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REPORT

ON THE

DRAINAGE OF MADRAS,

BY

W. CLARK,

MEMBER OF INSTITUTE OF CIVIL ENGINEERS.

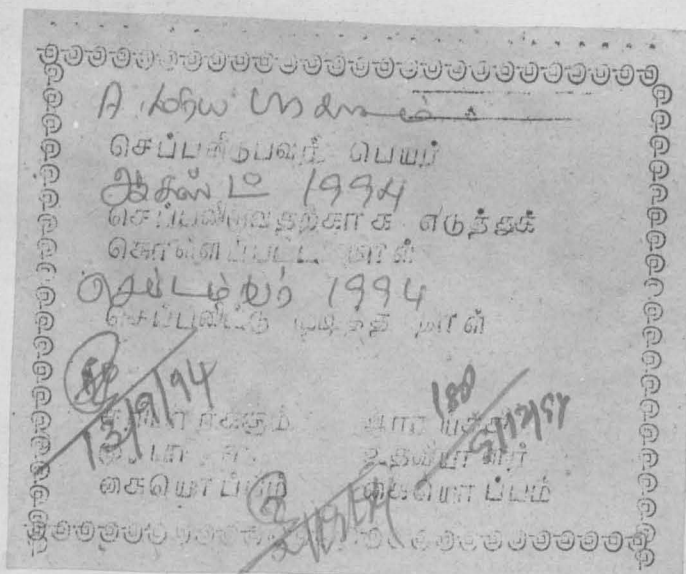
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DRAINAGE OF MADRAS.

DRAINAGE ENGINEER'S OFFICE,
123, MOUNT ROAD,
1875.

From
W. CLARK, Esq., C. E.,
Drainage Engineer, Madras,

To
Colonel G. W. WALKER, R. E.,
Secretary to Government, Public Works Department,
Fort St. George.

SIR,

In November last I was honored with instructions from the Secretary of State for India to proceed to Madras, for the purpose of laying out a scheme for the drainage of the Town.

In conformity therewith I proceeded by the earliest opportunity, and arrived in Madras on the 12th December 1874. I now have the honor to report the completion of my labors and to forward the plans, sections and estimates of the various works I propose should be executed, for submission to Government.

During the years 1864-5, Major Tulloch, R.E., had very carefully considered the whole question, and I have had the benefit of his report and plans to aid me. This Report is so full and complete on the various physical peculiarities of the district, its general features and conditions, that I need do little more than summarise what he has stated.

The Town stands on a sandy plain, the lowest part being from 2 to 6 feet, and the highest 16 to 24 feet above mean sea level; water is found in all parts of it, a few feet above or below mean sea level.

The rainfall averages about 50 inches per annum, which falls almost entirely during three months; and of this 20 inches in one month is not unusual. In fact the rain comes chiefly in the form of heavy storms at intervals, rather than as light rain of considerable duration.

I have also had the benefit of information contained in Dr. Cornish's Census Report which gives more accurate data as to the number of Population, Houses, &c., than existed in 1865.

Since that period also Madras has been provided with a water supply which has an immediate and most important bearing on the subject of drainage; the more abundant the use of water the more perfectly is the filth carried away in suspension in sewers.

Facilities for obtaining an abundance of this necessary of life leads to its larger use for domestic purposes; and the necessity for its more perfect removal thereafter becomes more urgent; for in the absence of proper drainage, not only is there a probability of larger absorption of fluid filth by the subsoil of the town; but evaporation, which is after all the principal means of removal from stagnant and inefficient drains, adds greatly to the generation and spread of malarious influences.

Municipal Divisions.

The city, for Municipal purposes, has eight divisions, which, with the number of inhabitants in each, and its area, is thus arranged.

Division.	VILLAGES.	Population.	Percentage to the Gross Population.	Total No. of Houses.	No. of Houses.			Population included in the area to be drained.	Population in each area to be drained.	Area of Divisions in square miles.	Area drained approximately.
					No. of Houses.	Tiled.	Thatched.				
1	Tondiarpettah	35,240	8.9	10,912	307	5,547	5,058	6,409	30,307	5.31	75
	Washerman's Pettah	6,409	1.6					426			
	Monegar Choultry	426	0.2					11,089			
	Royapooram	11,089	2.7					12,383			
	Cassimode	12,383	3.1					.....			
	Total	65,547	16.5								
2	Peddoo Naick's Pettah	65,629	16.6	7,493	2,096	5,003	391			0.74	
	Big Parcherry	5,179	1.3					.....			
	John Pereira's	2,330	0.7					.....			
	Fort Saint George	1,588	0.4					.....			
	Total	75,326	19.0					75,326			
3	Moothealpettah	32,062	8.2	5,782	1,442	3,912	408			0.91	1.65
	Uttapauliam	18,395	4.7					.....			
	Total	50,957	12.9					50,957	126,233		
4	Gunpowder Mills	641	0.2	1,492	65	904	463			3.88	
	Perambore	5,650	1.5					.....			
	Veyarapandy	3,500	0.8					.....			
	Total	9,791	2.5								
5	Choolay	15,600	3.8	7,538	552	5,771	1,210	15,600	65,491	2.44	2.44
	Pursewaukum	19,006	4.8					19,006			
	Perambore	11,375	2.8					11,375			
	Vepery	4,500	1.2					4,500			
	Poodoopettah	3,771	0.9					3,771			
6	Egmore	4,392	1.2	2,843	212	1,513	1,118	4,392		4.95	
	Comeleeswaram	7,544	1.8					7,544			
	Total	65,491	16.5								
7	Kilpauk	5,222	1.4	9,537	676	8,203	598	6,087		1.32	1.32
	Chetput	2,611	0.6					15,120			
	Kungumbakum	7,704	1.9					3,046			
	Mackay's Garden	3,833	0.9					33,258			
	Total	19,390	4.8					12,057			
8	Poodoopankum	6,087	1.5	6,169	295	4,431	1,503	6,087	20,575	4.40	1.01
	Chintadripettah	15,120	3.8					15,120			
	Narasimhapuram	3,046	0.7					3,046			
	Triplicane	33,258	8.3					33,258			
	Teroovatewarampettah	12,057	3.1					12,057			
9	Total	69,568	17.4					291,649		6.16	
	St. Thome	20,575	5.2	6,169	295	4,431	1,503	20,575		4.40	1.01
	Alwarpettah	1,163	0.2					.....			
	Royapettah	5,255	1.3					.....			
	Meersaib's Pettah	2,050	0.5					.....			
	Kistnampettah	5,193	1.3					.....			
10	Tenampettah	7,246	1.9	51,741	5,545	35,404	10,752		291,419	29.16	7.48
	Total	41,482	10.4					.....			
	Total Population 397,552.										

* To this must be added the area of unoccupied portions, such as the Esplanade, Island, Government House, Chepauk Ground, &c., which makes up the total area to 26.83 square miles.

No. 1 Division comprises the district of Royapooram and Tondiarpettah, and lies to the northward of the Railway at its sea side terminus; it is comprised between the sea on the east, and Cochrane's Canal on the south.

The southern portion of this area, about three-fourths of a square mile, is thickly inhabited, and will eventually be included in the drainage scheme.

The 2nd and 3rd Divisions comprise the whole of the Black Town, and the Fort St. George; it extends from the Railway on the north, to the river Cooum on the south; from the sea on the east, to Cochrane's Canal on the west.

These Divisions are about 1.65 square miles in area; the population amounts to 126,233 by the last Census Report.

The average number of population to the square mile is 98,732 in the 2nd, and 57,249 in the 3rd Division, and the number of inhabitants to each house averages 10, or about double the density of the most crowded European cities.

The 4th Division is entirely a suburban district, and is not included in the Drainage Scheme.

The 5th Division area is about 2½ square miles; for drainage purposes it is divided into two, the first including Choolay, Pursewaukum and Vepery. The second, New Town, Poodoopettah, Comeleeswaram and Egmore—portions of this area are also densely populated, amounting to 13.8 persons in the 'tiled' class of houses, which are about three-fourths of the entire number.

The 6th Division is suburban, and is not included in the Drainage Scheme.

The 7th Division includes Chintadripettah and Triplicane; this also for drainage purposes is divided into two districts. The population here averages from 7 to 8 persons in each house of the better class. Its area is a little less than one and a half square miles.

The 8th Division comprises Saint Thomé, Royapettah, and four other villages; of these Royapettah is adjacent to Triplicane, and is included with it in the drainage arrangements.

Saint Thomé, which contains about one-half of the 41,482, constituting its entire population, is one square mile in area,—it is too distant to be included in the general scheme of drainage; but its topographical features and proximity to the sea admit of a separate small scheme being devised for its drainage; which will be discharged into the sea in two places; the estimate for this work is included with the other.

The rise and fall of the Tide is about three feet, and I have assumed that the mean sea level is that taken by Major De Haviland in 1821, as 6 feet 10 inches below the mark cut by him in a stone fixed in the escarp of the North Ravelin of Fort St. George.

The datum to which the levels are referred in the plans and sections accompanying this Report is assumed to be 20 feet below the mean sea level, to avoid the use of + and—quantities.

The prevailing winds in Madras are supposed to cause the currents observed on the coast. From February to October winds varying from South-West to South chiefly prevail, they cause a more or less southerly littoral current, and continue nearly nine months in the year.

During the cold season, November to January inclusive, three months, the wind comes from North and North-East, with a corresponding change of the current,—this is of importance in connexion with the position of the outfall which has been chosen for the drainage system into the sea. This point is about two miles north of Black Town, it was selected by Major Tulloch for his drainage scheme, and I quite agree with his reasons for its adoption; it is at a sufficiently remote distance—about two miles from Black Town—to prevent any apprehension of inconvenience.

The present drainage of Madras is entirely of a 'surface' character, save where a few of the larger sewers near their outfalls have been covered over.

The smaller drains are usually about one foot square constructed of Brickwork, one on each side of the street, these receive all the slops and fluid filth of the houses, and conduct it to the main outfalls.

These are the Sea—the River Cooum,—and Cochrane's Canal, which is a tributary of the Cooum.

As a sample of surface drainage those who advocate that system may here see a fair example; a system of surface drainage which has doubtless been the result of careful enquiry and expensive addition from time to time during many years. How utterly it fails to remove without nuisance the matters discharged into it will readily be admitted by any one who will take the trouble to inspect the daily cleansing, and breathe the atmosphere then pervading the locality. These drains appear to be carefully attended to by the Sanitary Officer and his subordinates, but no amount of attention can render, what are in most cases stagnant receptacles of filth, otherwise than objectionable.

These drains also receive the rain water and conduct it to one or other of the outlets above named, and it is only on such occasions as a heavy storm that they are thoroughly scoured out, and for a brief period cease to be a nuisance.

The very small elevation of a large portion of Madras above the mean sea level, 6 to 8 feet only, and one and a half feet less at high water, renders the discharge of the sudden and violent tropical storms a matter of some difficulty.

Flooding of the lower parts of the town is not uncommon, which it would be impossible entirely to prevent, even if an expensive system of underground culverts be provided for the purpose.

Very early in my enquiry I was led to determine the necessity for omitting from the scheme any provision for storm water. The area of the town is so large and the distances so great, that any attempt to deal with it in the way of underground sewers would have entailed an expense quite beyond the means of the town to execute, as judged by the Assessment value of the houses.

An additional reason for excluding the storm water arises from the impossibility of making any provision which shall entirely remove the inconvenience of floods during the periods of storm.

The utmost that could be done within any reasonable cost, would be the construction of sewers to remove one quarter inch of rain fall per hour; as however this amount is exceeded, one inch falling not unfrequently in that period, it is evident on such occasions that the streets would be flooded, and the benefit would then be confined to the somewhat more rapid removal of the flood water when the storm had subsided.

