.

Improvements to measuring apparatus at reservoirs and filter-beds.

19. It is most important to measure the water, drawn from the reservoirs and from the filter-beds, with every possible accuracy. I have pointed out that the present arrangements are far from perfect. As the drawings of the improved arrangements are in hand, and as the instruments and appliances can be made locally, I will not lengthen this report by giving a full description of them.

As regards the measurement of the yield of filter-beds, I would observe that the best appliance is a modification of the Venturi Meter devised in connection with a small water-works in the West Indies. If, as is probable, the Albany Filter-beds require alteration, I recommend this adoption of the form of Venturi Meter, which has this advantage that it gives at a glance, without reference to tables or calculation, the quantity of water afforded by the filter-bed, and also the head of water lost in passing through the sand, information which is essential to proper filteration. I also recommend their introduction in connection with the new Kowloon Filter-beds. They are made by Messrs. KENT, 101, High Holborn, London. I cannot remember the price, but it is not great. Prices could be obtained by informing Messrs. KENT of the maximum and minimum quantities to be measured by each gauge.

Peak Water-supply.

Reserve pumping-plant required.

20. In order to meet the increasing demand for water, throughout the Peak District additional reserve steam-plant is desirable, especially at the Western or Bonham Road pumping-station. Here there is, at present, one hydraulic motor and one steam-engine.

Causes of falling-off in quantity of water raised by No. 3 Motor.

21. It was originally intended that the Peak District should be principally supplied, by the hydraulic motor at Bonham Road (No. 3), the power being afforded by the water which passes to the lower Zone of the City. The quantity that can be pumped, in this manner, is some fixed proportion of the water, consumed by the lower Zone. Now, however, the consumption of water, in the lower Zone, or that part thereof which is supplied from Pokfoolum, is so small that very little work is obtained from the hydraulic motor. The steam-engine, originally provided as a reserve, is now used, almost continuously. This condition is aggravated by the fact that No. 2 Tank is in a ruinous condition, and cannot be filled. If this tank were reconstructed, as I recommended for other reasons, in another report, the flow of water through the motor would be rendered uniform and more work would be obtained from it. I therefore recommend the prompt reconstruction of No. 2 Tank.

Reason for a new engine at No. 3 Station.

22. A large proportion of the water, supplied to the Peak, must always be pumped, by steam, at the Bonham Road Station. As aforesaid, the quantity of water, which can be pumped by hydraulic power, is a fixed fraction of the water consumed, within that portion of the lower Zone. For this reason, the necessary quantity of water, for working the motor, may not always pass through it. Again, though water from Taitam can be pumped, at this station, by steam, this water cannot be used for driving the motor, on account of the relatively low level of

Albany Reservoir, 350 feet above O.D., as against 430 feet, in the case of Pokfoolum. As the supply from Pokfoolum is relatively small, conditions may arise, as at the present moment, under which there will not be water enough to provide the motive-power for pumping even the present supply, far less an increased supply, to the Peak. Practically, therefore, the existing steam-engine is the principal means of pumping to the Peak, and the hydraulic motor must be considered as an auxiliary, to relieve the engine, and so save coal, whenever conditions obtain, permitting its use. It is not safe to trust to one steam-engine, especially to one that has been over-worked, and now requires thorough over-hauling.

Bowen Road or No. 4 Motor. Elevation to which it will raise water.

23. A new hydraulic motor and pumps have been recently erected, in connection with the Bowen Road Filter-beds and Reservoir. It is so constructed that it can pump a reduced quantity of water to the Peak, or a larger quantity to the 700 feet level, with equal efficiency. It was originally designed to pump to a proposed reservoir on Mount Gough, at a level of 1,550. As, however, the Mount Gough Reservoir, is not yet constructed, reduced high-lift pump-rams have been provided, so that it can pump a lesser quantity of water, to a height of 1800 feet. Therefore, No. 4 Motor at Bowen Road, can now pump 15,000 gallons per day, if not actually into the highest reservoir, on the summit of the Peak, it will, no doubt, pump into the large service-reservoir, which is 70 feet lower, and it will certainly pump into the general system of mains, when the pressure is reduced by the draw-off.

The Bowen Road motor cannot be considered as a principal supply to the Peak.

24. The consumption of water at the Peak now amounts in summer to 70,000 gallons a day. Most of this is pumped by the existing steam-engine. Now the hydraulic motor at Bowen Road can, with the reduced rams, pump only 15,000 gallons a day against the full head. If, however, the existing rams were replaced by larger ones, as originally proposed, it would then pump 26,000 gallons in 24 hours to the reservoir on Mount Gough. It cannot pump more, being limited by the supply of water for motive power, afforded by the Bowen Road filter-beds. The Bowen Road motor cannot be regarded as a principal or even an alternative source of supply to the Peak. The Bonham Road engine must be the principal source of supply, and the supply from Bowen Road must be regarded as secondary only. Moreover, the Mount Gough reservoir is not high enough to command the whole of the Peak Districts.

The Bowen Road motor may be required for 700 feet zone.

25. There is another reason for regarding the supply to the Peak from Bowen Road as secondary only. There appears to be a tendency to build above the conduit up to the level of about 700 feet. The consumption of water, in this zone, is, therefore, likely to increase and it is probable that, before long, the Bowen Road motor will be fully occupied in pumping to the 700 feet reservoirs (it is provided with large pumps for this purpose). This is a further reason why Bowen Road motor cannot be regarded as a principal source of supply to the Peak.

New Engine and Boiler to be provided at Bonham Road.

