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GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

Buildings and Roads.
Military Works.

READ—the following papers:—

Report on the Bangalore Water Supply by Colonel J. Mullins, R.E., Chief Engineer, on Special Duty, dated 31st March 1884.

Note by Chief Engineer, Public Works Department.

In this complete report, Colonel Mullins disposes conclusively of the various matters referred to him for investigation in connection with the water-supply of Bangalore.

2. The results are summed in paragraph 51 of the report, and may be briefly stated as follows:—

(1) The Ooparhalli project is incapable of supplying the station or the troops.

(2) The Halsur tanks are not capable of being made a satisfactory source of supply for the troops.

(3) Wells may be sunk which would yield a sufficient supply for the troops for drinking and cooking purposes, but the quality of the water must remain doubtful.

(4) The Agaram tank offers a new source of supply of suitable water, having an ample and sufficiently clean catchment basin.

(5) Water of unexceptionable quality is probably obtainable at Bangalore only by distillation.

3. Allusion is also made in the report to the possibility of supplying Bangalore by gravitation from a reservoir to be constructed near Nundidroog; but the expense would probably be prohibitive, being roughly estimated at from 25 to 29 lakhs of rupees.

The conclusions arrived at on these points may, I think, be accepted.

4. With respect to the Ooparhalli project, Colonel Mullins has apparently not noticed General Sankey's proposal to supplement the supply by sinking a line of wells below the bund of the reservoir, by means of which the leakage from the reservoir and the sub-soil drainage would be caught and pumped, to be distributed by gravitation. The omission may prove to be of importance with respect to the civil station, but not with respect to the troops; for Colonel Mullins' investigations have placed beyond doubt that the troops could not be properly supplied from the tail end of the Ooparhalli source, however enlarged and improved.

5. The proposed supply of the troops from the Agaram tank, the water from which is reported by the Chemical Examiner to be "usable," is estimated to cost Rs. 2,20,000 if the water is drawn direct from the tank, and Rs. 1,88,000 if water is taken from a well within the influence of the tank; but Rs. 13,000 should be added to the last-named sum, as enlargement of the tank is apparently advocated even if the supply is pumped from the well.

6. These amounts do not include compensation. It is not clear whether any would be necessary.

7. This source of supply seems to offer the most promising, if not the only practicable solution of the difficult question of water-supply to the Bangalore garrison; and I am of opinion that it would be well to appoint a qualified officer for the special duty of elaborating the scheme in the necessary detail and of preparing plans and estimates. This would, of course, have to be done in communication with the Mysore Government.

8. In paragraph 46 of his report, Colonel Mullins remarks that, to avoid the expense and complication of artificial filtration, "in any case it would be desirable to have an experimental well sunk in the bed of the tank to test, through the water therefrom drawn, the character of the soil through which the water has filtered, and its effect upon the potable qualities of the supply." This should be done; although I greatly doubt the possibility of dispensing with artificial filtration in the case of the Agaram tank water.

OOTACAMUND,
23rd May 1884.

(Signed) J. SHAW-STEWART, Col., R.E.,
Chief Engineer, P.W.D.

ORDER—dated 13th June 1884, No. 1473 W., Public Works.

His Excellency the Governor in Council concurs in the opinion that the Agaram tank scheme offers the most promising solution of the question of water-supply to the Bangalore garrison, which has been so exhaustively treated in the report by Colonel Mullins recorded above. A qualified officer will therefore be appointed to elaborate the scheme and prepare the requisite plans and estimates.

2. Captain Romilly, R.E., at present employed in the B Project division, has been recommended by the Chief Engineer for the duty, and he will accordingly be directed by the Superintending Engineer, IV Circle, to proceed to Bangalore as early as practicable, and to make the requisite preliminary arrangements in communication with the officers of the Mysore Government.

3. The suggestion in paragraph 44 of Colonel Mullins' report, for sinking an experimental well in the tank-bed in order to test the character of the soil and its effect upon the potable qualities of the supply, should receive proper attention.

4. His Excellency the Governor in Council desires to place upon record his appreciation of the thorough manner in which Colonel Mullins has so ably discharged the duty intrusted to him, forming a fitting termination to his long and arduous labors in the service of the State in the Public Works Department of this presidency.

5. The Mysore Government will be furnished with a copy of these proceedings and they will be requested to facilitate the proposed inquiry.

(Here enter No. 1474 W., dated 13th June 1884.)

(True Extract.)

(Signed) J. SHAW-STEWART, Colonel, R.E.,
Secretary to Govt., P.W.D.

To the Superintending Engineer, V Circle.
" " IV Circle.
" Military Department.
To Colonel Mullins, R.E.
To the Examiner, Public Works Accounts.

Rad. E. Fernandez.
Spare Copies

BUILDINGS AND ROADS.
MILITARY WORKS.

Govt. of {1884} Madras.

PUBLIC WORKS.

Dated June, 13*th*.

Read. *Encl.*

G.O., 13th June 1884, No. 1473 W.

JUNE.

Bangalore Water Supply

Orders on Colonel J. Mullins' report on the —.

1473

REPORT ON THE WATER-SUPPLY OF BANGALORE.

Appendix to G.O., No. 1473 *W., dated* 13*th June* 1884.

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3. Sheet 1—Longitudinal section of boundary catchment channels.
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4. Drainage area of Sampagi feeder and new reservoir (Ooparhalli).
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9. Survey of northern water-shed, Halsur tanks, and additional gathering ground to the eastward.
10. Levels for a channel to convey drainage of ground to eastward into Halsur lower tank.
11. Halsur lower tank, showing the alignment of proposed bund for excluding the western feeder from the tank, &c.
12. Additional catchment, Halsur lower tank, and diversion of town drainage. Details of works.
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16. Longitudinal and cross sections of the Agaram tank bund, showing the additions required in 2 sheets.
17. Section of sump well for water-supply from valley south of South Station Hospital, and approximate design for new waste weir, Agaram tank.
18. Rough plan and section of 11 vent tunnel and waste weir, Agaram tank.
19. Topographical survey, in 3 sheets.

** These parcels cannot be found Pencil marks are Removed from the Index to Plans of Project A for Rly 6153/87

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REPORT ON THE WATER-SUPPLY OF BANGALORE.

REFERENCES.

G.O., No. 3798 W., dated 8th October 1883.
Letter, No. 1798 W., — 2nd November "
G.O., No. 3840 W., — 1st November "
Memorandum, No. 2174-C., dated 18th November 1883, by the Chief Engineer, Public Works Department, with
Memorandum, dated 16th December 1879, by Major C. Bowie, R.E.
Appendices Nos. 1 to 17 (vols 2nd attached).
Plans " 1 to 19 (" ").

The investigations ordered to be made relate to the following distinct sources of water-supply :—

1st. The scheme for the supply of the troops, the civil and military station, and a proportion of the population of the Pettah with water from the Ooparhalli reservoir, which was constructed in 1874—78, the project having been drawn up when Major-General (then Major) Sankey was Chief Engineer of Mysore.

2nd. The Halsur* tank, the object being the improvement of the quality of the water of the tank by excluding from the latter altogether the drainage of the Cantonment Bazaar and other thickly-populated localities, which now enters the tank by the western feeder. The troops are at present supplied with water from this tank, the water being either naturally filtered in the case of that drawn from the Dhobies' wells, or artificially filtered by passing it through the usual media, viz., sand, charcoal, gravel, and stone.

3rd. Well water, the intention being, failing other means of obtaining sufficiently pure water, to construct a series of wells in the vicinity of the European barracks for the supply of the garrison.

2. These several proposals will be dealt with in the above order in this report.

3. General Sankey's scheme is much the most important project which has been taken up in connection with the water-supply of Bangalore, because it was designed to effect a radical improvement of the supply of the whole military and civil population excepting the Pettah, which has hitherto been generally fairly well supplied. More recently a partial supply of the Pettah has been proposed. It provided for—

1st. The construction of a reservoir in the 3rd mile of the Bellary or Tumkur road, at a level giving what was deemed to be a sufficient command of the whole station to secure water distribution by gravitation.

2nd. The supply of this reservoir by the formation of channels to intercept the drainage of approximately the whole area of ground available on a level higher than that of the tank itself.

3rd. The distribution of the water to the several parts of the station by means of conduits, pipes, &c. The further detailed distribution was not included in the project, but was to be left to the Municipality, and, so far as the troops might be concerned, to the Government, to carry out.

The instructions of the Chief Engineer, Public Works Department, in connection with this scheme are—

(1) To ascertain exactly the extent to which the original scheme sanctioned by the Government of India has been carried out;

* The spelling of the name varies in that here adopted is taken from the topographical survey, and is understood to be the proper transliteration of the native name.

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REPORT ON THE WATER-SUPPLY OF BANGALORE.

REFERENCES.

G.O., No. 1794 W., dated 16th October 1883.
Letter, No. 1796 W., " 1st November "
G.O., No. 1840 W., " 15th November "
Memorandum, No. 3154-C., dated 18th November 1883, by the Chief Engineer, Public Works Department, with
Memorandum, dated 18th December 1878, by Major C. Bowie, R.E.
Appendices Nos. 1 to 17 (with 3rd attached).
Plans " 1 to 19 (" ").

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* The spelling of the name varies in reports and plans of different dates: that here adopted is taken from the topographical survey, and is understood to be the proper transliteration of the native name.

(2) To definitely determine, from the experience gained since the work was discontinued, to what extent the completion of the works in their integrity, as per the sanctioned designs, would meet the requirements now considered necessary;

(3) To prepare a project for such modification or development of the existing works as will ensure the needful water-supply.

4. The first estimate of Rs. 5,69,257 for this scheme was sanctioned by the Government of India on the 23rd August 1870, and was made up of three sections:—

		Rs.
1. Reservoir		1,03,903
2. Channels of supply	11,850	
and subsidiary works (moderator tanks)	7,112	
		18,962
3. Distribution Works—		
Water tower or sluice	8,635	
Outlet pipe	1,605	
Filter and stone basins	72,603	
Distribution reservoir	24,123	
Delivery pipes, &c.	2,89,426	
		3,96,392
		5,19,257
Compensation for land		50,000
		5,69,257

Work was commenced on this sanction in October 1874.

5. An estimate, amounting to Rs. 5,36,363, for a revised project was sanctioned by the Government of India in July 1876, the items of the three sections being—

		Rs.
1. The reservoir		2,31,207
2. Channels of supply	31,756	
Moderator tanks	...	
		31,756
3. Distribution Works—		
Water tower or sluice including tunnel through the bund	11,768	
Filter and stone basins	39,133	
Distribution reservoir	...	
Delivery channels	1,15,552	
		1,66,448
Surveys and rainfall registration	5,250	
Extra—Inspection lodge, barracks and huts ...	12,705	
		17,955
		4,47,363
Land compensation		89,000
		5,36,000

6. There was a supplemental sanction given in October 1876 for—

		Rs.
1. The reservoir		3,939
2. The delivery channels		7,632
		11,571
Compensation for land		2,000
		13,571

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7. The total outlay up to date is shown below:—

		Rs.
1. The reservoir		3,14,868
2. Channels of supply	71,289	
Moderator tanks	...	
		71,289
3. Distribution Works—		
Water tower or sluice	729	
Outlet pipe	...	
Filter and stone basins	...	
Distribution reservoir	89,454	
Delivery channels	...	
		90,183
Extra—Surveys and rainfall registration ...	4,285	
Inspection lodge, barracks and huts	...	
		4,285
		4,80,625
Compensation for land		64,140
		5,44,765

8. The several sanctions and the outlay will be found side by side in Appendix No. 1.

9. The greatly increased cost of the reservoir was due to difficulties encountered in getting in the concrete wall which was used instead of puddle, to an augmentation of the section of the embankment, and to sundry minor causes. As the present inquiry is not concerned with the cost of the water-supply, it need only be mentioned here that connected with the efficiency of the water-supply, it need only be mentioned here that the embankment has but imperfectly answered its purpose of retaining water. The extent of the imperfection will be dealt with later on when showing what water has been received and what became of it.

Vide paragraph 27.

10. The channels of supply or catchment channels will require to be dealt with at some length, as upon their efficiency the success of the project was supposed mainly to depend. They were a special feature in the scheme, because the natural catchment basin of the reservoir is but small * or indeed insignificant, and the channels were intended to collect and bring into the tank the drainage of an area rather more than five times greater, which naturally would flow in other directions.

* 200 acres.

These channels as provided for in the estimate of 1869 (sanctioned in 1870) are described in paragraphs 16 and 17 of the report and in paragraphs 1 to 4 of the specification. They were to consist of two sets—the lower to embrace † the 105·00 contour line, and the upper set a 125·00 contour.

† Description indefinite.

These sets were practically to be divided into eight channels, having an aggregate length of about 23 miles and with normal sectional areas varying from 15 square feet near the discharge to 4½ square feet at the upper ends. The inclination or fall of the lower series was to be made small so as to embrace the largest available area, while that of the upper series was to be made steeper so as to obtain a quick delivery of the rainfall on the contained area. In the specification for the lower series the fall prescribed is not less than 9 inches a mile at the lower ends, and not more than 18 inches a mile at the upper ends. The corresponding falls of the upper series were to be 2½ feet a mile at the lower, and 10 feet a mile at the upper ends. In neither case are the starting levels given. The channel through the mantapam hill ridge, by which the water collected by the north-east upper and lower, and the south-west upper and lower, catchment channels was to be conveyed into the tank was to have a bottom width of 6 feet, side slopes of 1½ to 1 and a uniform fall towards the tank.

The total cost of these channels was to be Rs. 11,850, or Rs. 515 a mile, equivalent to just under 4·7 annas the yard run. The quantity of earthwork provided for was 56,191 cubic yards, or just under 1·40 cubic yards to the yard run.

11. Of all the plans, eleven in number, enumerated in paragraph 2 of the Executive Engineer's (Mr. Henderson) report on this project, only one * is now to be found. It is not practicable therefore to give any further details of these channels as designed for the first scheme that was sanctioned. This is however of little consequence, because in the revised estimate sanctioned in July 1876 a considerable extension of the catchment channel system was provided for.

Dated 8th October 1869.
*No. 9-A—Plan of cantonment.

12. The report singularly makes no allusion to the alteration of development of these channels generally, or to their very greatly increased cost, but it does, under the head of "water-shed area," notice the intended extension of the south-east boundary or lower contour channel, whereby the drainage of Acres 170 additional was to be brought into the tank. The estimate, however, indicates a very material extension of the system, the main items being for—

Initialled W.H.—9th March 1876.

Average Section. Square feet.					
33	...	...	63,000 feet, or 11·93 miles	of boundary or lower main channels.
16	...	...	49,000 " or 9·28 "	of upper mains.
8	...	...	58,000 " or 11·00 "	of secondaries.
2	...	...	90,000 " or 17·04 "	of catch drains.
			49·25	

The first two in the above list correspond to the two sets of the first sanctioned scheme, but they had been found, or were supposed, to need nearly three times as much work.