Whether this would warrant the increased expenditure is matter for question; there would be an undoubted advantage attending such an arrangement in many ways; the old surface drains would entirely disappear; footpaths forming a marginal channel for conducting the surface water into the nearest entrance grating, would add greatly to the appearance of the streets, and the segregation of the pedestrian passengers would facilitate traffic and personal safety; but it would be a surface improvement after all, not actually required for the removal of filth, and I have, therefore, in consideration of the greater cost, certainly three times, decided to exclude the surface drainage.

The covering in of the present surface drains would of itself be a great improvement, but it would be accomplished at a cost of about 6 Annas per foot, or double that amount for two sides of the street; seeing then that

Side Drains not to be covered.

there are 125 miles of street to be sewered, I have omitted to include the cost (about 5 lakhs of Rupees) from the estimate, because it is a surface improvement, one to be dealt with after the more pressing drainage arrangements are provided for.

It is however probable that when, as I propose, these surface drains shall be kept, for the sole purpose of conveying away the storm water, that improvements may be made.

The principal outlet for the present drainage of Black Town is a large sewer, which occupies the site of a former nullah, in what are now Umpherson and Davidson's streets, and a portion of Popham's Broadway; both ends of the sewer are carried to the sea, the northernmost near Old Jail Street at the north end of Black Town, the southern one near the Fort. Into this sewer is poured all the fluid filth of about two-thirds of Black Town, and its 126 thousand inhabitants, here it stagnates till eleven o'clock at night when both outlets are opened, with doubtless a very necessary discharge of the filth, but with an amount of nuisance which is spoken of by those who are exposed to it with superlative disgust. Various expedients have from time to time been devised, for lessening the evil, a ventilating shaft has been erected to permit the escape of the stagnant abomination without result; what is now called Kellie's Column remains to indicate that attempt; some years since a windmill was erected to pump out the sewage, but it did not remove the nuisance; and more recently a Steam Engine has been erected for the same purpose, but it is not now in use; the various papers placed at my disposal show that for many years past, repeated attempts have been made to remove this monster nuisance, but in the absence of a large and comprehensive scheme for dealing with the whole question, the desired result has never been realized, and the Black Town sewer is now as famous for its potency as ever.

Several smaller sewers discharge into the Sea, and the remaining portion of Black Town is drained into Cochrane's Canal, which communicates with the River Cooum; and both are the subject of loud complaint from those who reside within their influence.

By far the largest portion of storm water falling on the 27 miles of the Municipal area finds its way into the River Cooum, and about one-half the drainage in the dry season.

The outlet of this River to the Sea is usually closed from February to October, including the hot season. During this period the River is in fact a tank receiving about one-half of the fluid filth of the Town. Organic matter thus becomes mixed with brackish water, and produces the inevitable result, an offensive smell and a more or less malarious atmosphere in its vicinity.

Moreover the level of the water in this shallow pool falls gradually to about low water level of the Sea, and a large surface of seething mud highly charged with decomposing filth exposed to the action of the sun.

It is however quite a mistake to attribute to the great luminary any of the evils which result; his active influence is ever exerted for good. Where filth exists the effect of the chemical as well as the calorific rays is to promote the purity of the atmosphere; and the most potent of the poisons resulting from decomposing filth are found in those open but stagnant drains and ditches where they seldom or never penetrate.

The last published Municipal Report is for 1871-2, which gives the following table of death-rate in the Great Cities of India.

Madras...	... 33.4 per mille.
Bombay...	... 25.0
Calcutta...	... 23.7
Lahore...	... 28.5
Nagpore...	... 22.3
Delhi...	... 41.3
Agra...	... 26.3
Lucknow...	... 25.5

Madras owes much to its proximity to the Sea, and the purifying influences of the Sea breeze; but notwithstanding all this, its mortality amounted to 13,215 persons or 33.4 per thousand, while 40 per cent. of this was due to Zymotic diseases, and there were thus 5,290 more deaths than should have been, had no sanitary evils existed within its boundaries.

The death rate for Madras, obtained from the Sanitary Commissioner's office, for the past four years is:—

1871	-	-	-	28.96
1872	-	-	-	35.26
1873	-	-	-	36.7
1874	-	-	-	37.1

The drainage of other portions of the Town area, Chintadripett, Komlasvarar Covil, and Pudapauk, drain into the Cooum.

Triplicane has two outlets to the Sea, similar to the Cooum, much smaller but even more potent.

Milapore and St. Thomé have another, these three small Rivers are shut off from the Sea for about ten months of the year, for they are sooner closed by the shifting sand at the shore, than the larger river, and the stagnant pools they form are even more strongly impregnated with decomposing matter causing an insufferable nuisance.

Beach Road.

Beach Road, which is the evening resort of the European population, is a fine road extending uninterruptedly a distance of four and a half miles from Old Jail Street to St. Thomé.

Here the cool evening breeze from the Sea in its curative and invigorating influence has won for it the term of 'Doctor.'

How thoroughly enjoyable is this evening drive, and its ameliorating effect on the Indian climate, every one will be ready to admit; but it has this very modifying condition, it must be approached judiciously. A drive along this $4\frac{1}{2}$ miles is not altogether pleasant or enjoyable; at intervals of one mile from the starting point at Old Jail Street the sewer abominations are felt. The two outlets of the Black Town sewer are first passed, then the Cooum which becomes very offensive when its communication with the Sea is cut off by the 'bar.' Then at intervals of half a mile, come the three smaller channels or Pools which are always, according to my experience, most offensive.

Six stinks "all well defined," must completely mar what would otherwise be almost unrivalled in Indian stations, as a place of healthful exercise and recreation.

It is quite evident, I think, that the condition of the Cooum would be immensely improved by keeping open the communication with the Sea, so as to admit a fresh supply of water with every flood tide, and thereby dilute—and if the drainage works I now have the honor to propose be carried out,—eventually and entirely remove the nuisance arising from its present misuse.

The three smaller streams above alluded to will only be improved when the sewage which now flows into them is entirely diverted into other channels for disposal.

I am of opinion there would be but little difficulty in keeping open the communication between the Cooum and the Sea at all periods of the year; and if this can be done, the River will then be at all times in the best condition for receiving the surface drainage. I had the honor to forward for submission to Government a memorandum on this subject, which will be found at the end of this Report.

I may now generally describe the principles and operation of the scheme which I have the honor to submit for the approval of Government.

It is intended to remove

1st. The fluid filth proceeding from houses and manufactories;

2nd. The subsoil water, from those localities where it is found in the soil near to the surface;

3rd. The excreta of the population.

The fluid filth from houses comprises the cooking and bathing water, urine, and slops of all kinds that can be removed in running water.

It does not include ashes, entrails of fish and fowls, bones, cow dung, or any solid substances which should be removed by the Conservancy carts.

The quantity of this fluid filth, or 'house drainage' is represented by the water supply which after having performed its various uses should be removed by the sewers; and for the purposes of calculation, I have assumed that the supply is 20 gallons per head of the population residing in the divisions to which it is proposed the work should extend; these are given in a tabular form at page 2.

The new source of supply to Madras is said to be capable of giving 40 gallons per head to the entire population; a quantity I think not likely to be required, but which provides a satisfactory reserve for periods of drought.

The present consumption is said to be about 7 gallons per head; it is limited to this in consequence of there being, at present, but a small number of houses supplied direct from the mains, for which an extra charge is made; only a limited number of connections are allowed in each street, so as to prevent any undue decrease of pressure.

In the comparatively few streets to which the pipes extend, the applications for connections are numerous; and there appears to be no hesitation about incurring the expense of laying on the water to their premises by the owners in those favored localities; about 100 houses are so connected.

The people, however, generally resort to the public fountains, and carry the water to their houses; how great a labor this is, will be best seen when the aggregate amount is considered.

The total population of Madras at the time of the last Census, in 1871, was 397,552; at the rate of one gallon per head the weight to be carried is 1,774 tons; the distance of the fountains apart averages $\frac{1}{4}$ mile, one-half this distance is therefore the maximum distance the weight is carried. Seven gallons per head amounts to no less a quantity than 12,418 tons, nearly all of which has to be carried to the houses of the people.

The water would doubtless be a far greater boon than at present, if this amount of daily labor could be reduced, by a more extended means of distribution.

I am informed that all the larger pipes necessary for an extended consumption have already been laid; what is now required would therefore be confined chiefly to a longer length of the smaller pipes.

There can be no doubt, I think, that with increasing knowledge of the use, and value of an abundant supply of water, some extension of the pipe system will be made; and I have, as above stated, taken the usual quantity of 20 gallons per head for the purpose of calculation.

The quantity of 20 gallons per head of the population is therefore the quantity which the drainage system should remove and which comes under the denomination of House drainage.

This consumption is not, however, uniform during the 24 hours, it is greatest between the hours of 7 and 10 in the morning, and I have assumed that one-half or 10 gallons of the daily supply is used during six hours.

The next item is the subsoil water; this varies of course with the various seasons, wet and dry, of the year. It is greatest during the periodical rains, but it continues for a considerable period after their cessation, varying with the character of the subsoil; while sand parts with it readily, clay retains it for a much longer period.

During the rainy season of the year the quantity of subsoil water in Madras will probably fully equal the amount of the water supply at 20 gallons per head, and this, as I have explained, will continue for a considerable period after the rains have ceased. Under the head of subsoil water, I propose therefore to provide for the removal of a quantity equal to the water supply, 20 gallons per head, flowing away uniformly during the 24 hours.

The last item to be received by the sewers, is the night soil and excreta of the population. On this subject authorities are not agreed, and very divergent are the opinions offered.

Various systems have been brought forward and have found advocates. Among these are the Liernieur, dry earth, and charcoal systems—and many other substances and methods have been used for obviating the nuisance of its removal; while many are the objections urged to the principle of the water carriage system in sewers. Without entering into any long discussion of the subject I would call attention to the fact, that whether the night soil be admitted to the sewers or not, the cost of the drainage system will not be effected one single Rupee; the quantity to be thus removed is so small compared with that the sewers are competent to remove, that the small addition amounts practically to nothing.

With the exception of the Liernieur system (which is said to cost about £2 per head of the population; about three times the cost of the entire drainage works I am about to propose) all the various methods suggested for the disposal of this material involve the cost of carriage and manual labor. Up to the present time, as far as I know, not one of them has been successful in an economical point of view; and an expense is entailed on the community or company as the case may be, about equal to the cost of carriage and the substance with which it has been mixed; Liernieur himself up to this time has not, I believe, been able to show any financial results, though he has proved the possibility of removing the substance by his apparatus.

Sewage irrigation has been for several years gradually extending; by the water carriage system, no further expense is required when the water and proper drainage works are available; the handling of the substance is entirely unnecessary; moreover it passes away at once without any stoppage or detention, and is out of the limits of the populated area before decomposition can take place.

The water carriage system will, I think, be readily admitted to be the cheapest where water is available and abundant, as it should be in Madras, if the pipes for its distribution are extended throughout the town.

This not being the case it is too much to expect that the native inhabitants will carry an additional quantity of 20 lbs. per head (which would be sufficient) or an additional 3,548 tons of water daily for this purpose; and the night soil will not to any great extent, under the present state of the water supply, be put into the sewers.

I would, however, urge that every encouragement and facility be given to those who are inclined to adopt this plan; first, because it reduces the necessity for a most disgusting occupation; also because it reduces an inevitable nuisance; and lastly, because by sewage irrigation I believe it will find its most profitable employment in increasing the productive power of the soil, which is its proper and legitimate use.

I consider also that what in Bombay is known as the Halicore cess, a separate and distinct tax paid for removing excreta from the houses, is a legitimate source of revenue; which those of the inhabitants who may arrange for its removal by the use of the sewers, and a larger consumption of water will entirely escape.