26. These considerations shew that steam-power, at Bonham Road Station, must always be regarded as the principal source of the Peak supply. If the existing engine were to break down, it is clear that the Peak supply would be reduced to the small amount that the Bonham Road motor can pump, a quantity again limited by the consumption of water in the District supplied by gravity from Bonham Road Station. There must therefore be a reserve pumping engine at Bonham Road Station. In laying down a new engine it will be well to have one which will provide for future contingencies. I therefore recommend the prompt erection of a steam-engine, boiler and pumps capable of raising 100 gallons per minute to the summit of the Peak. The pumps, like those of the Bowen Road motor, should be so arranged that they can, if required, raise a much larger quantity of water to the lower level (700 feet zone) thus utilising the full power and developing the best efficiency of the engine, under both conditions.

27. The original rising-main from Bonham Road Station to the Peak is $2\frac{7}{8}$″ in diameter. It has recently been duplicated with one of 3″ in diameter. I learn that the old rising main is much corroded and that, at the present moment, it is not used. There is little doubt that it could be cleaned and repaired, were it worth while so to do. Rising main to Peak.

I find, however, that even two three-inch pipes will not suffice to carry the water that the proposed new steam-engine will pump. The new engine is to pump 100 gallons per minute, and the hydraulic motor will lift, when going full speed, about 40 gallons per minute. It is, therefore, desirable that a rising main, large enough to convey the water pumped, both by the new steam-engine and by the hydraulic motor, when working simultaneously, should be laid down. To this end I recommend that a new main, composed of equal lengths of 5″ and 6″ diameter, be forthwith provided. The larger pipe should be placed at the top of the hill, where the lesser pressure obtains. The existing mains should be removed, cleaned and re-coated. They may then be used elsewhere, perhaps in connection with the Kowloon Water-works.

28. The effect of the proposed works, at Bonham Road, will be as follows. The proposed new engine will lift 100 gallons per minute to the Peak. Working for twelve hours daily, it will give a supply of 72,000 gallons, about the present summer supply of the Peak District. When the No. 2 tank is re-constructed, the existing hydraulic motor will be able to work day and night, raising 57,600 gallons of water in addition to that raised by the steam-engine. Lastly, the Bowen Road motor will raise 15,000 gallons per day with the existing reduced rams, or 26,000 with those of the larger diameter as originally proposed. The Peak, therefore, may receive, from these three sources, 155,000 gallons per day. If the proposed new steam-engine were worked, night and day, then a further supply of 72,000 gallons per day could be given. By the time that this is wanted, it will be advisable to duplicate the proposed new engine, but this will not, I believe, occur for many years to come. Effect of proposed arrangement.

29. I shall not attempt to submit any estimate of the probable cost of the works which I have recommended. To do so, before surveys have been made and designs drawn, would be misleading. The following figures shew that the expenditure on water-works throughout Hongkong and Kowloon has not been excessive, compared with that which has been incurred in other cities. Financial aspect of water-works.

The following sums have been expended on water-works construction, exclusive of maintenance, according to the accounts of the Public Works Department:—

	$	Value of Dollar. s.	£
Expenditure prior to 1889, Pokfulam, Taitam, &c.,	1,752,933	4/–	350,587
Expenditure, 1890-1895 inclusive, Distribution Pipes, Peak supply, Kowloon supply, &c., ...	284,936	2/8	37,992
Expenditure, 1896-1901, New Works and Extensions, ...	429,794	2/–	42,979
Water Account, Cash and Stores, ...	38,830	2/–	3,883
Total Capital Expenditure,.....	$2,506,493		£435,441

The population of the Colony, according to the Medical Officer of Health, was, for the middle of 1901, 300,660, exclusive of the New Territory. The expenditure per head of the population is, therefore, $8.33, or, at the present rate of exchange (1/8$\frac{3}{8}$*d.*) 14/2*d.* It is not, however, correct to take the cost per head at any uniform rate of exchange for the dollar was formerly much more valuable than later on. I

have, therefore, reduced the expenditure to sterling, using the approximate rate of exchange that ruled during the several periods.

The capital cost of the water-works, throughout the Colony, may therefore be estimated at £435,441 or at the rate of £1.45 per head of the population, a very moderate sum, as the following figures, taken from the Presidential Address of Mr. JAMES MANSERGH, M. Inst. C.E., fully shew:—

	Capital Cost per million gallons per day.	Capital Cost per head.
London,	£ 87,253	£3.08
Liverpool,	183,297	5.15
Manchester,	182,927	5.40
Birmingham,	119,114	2.90
Glasgow,	66,320	3.60
Dublin,	60,000	2.20
Paris,	108,780	5.30
Berlin,	106,796	1.85
Vienna,	218,580	3.20
New York,	65,199	7.00
Chicago,	26,000	3.25
Philadelphia,	30,435	5.70
Boston,	73,578	7.00
Melbourne,	130,120	7.90

The supply, during 1901, was at the average rate of 3·53 millions of gallons per day. The capital cost per million gallons per day is, therefore, $£\frac{435,441}{3.53}$ = £123,354.*

The total expenditure, therefore, per million gallons per day, is also by no means excessive.

Taxation. 30. Nor is the taxation excessive. The total Water Revenue collected from all sources in 1901, was $168,966 or at the rate of $0.562 per head per annum. Taking it per 1,000 gallons delivered, the rate was $\frac{168,966}{1,287,000}$ = $0·13 per 1,000 gallons, a low price.

Conclusion. 31. I think, therefore, that it is clear that the Government of Hongkong may safely incur a fresh expenditure on water-works, at least equal to that incurred up to date, and also increase the water-rate or price for water sold by meter in such manner as to pay maintenance, interest and sinking-fund, on the augmented capital.

I have the honour to be,

Sir,

Your obedient Servant,

OSBERT CHADWICK.

The Honourable
THE ACTING COLONIAL SECRETARY.

* Note.—This amount does not include Kowloon or the Village supplies, so that the true capital cost per million gallons is somewhat less.