159,055 cubic yards against 56,191 cubic yards.

13. The position and extent of the boundary or lower main channels have always been fairly well defined, and for this set the plan shows the location, and gives the direction that the slope or fall was to be 1 in 5,000. For the upper mains and secondaries nothing is prescribed except that the upper mains were to have a fall of 1 in 500, and the secondaries 1 in 100. These channels do not seem to have at any time been surveyed or laid down on paper, and for none of them is the intended level at the commencement shown. Regarding the catch drains there are no directions or any indications as to what was intended.

14. The extent to which the system of catchment channels has been actually carried out up to the present time is shown in the accompanying plan,† which has been prepared under Captain Kensington's instructions.

† No. 2.

The following summary compares the work executed with the scheme of 1876 :—

	Scheme of 1876.	Executed.
	MILES.	MILES.
Boundary or lower main channels	11·93	9·85
Upper mains	9·28	7·42
Secondaries	11·00	2·31
Catch drains	17·04	4·25
	49·25	23·83

15. The boundary (of gathering ground) channels have been completed as far as intended, but the extension of the south-east channel has not been carried out, because it was found that to carry it round the Gootahalli hill would involve much greater expense than had been anticipated, while the yield of the 170 acres to be drained by it would be extremely small, the ground being flat and very absorbent. There is a gunta or pond on the line which, small as it is, very seldom gets filled; consequently

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the extension for a length of 2·75 miles of the channel has been deemed undesirable. Apart from this extension the length executed is rather greater than provided for in the scheme of 1876, and this is due to an extension of the south-west channel, by which an additional area of 22·30 acres has been brought into the gathering ground. As regards the arrangement of these channels, as already stated, the intention was in general terms to give a fall of 1 in 5,000, or rather more than 1 foot a mile. In this respect a departure from the intention of 1869-70 was made, as then the fall was to be not less than 9 inches a mile at the lower ends, and not more than 18 inches a mile at the upper ends.

11·93	
2·75	
9·18	
9·85	
Difference ... 0·67	

From levels recently taken, and from which the accompanying sections * have been plotted, it will be seen that the falls actually given are irregular, but that generally they are in excess of those specified at any time.

* Plan No. 3, Sheet 1, tabulated levels, Appendix No. 2.

With the exception of the south-east channel, the work was done in a fairly satisfactory manner, but the irregularities in the case of that channel are sufficient to affect its efficiency.

16. In May last, with a view to improve the efficiency of these channels, orders were issued for the following arrangements to be adopted, and the work has been partially carried out.

All four channels to have bed widths as follows :—

	FEET.
Lower half mile	8
Above this	6
With gradual reduction to, at extreme upper ends	3

The average section, as provided for in the estimate of 1876, allowed a bottom width of 8 feet. These, as well as the revised dimensions, are much in excess of the quantity of water to be carried.

North-west Channel—	
Level of bed at lower end	98·00
Rise in 1st mile from lower end	3 feet.
Do. 2nd do. do.	4 "
North-east channel—	
Level of bed at lower end	98·00
Rise in each mile from lower end	3 feet.
South-west channel—	
Level of bed at the lower end	98·00
Rise in 1st mile from do.	3 feet.
Do. 2nd do. do.	4 "
South-east channel—	
Level of bed at lower end	99·00
Rise throughout per mile	4 feet.

The effect of these alterations will be to increase the velocity of the water and so lessen the loss by absorption, and, as the increased fall is obtained by deepening the lower ends without diminishing the area drained, the result is likely to be beneficial.

Level of waste weir, 104·00.

When the tank is nearly full, the surface fall will be diminished in the lower parts; but, as the depth will be increased, the rate of discharge will probably not be affected. The estimated cost of these improvements is Rs. 7,605.

The original (1876) intended average depth of cutting was to be 3 feet. The intended depth of water is not shown. The actual depth of excavation is much in excess of that proposed, which latter however does not appear to have been based on levels taken along the selected line. The accounts do not show what the quantity of work done and the cost have been.

17. *Upper Main Channels.*—The levels of these as executed are shown in Appendix 2-A, and longitudinal sections plotted therefrom will be found on Plan No. 3, Sheet 2.

The fall specified for these channels was 1 in 500, or 10·56 feet a mile.

The average falls given are—

North-east channel	...	...	...	...	...	...	10·15 feet a mile.
South-west do.	...	...	...	...	...	...	14·45 do.
South-east do.	...	...	...	...	...	...	14·92 do.
North-west do.	...	...	...	...	...	...	10·58 do.

But in each case the lower part of the channel has a much steeper slope than the upper, the result apparently of having to drop the channel into the boundary channel. The smallest fall, however, is 6·13 feet a mile in the case of two miles of the north-east channel.

With regard to the difference of length, 7·42 miles against 9·28 miles, it will be readily seen from plan No. 2 that these channels could not well have been made longer, and for the reason that they were not surveyed and laid down on paper for the project it is not practicable to say how the 9·28 miles were distributed. In the estimate the entry is 49,000 feet in one item for the four channels, so probably the length was not based on measurement.

One channel, the south-east, is breached not far from its head at a deep ravine and again much lower down: the water is caught by the boundary channel which runs at a distance of from 55 to 75 yards. One or other of these channels was superfluous.

18. *Secondaries.*—Regarding these channels, there is nothing specified in the project papers as to number or position; but in one of the plans (No. 8) the average section is given, viz., 2 feet bottom width and 2 feet depth. The length excavated is less than one-fourth of that shown in the estimate, which shows a single entry for 58,000 feet. Only two channels have been cut, viz., one in the south-west and one in the north-west portions of the catchment, and it is doubtful whether they are of much use. Perhaps the catch drains, 4·25 miles, should be considered as belonging to the designation secondaries, but there is nothing to show what constituted the difference between the two classes.

19. *Catch Drains.*—For these no specification, beyond an average section 1 foot wide at bottom and 1 foot deep, was given. The estimate shows one entry for 90,000 feet of channel. About one-fourth of this length has been carried out.

20. In addition to the catchment channels, there are the road-side channels and numerous tracks and foot paths, all of which act as quick delivery channels. Altogether, even from the point of view of the rapid collection and delivery into the reservoir of the drainage, the development of the channels seems to be excessive, while, viewed economically, the cost has been out of proportion to the quantity of water to be conveyed. Had the boundary channels been laid out originally with the fall now to be given to them and been aligned so as to make the depth of cutting about 2 feet, the upper main channels might with advantage have been dispensed with altogether, and probably about half a lakh of rupees would have been saved.

21. In the revised project of 1876 the provision for moderator tanks on the line of the supply channels was omitted. Owing to the plans of the original project not being forthcoming, it is not known exactly what the arrangements were to have been, and the ground does not present any special facilities for the formation of even small tanks. Had any such been formed, they would have tended to diminish the quantity of water reaching the reservoir by increasing the loss from evaporation and absorption en route.

22. *Distribution Works.*—In the original scheme the main distribution was to have been effected by iron pipes. The great cost of the reservoir and of the supply channels led however to the substitution of concrete or masonry for iron, and the channels were in the project of 1876 designed as open ducts, but shortly afterwards supplemental sanction was obtained for covering in the ducts with slab stones. The only works done under this head are the construction of the sluice at the reservoir and the formation of a channel thence to Cathcart road, a distance of 1 mile, 5·57 furlongs, or 1·70 miles, where it ends in a square cistern on the lower side of the road. By the time the work had so far progressed, it had become evident that no such supply of water as had been supposed to be available could be relied on; and in June 1880, in applying to the Government of India to sanction the deviations and excesses which had occurred, it

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was recommended that the work should not be proceeded with further. From the delivery channel at its present terminus water can be run into the tanks * near the Cantonment Railway Station whenever the water in the reservoir may be above the level of the sluice sill, and a supply has in this way been recently passed into those tanks which are of much importance to the population of that part of the station.

* Usually called Miller's tanks.

23. *Reservoir Catchment or Gathering Ground.*—Before dealing with the water-supply, it may be convenient to explain the circumstances of the gathering ground, which form a distinctive feature of the project. Owing to the high level of the station and to the necessity therefore of placing the reservoir at a level which would command it, no site having a natural catchment basin of considerable area could be found, and that selected has an area of only 260 acres naturally draining into it. The rest of the catchment consists of ground the natural drainage of which runs in other directions and comprises an area of 1,340 acres, the drainage of which is diverted into the reservoir by the series of supply channels already described. The total area is thus 1,600 acres, or 2½ square miles.

Of the above-mentioned 1,340 acres, the drainage from 367 acres went, prior to the construction of the reservoir-supply, channels into tanks connected with the water-supply of Bangalore, viz.:—

Vide plan No. 4.

	ACRES.
To Sampangi tank, above the sluice connected with Miller's tank ...	143
To Halsur tank, viâ the Bellerhalli valley	53
To Dharmabadi tank between the Sampangi tank channel and the south-east supply channel of the reservoir	171
Total ...	367

The rest of the diverted drainage formerly flowed away from Bangalore.

It will be of interest to note here that the Sampangi tank has, from a period at any rate earlier than the year 1809, been supplied to a material extent from ground outside its own proper catchment basin, viz.:—

	ACRES.
Diverted from Nagavara tank	52
Do. do. Halsur tank above the sluice connected with Miller's tanks	40
Do. below do.	171
	211
Do. Dharmabadi tank	51
Total ...	314

It has to be noticed also that recently it was decided to discontinue the diversion of the drainage of 84 acres out of the 143 acres which had belonged to the Sampangi tank feeder, but the water so relinquished has been sent into Miller's tanks.

Proceedings, Government of Mysore, 6th June 1883.

The area now draining into the reservoir is therefore 1,516 acres. The Sampangi feeder has, from a point where the extension of the Madras Railway crossed its line to the Cathcart road, been more or less filled up, and water cannot be sent that way, while the tank itself has been long considered to be of less importance than the Miller's tanks.

It is recommended that all the drainage which formerly ran into the upper portion of the Sampangi feeder, *i.e.*, of the 59 acres not yet restored, and also of the 51 acres which drained in to the southern branch of the feeder, which had its head at the Bangalore and Nundidroog road at a small gunta or pond, should be allowed to run into Miller's tanks, because it is less wasteful to allow it to flow direct into those tanks than to divert it into the reservoir and then send it back by the delivery channel, even should the water level in the reservoir admit of this being done.

24. *Water-supply.*—From the register of water at the reservoir, the actual quantity received has been calculated in the Mysore Public Works Office, and a copy has been taken, the results are shown in the subjoined statement:—

Years.	Rainfall. Inches.	Quantity of Water received. Millions of Cubic Feet.	Equivalent in Inches over Catchment.	Proportion of Rainfall draining into Reservoir.	Area of Catchment. Acres.	Area of Catchment. Millions of Square Feet.
1878						
1879	41·93	42·340	7·34	0·18	...	...
1880	37·75	22·804	3·95	0·10	...	...
1881	39·56	26·478	4·59	0·11	1,600	69·696
1882	21·63	16·920	2·99	0·14	...	...
1883	36·92	23·106	3·98	0·11	...	...
	34·91	27·508	4·77	*0·13	...	...
	211·80	159·150	27·59	0·77	...	...
	35·30	26·525	4·60	0·13	...	...

An abstract from the rainfall register, showing the rainfall in each month from 1876 to 1883, will be found in Appendix No. 3. Up to October 1883 two of the three gauges were situated below the bund of the reservoir, and the third at the reservoir bungalow. The latter gauge has been retained, and the others removed to positions near the boundary channels north-west and north-east as shown on Plan No. 2, to obtain a better average for the gathering ground generally. It will be seen that the yield of the catchment in 1878 was in a very marked degree better than in either of the other years. This was due to exceptionally heavy rainfall in August, viz., 5·69 inches on the 20th and 3·48 inches on the 25th. The reservoir received from these two falls, nearly two-fifths of the total of the year, and the proportion of the rainfall which found its way into the tank was 0·31, or not far short of one-third.

16·541 millions out of 42·340 millions of cubic feet.

It was anticipated, when the project for this reservoir was first brought forward, that the yield from a part of the catchment would be one-third of the rainfall, and from the remainder two-fifths. So far the actual yield has been on the average just over one-eighth (0·13), and, even from the very exceptionally heavy rainfall of August 1878, the yield was less than the smallest proportion estimated as receivable on the whole annual rainfall. From the records it appears that the directly effective rainfall was in each year as below shown, the balance not producing any rise of water in the reservoir, though of course it contributed to increase the effect of that which did cause a rise:—

Vide paragraph 62 of Major Sankey's Memorandum, dated 9th September 1883. Proceedings of Madras Government, No. 2794 W., 5th October 1883, Public Works, page 23.

Years.	Total Rainfall. Inches.	Effective.	Non-effective.
1878			
1879	41·93		
1880	37·75	33·41	7·62
1881	39·56	26·85	10·90
1882	21·63	28·28	10·71
1883	36·92	17·91	3·72
	34·91	29·06	7·86
Total ...	211·80	27·27	7·64
Average ...	35·30	162·78	54·45
		27·13	9·07

N.B.—The effective rainfall yielded nearly 1 million of cubic feet for each inch.

The anticipated yield of the catchment was estimated at 62·125 millions of cubic feet from a rainfall of 28·2 inches, the average of the two years of lowest consecutive rainfall out of 20. How greatly the yield was over-estimated is now sufficiently evident, for even the best year, with a rainfall more than 45 per cent. in excess of that taken as the basis of the calculation, yielded but little more than two-thirds of

* In the latter part of this year the area was reduced to 1,416 acres.

the quantity, and the result of an average rainfall, during the six years, of 25 per cent. in excess, shows a shortcoming of nearly 58 per cent.

On what data the estimated yield was based is not stated. It will be seen, on referring to the appendices * containing particulars of the water-supply of the Halsur tank, that the water received by the new reservoir, so far from being exceptionally small, is considerably greater, in proportion to the area drained and the rainfall, than that obtained by the Halsur tank.

* Nos. 11 to 14.

25. This great difference between the estimated and actual yield of the catchment has been attributed chiefly to the following causes:—

Major-General Sankey's Memorandum of 23rd September 1883, paras. 16 and 17. Proceedings of Madras Government, No. 2794 W., 5th October 1883, Public Works, page 25.

(1) The presence of a tufted grass (*andropogon*) over very nearly the whole area of the catchment.

(2) The absence of certain quick delivery channels which were intended to expedite the off-flow.