The arrangements which I have made include the following separate and distinct areas for drainage:—

Drainage Divisions.	First.—North of the Railway.
	Second.—Black Town.
	Third.—The Fort.
	Fourth.—Pursewalkum, Egmore and Poodoopettah.
	Fifth.—Chintadripett.
	Sixth.—Triplicane, and
	Seventh.—St. Thomé.

The first of these is the only portion to which my scheme in detail has not extended; up to this time the levels are not taken, but it will be comparatively easy for any one who may have charge of the work to do this, as a Brick sewer extending from the Sea Beach along Old Jail Street, and capable of conveying its drainage in the quantity I have mentioned is provided. This sewer will also at once be available for draining the Government buildings on the North side of, and adjacent to, Old Jail Street.

In the second or Black Town Division there is a considerable variation of surface; there are two well defined ridges parallel to the Sea shore with the Street known as Popham's Broadway in the valley between them; the level of this and several adjacent parallel street is from 6 to 7 feet only above mean Sea level.

The ridge on the West is occupied by Salay, or Mint Street, and from this ridge the drainage on the West side is into Cochrane's Canal.

Along Umpherson and Davidson's Streets and a part of Popham's Broadway is the large sewer which occupies the site of an old stream, and terminates at both ends in the sea.

Along Popham's Broadway it is intended to construct a Brick sewer with a fall of 4 feet per mile towards Old Jail Street, where it meets with another Brick sewer for draining Royapooram, extending from North Beach Road along Old Jail Street.

From the junction at Popham's Broadway, it is still continued along Old Jail Street to Mooneappen Moodelly's Street, along which it is carried to Peddoo Naick's Lane; here it leaves the public thoroughfare and is carried through Garden Land till it reaches Annapilly's Street, thence it continues through Public Land, on which there is a Wood Bazaar, and the Cobra Tank to Wall Tax Road.

Here it joins the Pumping Station which it is proposed to place on the open space of ground at the foot of the Elephant Gate Bridge and close to the Canal.

This point is nearly central to the area to be drained, and its adoption insures the best available inclination to the sewers, while it avoids excessive depths.

The Southern portion of Black Town, and the Fort, will be drained into a Brick sewer extending along the Wall Tax Road, to the Hospital Gate Road, as far as Evening Bazaar Road; here the Brick sewer, which is laid at an inclination of 4 feet per mile terminates, and a 12-inch Pipe is carried into the Fort at an inclination of 1 in 625.

Crossing the Fort Ditch below the level of the water it will be possible to place a valve in the Pipe (which will here be of Iron) by which this Pipe can be flushed should occasion require.

Syphon under Cochrane's Canal.

The Main Sewer is carried from the Pumping Station by a 3-foot Iron Syphon under the Canal, through the People's Park, to Sydenham's Road, at an inclination of 2 feet per mile.

Here it sends off a Branch through Choolay Bazaar Road for a distance of 1,350 feet. It is then continued along Vijiavignaswarar Covil Street by a double 15-inch pipe, at an inclination of 1 in 700 up to Perambore Barracks Road; from this point a single 15" Pipe proceeds along Vencatasabuthen Street, and a low swampy portion of land, which is called Oday, and conveys away surface water in the wet season.

From this point it is carried along Condapah's Moodelly, High Road, into Pursewalkum High Road at the same size and inclination. Here it is reduced to 12" in diameter and the inclination is made 1 in 600; it terminates at Venethetha Moodelly's Street.

From the Choolay Bazaar Road the Main Sewer extends along Sydenham's Road to near Lawe's Bridge over the Cooum River, which is crossed by an Iron Syphon 2 feet in diameter, laid below the bed of the stream into Chintadripettah; here it enters Iyah Moodelly's Street which it traverses its whole length to the Waller's Road; it is then laid for a short distance through Nursingapooram Parcherry, to the compound occupied by Messrs. Taylor's Livery Stables which it crosses diagonally, and enters Blacker's Road, along which it proceeds to Wallajah Road.

Mount Road.

From this point a branch 12" Pipe Sewer is laid along Mount Road at an inclination of one in four hundred as far as Woods' Road.

Triplicane.

The Brick Sewer is continued along Triplicane High Road, to the Nabob's Palace; across the compound of which a 15" Pipe is laid through Chellapilliar Covil Street to Pycroft's Road, and terminating at Peter's Road, where it receives the sewage of Royapett.

In the Triplicane High Road, the Brick Sewer is continued to the crossing of Pycroft's Road; from this point it is extended to Peter's Road by a 15-inch Pipe. Another Branch Pipe is laid towards the East in Pycroft's Road to Vencatarunga Pillay's Street. The whole of these main sewers except where otherwise mentioned, have an inclination of 4 feet per mile.

One other Branch remains to be described; this extends from Sydenham's Road, along Poonamallee Road, to the East side of the Scotch Church compound; along which it is carried to Jordan's Road; it is then continued along this and Whannell's Road, to Pantheon Road; here the Brick sewer terminates, and a Pipe 12" diameter is carried through Lang's Garden Parcherry to Harris' Road, at an inclination of 1 in 765.

Main Sewers.

From Jordan's Road a 9" Pipe sewer is carried along Male Asylum Road to Egmore, at an inclination of 1 in 400.

I have thus described generally the position and particulars of size and inclination of the main sewers; they are all adapted to the work they have to do, and are sufficient for the purpose; in most cases they are laid below mean sea level, and will permanently receive subsoil water, even when other portions of the system during the dry season of the year may cease to do so.

No special arrangements for Flushing.

The conditions under which they are placed will necessitate no especial provision for flushing.

Deposit in sewers chiefly consists of road sand—the material of which the road is composed when ground down by the action of wheeled vehicles; on the occurrence of the first shower of rain this road sand is washed into

the sewer more or less according to the precautions taken to arrest it by 'Gully Pits,' where the storm water is first received; but however perfect the action of these pits may be in arresting the heavier particles, a large quantity is carried into the sewers;—many hundred tons are thus washed into the sewers of a town as large as Madras by a single shower, and expense is usually entailed when its removal by hand, is necessary.

For this purpose the Brick sewers were only a few years ago generally constructed of Brickwork, of a size to admit of the entrance of men for the purpose of cleansing them, and without reference to the quantity of fluid filth they have to remove; sewers were thus frequently made too large for the work they had to do. It is now well known that the more concentrated the flow of any given stream, the greater is its power to keep itself clear and free from deposit; this led to the adoption of the oval shaped sewers, where the invert is generally struck with a radius not exceeding that of a Pipe Sewer, hence the oval Brick Sewer combines both advantages.

The only legitimate argument for making a sewer large enough for a man to enter it is for the purpose of making good the House connections.

But in the scheme which I now propose, it is intended to exclude the surface water, and this source of deposit material is at once got rid of, while of the household processes by which sandy material is produced, probably that of scouring brass cooking utensils in this country is the only one from which such deposit could occur.

There is, however, every reason why the cleansing of the sewers should be provided for. When Pipe Sewers are laid in sandy soil it is always necessary to thoroughly cleanse them of the sand which unavoidably enters the pipes during the process of laying, especially if it happens to be in wet and difficult ground.

For the purpose of cleansing the Pipes, my practice has been to lay them in straight lines, and never on any account to depart from this rule. At a distance not exceeding 300 feet a 'man hole' is constructed; this is a well extending from about 1 foot below the surface of ground, where it is covered by an Iron cover, to the depth of the sewer; it is usually of oval from 3' 6" long by 2 feet in its greatest width; it is sufficiently large for a man to enter; if the Pipe Sewer is clean he is able to see light at the other end, as a perfect circle; if it be obstructed, a split bamboo with a small line attached can be forced through to the next man hole, this is made to draw a light chain with a circular Iron Scraper made for the purpose.

If then there be any quantity of water running through the Pipe, by the help of the agitation caused by drawing the chain back and forward, it is speedily removed and carried down the Pipe to the next man hole.

All Pipe Sewers are thus easily cleansed if necessary. If the Pipes be properly laid and all entrances to House drains trapped by Syphon traps, *as they should be*, it becomes exceedingly difficult to put anything into the sewers which will stop them.

As the same velocity can be obtained by a given quantity of fluid in a pipe as in a Brick Pipes or Brick Sewers may be employed. Sewer, and if the pipe be of sufficient size to do the work required of it, it is manifestly more desirable to put down the cheaper small pipe, than an unnecessarily large Brick Sewer, and this principle has guided me in laying out the main sewers which I have above described.

In the arrangement of the smaller Pipes the same principle has been followed, save that when the quantity of fluid to be passed through a pipe is very small, it becomes necessary to assist its self cleansing action by a better gradient, thus the smaller pipes have better falls than the larger into which they discharge.

Greater fall given to the small pipes.

In the present scheme no 6 inch pipe, which comprises five-sixths of the whole, has a Minimum fall of smaller smaller gradient than one in three hundred, or something more than 17 feet per mile, and many of them much more than this.

Man holes such as I have described at every 200 to 300 feet, are also constructed at every junction of one Street Sewer with another; in these cases the floor of the man hole is formed by brick in cement into a sort of half pipe channel, having the effect of a curved junction. It is also desirable at all junctions of Pipe Sewers, to give the tributary Pipe a fall of from one to three inches to accelerate rather than retard the main stream.

When, owing to the tortuous windings of a lane, the man holes would be very close together. Lamp holes are adopted in their place alternately with the man holes. These are considerably cheaper, being from 9 to 14 inches square only. A lamp suspended in them enables a person in the adjacent man holes to ascertain if the Pipe be clear, and if not the position of the obstruction; all these are provided for in the Estimate.

From what I have said in Page (7) the quantity of fluid to be passed through the sewers will be at the rate of 20 gallons per head of the Population; and half of this or 10 gallons will enter the sewers in 6 hours.

To this must be added the sub-soil water equal to 20 gallons flowing in uniformly during the 24 hours, or at the rate of 5 gallons in 6 hours. Thus 15 gallons in 6 hours may be considered as the maximum flow for each unit and 15,000 gallons per 1,000 of the Population. This quantity is 41.66, say 42 gallons per minute.

In Black Town an examination of the Revenue Survey shows that the holdings average 30 feet of Frontage.

The number of persons residing in each of these is greatest in the 6th Division, where 13 persons reside in 'Terraced Houses' there however this description of house is not numerous, the 'Tiled House' are more than double the number, and in these 6.7 is the average.

In Black Town the greatest number also reside in Tiled Houses and the average is 10.3; but taking 10 as the average for all houses, then there will be 10 persons residing on every 30 lineal feet of the street on one side, or double the number on both sides; this amounts to 20 persons on every 30 feet or 2,852 persons per mile; if therefore 2.852 be multiplied by 42, it will give the quantity, 120 gallons per minute.

Now a 6 inch pipe sewer laid with a gradient of 1 in 300 will discharge 134 gallons per minute. It is evident therefore that in Black Town a 6 inch pipe may be laid so as to receive the drainage of one mile of houses. In no case however has this limit been approached in the present scheme, and ample provision is therefore made for the maximum flow of drainage fluid as above calculated.

Similarly all the large sizes are determined and a margin left for even an increased flow.

There is much reason to fear that the quantity to be carried away will be much less than what is shown above, until the water supply is further extended.

The larger the quantity of fluid flowing within their capacity, the more perfect the action of the sewers.

The pipes are laid as before described in perfectly straight lines, they are bedded in concrete to prevent unequal settlement and preserve the accuracy of the line both vertically and horizontally. Regularity of shape and perfect lines and levels are both necessary to success and both are attainable.

The Pipe joints are made with Portland cement for three parts of the circumference the remaining one-fourth at the top is packed with well tempered clay and covered with concrete. This prevents the entrance of sand but permits small quantities of sub-soil water to pass in at the top of the pipe and thus the sub-soil drainage is effected.