With regard to the first of these causes, the grass referred to is very thick and luxuriant in the catchment basin proper of the reservoir, but it is by no means general elsewhere. There is much of the area covered with short grass, than which nothing better could be desired, and it will be advantageous if the long, can be generally superseded by the short, grass. Possibly burning the grass annually, or as frequently as it may be dry enough, will tend to the production of a better kind. To get rid of it by weeding would be expensive, even if it were likely to be effectual; and it may well be doubted whether it would be successful, for this particular grass propagates itself rapidly wherever certain kinds of soil are thrown out of cultivation, and it will continue to grow on the reservoir catchment unless it can be ousted by some other form of vegetation. As the quick delivery channels—if by these were meant the catch-drains—were never planned in detail, or any specification as to the way in which they were to be laid out given, it is not clear what the intention was.

Above the lower part of the south-east channels there are some cuts which may have been formed as catch-drains.† The general tendency of all such drains with steep falls is to cause rapid erosion of the soil, and, were the complete scheme of catch-drains, viz., 17·04 miles, or 6·81 miles of drain to the square mile of catchment, carried out in this manner, the effect would be a rapid silting up of the larger channels or of the bed of the reservoir. To a certain extent this latter might be beneficial as tending to reduce subsoil leakage, but the process once started could not be stopped at will, and it might end in the destruction of the greater part of the storage capacity, and consequently of the utility, of the reservoir.

† Exclusive of those, 4¼ miles of regular catch-drains have been formed.

26. *Capacity of the Reservoir.*—A condensed table of capacity and water-spread of the reservoir is given in Appendix No. 4. Below 75·00 the contents are estimated to be 6·275 millions of cubic feet. Between that level and that of the sluice sill, which is at 80·00, the contents are 16·330 millions, so that below the level at which water can be drawn off the capacity is or was 22·603 millions of cubic feet. Certainly a good deal of silt has been carried into the tank, and probably the quantity of water below 75·00 is not considerable.

The waste weirs crests are at 104·00, and the contents to that level, above the sluice sill, are 28·617 millions of cubic feet. The full tank level was originally intended to be at 105·00 and water was to be retained above the crests of the waste weirs by small bunds thereon: at the higher level 31·351 millions of cubic feet would be retained above the sill of the sluice. The sluice sill was placed at the lowest level which would command the higher parts of Bangalore which it was intended to supply, and, as regards the troops, the highest point is the cistern of the European Infantry Barracks, the floor of which is 10·35, and the necessary level of delivery about 9·35 feet below the reservoir sluice sill, which leaves not more than sufficient head, and, indeed, less than conveniently sufficient were filtration provided for. It would not be practicable, therefore, to lower the sluice even if it would be worth while to incur the expense of cutting another channel through the Geetahalli ridge.

Years.	Rainfall. Inches.	Quantity of Water received. Millions of Cubic Feet.	Equivalent in Inches over Catchment.	Proportion of Rainfall draining into Reservoir.	Area of Catchment. Acres.	Area of Catchment. Millions of Square Feet.
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27. The reservoir has not once filled even to the 104·00 level. The highest and lowest gauge readings in the several years have been as shown below:—

Years.	Dates.	Highest Gauge Readings.	Contents, Millions of Cubic Feet.	Dates.	Lowest Gauge Readings	Contents, Millions of Cubic Feet.
1878	21st October ...	100·25	19·299	18th April ...	81·42	
1879	5th November ...	96·75	11·782	17th May ...	90·33	0·504
1881	28th October ...	97·85	14·045	12th April ...	88·62	..
1882	13th November.	93·12	5·000	8th June ...	87·67	...
1883	20th May ...	92·87	4·571	13th May ...	84·69	...
	17th October ...	98·00	14·355	10th August ...	84·53	...

The contents shown are above sluice sill level.

From these figures it will be seen that in the best year the reservoir contained, when at its highest level, but little more than one-third of the supposed quantity * annually required apart from wastage by evaporation and other causes, while in other years the proportion was very much less.

The wastage or loss by evaporation, &c., was estimated at 9·125 millions of cubic feet. What it has been is as follows:—

—	Millions of Cubic Feet.	Difference to be accounted for.	Quantity Drawn off.	Balance. Loss.	—
1878 Contents 1st January ...	0·000				
Receipts during year ...	42·340				The small loss in this year is partly due to there having been but little water in the reservoir prior to April, from the first of which month the register commences.
Contents end of year ...	42·340				
	33·055				
1879 Contents 1st January ...	33·055	9·285	...	9·285	
Receipts during year ...	24·568				
Contents end of year ..	57·623				
	27·532				
1880 Contents 1st January ...	27·532	30·091	...	30·091	
Receipts during year ...	22·738				
Contents end of year ...	50·270				
	29·698				
1881 Contents 1st January ...	29·698	20·572	...	20·572	
Receipts during year ...	16·920				
Contents end of year ...	46·618				
	24·306				
1882 Contents 1st January ...	24·306	22·312	..	22·312	* A small quantity is believed to have been pumped out in March and April, but there is no record of the quantity, and the gauge register indicates no abnormal fall.
Receipts during year ...	26·100				
Contents end of year ...	47·406				
	23·303				
1883 Contents 1st January ...	23·303	24·103	2·890	21·213	
Receipts during year ...	27·507				
Contents end of year ...	50·810				
	25·554				
	...	25·256	5·905	19·351	
	...	131·619	8·795	122·824	
Average ...	...	...	...	20·471	

The contents here shown are total contents.

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The evaporation is probably greater at this reservoir, the situation of which is high, than at the Halsur tank; but the leakage under the bund is accountable to a very material extent for the rate at which the water surface falls. In November 1883 when the gauge reading was 97·44, that part of the leakage which came to the surface was gauged to be about 0·683 cubic feet a second, or 4·77 millions of cubic feet a month. This would account for 0·355 of a foot of fall in the water surface in a month, or just over one-third of an inch a day, between the levels 98·00 and 97·00. The actual total fall was three-quarters of an inch a day, and this leaves 0·41 of an inch to be accounted for by evaporation and leakage not coming to the surface. At Halsur tank the fall in the surface, including the water drawn off, was 0·208 of an inch a day. The net result is that these water works have in the six years, in addition to about 9 millions drawn off, been able to reserve 25·554 millions of cubic feet for the supply of Bangalore, but of this quantity only 2·951 millions were at the end of December above the level of the sluice sill, and they would not suffice, were the distribution works in operation, for more than about three weeks. Again the reservoir contained no water above the level of the sluice sill for the following periods. The details will be found in Appendix No. 5:—

	No. of Days.
1878	198
1879	77
1880	167
1881	184
1882	268
1883	
Total ...	894
Average ...	149

Had the supply of Bangalore been attempted, the above periods would of course have been largely increased, and the days on which anything like a full supply could have been afforded would have been extremely few. No doubt it was foreseen that it might be necessary to pump water occasionally into the distributing mains, but the project was essentially a gravitation scheme, and it was not contemplated that pumping would have been needed otherwise than as an exceptional arrangement. It may be added that even with pumping the circumstances are altogether hopeless. In 1883 there would have been no water above the 75·00 level between the middle of May and the middle of October had the supply of the place been started at the beginning of that year. With an earlier start the balance of water at the beginning of the year would have been still less. On the 3rd October moreover there would have been a deficit of upwards of 11 millions of cubic feet. Not until the 13th October would the supply have balanced the expenditure, and at the best time of the year, viz., in November, when at least six months' consumption should have been stored, there would have been less than one month's supply.

The reservoir may occasionally be able to supplement to a moderate extent the supply to Miller's tanks; and with a sluice at a lower level it will be capable of improving the supply of that part of the Pettah which is said to be indifferently provided with water. It is clearly out of the question to think of supplying the station generally, or the troops, from so precarious and inadequate a source as the reservoir now is.

28. With regard to the possibility of adding to the catchment or gathering ground of the reservoir, it may be desirable first to consider what area might reasonably be expected to supply the reservoir adequately and prevent risk of failure of supply in, at any rate, all but remarkably and exceptionally dry years, such as, for instance, 1876. The data now available show first that the water losses have amounted to about 20½ millions of cubic feet per annum, but the quantity lost would have been very much greater if the water level had been such as would have admitted of the adequate supply of Bangalore; secondly, that the receipts cannot safely be taken at more than one-eighth of the rainfall at most, while one-tenth would be a safer assumption; thirdly, that no material accession to the water stored can be depended on between November and May, or say for 6½ months, so that the reservoir should, at

the end of November, contain enough water to meet the losses and provide the supply of 5½ or 6 months. Now the losses by evaporation, &c., in these 5½ months have amounted on the average to a depth of 6·55 feet.

Vide Appendix No. 6.

Further the minimum level to which it would be prudent to allow the water in the reservoir to fall may be taken to be 95·00, at which level the contents above sluice sill are 8·380 millions of cubic feet.

It follows then that the reservoir on the 30th November should, to be efficient for its intended duty, contain 26·25* millions of cubic feet above the level 95·00 *plus* 6·55, or 101·55. Now at 101·55 the contents are 22·374 millions, and at the present weir crest level they are 28·617 millions; consequently the reservoir would have to be enlarged to hold 26·25 *minus* 6·243, or 20·007 millions of cubic feet more than at present. To effect this the weir and the bund in proportion would have to be raised about 6·62 feet, and the contents at this higher level would be 48·711 millions of cubic feet. On the average the reservoir has held on the 30th November only 7·997 millions, and the additional supply required is 40·714 millions, to obtain which an increase to the area of the gathering ground of at least 3·78 square miles would be necessary; while, taking into account the great distance from which water would have to be brought, probably 5 square miles would be none too much, or, in other words, the present area would need to be trebled.

* Half of 52·50 millions (*vide* preceding paragraph).

28·617
22·374
6·243

29. In the above calculation the scope of the original project has been adhered to, but in his memorandum of the 23rd September 1883, paragraphs 40 and 41, General Sankey proposes to reduce the unit of supply from 10 to 6¼ gallons a head per diem, and on the other hand estimates that the number to be supplied may be taken not to exceed 130,000 instead of the 90,000 previously to be provided for. The quantity required at 6¼ gallons a head for the larger population would be 47·45 millions of cubic feet yearly, which does not differ very greatly from the supply originally intended to be distributed. With regard to the unit of supply, it may be assumed that the quantity of water consumed will, under similarly more or less complete arrangements for the prevention of waste, depend chiefly upon the facilities afforded to the population for getting at the water. If the people can get the good water with as much facility as that of more or less indifferent quality heretofore used, they will use it freely and exclusively so far as it may be available, but, unless the old sources of supply be very bad, they will not go to a much greater distance to get the better water. Of course it would be an advantage to the people to be able to get even a gallon or two of really good water daily, but, were the supply small and at the same time accessible, the inevitable result would be that some would have to go without any. When the circumstances are such as to make it desirable in the interests of the public health to introduce a purer supply of water, it is obviously also desirable to make that supply ample and to place it within easy reach of the people, so that it may be freely and universally used. Statistics of actual consumption by native populations are not to any great extent available.

At Madras it is believed that 300 out of 400 thousand of the population are now supplied, and the consumption is stated to be 11 gallons per head per diem.

President's letter, P. W. and C. No. 293, dated 26th February 1884.

In Appendix No. 7 will be found some particulars of most of the water works schemes which have been carried out in India, and it will be seen that the unit of supply varies greatly, and in some cases it was based rather on the quantity of water to be had than on what would have been desirable.

In support of his proposal to reduce the unit of supply from 10 gallons to 5 gallons, or, "to err on the side of liberality," to 6¼ gallons, or 1 cubic foot per head per diem, General Sankey mentions† that "investigations of a very painstaking character in the town of Mysore brought out the fact

† Memorandum, dated 23rd September 1883, paragraphs 41-42.

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that for these (drinking and culinary) purposes the average amount actually used by natives only amounted to 1¼ gallons per head per diem, or just one-fifth of the quantity proposed to be given" at Bangalore.

The paper whence this information was obtained is a letter from the Commissioner of General No. 337-73, dated 25th August 1874 (*vide* Appendix No. 9).

the Ashtagram Division; and of the investigations, Colonel Hay remarks that "accuracy is unattainable," and the object of the inquiry was to give a "general view of existing circumstances." The general result arrived at was that 25,000 to 30,700 pots of water, estimated to contain 2½ gallons each, were used daily, the population being 57,765. The larger quantity, 76,750 gallons, makes the average just under 1⅓ gallons a head, but (paragraph 68) 20,000 people are supposed to have used 45,730 gallons; so 37,765 people were left with 31,020 gallons only. Even were the data reliable, they would merely show that in an extremely badly-supplied locality the people took so much water to their homes. The population of Mysore obtain water for domestic purposes with very great difficulty, and a more abundant and accessible supply has been deemed to be of so much importance that a water-supply scheme calculated to afford 6¼ gallons per head per diem has been drawn up and will, it is hoped, be carried out at an early date. The unit adopted is no doubt based on General Sankey's revised estimate of requirements, but on the other hand a wide margin has been left to prevent disappointment, for the main distributing channel is capable of discharging the above supply in six hours, and the reservoir is to hold 100 millions of cubic feet, or nearly five times as much as the estimated yearly consumption. Consequently, should the quantity used be double that of the assumed unit, the water will, should the tank fill, be available, as also the means of distributing it.

Vide Appendix No. 7.

Under any circumstances the European troops could not be supplied from the tail end of a system based on a unit of 6¼ gallons a day per head. The Ooparballi reservoir is at, or rather beyond, the extreme western limits of Bangalore, and the troops are at the eastern end and some at the extreme eastern limits. As it is, there are sometimes complaints of want of water though their supply is specially provided on a sufficiently liberal scale. What would be the result of attempting to supply them from the tail end of a system based on a low unit may easily be imagined.

30. Result of examination of the country to the north of Bangalore. The country to the north has been examined, and the additional catchment area a little to the south of Yellahanka, which was supposed* to be available, has been contoured. There is first a hill to the west of the 7th milestone of the road, and this would afford an area of about 0·43 of a square mile: then proceeding westward, there is the Bettahalli hill, of which the part sufficiently high measures 0·70 of a square mile. A mile south of the western side of the above hill there is a small hill with an available area of 0·04 of a square mile, or altogether 1·17 square miles could be obtained in this locality. The distance the water would have to be brought would be between 9 and 10 miles, and the section shows what the circumstances would be. The most favorable line, viz., the water-shed between the Pennakini and Arkavatti rivers has been selected, but this at Subedar's chuttrum is about 40 feet below the necessary level; at 1 mile and 50 yards therefrom is the lowest point, which is 23½ feet lower, for nearly 4½ miles a continuous and for the most part lofty aqueduct would be needed, and in the 8th mile and again to the east of the Bettahalli hill aqueducts would be required. The expense of aqueducts for so small a catchment would be prohibitive, and it is certain therefore that no addition to the gathering ground of the reservoir in this neighbourhood is feasible. In order moreover to ascertain the circumstances of the country conclusively, another set of levels has been run from Subedar's chuttrum along the water-shed to the southern spur of Nundidroog, and thence to the Mélékoté tank, which was, in the earlier discussions, supposed to be a possible source of supply, but which is not on a sufficiently high level, its waste weir being at 3046·49, or only

* Memorandum of 23rd September 1883, paragraph 34

Plan No. 5.

Plan No. 6.

Plans Nos. 7 and 8.

12·52 feet above the weir of the Ooparhalli reservoir. From these levels it will be seen that there is no considerable extent of ground, which is on a level high enough to supply the reservoir, nearer than the sloping ground at the foot of Nundidroog itself, or at 27 miles from Subedar's chuttrum. Also that to bring in water by a channel would involve some 24 miles altogether of aqueducts owing to the low level of the water-shed. It is, therefore, economically impracticable to bring in water to the reservoir from gathering ground to the north by means of a channel. If water is to be brought from the neighbourhood of Nundidroog, a reservoir must be made there, the water stored therein, and the supply taken to Bangalore in a cast-iron pipe. In that case it would be doubtful whether it would be wise to make any connection with the Ooparhalli reservoir, seeing how much water would in consequence be wasted by evaporation and leakage, &c., and it would probably be deemed better to construct a comparatively small masonry-lined reservoir to hold only about a week's supply. On this supposition, the conclusion would be that nothing can be done to improve the circumstances of the Ooparhalli reservoir, the utility of which would then necessarily be limited to occasionally supplementing the supply of Miller's tanks and improving the water resources of the Pettah, as mentioned in the latter part of paragraph 27 above.

31. The feasibility of supplying Bangalore from Nundidroog has not been fully investigated, as it has not been ascertained whether a good site for a reservoir at a suitable level can be found, but the general circumstances of such a scheme in other respects can be indicated.

(1) The extent of gathering ground available would probably be about 9 square miles, but whether any reservoir site could be found into which the whole of this drainage could be conveniently conducted is problematical. The above area is on the [illegible] by the topographical survey, a site is the more likely to be [illegible] the eastern slopes there is an area of about 3 square miles, which is probably high enough to allow of the drainage being diverted into a reservoir on the west side. Altogether it is certainly disappointing to find that, even at this distance from Bangalore, no large area is to be met with at a sufficiently high level.

(2) The supply required for a population of 135,000 at 10 gallons a head per diem being 216,000 cubic feet a day, and as it would be desirable in a project of this kind to allow for an increase of the population to say 150,000, 240,000 cubic feet a day may be taken as the quantity needed.

(3) The head available would probably be about 60 feet, and the length of main not less than 150,000 feet. As the water would be delivered into a service reservoir, it could run continuously, and the diameter of the main would be 2 feet.

(4) The proper capacity of the storage reservoir would be not less than 60 millions of cubic feet.

(5) The capacity of the service reservoir near Bangalore would be five days' supply, or 1·20 millions of cubic feet. The desirable level for its floor would be 100 feet above the Halsur tank datum, equal to 10 feet above the sill of the Ooparhalli reservoir sluice, or reduced level 3029·97. With a depth of water of 10 feet it would have an interior superficial area of 120,000 square feet. The form would be influenced by the site chosen, which would be somewhere between Subedar's chuttrum and the Ooparhalli reservoir, but probably a rectangle, affording clear room, 600 by 200 feet, would be found convenient, and to make it fully satisfactory as a pure water reservoir it would have to be covered in by arches over which some 3 feet of soil would be laid.

(6) The water would in all probability have to be filtered either near the storage reservoir or before entering the service reservoir.

The following summary gives an approximate estimate of the cost of the project. For scales of 24 inches in diameter a thickness of 1 inch of metal is usual, but, so far as head is concerned, ¾ of an inch would be ample; so estimates are given for each thickness, and in Appendix No. 8 further details will be found :—

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	Rs.	Rs.
Storage reservoir	45,000	45,000
Filters	75,000	75,000
Main between storage and service reservoirs, 24-inch	17,70,000	13,77,000
Service reservoir	2,40,000	2,40,000
Distribution mains, &c., at 3 rupees a head	7,50,000	7,50,000
	28,80,000	24,87,000

Assuming that 10 per cent. on these sums would be required to cover interest, maintenance, and deterioration, and that establishment for regulating the supply and looking after the works would cost Rs. 6,000 a year, the annual cost of the water-supply would be either Rs. 2,94,000, or Rs. 2,54,700, equivalent to Rs. 1·960, or Rs. 1·698 per head of a population of 150,000, or Rs. 2·262, or Rs. 1·96 a head of the present population of 130,000.

This would not, under the circumstances, be at all an extravagant charge, and at Lahore, with an abundant supply of water at a distance of half a mile from the service reservoir, the charges based on the same percentage, but with pumping, amount to Rs. 1·258 per head of the population of 130,000.

Capital outlay, a little over 15 lakhs.

Were 25 to 30 square miles of gathering ground available, as also a good site for a reservoir, it might be well worth while to incur the considerable outlay indicated for the purpose of supplying the whole of Bangalore with good water. As it is, in years of scanty rainfall there would be a risk of partial failure of supply, though it is probable that even in a year like 1876 a sufficient quantity for essential requirements would be forthcoming.

32. *Halsur Tank.*—This tank, the present source of water-supply for the European troops, had naturally a catchment basin of about square miles ... ... 5·50
A small portion of the western part of this area was diverted prior to the early part of the century into the Sampangi tank ... ... 0·33

5·17

And between the years 1854 and 1867 the construction of the four tanks known by the name of Miller's tanks, near the Madras Railway (cantonment) station, further curtailed the area by ... ... 0·53

Present effective area ... 4·64

In 1877 an upper Halsur tank was formed by throwing a bund across the northern margin of the old tank, and the catchment is now divided therefore into two sections of 2·54 and 2·10 square miles, respectively, for the supply of the upper and lower tanks. The upper tank discharges its surplus into the lower, and its contents are also from time to time turned into the lower tank to supplement the supply of the latter when required.

33. The greater part of the catchment or gathering ground of the lower tank, with the exception of less than one-fifth of a square mile to the eastward, is occupied by the large population of the cantonment bazaar, and, until the completion of the main sewer in 1864, most of the filth from a population of about 75,000 was washed down into the tank whenever a heavy fall of rain occurred. The sewer has much improved matters, as it is capable of carrying off all the bazaar drainage, provided the rainfall does not exceed about one-tenth of an inch an hour. There is no doubt, however, that the water flowing into the tank after a considerable period of dry weather followed by heavy rainfall is decidedly foul and unsuitable for drinking and culinary purposes.

The whole of the drainage of the 1·68 square miles which reaches the tank by the western feeder, which runs from just below the lowest of Miller's tanks through the bazaar, might without difficulty be diverted from the tank by running a bund across from the culvert by which it passes into the tank to the main bund a little to the north of the present surplus weir, which latter would be lowered and a new weir built in the

new tunnel; this tank receives drainage from foul ground at its north-west corner, and this also would need to be diverted into the western feeder above the culvert just referred to.

Moreover, the water-supply of the upper tank is far from pure. There is a large population on this part of the gathering ground, and there are tanneries and a large native cemetery, which are quite sufficient to account for the quality of the supply.

24. It has been ascertained that a considerable area of fresh ground could be drained into the lower tank by running a supply channel at a gradient of 2 feet per mile to the eastward.

The position and general circumstances of this area are shown on the general plan,* and on a larger scale and in more detail on plan No. 9. This ground measures 3·10 square miles, and the soil is generally of the light sandy character which is common to the neighbourhood. The water-supply from it would be of a better character than that now received by the tank, but it certainly would not be even approximately pure, for, though the land is for the most part under dry cultivation, it is extensively manured with all the various more or less filthy material which is conveyed from the barracks, the station, and the bazaar by the conservancy carts. There is further the additional objection that the construction of such a channel would interfere with, and diminish the supply of, a great many small tanks, some of which belong to the Mysore Government, while others are privately owned.

* No. 1.

The settlement of compensation would be difficult and troublesome, because there are not only the tanks of which the supply would be directly diminished to a demonstrable extent, but many others which get water from the surplus of the former, and no reliable estimate could be formed of the extent to which the supply of these lower tanks would be affected. On the whole then, promising though the plan of bringing in a supply from the open country to the eastward appeared in the first instance, it is considered that the circumstances are too unfavorable as regards quality of the supply to warrant relief being sought in this direction.

To secure the drainage from the 3·10 square miles above mentioned, a channel 9½ miles in length would be needed, but a fresh area of 2·174 square miles could be secured by stopping the channel at 5 miles, and, as this would more than compensate for the 1·68 *plus* 0·22, equal to 1·90 square miles of the present catchment, which would be diverted from the tank, and as the shorter channel would interfere with but few existing tanks, it would be the better arrangement.

	Rs.
The cost of diverting the western and north-west feeders of the tank would be about	18,850
The supply channel 9½ miles in length for the catchment of 3·10 square miles would cost about	11,120
The channel 5 miles long for the catchment of 2·174 square miles would cost about	6,460

So that the larger scheme would require an expenditure of Rs. 29,970 and the smaller of Rs. 25,310 exclusive of compensation for water diversion. Approximate abstract estimates and specifications are given in Appendices Nos. 16 to 17-C. In either case it is proposed to raise the full tank level 1 foot, and so increase the storage by 5·113 millions of cubic feet.

35. The Halsur tank, prior to the formation of the upper tank, held, when full ... ... millions of cub. ft. 38·293

At present the capacities of the two tanks are—

Upper tank	millions of cub. ft.	11·240	
Lower do.	do.	37·633	
			48·873
	Increase ...		10·580

A table of capacities has been drawn up and will be found in Appendix No. 10. Statements of particulars of water-supply have been worked out from the registers for the years 1880 to 1883 inclusive, Appendices Nos. 11 to 14, and a summary is given in Appendix No. 15. From the latter it will be seen that the year 1880 was one of exceptionally heavy rainfall, and the tanks received no less than 165·372

millions of cubic feet, but in neither of the other years was the yield of the basin equal to the capacity of the tanks. The average receipts of these three years were indeed only just one half of that capacity.

36. It has been alleged that the falling off in the supply of the Halsur tank has resulted from the diversion of part of the drainage by the catchment channels of the new (Ooparhalli) Reservoir, but the area of drainage so diverted is only one-twelfth* of a square mile, and would account for only 1·32 millions of cubic feet in the last three years or on the average 0·44 millions per annum, or 1·8 per cent.

* 32 acres (*vide* paragraph 23).

Compared with the period prior to 1864 the supply has no doubt suffered material reduction by the construction of the main sewer, but the idea of the prejudicial effect of the Bangalore water-supply project works doubtless originated in the contrast between the abundant supply of 1880, when the waste weir discharged surplus on no less than 88 days between the 14th August and the 7th December, and the short supply of subsequent years. The real cause is explained by the rainfall register, and a reference to the statistics of the Halsur water works, Appendix No. 20, will show that the water level in the tank on the 31st December was much the same in 1878, the first year in which the new reservoir held water, as in 1877, and that in 1879 and 1880 it was at a higher level than in any year after 1872.

37. It will be noticed that the rainfall registered at the Halsur rock is about 18¼ per cent. less than that registered at the Bowring Civil Hospital, which is distant 1,900 yards but little more than a mile. This is due chiefly to the gauge at the rock being on the top of the rock, or indeed some feet higher than the latter.

An examination of the monthly abstract of the registers shows that, on the other hand, in February the rainfall gauged at Appendix No. 12. the rock has always been higher than that at the hospital, but for the other 44 months this was the case in only 6 months.

It is further noticeable that the rainfall register at the Bowring Hospital is not always a guide to the rainfall over the catchment of the Ooparhalli reservoir, distant about three miles, for 1880 was only an average year in the latter locality, the figures being 39·56 inches against 51·69 at the hospital, and again in 1881 the figures are 21·63 and 27·44 respectively. In 1882 and 1883 the two sets of registers agree very nearly.

38. The yield of the Halsur catchment basin for the four years averaged 0·174 and 0·146 of the rainfall registered at the rock and hospital respectively. The proportion at the Ooparhalli reservoir averaged 0·12 for the same period. Omitting 1880, the proportions for the Halsur catchment are 0·085 and 0·071, and for the Ooparhalli reservoir 0·127.

39. *Wells.*—These, as a means of procuring water, are in very general use, and, seeing how small a proportion of the rainfall runs off the ground, it might be expected that a fairly abundant supply would be met with below the surface. The ordinary surface soil is very sandy, and below this, at varying depths, a subsoil composed of gneissic rock in a more or less advanced state of disintegration and decomposition is met with; this overlies gneiss in either the massive or detached state. In many places the rock comes to the surface, but more generally it is at a considerable, and sometimes at a very considerable, depth therefrom. Many houses possess wells which are said to yield water of excellent quality, but there is no certainty that two wells, though only a short distance apart, will contain water of at all similar character. The water of the wells in that part of the station which has for a long time been thickly populated is generally confessedly bad, as is to be expected, but besides these there are many wells the water of which is unfit for domestic use because it is impregnated with salts, which render it brackish or bitter.

There is at Bangalore ample space on fairly clean ground for a sufficient number of wells to produce collectively a much greater quantity of water than is required, but, while it is certain that a very considerable proportion of such wells would contain brackish water, there would be no means of determining beforehand where wells of

good water would be obtainable. Borings would afford *prima facie* evidence of the character of the soil at the spot, and the water drawn therefrom could be tested, but even then it would not be demonstrable that the water taken from a large well on the same spot would be of the same quality, for directly the quantity taken out becomes considerable, the area drawn from would be extended proportionately, and new conditions would be met with.

There is no generally-distributed water-bearing stratum, containing good and pure water, into which wells can be sunk, and a supply of this character obtained with certainty.

40. To the south of the South Station Hospital there is a small water course on the banks of which some wells were sunk in the famine years 1876—77. One of these wells, No. 2, at 760 yards from the hospital and conveniently situated as regards the Field Artillery and European Cavalry Barracks has been tested, and the partial (qualitative) analysis made under the direction of the Deputy Surgeon General is fairly favorable.

Plan 15.

Vide first entry in Appendix No. 26-P.

If an abundant supply of such water could be obtained, this source might be considered satisfactory, but the experiment made in March with an engine and pump lent for the purpose by the Secretary to the Mysore Government, Public Works Department, shows that at a time when the yield of a well is certainly not at its minimum, the inflow averaged during 138½ hours only 5·37 cubic feet, or 33·56 gallons an hour. On the average of four years the hourly consumption of water by the troops has been 2,349 gallons.

Appendix No. 21.