It is well nigh impossible to make Brick sewers water-tight, when they are laid, as they will be here, beneath the permanent level of saturation; most Bricks are so porous that the water passes through them. It is however, usual to put an agricultural drain pipe through the side wall of the sewer at intervals of 50 feet above the general line of flow; this terminates in a lump of broken bricks on the outside, it admits the sub-soil water, and excludes the sand and by this means also the sub-soil drainage is effected.

It may be, that owing to the intrusion of some semi-fluid substance flushing may be necessary; one cause of this I have found in semi-fluid cow-dung, which the cow-keepers thus endeavour to dispose of, when they are unable to dry and sell it, in the wet season.

For flushing, the man-holes are a great assistance. Some temporary expedient such as a ship's 'swab' may be jammed in front of the pipes so as to prevent the water from escaping; if the man hole then be filled with water by a hose from a neighbouring water main, and the stoppage of the line requiring to be cleansed is suddenly removed, a considerable body, 40 or 50 cubic feet, of water may be forced through the pipe and wash it out completely.

When constructing Brick sewers in ground saturated with water, it is usual to first lay a drain pipe in concrete, a few inches below the level of the sewer; this collects the water from the subsoil, and it is pumped out from small wells or 'sumps' at intervals; this plan enables the construction of the Brickwork to be more satisfactorily accomplished than it could otherwise be, and notwithstanding the cost of the drain pipe it is the most economical mode of proceeding. It also enables the coating of Cement Plaster to be laid on the surface of the Bricks, which, if the cement be good, is impervious to water; it prevents their absorbing the sewage, and gives a smooth surface to the channel. This cannot possibly be accomplished unless the sewer be kept free from water.

Cement Plaster for the interior of the sewers is provided in the Estimate.

After the sewer is completed it is usual to fill up the wells or sumps with concrete, and exclude the subsoil water; I have, however, in a few cases left a small space to be filled with agricultural drain pipes placed vertically so as to admit the subsoil water to rise into the sewer from the drain pipe; where these are left however there should always be a greater pressure of water tending to enter the sewer, than is due to the depth of the ordinary flow favoring its escape.

Where the sewer is constructed at any considerable depth—4 or 5 feet below the level of saturation—this will usually be the case, and in such cases small fountains remain permanently, and are most useful in keeping the sewer clean, while the subsoil drainage is also provided for.

The ventilation of the sewers will be effected by gratings fixed in the Road surface near to the man holes and in connexion with them at distance of about 100 feet, these are provided for in the Estimate and shewn in the drawings.

I have now generally described the positions and the action of the main and pipe sewers for conveying the sewage to the pumping station, which, as I have before mentioned, I propose should be constructed near the Elephant Gate Bridge.

Three main sewers, viz., from Royapooram and north side of Black Town,—the second from the south end of Black Town and the Fort; and the third from People's Park, which receives all the drainage of Pursewaukum, Chintadripettah and Triplicane. All these will be received into a well 30 feet in diameter, at the Pumping Station. This well will be sunk 10 feet below the level of the sewers, and the inverts of these will be 8 feet below mean sea level.

The work required to be done by the Engine will be as follows:—

The total population living on the drained area will be (as per Table, page 2) 296,904; 300,000 may be taken for calculation.

The maximum quantity of House and sub-soil drainage may be taken at 42 gallons per minute per 1000 of the population, page 12.

then $300 \times 10 \text{ lbs.} \times 42 \text{ gallons} = 126,000 \text{ lbs.}$
and the lift will be 19.5

630,000
1,134,000
126,000

2,457,000.0 foot lbs. per minute.

$\frac{2,457,000}{33,000} = 70 \text{ Horse power.}$

When the works are fully completed the working of 70 Horse power effective, will be required during 6 hours of the day.

This power must be supplemented by one-half more, or 105 Horse power effective, in the aggregate.

For the present two Engines of 35 Horse power effective, will be amply sufficient, and the cost of these and the Engine House, &c., to contain them is provided in the Estimate.

The Engines and Pumps I propose to erect will be precisely similar to those which in Calcutta have proved successful, with such improvements as experience since their erection has suggested.

The principal feature of these combined Engines and centrifugal pumps, is a large cast Iron cylinder, extending from a little above the invert level of the sewers, to the top of the outlet culvert; in this case it will be 20 feet high, by 8 feet diameter.

On this cylinder the Engines, and A frames, carrying the driving wheel are supported; and the vertical shaft and centrifugal pump disc are suspended.

The suction pipes extend from the bottom of this cylinder to a low level in the pump well.

The Pump disc is formed of two circular metal plates, with a circular hole in the centre. The two plates are kept apart by curved division pieces extending from the circular hole to the periphery of the disc, which is open.

The disc is attached to the end of the vertical shaft at its lower end, and when in place is at the bottom of the vertical Iron cylinder.

The Suction pipes, are so arranged as to carry the sewage to the circular hole in the disc which is made to revolve with great rapidity.

This motion causes the sewage to be thrown out of the disc at its periphery, as it continues to enter at the circular hole at the centre, and with the force necessary to insure its rising in the Iron cylinder to the required height above the invert of the outfall culvert. The outlet Pipe from the cylinder leaves it at a higher level, and thence the sewage flows to its outfall.

In the present case the top of the cylinder will be somewhat higher than the top of the outfall culvert in Mint Street, and the connecting channel between them will be an Iron Pipe 3 feet 6 inches in diameter, laid in Rawmanen Street; up this Pipe the sewage will be forced into the outfall culvert by attaining a sufficient height in the Pump cylinder.

I have thus endeavoured to describe the Pumping operation in order to show that it can be so arranged as to prevent any nuisance from arising.

The Pump well will be entirely closed from the outer atmosphere, but a flue will be constructed from it to the Boiler furnaces, the Pump well will be thus ventilated and the gas consumed by the Engine furnaces.

The suction Pipes are of Iron, air tight in their connection with the cylinder, the top of the cylinder is also closely covered; it is evident therefore that the sewage is not in any way exposed to the air during the process of Pumping, and there can be no escape of gas and no nuisance.

An apparatus consisting of an air blowing cylinder will be attached to each Engine and Iron Pipes to convey compressed air to the Pump well, this Pipe terminates in an open perforated Pipe laid on the bottom of the well. The use of this is to agitate the sludge or semi fluid which may accumulate in the well, and mix it up with the more fluid sewage, and so dilute it as to permit its being pumped away, thereby obviating all necessity for manual labor in cleansing the well.

This arrangement has been perfectly successful in Calcutta, where frequently a quantity equal to 600 tons of solid in the form of road grit is disposed of in about 4 hours.

A culvert to convey water from the canal, when required for the purpose, will be provided.

The outlet Pipe from the Pumps will as above stated be 42 inches in diameter, of Cast Iron, it will be laid along Rawmanen Street as far as Mint Street which occupies the ridge of high ground above referred to Page 9. It is of such a level as to admit of a Brick culvert four feet nine inches high being laid beneath the surface, with an inclination of five feet per mile; at its highest point where the Iron Pipe from the Engines joins it, its invert is 10 feet over mean sea level or 30 feet over datum. The total fall in the outfall culvert will therefore be 10 feet, which is thus distributed.

Dimensions and Fall.

3,170 feet 4'9" x 4'0 oval culvert fall 5 feet per mile
12,536 " 5'0" x 4'6 " " " 2 feet per mile
3,866 " open excavation with walling at bottom 4 feet; fall 1 in 3,040.

The open excavation is carried through market Gardens, and waste land to the sea.

At the sea end a length of 200 feet of 5'9" x 5'0" oval brick culvert will be constructed with a further length of 22 feet of stone masonry work in which the junction lengths of a 4'6" cast Iron pipe will be firmly secured at the margin of the sea. This four feet six inch Pipe will be continued into the sea for a distance of 100 feet, supported on Screw Pile jetty work.

At the end of the Pipe a valve is arranged to close by a float, the object of this is to prevent sea water entering the Pipe, while the sewage is allowed to escape freely. The level of the Pipe is one foot above mean sea level.

The point chosen for the discharge of the sewage into the sea is 2 miles to the north of Old Jail Street, there are no habitations near, and along the line of the open excavation, it is equally removed from residences of the population.

This open portion of the outfall channel can also be made in the form of a Brick culvert, of course at some increase of cost, but I have considered desirable that it should be constructed as an open channel, and every facility given to the market gardeners on the line to irrigate their gardens with the sewage; there is no doubt whatever of the result.

The fertilizing value of sewage being thus illustrated, it is to be hoped that some capitalists may be found to take up the question of the utilization of the entire sewage of Madras, any of the waste land lying at a level not higher than 8 or 9 feet over mean sea level and within a distance of 5 or 6 miles of Madras may be irrigated with the sewage without further pumping.

There is an enormous area of low land in the direction of the Canal which may thus be fertilized. Much of it would however, require special works for its drainage, but even this will not be too expensive an operation to exclude its use.

Of all the various schemes which have been adopted for the disposal and utilization of sewage, irrigation is the one which has, according to my experience, proved remunerative, which requires no manipulating or manufacturing process, always expensive, previous to use; and which is most readily applied. Sewage farms in the neighbourhood of London and other large Towns in England are rapidly increasing with promise of great success.

In England the one great difficulty is the cost of keeping the land clear of weeds, which grow as rapidly as the crops, this is a serious difficulty in sewage farming. In India however, where crops of equal value, sugar-cane, tobacco, corn, garden vegetables, and the grasses grow under its influence most luxuriantly, the cost of manual labor is cheap, and the great difficulty disappears.

Having had the management for a short time of a small sewage farm, I can speak with great confidence on this question. It is too much to expect that any profit can be immediately realized by the Municipality out of sewage operations of this kind, but after the requisite experience has been obtained there can be no doubt whatever that capital may thus be profitably employed, and the necessity for discharging the sewage, except on rare occasions into the sea, be avoided.

Such is a general view of the Drainage scheme I propose for consideration of Government. I may now add a few ideas on the subject of material.

I have throughout spoken of Brick sewers and the estimate has been made for Brick-work of a very superior kind; but the Bricks I have seen in Madras are not well suited to this work, though well shaped, and burned, they are too absorbent; the material of which they are made is not good, and I have included in the estimate the cost of inside plastering with cement, if this is properly done it is like a coating of smooth stone, and will remove the objection of absorption.

I have also provided for a large quantity of concrete in which the Brick sewers are to be embedded, this will very materially strengthen them, but it involves considerable expense.

Laterite.

It has occurred to me, and I have taken steps to enquire, as to the use of laterite Blocks for this purpose in substitution for Brick sewers, to be plastered with Cement on the inner surface of the sewers.

The questions to be solved are, can this material be cut with sufficient accuracy and to the required shape? If so will the cost be less than that of Brickwork? I have very little doubt that all these questions may be answered in the affirmative, some blocks are now being cut of the required shape, and the point may soon be settled.

Cement Plaster.

The next question, will Portland Cement adhere to the Laterite blocks in the sewage? this will take a longer time to answer, and I would propose that some of the Blocks should be cemented and placed in one of the sewers to ascertain if the adhesion of the Cement continues perfect under these circumstances; I would advise the continuation of this inquiry.

Concrete blocks.

Failing the use of laterite, concrete blocks may, I believe, be employed with advantage, and almost equal economy.

So much of the material for these works requires to be of special form, if brick be used some considerable time must elapse before a commencement can be made; the sewers require almost exclusively bevelled bricks; the man holes wedge-formed bricks, and so on; all this will take time to prepare, but if laterite be used this loss of time will be wholly avoided, as I am informed there is an abundance of material within 12 miles of Madras and labor to cut it.

The drain pipes to be used should be of the best quality procurable; India according to my experience though possessing the crude material has not at present produced pipes with the accuracy of shape required. The best English Pipes leave little to be desired in this way; not only must the pipe be good, but of even greater importance is the accuracy of the workmanship required to lay them. Native workmen when carefully instructed are quite competent to this; and the considerable quantity of concrete provided for in estimate on which to bed them will, I believe, prevent sinkage and insure permanent and good lines.