It would therefore require 70 such wells to supply the total quantity required, and probably not less than 40 larger wells, distributed so as to drain the greater part of the basin of the water-course, which has an area of 258 acres, would suffice, while there would be always the possibility of the failure of the supply towards the end of the dry season. With a bund across the valley above the road, it is probable that sufficient water would be obtainable for cooking and drinking purposes for the Cavalry Regiment, the two Field Batteries, and the Hospitals, as this part of the supply might be taken to be one-sixth of the whole, or say 400 gallons an hour, which quantity might be obtained from say six connected wells of 20-feet diameter each, and the supply could be lifted by a pump worked by coolies or bullocks, which would be less expensive than a steam engine, as the cost would not exceed Rs. 1,000 per annum.

41. Similar arrangements might be made for the supply of the Horse Artillery and the European Infantry at a cost of about Rs. 1,500 per annum, but for other purposes two-thirds of the present supply would still have to be pumped up from the Halsur water works, and the cost of these two-thirds would be but little less than the Rs. 10,400 expended at present on the whole supply of the troops.

The register of the pumping operations at No. 2 well will be found in Appendix No. 22.

42. Some of the data—*e.g.*, the number and length of the connections with the several buildings—for an approximate estimate of the cost of the arrangements above indicated would require more time for their collection than is now available, but the following summary will give a tolerably good idea of the probable outlay required. The way in which the calculation has been made will be found in Appendix No. 23.

	Rs.
Seven wells	4,550
Pump with gear	1,200
Pipes and laying	8,354
Trench for connecting pipes	3,000
Unwatering during construction	3,000
Taps and fittings	2,000
Contingencies	1,896
	24,000

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About an equal amount would be required to supply the Horse Artillery and the European Infantry Regiment with water from wells, or say Rs. 50,000 altogether. The current charges being estimated at Rs. 1,000 *plus* 1,500 annually, this, capitalized at twenty-five years' purchase, would represent Rs. 62,500 ; so the entire cost of supplying well water for drinking and cooking purposes only to the European troops would be about Rs. 1,12,500.

43. None of the heretofore considered sources of supply being likely to be acceptable and also adequate, attention has been given to others which it seemed possible might be better suited to meet the requirements. Necessarily there could be no adequate supply obtainable without pumping, and all that could be hoped for was sufficient water at a level not very much below that of the station and at a moderate distance. The Hoskote tank, which is much the largest in the neighbourhood, was visited. It has a catchment basin of 540 square miles, and is the terminal of a very large group of tanks, of which at present only one sub-series has been surveyed, so the statistical information is incomplete. Notwithstanding the large number of tanks above it, the supply is said to be good. In 1876 there was some water, but not enough for cultivation ; in 1877 the tank got a good supply. About twenty years ago (probably 1866) the tank was entirely without water. In 1875 the supply was so great that it was feared the tank would breach.

The extent of irrigation is about 2,000 acres and the revenue about Rs. 5,000 ; the assessment has been reduced since 1877. The season of cultivation is from December to August or September. Only one crop is cultivated, and this is commenced from December to April, the harvest being from June to September. The tank is from 12 to 13 miles from the barracks, and it is about 104 feet lower than the Halsur tank. There is a small hill, 2 miles west of the 14th mile-stone, which would be a convenient site for a stand pipe as it is 190 feet above the tank level. The appearance of the water in January, when the tank was nearly if not quite full, was not prepossessing, and the native opinion of it is unfavorable, the expression used being that they would not give it to a horse to drink, and they say that to bathe in it is apt to produce fever. The inhabitants of the town use the water of a small tank which lies immediately east of the large tank and north of the town, and its water is altogether different in appearance. Under these circumstances it seemed unnecessary to carry the investigations further. The information above given was obtained from the native accountant of the amani tanks.

44. About three miles south-east of the Race Course, or Cavalry and Field Artillery Barracks, there is the Agaram tank, which on the whole affords the best prospect of being a suitable source for the supply of the troops. It has a catchment basin of 32·10 square miles, of which however a considerable part is rendered non-effective or only partially effective, by the upper tanks in the same basin. It receives no drainage from the pettah or cantonment. It is said to be generally well supplied, though in 1876 it was, in common with nearly every tank in the country, for a time dry. This season, though the rainfall was below the average, the tank was full up to the 19th January, or 4½ weeks after the last considerable rainfall. On the 6th March the water had fallen 0·26 of a foot, so that, inclusive of the water drawn off for cultivation, the water surface had fallen less than one quarter of an inch a-day.

The position of the tank with regard to the barracks and that of its catchment basin will be seen on referring to plan 1, sheets 1 and 2, and the survey of the tank is given in plan 13.

The area of the water-spread at full tank level is 131 acres, or 5·706 millions of square feet. The sill of the lowest sluice is at 7·16 feet below full tank level, and the area of water-spread at this sill level is computed to be about 1·017 millions of square feet. The capacity between sluice sill and full tank level is about 24·068 millions of cubic feet, and it has been ascertained that, were the full tank level raised three feet, 20·601 millions of cubic feet would be added to the contents. There are 280·17 acres of land classed as wet under the tank, and of these 129·10 acres are usually cultivated and yield a revenue of Rs. 617-8-0.

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The full tank level is 58·25 feet below that of the Halsur tank, and the water would have to be pumped at least so much higher in order to secure as much command as at present.

45. Samples of the water have been analysed by the Chemical Examiner with the result shown in Appendix No. 26. It will be seen that the water has obtained only the qualified character "usable," but that is the highest character given in any of the analyses of Bangalore water, and it seems to be more than doubtful whether anything more favorable is likely to be found.

The Agaram water is slightly clouded, but it is good wholesome looking water and very different indeed from that which even at the best of times is to be found in the Halsur tank. It will be noticed that the analysis differs somewhat in the case of the two samples, though the water was all taken from the tank at one time and at one place.

46. It was at first intended to get rid of all matter capable of removal by filtration from the water by sinking a large well in a convenient spot near the north-west corner of the tank, and allowing no water to enter the well except through several feet of soil. The analysis by the Chemical Examiner however of the water of one well to the north-west of the tank, and the partial analysis at Bangalore of the water of four wells but a short distance from its water-spread on the west side, which, and more especially Nos. 3 and 4, were chosen to serve as an index to the probable quality of the soil through which a supply well would be sunk, render it more than probable that such an arrangement might materially injure the quality of the water. The fixed hardness, for instance, is 6·2 degrees in the best, No. 4, of these four wells against 1·4 to 1·75 degrees for the tank water, while in other respects the well water is considerably less pure than that in the tank, though the former looks clearer.

Appendix No. 26-E.
Do. No. 26-F.

It would be desirable, if possible, to avoid the expense and complication of artificial filtration, and so in any case it would be desirable to have an experimental well sunk in the bed of the tank to test, through the water therefrom drawn, the character of the soil through which the water has filtered, and its effect upon the potable qualities of the supply. Samples of water have been taken from two wells or pools in rear of the western end of the bund, and their analyses will be found in Appendix No. 26-G. The results are satisfactory as the turbidity of the water is no doubt due to the wash of the water on the soil, the pools or wells being used for irrigation.

47. On plan 14 are shown the relative levels of the tank and the several service cisterns attached to the barracks, hospitals, &c. Also the proposed height of the standpipe, which is intended to be rather more than 15 feet above the water surface, when full, of the highest cistern to be filled.

48. Appendix No. 24 contains specifications and approximate estimates for the work to be done, and a short summary of the latter is subjoined. It appears to be essential to increase the capacity of the tank if the water be drawn direct from the latter, and in the estimate for this arrangement such increase has, it will be seen, been provided for. The average consumption of water by the troops has been 3·292 millions of cubic feet per annum, or less than one-seventh of the contents of the tank, and probably not more than one-twentieth of the quantity received: the estimated maximum consumption also has been taken as 5·256 millions of cubic feet in the year, or perhaps one-twelfth of the supply coming into the tank. Were however a corresponding extent of land, viz., about 25 acres, thrown out of cultivation and compensation on that account paid, there would still be much risk of the storage proving insufficient at times. With an addition to the storage capacity of nearly four times the maximum off-take, there is every probability of there being always in the tank an ample reserve to meet the contingency of an unusual interval between successive receipts from rainfall. It is indeed worth consideration whether it would not be the better plan, even if water be drawn from a well within or below the tank, to enlarge the tank, as by so doing all question of injury to land-holders under the tank would be avoided, and that is a matter of importance.

Particulars.	Water drawn direct from tank.	Water drawn from supply well 30 ft. below tank.
	Rs.	Rs.
Engines and pumps	56,500	56,500
Stand-pipe including masonry	3,500	3,500
Delivery mains	1,18,000	1,18,000
Suction pipe from supply well	...	2,520
Supply well	4,000	900
Suction pipe from tank	500	...
Do. from pure water well	15,000	...
Two filters	250	250
Enlarging tank	12,500	12,500
Ground for pumping station	3,000	3,000
Engine-house and chimney	4,000	4,000
Quarters for Engineer, &c.	2,11,250	1,81,220
Enclosure walls	8,000	6,780
Contingencies ...	2,20,000	1,88,000

49. Inquiry has been made as to whether any of the pumping plant at the present water works would be suitable and available for transfer to the Agaram water works. The engine at the rock is an old one, but with new boilers it would be serviceable for some years to come. The engine at the Dhobies' wells is comparatively new, and it ought to be capable of a much higher duty than has so far been obtained from it. At present it is costly as regards fuel consumed as compared with work done, but it seems probable that this is in a considerable measure due to the use of a small delivery pipe.

However the chief difficulty would lie in the necessity for continuing the present water-supply arrangements until other and better arrangements have been carried out and are perfectly ready to be substituted. The troops cannot be left without water for two or three weeks or perhaps longer, and so the engines and pumps must be kept where they are and others be provided for the new works. It may be taken as certain however that it will in the long run be the more economical and satisfactory plan to get complete machinery, suited in all respects to the work to be done, from a firm which understands the special requirements of such works. Water works need to be well carried out in all respects, and all the parts should be in harmony. The old plant will fetch something considerable when done with though much less than its value. The pipes now in use ought to fetch their full value, or some of them might with advantage be used for extending the distribution arrangements to the lines occupied by the officers of the regiments supplied.

50. It is nearly certain that water of perfectly satisfactory quality could be obtained at Bangalore only by distillation, and it seemed desirable therefore to complete the water-supply investigations by ascertaining the cost of the necessary apparatus and the expense of producing potable water in this way. General Hyde of the India Office has obligingly furnished the requisite information. In Appendix No. 25 will be found a statement giving the results of the working of the new and old Government condensers at Aden, as well as those of two private owners. The new condensers were made by the Normandy Company and are considered to be the best and most economical known. Also two letters from the Normandy Company to General Hyde and estimates for three sets of apparatus. It will be seen that the cost of two sets of apparatus to produce together 12,000 gallons in 24 hours would be ... £ 4,362
One set to produce 9,000 gallons ... ...

	GALLONS.
The smaller or 6,000-gallon size has, in an experimental trial at Aden, produced in 24 hours	7,082
The larger, or 9,000-gallon size has, in an experimental trial at Aden, produced in 24 hours	12,110

But the average yield is shown by the statement to be about four-fifths of the above. Coal is the fuel used at Aden, and one pound of coal is equivalent to four pounds of wood, the fuel available at Bangalore.

The yield is 16 lb. of condensed water for 1 lb. of coal, and therefore 4 lb. of water would be obtained for 1 lb. of wood fuel.

The Company's estimate of outturn is higher than the above and varies slightly according to the size of the apparatus, the yield being 18·0, 18·8, and 19·8 lb. of water to 1 lb. of coal for the three sizes respectively.

The Aden experience may, it is considered, be accepted as a safe guide.

No better water than that of the Dhobies' wells could be obtained for distillation. Assuming that 9,000 gallons a day would meet the requirements of the troops if the use of the condensed water were restricted to drinking and cooking purposes, one set of apparatus at a cost of Rs. 45,780 would suffice if kept constantly at work, but as at any rate it would be advisable to stop the machinery on Sundays, it would be desirable to have a 12,000 gallons set which would produce in six days enough water for eight days' consumption, and its cost would be Rs. 60,690. The weight of 12,000 gallons is 120,000 lb., and the wood fuel required would be 30,000 lb. The present price of wood is 1 rupee for 268½ lb., therefore the daily cost of fuel would be Rs. 112 nearly, and the annual cost 52 × 6 × 112 ... ... Rs. 34,344

Small stores, &c. 256

Working expenses 34,600

The apparatus includes pumps capable of delivering the water where required. It is stated that the attendance of one man will suffice to work the apparatus, and therefore the existing establishment at the Dhobies' wells would suffice; and, as the engine and pumps there would not be required, the buildings would be available for the condensers.

The only other outlay would be for pipes, cisterns at the barracks, &c., say 25,000, and the total annual outlay may be thus estimated:

	Rs.
15 per cent. interest and depreciation on the cost of the condensers ...	9,104
10 per cent. do. on rest of outlay	2,500
Working expenses	34,600
	46,204

or about 15·40 rupees annually per head. The present cost, about Rs. 10,400 a year, for the working expenses of the Halsur water works would remain unaffected, as water for other purposes would have to be pumped up by the Halsur rock water works.

51. The results of the investigations that have been made are briefly these:

(1) The Bangalore water-supply project was designed and has been, with the exception of the greater part of the distribution works, carried out to supply the population generally with good water.

The (Ooparhalli) reservoir is inadequately supplied. It has never been full or nearly so for nearly five months in the year; on the average of six years the water level therein has been below the sill of the off-take sluice. The cause of this failure is the very small extent of the gathering ground, 2¼ square miles, which is not more than about one-third of the area necessary to enable the reservoir to perform the duty for which the works were constructed.

Paragraph 27.

Paragraph 28.

There is but an insignificant extent * of additional ground the drainage of which could be brought into the tank within a distance of eight or nine miles, and, owing to the low level of the intervening country, the cost of bringing in the water therefrom would be out of all proportion to its quantity and value.

* A little over one square mile.

Paragraph 30.

The Bangalore water-supply project is therefore incapable of supplying the station or the troops, and its utility will necessarily be confined to the improvement of the supply of a part of the Pettah or native town and to occasionally supplementing the supply of Miller's tanks, which are of much importance to the inhabitants of the cantonment bazaar. The high ground at Nundidroog is the nearest and indeed only locality in which there is any considerable extent of ground on a sufficiently high level to command Bangalore, and even there the area between 9 and 12 square miles is much less than would be desirable. It is not yet certain that a suitable site for a reservoir in that neighbourhood can be found, but, if there be such a site, the cost of supplying Bangalore generally including the garrison would be between Rs. 24,87,000 and Rs. 28,80,000, depending upon the thickness of the cast-iron mains. These amounts represent, together with an allowance for working expenses, annual charges of from Rs. 1·693 to 1·960 per head of a population of 150,600 and of from Rs. 1·960 to 2·262 per head of the present population of 130,000.