Probably most important to the efficient action of any drainage scheme is the House Drainage. This is usually left to ordinary workmen who may or may not have the requisite skill and experience. The unanimous opinion

of all Sanitary Engineers I have met with, and it is decidedly my own also, is that none but men who are experienced in the work should be permitted to touch it; this of course necessitates the employment of a department for the purpose; where every man's work can be known, and any failure traced to its proper source; where work must be at once covered up and remain unseen, it is too great a temptation for irresponsible and often very ignorant men, to scamp it.

It may, and generally does happen, that on completing a House Drain Pipe a length is required to fill up an interval, not exactly 2 feet (the manufactures' length) and another of the required length is not procurable; it is a material impossible to cut, the consequence is that a broken pipe is put in and an open joint is left, through which the sewage can escape and saturate the surrounding soil; and which may also admit the earth and cause a stoppage in the pipe.

There are innumerable ways in which the efficiency of a Stone-ware Pipe House Drain can be impaired in its efficiency without actually failing; the result may be, and often is sickness in the household; and from such causes the bad workmanship of incompetent workmen House Drainage as a system is actually in some cases condemned as an evil rather than a good; every one who has experience in the

subject will be able to confirm what I have now stated, and as to the general inefficiency of the work done by persons without the necessary especial experience.

I have spent many years in endeavouring to perfect the scheme of drainage in Calcutta but I entertain serious apprehensions that the good which has been done will be very considerably diminished by the 'free trade' in House Drainage which has been encouraged, notwithstanding my repeated remonstrances; and in Madras I would commend this subject to the consideration of those who may be intrusted with framing the rules and regulations under which such works are undertaken.

House Drainage should be executed by the Department.

All these evils would be avoided, by a responsible department who should not only construct, but give necessary attention to the working and maintenance of the drainage, at the expense of the owners.

I am of opinion also that every facility should be given for the economical construction of the house drains. The mass of the people who have to pay for them are poor and can ill afford to do so, the order to expend 40 or 50 Rupees is to them a serious difficulty, usually they are desirous of having the benefit of the improvement, but oppose it rather than have to pay for it.

Cost of House Drainage oppressive to the poor class of owners.

In such cases the Public Health Act of England provides that, the Sanitary authority may execute the work and hold the property as security for payment of principal and interest in a certain number of years.

Thus for a loan of Rupees 100 with interest at 5 per cent. for 5 years, the quarterly payments would be Rupees 5-13 to pay off principal and interest in that period.

I am persuaded few people would object to the improvement carried out in this way; I would therefore submit for the consideration of the Government the desirability of such an addition to the Municipal Act as will enable the Municipality to undertake the work of private drainage charging just as much as the work may cost, and obtain re-payment in the form of

Private Improvement Rates.

private Improvement Rates collected in the ordinary way quarterly, with the other Taxes.

The actual cost of Private Drainage of Premises is of course dependant on their size, arrangement, and position; it is also dependant somewhat on the width of the Road.

	RS.	A.	P.
4 inch Stone-ware pipes cost, landed in Madras, per foot	-	-	0 4 0
Laying in the ordinary way with concrete	-	-	0 6 0
Total per foot	-	0	10 0
For a small house the length required may be assumed as 50 ft. @ 10 As.	31	4	0
Cost of connecting House Drain with Public Sewer	-	3	0 0
One Syphon Trap fixed	-	3	8 0
Total Rs.	37	12	0
Should a simple Privy inlet be added without additional Pipe, the cost will be	8	4	0
Total Rs.	46	0	0

This would be exclusive of the cost of cutting walls and repairing Brickwork disturbed.

The one item of connecting the house drains with the street sewer can be in some degree reduced, by putting in the Junction piece when the Pipe Sewer is laid; if this plan be adopted generally, it will not only reduce the cost by a length of Pipe (which must be broken to get it out) but it will obviate the risk of damage and disturbance to the pipe line which to some extent is unavoidable; moreover, there are some places where the cost of the connection is double what it would be in other places, without any corresponding benefit to the house connected, as when the connection is made with a 9 or 12 inch pipe, in place of 6 inch.

In consideration of all the circumstances, I recommend that the Junction Pipe for every house should be put in as the street sewer is laid, and I have included in my Estimate an amount of Rs. 43,055 for this purpose.

For efficient record of the position of House Drains, it is necessary that a Plan should be made of all premises drained, at a scale of 20 feet to the inch; at this scale the position of drain and water pipes, &c., can be accurately shown; each house-owner should be called on to furnish such a plan of his premises on which to lay out the drainage, or pay the cost of it as a part of the House Drainage to the Municipality.

House Drainage Plans.

The 100 feet Revenue Plan should then be corrected, and filled in with the buildings, which are now entirely omitted; if this be done, at any time when examination of the House Drain may be required it will be possible to ascertain its exact position.

Revenue Plan.

The Act empowers the Municipality to supervise all additions and alterations to House Drains.

The survey of the houses in every street should thus precede the execution of its drainage, as it is only by such means the exact position of the connection can be correctly determined.

One other important matter must be borne in mind when arranging the House drains.

Level of inlets to sewers.

As the system is not intended for surface water, the inlets to the House Drains must in every case be so arranged as to exclude rain and flood water.

Most of the houses, especially in the lower parts of the Town, are raised two or three feet above the road level. If the inlet be so raised to 30 feet above datum it will exclude flood water; but it must also be raised a few inches at least above the general level of the compound, backyard, or other place where it may be fixed, to exclude Rain water; and it must always be subject to inspection by the proper officers.

It should also be a regulation that all inlets to House Drains be trapped by a Syphon Trap, guarded by an iron grating, and in the open air; should any Pipe drain from an upper apartment or interior of the house be brought to this trap, it should not be connected with the interior. Its continuity should be broken, and the fluid be discharged a few inches above the grating.

This does not apply where privy or water closet connections are required, these apartments should be adjacent to an outside wall in all cases and freely ventilated.

The soil Pipe in the case of water closets should be carried to the highest level the house admits of, and open at the top.

Where the premises are large and several branch drains are constructed, it is desirable to collect them into one Pipe and construct a trap in its length before it enters the sewer.

As I have before mentioned Page (4) the surface channels will be left open as at present, this leads to a difficulty which it is most desirable should be thoroughly understood.

Were these surface channels destroyed, filled up, or covered and cut off from the Houses in any way, then the house owners would be compelled to connect their houses with the new sewers, or the filth would be discharged upon the Road surface, an intolerable nuisance would be created and speedily suppressed by the operation of the Law.

Where however the surface drains are left as at present, and house owners are content to allow matters to remain as they are, without connecting their houses with the new sewers, there would of course be no departure from the usual state of things, and this has only to be of frequent occurrence to render the entire work useless.

I would therefore strongly urge on the Government the importance of doing whatever portion is taken in hand completely, rather than that an expense should be incurred for the public sewers while the equally important House Drains are left to the decision of the owners. The result of this would undoubtedly be, in most cases, that when an expense varying say from 10 to 100 Rupees has to be incurred, they will generally see reason why matters should remain as they are and the expense be avoided.

I would venture to advise, that in the event of Government adopting the scheme that, it should be executed in separate and distinct portions; and each should be well advanced towards completion before another is undertaken. The first work I think should be confined to Black Town and the Fort; the greatest existing nuisance would be removed, and I believe, the most benefit derived from the expenditure of a given sum. The construction of the Pumping Station, and the outfall sewer, should be simultaneous with that of the Street sewers. I believe that this could be completed within three years; and the remaining portion could then be taken up in Divisions as considered most desirable.

The total estimate for Black Town and the Fort is Rupees, 7,07,109

The Pumping Station 1,62,374

Outfall complete 2,71,451

11,40,934

Add for Contingences and Engineering 15 per cent. „ 1,71,139

Total Rupees... 13,12,073

STATEMENT

Statement of Quantities and Cost of the Drainage works in the various Divisions of Madras.

DESCRIPTION.	Black Town and Fort.	Purse-walkum and Egmore.	Chintadripett.	Triplieane and Royapett.	Mylapore.	Total of each description.
						Quantity.
6" Inch Pipe.....Feet	249,578	127,875	33,470	99,743	37,477	548,143
9" Do. „	23,375	11,440	760	15,955	4,820	56,350
12" Do. „	2,440	920	..	..	5,040	8,400
15" Do. „	1,000	5,815	..	9,170	..	15,985
15" Do. double..... „	..	3,260	..	..	..	3,260
Man Holes..... No.	823	536	114	435	178	2,086
Ventilators..... „	426	270	60	209	90	1,055
Lamp Holes..... „	285	64	29	59	12	449
6" Pipe connecting House Drainage.....Feet	11,209	5,691	1,885	6,600	3,203	28,588
9" Do. do. „	1,401	632	50	1,100	1,068	4,251
Brick Sewer, 3' 6" x 2' 4" of 2 Rings....Feet	13,215	4,035	4,965	2,805	..	25,020
Do. 3' 6" x 2' 4" of 3 do. „	..	1,350	..	..	..	1,350
Do. 4' x 2' 8" of 3 do. „	8,260	3,525	..	..	..	11,785
Do. 5' x 3' 4" of 3 do. „	..	1,675	..	..	..	1,675
Bell-mouth..... No.	2	4	..	..	..	6
Side Entrance..... „	4	4	1	3	..	12
Man Holes..... „	25	22	10	6	..	63
Ventilators..... „	25	22	10	6	..	63

The total cost of each Division and work as given in the detailed Estimate is as follows:—

Black Town and Fort	-	Rupees 7,07,109
Pursewalkum and Egmore	-	4,12,568
Chintadripett	-	1,06,007
Triplieane and Royapett	-	2,68,273
Mylapore	-	94,197
Out-fall complete	-	2,71,451
Pumping station	-	1,62,374
Syphons	-	19,755

Total Rupees... 20,41,734

Engineering and Contingencies at 15 per cent. 3,06,266

Grand Total Rupees... 23,48,000

The working expenses of the scheme I have proposed when fully carried out will be as follows:—

ENGINE ESTABLISHMENT.

1 Superintendent at	-	-	-	Rupees 300 per mensem.
1 Assistant at	-	-	-	100 do.
3 Engine men at 20 Rs.	-	-	-	60 do.
12 Firemen at 12 "	-	-	-	144 do.
6 Coal men at 6 "	-	-	-	36 do.
6 Coolies at 6 "	-	-	-	36 do.

Total per mensem...676

Fuel

Working one Engine - 8 hours per day.
" 2d " - 24 do.

Total 32 hours, Engine 35 Horse power effective.

The consumption of Indian coal will be at the rate of $4\frac{1}{2}$ lbs. of coal per Indicated Horse power per hour.

The Engine will give 65 per cent. of effective duty, and the total power will be 54 horses.

H. P. lbs. hrs.
thus $\frac{54 \times 4.5 \times 32}{2240} = 3.47$, say $3\frac{1}{2}$ Tons per day.

Rs. days.	Rs.
3.5 Tons $\times 21 \times 30 =$ per mensem	2,205
Engine Establishment	676
Oil Stores and Contingencies	200
	3,081

Working Expense at 3,081 per mensem, annual cost - Rupees 36,972

The annual instalment necessary to repay Principal 23,48,000 in 30 years with Interest at $4\frac{1}{2}$ per cent. will be - 1,44,148

or a Total annual payment of Rupees - 1,81,120

If the Principal be repaid in 50 years, the annual payment and working expenses will amount to Rupees 1,55,740.

SURFACE DRAINAGE.—The improvement of the Surface Drainage of Madras is a very large subject, one requiring much thought and many levels to be taken, and probably great improvement might be made in providing new, and improving the old channels by which the water reaches the Cocum or the Sea as the case may be.