Paragraph 31.

(2) The Halsur tanks, the present source of supply for the troops, are supplied from, for the most part, a densely-populated gathering ground, and the quality of the water is therefore unsuitable for drinking and cooking purposes. It would be possible to exclude the whole of the foul drainage from the lower and larger of the tanks, and to compensate for this exclusion by bringing in the drainage of open cultivated country to the eastward. This new gathering ground, however, though comparatively clean, is manured with the dirt and refuse of the cantonment bazaar, barracks, &c., and is therefore not capable of yielding anything like pure water. It is moreover not practicable to get rid of the foul supply of the upper tank, which receives drainage not only from ground carrying a considerable population, but from that occupied by tanneries, a large native cemetery, &c.

The Halsur tanks therefore are not capable of being made a really satisfactory source of water-supply for the troops.

The cost of such improvements as are feasible would be from Rs. 25,810 to Rs. 29,970, the former for a new catchment of 2·174, and the latter for one of 2·10 square miles.

Paragraph 32.

(3) The proportion of the annual rainfall which does not run off the surface of the ground, but which is absorbed thereby, is in favor of wells as a source of water-supply, and there is still a large extent of open and fairly clean ground in the neighbourhood of the barracks occupied by the troops, in which wells could be sunk to obtain the water-supply required, for drinking and cooking purposes.

The nature of the sub-soil composed of gneissic rock in a more or less advanced state of decomposition makes it difficult to find subsoil water of suitable quality, and there is great uncertainty as to the quality of the water which wells sunk in any given locality would yield.

Separate sets of wells would moreover be needed to supply—

1st—The European Cavalry,
The two Field Batteries,
The South Station Hospital.
2nd—The Horse Artillery.
3rd—The European Infantry Regiment,
The North Station Hospital.

The water-supply of one well, No. 2, about 760 yards south of the South Station Hospital has been tested as regards both quantity and quality. The latter is satisfactory, and the former indicates that, for drinking and cooking purposes only, six supply wells, each 20 feet in diameter, would be required for the first section above mentioned of the garrison.

Paragraph 42.

The total cost of supplying the troops from wells is estimated at Rs. 1,12,500, representing the following annual expenditure:—

	Rs.
Interest and depreciation on cost of works at 10 per cent. ...	5,000
Working expenses	2,500
Total ...	7,500

which would be in addition to present charges on this account.

The difficulty of forecasting the quality of the water and the uncertainty as to the maintenance of that quality if found suitable in the first instance render it unadvisable to resort to wells as a source of supply if any better arrangement can be made.

(4) A new source of supply for the troops has been found in the Agaram tank, a reservoir situated about three miles to the south of the SouthStation Hospital, and having a catchment basin of 32·10 square miles, of which however a considerable part is rendered non-effective by a number of tanks in the upper part of the valley. The tank is well supplied; it receives none of the drainage of Bangalore, and the quality of the water, which has been analysed by the Chemical Examiner, is described as "usable," the highest character given to any water, from the neighbourhood of Bangalore, which has been examined. The surplus weir is 56·82 feet below that of the Halsur (lower) tank, and water would have to be pumped up to a level sufficiently higher than at present to cover this difference and the head due to the greater distance. The water could either be drawn direct from the tank, filtered, and then pumped into the existing service cisterns, or it could be drawn from a supply well in or below the tank, in which case artificial filtration might not be needed. The tank at present has a capacity of 24·068 millions of cubic feet, and by raising the weir 3 feet an additional storage capacity of 20·601 millions would be secured, making the total 44·669 millions of cubic feet. The estimated outlay required is Rs. 2,20,000 if water be taken direct from the tank, and Rs. 1,88,000 if it be drawn from a supply well within the influence of the tank. These amounts would represent an annual expenditure as follows:—

Paragraph 44.

Paragraph 45.

	No. 1. Rs.	No. 2. Rs.
Interest and depreciation on cost of engines, pumps and boilers, &c., at 15 per cent.	5,475	5,475
Interest and depreciation on other outlay at 10 per cent.	18,350	15,150
Total ...	23,825	20,925

or from Rs. 7·94 to 6·87 per head.

The present working expenses for pumping, &c., amounting to about Rs. 10,400 per annum, would suffice for the new pumping station; and the engines and pumps at the Halsur rock and Dhobies' wells could, after the new arrangements had been completed, be disposed of.

Troops and families, 3,000.

(5) Water of unexceptionable quality is probably obtainable at Bangalore only by distillation.

It has been ascertained that the best known apparatus for this purpose is the Normandy Company's condenser, which is that recently introduced for the Government water-supply at Aden.

Paragraph 50.

Taking 9,000 gallons, or 3 gallons a head, as the quantity essential for the use of the troops for drinking and cooking purposes, the annual expenditure on this account would be about Rs. 46,204, or Rs. 15·40 per head.

The working expenses of the present water works would be unaffected, as all the rest of the supply would have to be obtained from the Halsur tanks.

The Dhobies' well water would be the best for distillation, and the buildings there would be suitable for the condensing apparatus.

The Normandy condenser produces pure, cold, palatable, and well aerated water.

52. The thanks of the undersigned are due to Captain Kensington, R.E., the Secretary to the Mysore Government, Public Works Department; to Lieutenant-Colonel Barton, R.E., Executive Engineer, Presidency Division, and to Mr. J. Smith, the Engineer of the Halsur Water Works, for much valuable assistance given in carrying out the investigations referred to in this report; as also to Dr. T. Tarrant, Deputy Surgeon-General, Bangalore Division, for the very useful information afforded, at short notice, as to the quality of samples of water taken from several wells, and to the President of the Madras Municipal Commission, for particulars of the consumption of water, cost of distribution and maintenance, and of pipes and fittings, &c.

(Signed) J. MULLINS, Col., R.E.,
Chief Engineer, on special duty.

Bangalore,
31st March 1884.

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APPENDIX No. 1.

Comparative Statement of Sanctions and Outlay, Bangalore Water Supply Project.

Heads.	Original Estimate sanctioned by the Government of India on the 28rd August 1876.	Revised Estimate, sanctioned by the Government of India.		Total Revised Estimate.	Total Outlay.	—
		July 1878 Revised Estimate.	October 1876 Supplemental Estimate sanctioned by Chief Commissioner.			
	Rs.	Rs.	Rs.	Rs.	Rs.	
Embankment and weir	1,03,903	2,31,207	3,329	2,34,536	3,14,868	
Catchment channels	11,850	61,758	..	61,758	71,288	
Moderator tanks	7,113	..	..	..	..	
Water tower	8,635	11,763	..	11,763	729	
Filter and store basins *	72,603	26,123	..	26,123	..	
Distribution reservoir †	24,123	..	..	..	..	
Delivery channels	2,97,031	‡ 1,15,552	§ 7,032	1,22,584	‖ 20,454	
Compensation for land, &c. ..	50,000	69,000	2,000	71,000	69,340	
Surveys and rainfall registration ..	..	5,250	..	5,250	¶ 4,285	
Inspection bridge, barracks and huts ..	..	12,705	..	12,705		
Total ..	9,69,257	5,36,358	12,901	5,49,724	5,44,765	

* Design modified and then given up.
† Fine part of scheme abandoned.
‡ Open masonry channels instead of iron pipes.
§ Covering the channels.
‖ Nothing done beyond Cubbon road.

		Millions of Cubic Feet.	Cost per Millions of Cubic Feet.
			Rs.
Reservoir.	Total capacity ..	51	10,681.
	Available do. ..	29	18,785.

APPENDIX No. 2.

Levels of the Boundary Catchment Channels, Ooparhalli Reservoir, Bangalore Water Supply Project, taken in April and May 1883.

Mileage.	Bed-levels, &c.	Remarks.	Revised bed-levels May 1883.	Mileage.	Bed-levels, &c.	Remarks.	Revised bed-levels May 1883.
		North-east Channel.		ms. y.		*North-west Channel*—cont.	
ms. y.		Newly excavated beds at		0 2	101·65	On grade stone ..	98·75
0 0	99·97	zero stone	98·00	0 3	101·89	Do. do.	..
		On grade stone ..	..	0 4	101·82	Do. do.	99·50
0 1	101·42	Do. do.	98·75	0 5	102·17	Do. do.	..
0 2	101·44	Do. do.	..	0 6	102·29	Do. do.	100·25
0 3	101·53	On bed	99·50	0 7	102·51	Do. do.	..
0 4	101·97	Do.	..	1 0	102·72	Do. do.	101·00
0 5	102·08	Do.	100·25	1 1	102·91	Do. do.	..
0 6	102·44	Do.	..	1 2	103·25	On bed of channel ..	102·00
0 7	102·52	Do.	101·00	1 3	103·33	On grade stone ..	..
1 0	102·58	Do. Rise 1·23 per mile..	..	1 4	103·46	On bed of channel ..	103·00
1 1	102·58	Do.	101·75	1 5	103·74	Do. do. ..	..
1 2	102·48	Do.	..	1 6	104·05	On grade stone ..	104·00
1 3	102·42	Do.	102·50	1 7	104·49	On bed of channel ..	..
1 4	102·50	Do.	..	2 0	104·76	On grade stone ..	105·00
1 5	102·67	Do.	103·25	2 1	105·09	On bed of channel ..	..
1 6	102·21	Do.	..	2 2	105·13	Do. do.	..
1 7	102·28	Do.	104·00				
2 0	101·93	Do.	..			*South-west Channel.*	
2 1	101·73	Do. Rise 1·29 in mile..	104·75	0 0	100·26	Bed of channel and floor of culvert	98·00
2 2	101·74	Do.	..			N. S. Waste weir 104·11.	
2 3	101·55	Do.	105·50				
2 4	101·99	Do.	..	0 1	101·04	On grade stone ..	..
2 5	101·81	Do.	106·25	..	99·34	Bed newly excavated ..	98·75
2 6	101·69	Do.	..	0 2	101·48	On grade stone ..	..
2 7	101·61	Do.	107·00	..	99·88	Bed newly excavated ..	..
3 0	101·43	Do. Rise 4·14 in mile..	..	0 3	101·64	On grade stone ..	..
3 1	101·34	Do.	..	..	100·14	Bed newly excavated ..	..
3 2	101·44	Do.	..	0 4	101·89	On grade stone ..	99·49
3 3	100·44			..	101·26	Bed newly excavated ..	..
		North-west Channel.		0 5	101·97	On grade stone ..	..
		Newly excavated bed ..	98·00	0 6	101·45	Bed newly excavated ..	100·25
0 0	99·23	On grade stone ..	..	0 7	102·38	On grade stone ..	..
0 1	101·69	On bed newly excavated.	..				
..	100·48						

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Levels of the Boundary Catchment Channels, Ooparhalli Reservoir, Bangalore Water Supply Project, taken in April and May 1883—(*Continued*).

Mileage.	Bed-levels, &c.	Remarks.	Revised bed-levels May 1883.	Mileage.	Bed-levels, &c.	Remarks.	Revised bed-levels May 1883.
MS. F.		*South-east Channel*—cont.				*South-east Channel*—cont.	
1 0	102·67	On bed	101·90	MS. F.		On grade stone ..	..
1 1	103·18	Do.	..	.. ..	100·89	Bed newly excavated ..	..
1 2	103·11	Do.	..	.. ..	97·99	On grade stone	100·00
1 3	103·41	On grade stone ..	102·90	0 1	102·75	Do. do.	..
1 4	103·29	On bed ..	..	0 2	103·00	Do. do.	101·00
1 5	103·61	On grade stone ..	103·00	0 3	103·27	On bed	..
1 6	103·65	Do. do. ..	..	0 4	102·09	On grade stone ..	102·00
1 7	104·56	Do. do. ..	104·00	0 5	100·35	Do. do. ..	..
2 0	104·57	Do. do. ..	..	0 6	101·01	Do. do. ..	103·00
2 1	105·48	Do. do. ..	105·00	0 7	103·24	On bed ..	..
2 2	106·42	Do. do. ..	..	1 0	104·04	Do. ..	..
		South-east Channel.	..	1 1	103·97	Do. ..	..
0 0	99·76	Floor of culvert ..	99·90	1 2	103·81	Do. ..	..
				1 3	104·19	Do. ..	..

Copied from level book lent by Mysore Public Works Office. December 1883.

APPENDIX No. 2-A.

Levels of the Upper Main (No. 2) Catchment Channels, Ooparhalli Reservoir, Bangalore Water Supply Projects, taken in October and November 1883.

Mileage.	Bed-levels, &c.	Remarks.	Mileage.	Bed-levels, &c.	Remarks.
MS. F.		*North-east Channel.*			*South-east Channel.*
0 0	100·62	Bed.	MS. F.		
0 1	105·48	Do.	0 0	101·90	
0 2	110·31	Do.	0 1	106·83	
0 3	112·24	Do.	0 2	111·96	
0 4	112·46	Do.	0 3	113·36	
0 5	113·05	Do.	0 4	114·39	
0 6	114·21	Do.	0 5	115·22	
0 7	114·14	Do.	0 6	115·39	
1 0	114·95	Do.	0 7	117·38	
1 1	115·50	Do.	1 0	118·09	
1 2	116·09	Do.	...	118·69	End of channel.
1 3	118·05	Do.			*North-west Channel.*
1 4	118·13	Grade stone.			
1 5	118·46	Do.			
1 6	119·35	Do.	0 0	102·30	
1 7	119·67	Do.	0 1	104·54	
2 0	120·98	Do.	0 2	107·44	
2 1	121·52	Bed.	0 3	109·61	
2 2	122·84	Grade stone.	0 4	111·68	
2 3	124·72	Bed.	0 5	112·76	
			0 6	113·43	
			0 7	113·65	
		South-west Channel.	1 0	114·04	
0 0	100·84		1 1	114·64	
0 1	104·33		1 2	115·42	
0 2	107·79		1 3	116·47	
0 3	110·75		1 4	117·44	On grade stone.
0 4	114·66		1 5	117·94	Do. do.
0 5	117·31		1 6	118·04	Do. do.
0 6	118·97		1 7	120·02	Do. do.
0 7	118·74		2 0	121·24	Do. do.
1 0	119·15		2 1	122·77	Do. do.
1 1	119·84		2 2	124·02	End of channel.
1 2	120·52		...	126·93	
1 3	121·23				
1 4	122·57				
...	123·92	End of Channel.			

Copied from the level books in the office of the Secretary of the Mysore Govt., Public Works Dept., on the 7th January 1884.

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APPENDIX No. 3.

Abstract of the Rainfall registered at Stations of the Bangalore Water Supply Works.