In only one case have I been able to extend my enquiries to this subject, and these refer to the Black Town sewer of which the levels have been taken.

The area drained by this sewer is about 5-6ths of a square mile, one quarter inch of Rain per hour falling in this area would give about 8,000 cubic feet per minute.

The sewer is, I believe, well constructed of Brickwork with a granite floor, it was built between 1850 and 1856, at a cost of about 2½ lakhs of Rupees. It extends from the sea near, and on the north of the Fort, crosses the Glacis to Umpherson and Davidson's Street which it traverses, and a part of Popham's Broadway, till it reaches Old Jail Street, there it turns to the East, and along this latter street to the sea.

At the South end it has a fall in 4,180 feet from 21.7 over datum to 18.7 at the sea; 3 feet. The lower end is about the level of low water in the sea.

The other portion is 6,900 feet long and the fall is from 21.7 to 19.0 over datum, a fall of 2.7 to near low water.

If the sewer be perfectly clean and unobstructed it would discharge about 5,000 cubic feet per minute from each end, and would therefore be capable of carrying off a little more than $\frac{1}{4}$ inc. of rainfall per hour from the area. But I am informed it requires to be cleaned out twice per annum, it is probable therefore that very much less than its entire capacity is available to take away storms when they occur.

Moreover as the ends of the sewer are closed by Pent stocks which require to be lifted before the contents of the sewer can escape, it may be that there is some obstruction on this account. Of course when the fall exceeds $\frac{1}{4}$ inch per hour flooding will occur.

For improving the action of the sewer I would advise that gully pits be constructed at every inlet, of sufficient capacity to receive and intercept the Road grit, which washes into it on the occurrence of every storm, these should be cleaned out regularly.

If then the outlet to the sea be closed by proper self acting sluices, I think the sewer will be found to render greater service than at present in discharging Rain water.

I have found no road surface in this locality below the level of the sea; 5 to 7 feet above mean sea level is usual, and 5 feet is about 3 feet 6 inches above high water.

China Bazaar street is slightly higher, a few inches only, than Popham's Broadway, and causes a very slight obstruction to the flow of flood water across the Glacis of the Fort to the Cocum.

The existence of a mass of stagnant filth in this sewer cannot but be prejudicial to the health of the locality.

PUBLIC LATRINES.—In Calcutta and in Bombay also, a very large number of the poorer population resort to Public Latrines and pay a few cowries for the accommodation. In Calcutta some of these places are the property of individuals who derive very considerable emolument from them. The Municipality also derive a Revenue from these Public Latrines.

Where the Drainage Works are completed, these have now been altered and the Water carriage arrangement adopted with the most perfect success.

In Madras there are many of these places, they occupy large spaces and are a very decided nuisance where they exist; for this reason they are generally removed from the immediate vicinity of crowded places, and the people have some distance to travel to them.

If these Public Latrines were increased in number, reduced in dimensions and the Water carriage system adopted a great improvement would be effected, and they could be placed wherever most convenient for those who use them.

When the Drainage Works are completed, one or two localities may be selected in thickly populated places near to a Water Works Pipe, wherein to try the experiment of an improved latrine similar to those in use in Calcutta.

The arrangement consists of a water trough passing through or under a small apartment into which the place is divided, the trough has a sloping bottom it is filled with water from a tap at the top when prepared for use, and is emptied at the lower end where an Iron socket closed by a wooden plug is arranged in connection with the sewers. After several hours use, the plug is lifted and the contents of the trough discharged, it is then re-filled with water and is again ready for use. At a cost of Rs. 2,400 a covered place to accommodate 20 persons may be constructed, exclusive of the land.

DOCUMENTS ACCOMPANYING THIS REPORT.—A Level Book, accompanies this Report containing values of Bench Marks which have been established in various points throughout the town, these Bench Marks are blue Whin stone posts numbered 1 to 122. The level of the squared tops is the level taken, and they are all referred to a datum 20 feet below mean Sea level.

In taking these Bench Marks surface levels were taken also at 200 feet apart, in every Street and Road. These levels are written in blue ink on the Plans, but are there made to indicate the height above mean Sea level.

The Revenue Survey Plans at a scale of 100 feet to the inch have been found generally very correct, and are adopted as the basis of the scheme; on these I have laid down the line and levels for every sewer; the gradient and direction, as well as the height above datum at the different junction of the sewers, are all shewn on these plans.

Plans of the Streets and, Working Sections of the same are also prepared, on these the position and inclination of the sewers is shewn.

These Plans and Sections are given for the whole area to be drained. They have been carefully checked and may, I believe, be considered as strictly accurate. Drawings of the Section of Sewers, Man Holes, Syphons, Pumping Station, and Sea end of outfall sewer with an index map to the various blocks of the Revenue Survey are also prepared.

The Estimate Book shews the name and number of the Streets in the various Divisions, corresponding with those on the Revenue Survey. It gives the length, average depth, and inclination of each street sewer; the street number into which it discharges; the number of Lamp Holes and Man Holes; also the estimate for any special work, and for compensation or damage to property; and the total cost of each Division Drainage. A list of the Streets in the various Divisions, numerically and alphabetically arranged has also been prepared.

As an Engineer it is no part of my duty to compare mortuary results, but it is no small satisfaction to be able to point to cases where lives are saved and sickness prevented.

The following is taken from the Administration Report of the Calcutta Municipality for 1873-74 as the total deaths occurring in that city during previous years.

1865	...	...	...	...	...	...	23,242
1866	...	...	...	...	...	...	20,283
1867	...	...	...	...	...	...	12,097
1868	...	...	...	...	...	...	13,733
1869	...	...	...	...	...	...	12,795
1870	...	...	...	...	...	...	10,102
1871	...	...	...	...	...	...	10,300
1872	...	...	...	...	...	...	11,825
1873	...	...	...	...	...	...	11,557

Calcutta, however, is far from being complete in its Sanitary arrangements. The water supply is generally distributed, but at least one-half of the community still have little or no benefit from the drainage works; all the more expensive portions are completed, but the less expensive Pipe system which will make these available to the great mass of the poor native population still remains to be done, and during the present year I believe the works are suspended; Calcutta therefore even now is not in the favorable position it is to be hoped it will be when the works are completed. In 1869 the Water and Drainage works were first brought into operation and a marked change is at once visible.

But tables of mortality in this form entirely fail to convey the full value of a life saved; it also means *sickness prevented*.

Medical Statisticians know that for every life saved there is a large number of cases, (28 may be taken as under the mark) of serious sickness prevented, with all their concomitants of privation and misery; and the heavier portion of this burden falls on the poor.

In a community like Madras with its 3,97,552 inhabitants, if the mortality can be reduced from 33 to 23 per 1,000, as there is no doubt whatever it may be, this would amount to no less a number than 3,970 lives, and in the proportion I have mentioned no less than 1,14,160 cases of sickness per annum would be avoided.

It would be a great mistake to suppose that the community does not pay for this, not only in the physical suffering, but in loss of money.

If we take 10 years as the period which is lost by a life cut off prematurely, by preventable sickness and its value at Rupees two per month only.

And the cases of serious and unnecessary sickness as incapacitating the sufferer for a period of two months from employment, we shall then have as

	Rs.
Value of life lost $3970 \times 10 \times 12 \times 2 =$	9,52,800
and by sickness $111,160 \times 2 \times 2 =$	4,44,640
Loss per annum, Total Rupees.....	13,97,440

It is not pretended that these figures are strictly accurate as applied to Madras, they are believed to be rather under than over the actual amount.

When, therefore, it is stated that it is too poor a place to indulge in the luxuries of drainage, and Water Supply, let it be remembered that this is one of the penalties of filth, and that it is chiefly paid by the poor who cannot help themselves; but the rich do not escape, and when surrounded by such conditions as abound in this city, nature frequently exacts the penalty from all, rich and poor alike, who neglect or break her laws.

MADRAS,
7th April 1875.

W. CLARK,
Member of the Institution of Civil Engineers.

THE RIVER COOUM.

The condition of the River Cooum as the chief receptacle for the surface waters of Madras is of the greatest importance.

The area of the city is far too large to permit of any measures for effecting its surface drainage, excepting by the ordinary means of gravitation to a lower level; and as the level of the sea is the lowest that can possibly be obtained, it is evident, that if the River Cooum can be kept down to this, it will be in the best condition for effecting the surface drainage of the city.

It is moreover desirable for many reasons that fresh supplies of sea water should enter with the daily tidal current—the presence of a stagnant lagoon of sea water closely adjacent to the most populous part of a large city is most undesirable,—but when it is made to receive the sewage of the population for weeks and months together, as at present, it becomes a source of nuisance and danger to health. The greatest benefit to the Cooum undoubtedly will be the diverting of the sewage into other channels, and to prevent entirely the contamination of its waters; and should the very necessary works of drainage be executed, still in the present condition of the bed of the River Cooum (which has for many years received the greater part of the sewage) the necessity for an improvement in its condition will only be lessened in degree, and therefore I venture to offer for the consideration of Government a few remarks on the subject.

From a daily observation of the 'Bar' since my arrival in December last, and from information with which I have been favored by Colonel Goddard, Colonel Moberly and others, it is apparent that no regular discharge of upland fresh water throughout the year can be expected; and it is from the tidal influence alone that any power can be obtained towards the keeping of the 'Bar' open throughout the year; and the case at once resolves itself into the question of quantity, and velocity of the current, entering and issuing four times in the 24 hours.

In this view of the matter the area of the Cooum affected by the tidal influence, and regarded as a *reservoir* for the flood water at high tide, to be discharged as the tide falls, is an important feature. The river when in flood, as during October last, scoured out the entire channel through the Bridge, and a clean channel was left; this was the result of an enormous body of water moving at a high velocity.

As the quantity diminishes at the cessation of the rains, the water of the flood tide gradually finds its way in, and it becomes a contest between the loose sand thrown up by the surf at the mouth of the river, and the entering and issuing tidal water; as this process goes on during the North Eastern monsoon current, the river is forced towards the southern end of the Bridge, where there is a short groyne, and the drift sand occupies four-fifths of the water-way of the Bridge leaving a narrow channel only; this channel is kept open for several months by the scouring action of the tidal water in passing to and from the *reservoir* of the Cooum.

As the river succeeds in forcing for itself a channel through the enormous quantity of loose shifting sand for several months, it may I think be expected that if some comparatively small means of assistance were afforded, it would remain permanently open.

Those who have known the River before the rough groyne of granite boulders above alluded to was placed on the sea side of the Bridge at its southern end, will be able to say how far or for what period the closing of the 'Bar' has been protracted.

My observations during the past two months have shewn that the outlet of the channel into the Sea shifts towards the north. A quantity of sand accumulates on the 'Bar' side at the head of the groyne, and gradually increases in extent, causing the opposite or north side of the channel to scour away the sand by the action of the waves which break on its face during flood tide, and carrying the sand nearer to the Bridge, where a very considerable eddy is formed, and a quantity of sand is piled up at the back of the shoal first formed as above; as this action proceeds, the northern side of the channel becomes more and more exposed to the action of the waves, and the silting up of the channel is more and more rapid, until the time when the pro-

jecting shoal on the south side will overlap the northern side of the channel completely (it now extends to a point opposite the seventh arch from the southern end of the Bridge) and will soon completely overlap the channel; in this condition of things the waves (which break nearly parallel to the shore) will commence to cut the point of the shoal itself and drive it bodily in towards the Bridge, and the 'Bar' will then at once be closed.

I am of opinion that if a channel of suitable width be formed by the construction of groynes on both sides, and the entering and issuing water be confined to this channel during the dry season, that a quantity of water moving at sufficient velocity will be obtained to keep the channel open throughout the year, by the scouring action of the tidal water alone.