Months.	1876.		1877.		1878.		1879.		1880.		1881.		1882.		1883.		Days.		Inches.	
	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Total.	Average.	Total.	Average.
January ..	..	..	..	..	..	..	1	0·27	..	..	..	..	1	0·75	..	..	2	0·08	1·02	0·13
February ..	..	..	..	..	..	..	2	1·24	..	..	..	..	..	..	..	..	2	0·29	1·24	0·15
March ..	..	0·88	2	0·60	..	..	1	1·56	..	..	..	..	..	..	..	..	7	1·00	4·34	0·53
April ..	..	0·48	2	1·08	1	2·13	2	0·60	..	..	..	..	1	0·09	..	..	11	1·67	6·95	0·87
May ..	..	5·69	6	2·68	4	5·31	2	0·65	..	..	..	..	10	6·77	1	0·09	47	6·71	30·16	4·52
June ..	..	1·89	7	1·82	6	3·23	3	2·02	..	..	..	..	5	1·89	6	1·24	46	6·43	17·17	2·15
July ..	..	2·35	6	1·03	11	6·33	4	8·49	..	..	..	..	16	7·29	7	3·94	82	11·71	32·90	4·11
August ..	..	3·11	8	2·75	13	12·77	14	3·82	..	..	..	..	16	7·29	14	6·92	88	12·57	50·31	6·29
September ..	..	1·11	21	12·33	15	6·99	15	4·32	..	..	..	..	12	3·89	4	0·96	77	11·00	82·14	4·64
October ..	..	0·66	14	9·96	11	5·11	7	7·46	..	..	..	..	14	6·47	14	12·96	71	10·14	49·71	6·21
November ..	..	0·42	3	2·07	1	0·23	10	1·90	..	..	..	..	10	4·73	14	3·94	35	5·00	28·12	2·89
December ..	..	..	..	..	..	..	2	..	..	..	..	..	5	8·09	6	2·03	4	0·57	2·61	0·33
Total ..	..	16·52	69	34·25	62	41·02	68	37·75	73	39·46	40	21·63	82	36·92	72	34·91	471	67·28	262·57	32·82

* As registered at the Bangalore Observatory, Bowring Civil Hospital.

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APPENDIX No. 4.

TABLE of Area of Waterspread and Capacity of the Ooparhalli Reservoir.

Reduced levels, M.S.D.	Levels of survey contours	Area in acres.	Area in millions of square feet.	Capacity		Remarks.
				Between contours, millions of cubic feet.	At contours, millions of cubic feet.	
3001·97	55·00 to 75·00					
	76·00	15·6	0·7241			
	77·00	15·8	0·7330	0·273	0·273	Approximation based on area at 75·00 and estimated mean depth.
	78·00	19·6	0·9103	0·822	1·095	
3080·97	79·00	19·4	0·8416	0·779	1·874	
	80·00	21·7	0·9486	0·897	2·771	
	81·00	22·0	0·9765	0·957	3·728	
	82·00	22·0	0·9152	0·958	4·686	
	83·00	24·0	1·022	0·969	5·655	Millions of cubic feet.
	84·00	25·6	1·041	1·036	6·691	6·273
	85·00	26·9	1·089	1·067	7·758	16·139
	86·00	27·9	1·133	1·111	8·869	
	87·00	28·4	1·175	1·156	10·025	22·412
	88·00	28·6	1·227	1·205	11·231	
3012·97	89·00	31·2	1·288	1·255	12·486	Total capacity up to sluice sill level.
	90·00	32·6	1·340	1·328	13·161	
	91·00	34·0	1·420	1·380	15·189	
	92·00	35·3	1·481	1·451	16·679	
	93·00	37·5	1·540	1·511	18·190	
	94·00	39·4	1·628	1·600	19·844	Sluice sill level.
	95·00	41·2	1·716	1·673	21·517	
	96·00	43·0	1·795	1·756	23·273	
	97·00	44·8	1·873	1·834	25·107	
	98·00	46·6	1·951	1·912	27·019	
3039·97	99·00	48·4	2·030	1·992	29·011	
	100·00	50·3	2·108	2·070	31·081	
	101·00	52·0	2·187	2·148	33·229	
	102·00	54·4	2·265	2·226	35·455	
	103·00	56·3	2·344	2·305	37·760	
3033·97	104·00	58·2	2·423	2·384	40·144	
	105·00	61·6	2·560	2·492	42·636	Millions of cubic feet.
		64·0	2·679	2·620	45·256	22·412
			2·667	2·673	47·929	28·617
	106·00			2·734	50·663	51·029
	107·00	..	..		53·451	Weir crest level ..
	108·00	..	..	2·930		Total capacity to weir crest level.
	109·00	..	..	2·946	56·397	
	110·00	..	..	3·062	59·459	
	110·62	..	..	2·160	61·619	
				2·240	63·859	
				2·093	65·952	
					68·046	
					68·711	

N.B.—Abstracted up to 105·00 from book in Mysore Public Works Office, of which a copy has been made.

The reduced levels refer to provisional datum 100 feet below level at Karwar G.T.S. value of bench mark at base line station near Mantapam 3113·26.

APPENDIX No. 5.

TABLE showing the Periods during which Water was above or below the Level of the Sill of the Ooparhalli Reservoir Sluice, viz., 90·00, or 3019·97.

Years.	Months.	Days. Above Sill.	Days. At or below Sill.	
1878 ..	January ..	..	31	
	February ..	..	25	
	March ..	..	31	
	April ..	..	30	
	May ..	..	31	
	June ..	14	30	
	July ..	31	17	Highest W. L. 91·25 on 19th. Lowest W. L. 87·58 on 9th.
	August ..	30	..	Do. 99·58 on 26th. Do. 96·48 on 10th.
	September ..	31	..	Do. 100·12 on 29th. Do. 98·89 on 27th.
	October ..	30	..	Do. 100·25 on 21st. Do. 99·33 on 19th.
	November ..	31	..	Do. 99·62 on 1st. Do. 97·87 on 30th.
	December ..			Do. 97·77 on 1st. Do. 96·10 on 31st.
	Total ..	167	198	
1879 ..	January ..	31	..	Highest W. L. 96·07 on 1st. Lowest W. L. 94·66 on 31st.
	February ..	28	..	Do. 94·56 on 1st. Do. 93·67 on 28th.
	March ..	31	..	Do. 93·62 on 1st. Do. 92·50 on 31st.
	April ..	30	..	Do. 92·44 on 1st. Do. 91·12 on 30th.
	May ..	31	..	Do. 92·83 on 22nd. Do. 90·29 on 18th.
	June ..	30	..	Do. 92·92 on 13th. Do. 91·00 on 30th.
	July ..	31	..	Do. 95·08 on 29th. Do. 91·17 on 16th.
	August ..	31	..	Do. 94·83 on 1st. Do. 93·79 on 23rd & 31st.
	September ..	30	..	Do. 94·81 on 15th. Do. 93·75 on 1st.
	October ..	31	..	Do. 96·42 on 11th. Do. 93·42 on 10th.
	November ..	30	..	Do. 96·75 on 5th. Do. 94·93 on 30th.
	December ..	31	..	Do. 94·86 on 1st. Do. 93·12 on 31st.
	Total ..	365	..	
1880 ..	January ..	31	..	Highest W. L. 93·08 on 1st. Lowest W. L. 91·69 on 31st.
	February ..	29	..	Do. 91·63 on 1st. Do. 90·29 on 29th.
	March ..	5	26	Do. 90·26 on 1st. Do. 89·17 on 31st.
	April ..	..	30	Do. 89·10 on 1st. Register incomplete.
	May ..	..	21	Do. 92·33 on 27th. Do.
	June ..	30	..	Do. 92·17 on 2nd. Lowest W. L. 91·04 on 30th.
	July ..	31	..	Do. 92·04 on 11th. Do. 90·83 on 5th.
	August ..	31	..	Do. 96·92 on 16th. Do. 91·04 on 11th.
	September ..	30	..	Do. 95·83 on 1st. Do. 94·33 on 30th.
	October ..	31	..	Do. 97·86 on 28th. Do. 94·08 on 20th.
	November ..	30	..	Do. 97·58 on 1st. Do. 95·83 on 30th.
	December ..	31	..	Do. 96·04 on 1st. Do. 94·33 on 31st.
	Total ..	289	77	
1881 ..	January ..	31	..	Highest W. L. 94·29 on 1st. Lowest W. L. 92·75 on 31st.
	February ..	28	..	Do. 92·71 on 1st. Do. 91·37 on 28th.
	March ..	31	..	Do. 91·33 on 1st. Do. 90·06 on 31st.
	April ..	1	29	Do. 90·04 on 1st. Register incomplete.
	May ..	..	31	Do. 89·25 on 31st. Lowest W. L. 87·96 on 30th.
	June ..	11	19	Do. 90·42 on 8th & 9th. Do. 89·00 on 7th.
	July ..	..	31	Do. 89·37 on 1st. Do. 88·08 on 31st.
	August ..	4	27	Do. 90·42 on 29th. Do. 87·96 on 7th.
	September ..	18	17	Do. 90·75 on 28th. Do. 89·65 on 15th.
	October ..	22	9	Do. 90·71 on 6th. Do. 89·67 on 31st.
	November ..	26	4	Do. 93·12 on 13th & 14th. Do. 89·58 on 2nd.
	December ..	31	..	Do. 92·42 on 1st. Do. 91·17 on 31st.
	Total ..	183	187	
1882 ..	January ..	29	2	Highest W. L. 91·12 on 1st. Lowest W. L. 89·94 on 31st.
	February ..	..	28	Do. 89·90 on 1st. Do. 88·77 on 28th.
	March ..	..	31	Do. 88·75 on 1st. Do. 87·29 on 31st.
	April ..	13	30	Do. 87·21 on 1st. Do. 85·48 on 30th.
	May ..	25	19	Do. 92·87 on 20th. Do. 84·69 on 13th.
	June ..	..	6	Do. 92·25 on 1st. Do. 89·83 on 30th.
	July ..	31	31	Do. 89·79 on 1st. Do. 89·17 on 24th.
	August ..	11	10	Do. 91·46 on 11th. Do. 89·35 on 8th.
	September ..	22	19	Do. 90·92 on 1st. Do. 89·87 on 21st & 22nd.
	October ..	20	9	Do. 90·92 on 14th & 16th Do. 89·58 on 9th.
	November ..	31	..	Do. 91·79 on 30th. Do. 90·08 on 5th.
	December ..			Do. 91·75 on 1st. Do. 90·66 on 31st.
	Total ..	181	184	

TABLE showing the Periods during which Water was above or below Level, &c.—(*Continued*).

Years.	Months.	Days. Above 802.	Days. At or below 802.					
1882	January	11	20	Highest W. L.	90·46 on	1st.	Lowest W. L.	89·21 on 31st.
	February	..	28	Do.	89·17 on	1st.	Do.	88·50 on 28th.
	March	..	31	Do.	88·47 on	1st.	Do.	87·37 on 31st.
	April	..	30	Do.	87·34 on	1st.	Do.	86·27 on 30th.
	May	..	31	Do.	86·34 on	1st.	Do.	85·88 on 31st.
	June	..	30	Do.	98·34 on	1st.	Do.	84·97 on 30th.
	July	..	25	Do.	83·95 on	2nd.	Do.	84·66 on 17th.
	August	..	31	Do.	84·93 on	1st.	Do.	84·53 on 18th.
	September	..	31	Do.	89·43 on	19 & 20th.	Do.	84·03 on 30th.
	October	..	30	Do.	89·96 on	1st.	Do.	87·95 on 2nd.
	November	25	6	Do.	99·00 on	17th.	Do.	89·33 on 20th.
	December	31	..	Do.	97·90 on	3rd.	Do.	91·90 on 21st.
	Total ..	97	268	Do.	95·15 on	1st.	Do.	

SUMMARY.

Years.	Days. Above 802.	Days. At or below 802.
1878	167	198
1879	280	77
1880	198	167
1881	131	234
1882	97	268
Total ..	1,007	894
Average ..	2·16	1·49

APPENDIX No. 6.

STATEMENT showing the Differences of Water Level and Contents on the 30th November of each year and the 15th May of the year following, Ooperhalli Reservoir.

Year.	30th November. Gauge reading.	30th November. Contents, Millions of cubic feet.	15th May. Gauge reading.	15th May. Contents, Millions of cubic feet.	Difference, Millions of cubic feet.
1878					
1879	97·87	14·686	90·42	0·635	13·451
1879					
1880	94·93	8·352	89·67 *	0·484	8·736
1880					
1881	95·83	9·968	88·58	2·045	12·013
1881					
1882	92·46	3·883	85·69	5·808	9·691
1882					
1883	91·79	2·775	83·74	6·747	8·522
	95·33	9·018	..	..	..
Total ..	..	47·382	..	..	..
Average ..	..	7·997	..	..	..

* An approximation, the register not giving the water-level between 24th April and 22nd May.

FALL OF SURFACE.

1878	..	..	..	..	..	..	..	..	..	7·45
1879										
1879	..	..	..	..	..	..	..	..	..	5·26
1880										
1880	..	..	..	..	..	..	..	..	..	7·25
1881										
1881	..	..	..	..	..	..	..	..	..	6·77
1882										
1882	..	..	..	..	..	..	..	..	..	6·05
1883										
										32·76
								Average	..	6·55

APPENDIX No. 7.

ABSTRACT Particulars of Water Works.

Name.	Rate of supply per 24 hours per head per diem.		Description of Works.
Halsur Water Works, Bangalore.	14	Europeans ..	Water pumped into service cisterns holding from 7 to 33 days' supply. Source of supply—a tank and wells below the tank. Cost about Rs. 3,28,000. Population— Europeans 2,460
	1	Native followers.	Native followers 1,302
	12	Horses.	Horses 834
Almora Water Works.	2	....	Population 8,000. Cost Rs. 21,000. Supply collected from ravines and springs and conveyed in a concrete channel from an extreme distance of 3½ miles to a storage reservoir holding 10,000 cubic feet, or 62,500 gallons. Distribution by water posts.
Ahmedabad Water Works.	About 5½	....	Population supplied 25,000 out of 111,680. Consumption 133,000 gallons daily. Water pumped from river Sabarmati by engines of 5 and 6 horse power in 10 hours daily to a height of 52 feet into a settling tank holding but little more than ½ of a day's supply. Distribution by covered tanks and stand pipes. Cost, prior to substitution of engines for pumping, Rs. 1,09,583.
Karandwad Water Works at junction of Panchgunga and Kistna rivers.	5	....	Population 8,000. Cost Rs. 23,807. Water pumped by a wind engine from well on bank of river into a stand pipe 20 feet high, and thence into a storage tank (fort ditch) holding 2·4 millions of gallons. No distribution. Works not successful owing to wind engine not working properly.
Ichalkarangi Water Works.	5	....	Population 8,000. Cost Rs. 1,11,174. Lift 80 feet. Source of supply—the river Panchgunga. Water pumped up and conveyed to storage tank holding 1·20 millions of gallons. Distribution by pipes to four dipping wells and two cattle troughs.