I have roughly estimated the quantity of water which the River Cooum will contain between the South Beach and Harris' Bridge.

The ordinary rise of the tide I learn is about three feet, for purposes of calculation I have taken 2 feet 6 inches as spread over the area of the Cooum between the above points, and I find the quantity to be about $16\frac{1}{2}$ millions of cubic feet which must enter through the channel at the 'Bar' in 6 hours; this quantity in a channel having a sectional area of 300 square feet would give an average velocity of $2\frac{1}{2}$ feet per second. Of course this velocity is not uniform, it is greatest about half tide of both flood and ebb; and at extreme high or low water the velocity for a brief period is *nil* but for a very considerable portion of the 6 hours the velocity will be much higher, from 4 to 5 feet per second, and I consider quite sufficient to keep the channel with a capacity, such as I have mentioned open, if the loose sand at the mouth be so far confined and controlled as to admit of the scouring action of the water being concentrated on its sectional area only, and in a direction at right angles to the general shore line.

I have repeatedly observed the water entering with a velocity at the surface of 4 feet per second (and the channel I take to be about the size I have indicated) under the present condition of things, but the mass of sand it has to contend with, on both sides, along its whole length, is too great to be overcome by the small stream opposed to it.

I am unable to say whether the water-way of the Bridge is sufficiently ample to admit of 50 feet out of its 500 feet, to be appropriated to the construction of a groyne on the north side of the channel, but judging from the other Bridges higher up, where the water-way is very considerably less, I should think 50 feet might be spared; in that case I should appropriate the 3rd arch (from the south end of the Bridge) to the construction of the groyne which with the existing one on the south side should be extended about 200 feet further seaward and to a depth which experience has proved to be the lowest point of scour under the Bridge.

Should it be inadmissible to construct a groyne in that position, then an independent opening further to the north, would be necessary at a considerable increase of expense.

The river in its shoal portion should be deepened so as to be from one to two feet of depth at low water.

It would also be necessary on the approach of the monsoon season to keep the sand at the Bar down to a level which would easily admit of the flood water topping and scouring it away, so as to avoid any undue strain on the permanent channel.

The upper reaches of the river may be immensely improved by training walls at intervals, to confine the stream during the dry season to a defined channel; the general bed being levelled, and it is I believe sufficiently high for grass to grow upon; not only would the general appearance of the river then be improved but its discharging power would I consider be improved also.

DRAINAGE ENGINEER'S OFFICE,
123, MOUNT ROAD.
12th February 1875.

W. CLARK.

MEMORANDUM.

April 3rd 1875.

Since the above was written the South-west winds and current have fairly set in, and a body of sand from the South has accumulated at the end of the groyne, about 100 feet in width measured seaward.

It has also advanced towards the North, and the Cocum up to a few days ago has continued its struggle for existence. A week since the Sea end of the Channel had moved northward about 400 feet from where I first observed it; and in this process an enormous mass of sand had been cut away from the land side of the Channel. Suddenly, about 4 days ago a tongue of sand about 250 feet in length shot forward from the growing bank, and the Channel was forced into a position about parallel with the shore line; the surf breaking over this sand has now closed the Channel, and the Cocum will remain a stagnant pool till the middle of October.

The view I took two months ago of this subject is confirmed by what I have since observed.

W. CLARK.

LIST OF PLANS AND SECTIONS, &c., TO ACCOMPANY MR. CLARK'S DRAINAGE REPORT.

1 Portfolio containing 14 Survey Blocks for Black Town.

1 Do. 86 Sections for do.

1 Do. 1 Survey Block for Chintadripett.

1 do. for Fort, and

1 Section for Fort.

1 Do. 11 Sections for Chintadripett.

1 Do. 9 Survey Blocks for Triplicane and 1 for Royapett.

1 Do. 29 Sections for Triplicane and 2 for Royapett.

1 Do. 8 Survey Blocks for Parawalkum.

1 Do. 40 Sections for do.

1 Do. 6 Survey Blocks for Egmore.

1 Do. 10 Sections for do.

1 Do. 2 Survey Blocks for Mylapore.

1 Do. 13 Sections for do.

1 Do. 5 Sections for out-fall complete.

1 Do. 2 Plans for Pumping station.

1 do. for Chimney.

2 do. for Out-let Pipe at the sea end.

1 do. for Out-let Pipe for Mylapore.

2 do. for Syphons.

1 do. showing the arrangement of Pipes in Mint Street.

1 do. for Brick and Pipe Sewers, &c., &c.

1 do. Water Latrine.

1 Index Plan for Black Town, and

1 do. for Black Town and Suburbs.

30 Level Field Books.

1 Estimate Book.

1 Data Book for Estimate.

1 Book, Alphabetical and Numerical order of Streets.

1 Bench-mark Book.

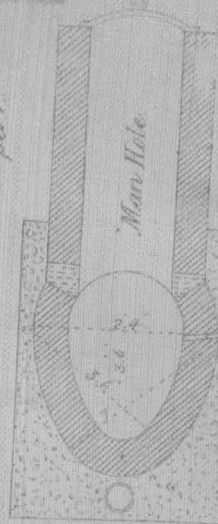
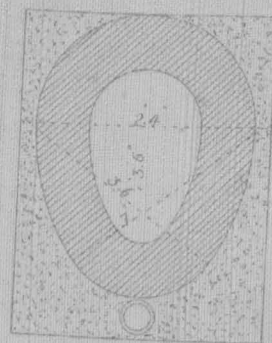
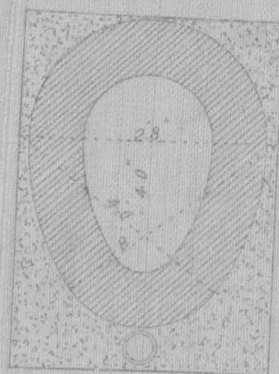
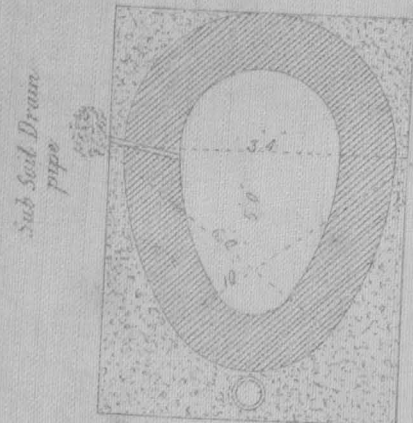
BRICK SEWERS.

17

Brick Work 187
Concrete 210

Brick Work 156
Concrete 180

Brick Work 74.25
Concrete 12.5



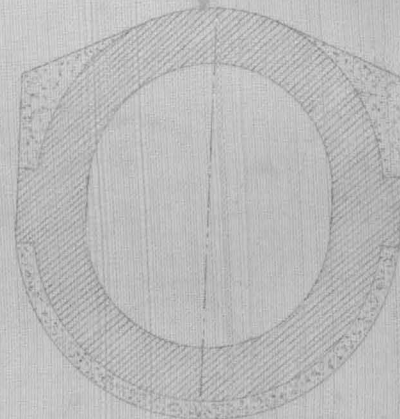
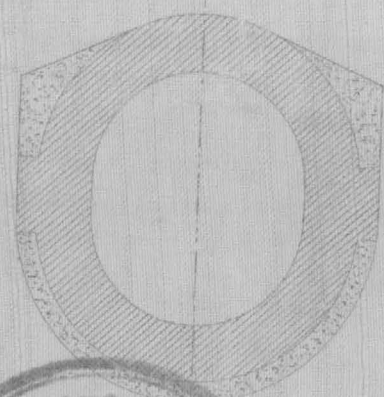
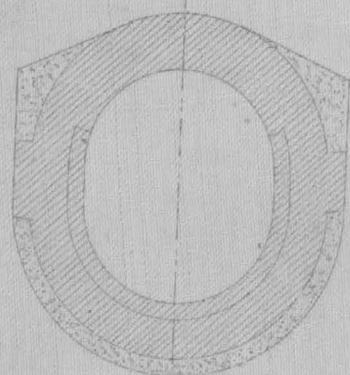
Sub Soil Drain pipe

OUTFALL CULVERT.

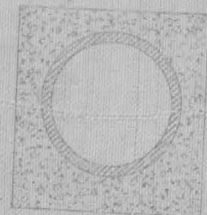
Brick Work in Mortar 16.33 C. 18
D^o in Cement 5.00
Concrete 5.25

Brick Work in Mortar 23.00 C. 18
Concrete 6.00

Brick Work 25.25 C. 18
Concrete 6.85



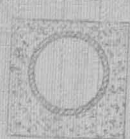
15 Pipe
Concrete 3.5 C. 18



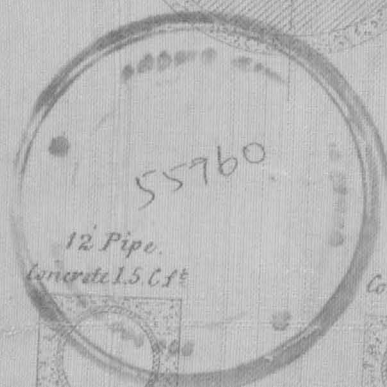
12 Pipe
Concrete 1.5 C. 18



9 Pipe
Concrete 1.0 C. 18

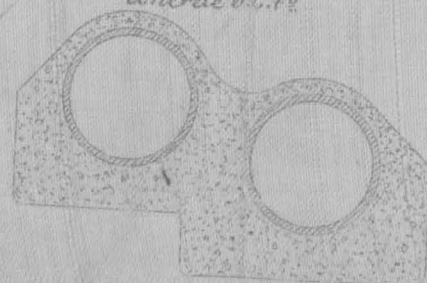


6 Pipe
Concrete .75 C. 18



R
286-2111 M 75
M 75

PIPE SEWERS.
Double 15 Pipe
Concrete 6.6 C. 18



Scale 1/4" = 1 Foot

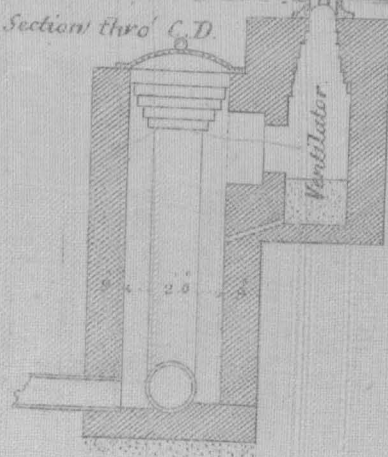
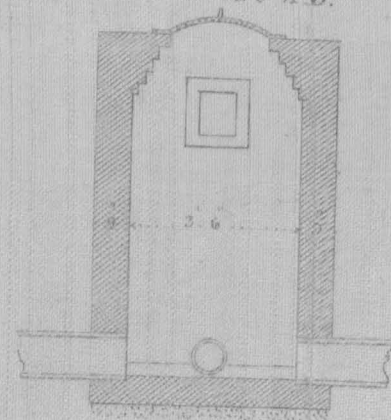
MAN. HOLE
FOR
PIPE SEWERS.

18

Surface of Ground

Section thro' A.B.

Section thro' C.D.

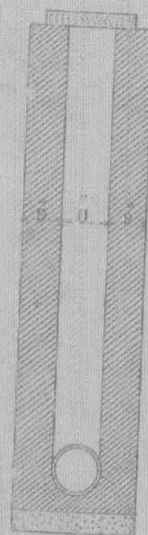
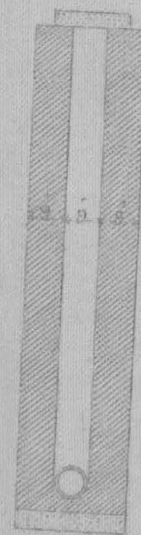


Place at Pipe Level.



LAMP HOLES FOR PIPE SEWERS.

Surface of Ground



Scale 1/4" = 1 Foot.

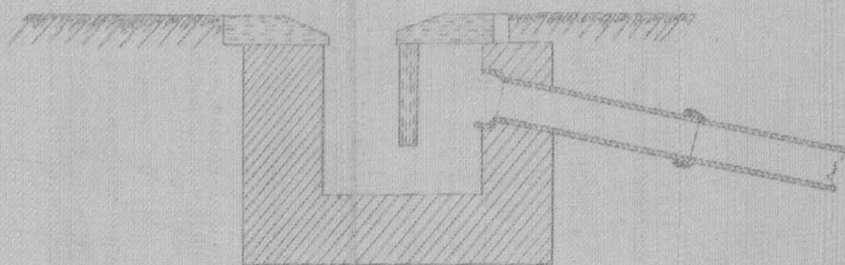
DESIGNED BY J. H. BARNARD, CIVIL ENGINEER, 10, BALDWIN STREET, NEW YORK. ST. GEORGE, MAR 1875.

19
PRIVY TRAP

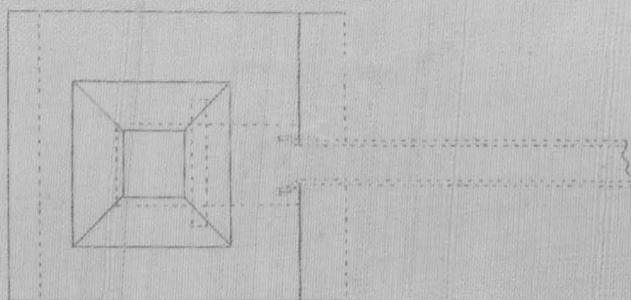
BRICK AND STONE

COVER.

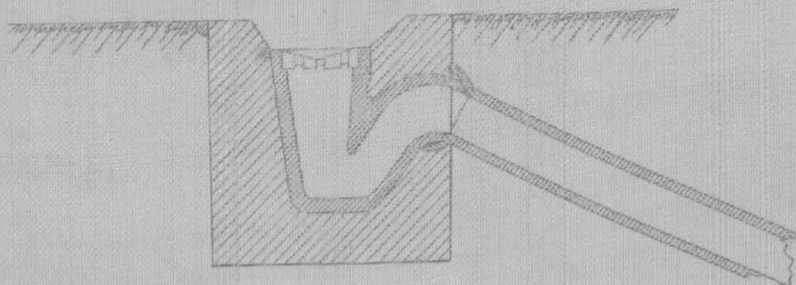
Section



Plan



*Sink Trap
of
Stone ware*

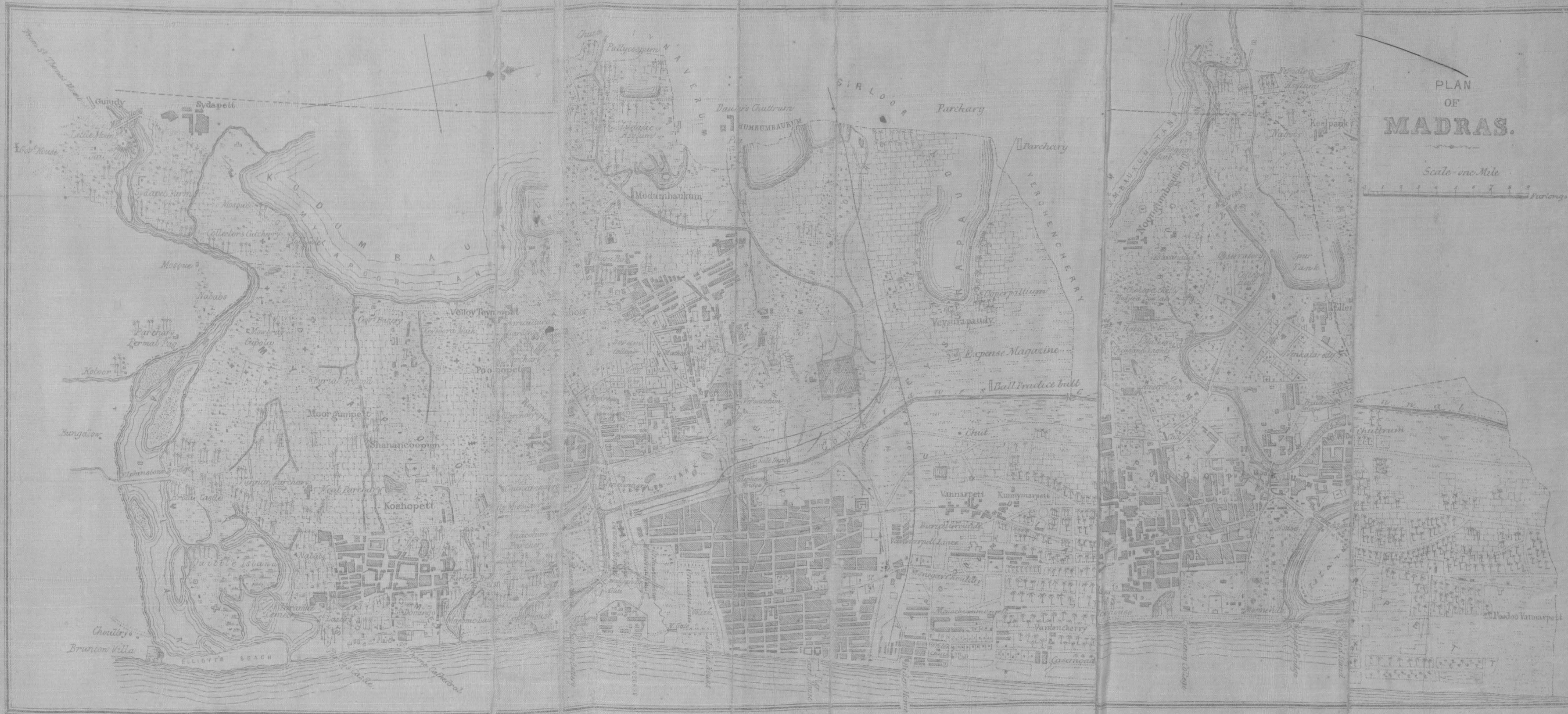


Scale $\frac{1}{2}$ " = 1 Foot.

20

21

22

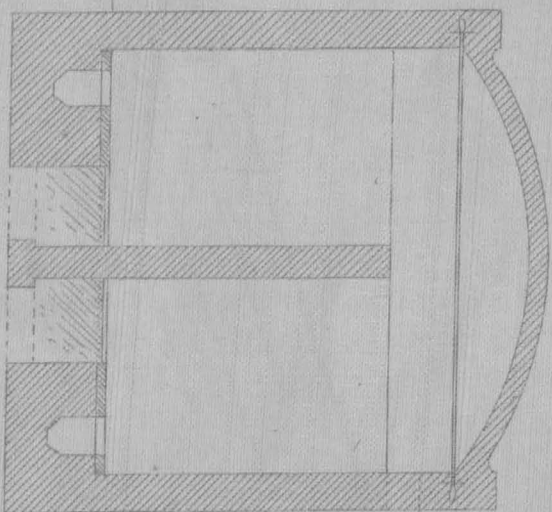


PLAN
OF
MADRAS.

Scale one Mile

Gov. Litho. Depos. Fort St. George
Madras April 1875

By J. BALCHY CIV. ENGR. DEPT. FORT ST. GEORGE MADRAS 1875



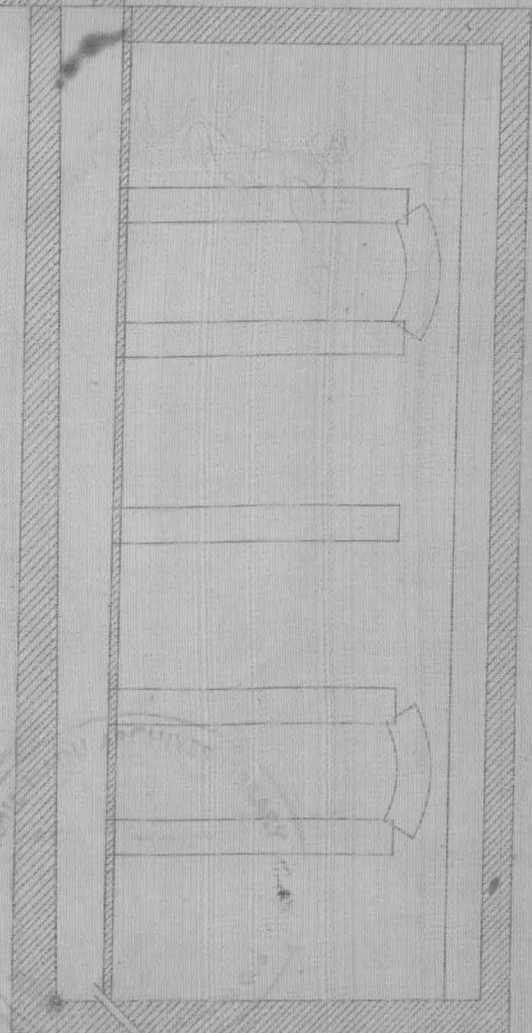
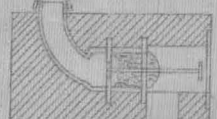
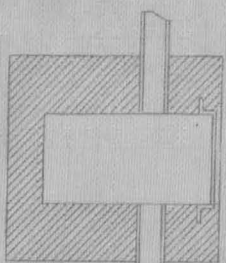
Section thru A.B.

23

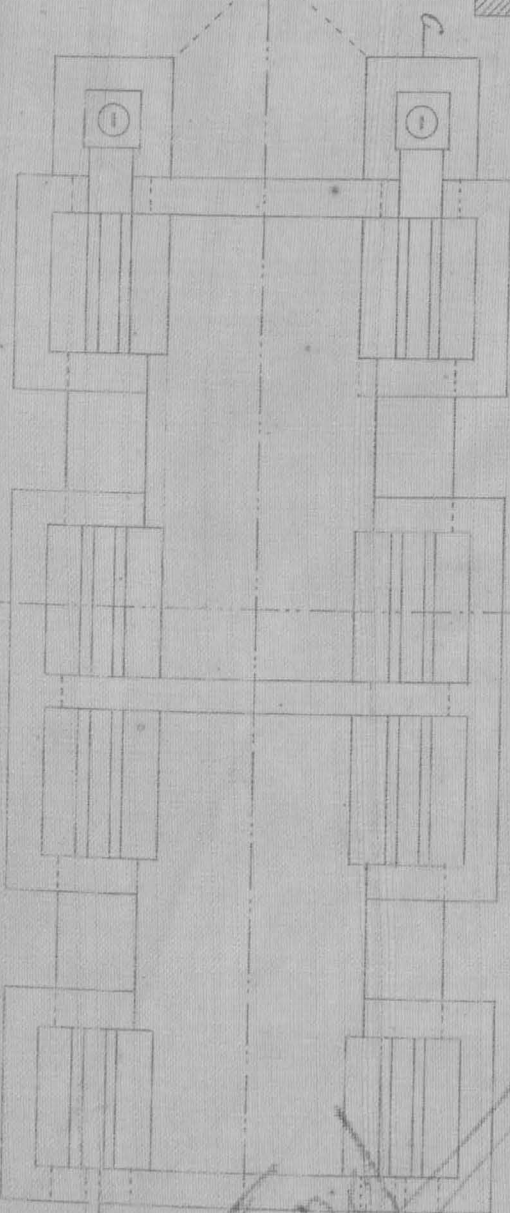
R
D86.2111 M756
M75



PUBLIC WATER LATRINE



Section thru C.D.



Scale 1/4" = 1 foot

TRANSFERRED BY THE ENGINEER TO THE ARCHITECT FOR THE ARCHITECT'S RECORDS