Abstract Particulars of Water Works—(*Continued*).

Name.	Unit of supply Gallons per head per diem.	——	Description of Works.
Secunderabad Water Works.	16 80	European troops Officers.	European troops—men 3,719, officers 140. The women and children not included in the above. Source of supply—wells. Water pumped by engines into service reservoirs. Quantity 70,704 gallons per diem. Maximum height of delivery above water in well, 139 feet. Total cost Rs. 3,12,913. Cost of machinery and piping Rs. 1,75,000. *South supply.*—24,160 gallons per diem. One well, 30 feet diameter and 55 feet deep from ground surface. Cost of this part of system Rs. 85,060. Monthly cost of working Rs. 380 *North supply.*—46,544 gallons per diem. Main well and quarter guard well, which are connected. Dimensions not stated. Cost of this part of system Rs. 2,27,853. Monthly cost of working Rs. 500. The service reservoirs hold 3 days' supply. Results satisfactory.
Ootacamund Water Supply.	30	Domestic .. 12 General baths 4 Trade .. 4 Waste .. 10	*North supply.*—300,000 gallons per day. Source of supply—reservoir. Capacity 46·48 millions of gallons. Catchment 260 acres. Supply insufficient and intended to be supplemented by a second reservoir with capacity about 24 millions of gallons and catchment 60 acres. Cost .. Rs. 28,629. Proposed additions .. 1,02,940 = 1,31,569 *South supply.*—Reservoir, capacity 3 millions of gallons. Catchment 184 acres. Reservoir too small, as the supply would fill one holding 30 millions of gallons. So far supply not satisfactory, and extensive improvements contemplated.
Royal Alibag Water Works.	16	....	Population 5,500. Reservoir, capacity 22·50 millions of gallons, fed by a stream which can fill the reservoir in 48 hours. Distribution by pipes to about 20 dipping wells or service reservoirs. Cost Rs. 84,000. Reservoir has a small command over town.
Pen Water Works, Kolaba Collectorate.	26⅔	....	Population 6,000. Cost Rs. 28,000, of which reservoir Rs. 18,000 and distribution Rs. 10,000. Catchment basin 100 acres. Annual rainfall 110 inches. Estimated yield of catchment 120 millions of gallons, or 19·20 millions of cubic feet, equivalent to 52·8 inches, draining off the catchment or nearly half the rainfall. Estimated maximum consumption of water 160,000 gallons per diem, equal to 26⅔ gallons per head per diem. Distribution below filter by cast iron mains to 15 tanks or cisterns, with option of house connections at owner's expense.

Abstract Particulars of Water Works—(*Continued*).

Name.	Unit of supply. Gallons per head per diem.	——	Description of Works.
Kolhapur Water Works.	10	....	Population 40,000. Cost— Head works .. .. .. 15,209 Alterations to duct .. .. .. 40,486 Reservoir .. .. .. 18,403 Pipes .. .. 1,09,373 Fountains, &c. .. .. .. 70,699 Total .. 2,54,270 Source of supply—springs in a water-course 4¼ miles south-west of town. Catchment basin of water-course above dam 4 square miles. Water drawn from well 10 feet below bed of stream, and flows into duct which has a fall of 16 feet per mile and can discharge when running full 262 cubic feet per minute, or 2½ millions of gallons a day, or 5 times the daily requirement at 10 gallons per head. Duct discharges into service reservoir, a circular masonry tank 100 feet in diameter and 6 feet deep, holding 294,500 gallons. Distribution by cast iron pipes and 267 stand pipes. Rainfall 40 to 45 inches. Works only partially successful, as the supply has been as little as 112,200 gallons a day in the hot season, or 2·8 gallons per head per diem. It is intended to form an impounding reservoir above the head works.
Jalgaon Water Works.	89	3 Presses, 5,500 gallons daily for 6 months. 1 Factory, 6,000 gallons daily for 12 months.	Population (July 1879) 8,406. Source of supply—Mehrun large and small tanks with a catchment of 3·45 square miles. Rainfall 7·68 to 35·92 inches. Average of 8 years (1868 to 1875) 22·20 inches. Capacity of large tank 421 millions of gallons. Depth draining off catchment to fill tank 8·4 inches. Tank filled to overflowing in 1878 and in 1879, but rainfall not stated. Supply available, by gravitation, after deducting allowance for evaporation, 278 millions of gallons for the year, of which 3·2 millions used by factories, &c., and 274·8 millions remain for distribution among population, or over 89 gallons per head per day. Cost of works— Rs. Small tank .. .. .. 27,671 Piping .. .. .. 16,136 Large tank .. .. .. 73,588 Total .. 1,17,395 or Rs. 1,743 per million cubic feet stored and Rs. 14 nearly per head of population.

Abstract Particulars of Water Works—(*Continued*).

Name.	Unit of supply, Gallons per head per diem.		Description of Works.
Lahore Water Works.	10	....	Population 130,000. Source of supply—wells in Khadir of River Ravi. Supply practically inexhaustible, the Khadir having formerly been the bed of the river and having a constant subsoil flow. Extreme lift 140 feet. Length of pumping main 2,660 feet. Water pumped into covered service reservoir with a capacity of 381,600 cubic feet or 2 days' supply, and distributed thence by iron pipes. Greatest quantity of water pumped 60,000 gallons per hour. Cost of works Rs. 15,00,935. Rs. A. P. Working expenses per annum— Establishment .. 356 0 0 Engine establishment .. 763 8 0 Fuel, oil, &c. .. .. Total .. 1,119 8 0 The outlay is just under Rs. 11·55 per head of the population, and the cost of pumping just under 1¼ annas a head per annum. Allowing 10 per cent. on outlay to cover interest, maintenance, and deterioration, the whole cost of the water-supply would be 1·155 + 0·103 = 1·258 rupees per head per annum.
Mysore Water Works.	6½ Nominal.	....	Population 57,765. Estimated cost, 4 lakhs, of which distribution Rs. 80,000 and filters Rs. 30,000. Source of supply—a reservoir about 7 miles from the town. Natural catchment of reservoir, acres 549 Natural catchment of reservoir, acres 4,300 Total do. do. .. „ 165 Waterspread of do. .. „ Storage capacity of reservoir, millions of cubic feet .. .. 100 Level of waste weir .. .. 2491·00 Level sill of sluice (bottom of lowest opening) .. .. .. 2469·00 Level centre of sluice .. .. 2470·00 Rainfall 20 inches, of which one-eighth expected to drain into the tank. Depth draining off required to fill the tank 6·40 inches. The water is to be conveyed in a covered masonary or concrete channel, designed to carry the nominal supply in 6 hours, to 2 settling basins, each to hold 60,000 cubic feet. The loss by evaporation, &c., estimated at nearly 40 per cent. The reservoir was ready to store water in March 1881. No water had been drawn off up to October 1883, when the water stood at 2474·85 or 16·15 feet below sill level, and the contents were 10·80 millions of cubic feet. The highest water level so far reached appears to be 9½ feet above sluice sill.

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APPENDIX No. 8.

PARTICULARS of the Calculation of approximate Cost of supplying Bangalore with Water from near Nundidrog.

Storage Reservoir.—The estimate, Rs. 45,000, has been, in the absence of any data for a definite estimate, calculated at Rs. 750 per million cubic feet. The actual cost of storage ranges from Rs. 500 upwards.

2. *Filters.*—The quantity of water being 10,000 cubic feet an hour, and the usual allowance being 2 square feet of filter bed for every cubic foot per hour, the area will be 20,000 square feet, or 200 by 100 feet. A second filter will be necessary to admit of alternate cleaning; so 40,000 square feet of filter bed may be taken as the requirement. The estimated cost of the service reservoir, a covered work, is Rs. 2 a square foot; so Rs. 75,000 will probably suffice for the filters.

3. *Cost from Main.*—The length, 150,000 feet, is that indicated as probable by Mr. Andrews' survey. The assumed required discharge being 240,000 cubic feet a day, or 2·778 cubic feet a second, while Nevilles' formula, $v = 140\sqrt{r.s.} - 11\sqrt[5]{r.s.}$, makes the discharge 5·786 cubic feet a second. The main would have to be laid with many variations of gradient, and it was considered therefore advisable to use the formula which gives the lowest discharge and to allow a moderate margin.

4. The length of 150,000 feet has been divided into 149,000 feet of straight pipe, and 1,000 feet of bends, &c. The bends or changes of direction, both vertical and horizontal, will, for the most part, be so gentle that straight pipes will suffice.

5. The rates are based on information obtained from the Madras municipality, viz., Rs. 80 a ton for straight pipes, and Rs. 120 for bends, &c.; the corresponding rates for the neighbourhood of Bangalore are Rs. 90 and Rs. 135, thus made up:—

	Rs.
Rate per ton at Madras	80
Rail to Bangalore	10
Cartage to work	5
Total ..	95

The weight per foot is for one inch thickness of metal taken from the Madras municipal tables, and that for the three-fourth inch thickness has been deduced therefrom and checked by Bourdaone's table. The cost of laying the pipes is that paid at Madras and includes all the necessary materials.

Main with 24-inch C. I. Pipe, 1 inch thick.

		Rs.
149,000 feet × 245 lb. = 36,505,000 lb. = 16,297 tons.		
1000 „ × 245 „ = 245,000 „ = 109½ „		
16,297 tons of straight pipe, at Rs. 95	=	15,48,205
109½ do. do. at „ 135	=	14,782½
Laying 50,000 yards, at Rs. 2½	=	1,25,000
Contingencies	=	82,012½
		17,70,000

Main with 24-inch C. I. Pipe, ¾ inch thick.

		Rs.
149,000 × 186 = 27,714,000 lb. = 12,732 tons.		
1000 × 186 = 186,000 „ = 83 „		
12,732 tons of straight pipe, at Rs. 95	=	11,75,340
83 do. do. at „ 135	=	11,205
Laying 50,000 yards, at Rs. 2½	=	1,25,000
Contingencies	=	65,455
		13,77,000

6. *Service Reservoir.*—The capacity is intended to be 1·20 millions of cubic feet, or 5 days' supply, the depth of water 10 feet, and in making the estimate it has been supposed that a clear space for water 600 by 200 will be the form adopted. The length is to be divided into two equal parts by a pier 4 feet thick, and each part into 20 bays of 15 feet by piers 2½ feet thick. The abutments and side-walls to be 6 feet thick at bottom and 3 feet at top. The foundation to be of concrete 5 feet deep from the springing of the inverts, which are to have a versed sine of 1½ feet and a thickness of 1½ feet; the concrete under the inverts will therefore be 2 feet thick.

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The 2½-feet piers will have openings in them, arched both below and above, to allow of the free circulation of the water. The central 4-feet pier will have no opening, and there will be no communication between the two parts of the reservoir except by pipes with regulating valves. The piers and abutments will be 10 feet high, and will carry arches with a versed sine of 3½ feet, and thickness of 1½ feet. The abutments, spandrils and side-walls will be carried up to the level of the tops of the arches, and over all 3 feet of earth will be placed with slopes of 2 to 1 down to ground-level on all sides, except where the valve house, &c., may be placed. The abutment faces, side-walls, and inverts will be plastered with Surki mortar for a thickness of half-an-inch, and the surface will be rendered with Portland cement. Bricks of good quality to be used for all work above the concrete.

The concrete platform will project 3 feet beyond the base of the walls.

Total length between abutments—

$40 \times 15 + 38 \times 2\frac{1}{2} + 1 \times 4 = 600 + 95 + 4 = 699$ feet

Length of concrete platform	$699 + 2 \times 6 + 2 \times 3$	= 717	"
Width of do. do.	$200 + 2 \times 6 + 2 \times 3$	= 218	"
Concrete	$717 \times 218 \times 5$	= 781,530	
Deduct .. $600 \times 200 \times \frac{2 \times 1\frac{1}{2}}{3}$		= 120,000	
Do. $40 \times 200 \times 16\frac{1}{2} \times 1\frac{1}{2}$		= 198,000	
		318,000	
			463,530 c.ft.

Brickwork—			
Inverts..		=	198,000
Abutments	$2 \times 200 \times 4\frac{1}{2} \times 10$	=	18,000
Centre pier	$200 \times 4 \times 10$	=	8,000
Piers	$38 \times 200 \times 2\frac{1}{2} \times 10$	=	190,000
Arches	$40 \times 200 \times 19 \times 1\frac{1}{2}$	=	228,000
Backing over abutments	$2 \times 200 \times \frac{10 \times 5\frac{1}{2}}{2}$		11,000
Spandrils ..	$38 \times 200 + \frac{16 \times 4}{2}$		243,200
Do.	$1 \times 200 \times \frac{17\frac{1}{2} \times 4}{2}$		6,000
Sidewalls	$2 \times 711 \times 4\frac{1}{2} \times 10$		63,990
			967,190 c.ft.

Excavation	$720 \times 220 \times$ say $6 + 5$	=	1,742,400
Covering in reservoir	$705 \times 205 \times 3$	= 433,575	
Do. ..	$2 \times 200 \times 24 \times \frac{12}{2}$	= 57,600	
Do. ..	$2 \times 705 \times 24 \times \frac{12}{2}$	= 203,040	
		694,215	
			2,436,615 c.ft.

Plastering			
Do.	" $2 \times 200 \times 10$	= 4,000	
Do.	" $2 + 600 \times 10$	= 12,000	
	" $40 \times 16 \times 200$	= 128,000	
		144,000 sq.ft.	

	rs.
4635·30 concrete, at Rs. 9-8-0 per 100	44,035
9671·90 brickwork, at Rs. 16-8-0 per 100	1,59,586
2436·609 earthwork, at Rs. 4-0-0 per 1000	9,746
1440·00 plastering, at Rs. 4-0-0 per square	5,760
Contingencies	14,883
	2,34,000
Pipes, valve-house, dwellings for establishments, &c.	6,000
	2,40,000

5. *Distribution Mains, &c.*—This head includes all the works below the service reservoir, viz., the mains, branches, stand pipes, dipping wells, fountains, &c., which may be needed for bringing the water within easy reach of the population. The rate of Rs. 5 a-head of the population is the actual cost at Madras. If the service reservoir floor can be placed as high as 3029·97, the distribution will probably cost less than the sum allowed.

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APPENDIX No 9.

From Colonel A. C. HAY, Commissioner, Ashtagram Division, to the Secretary to the Chief Commissioner of Mysore, Public Works Department, dated Mysore, 25th August 1874, No. 357-73.

I have the honor to acknowledge the receipt of your No. 1494 of 18th July, forwarding copy of a memorandum to Captain Clive regarding the drainage and water-supply of the town of Mysore.

2. Before Captain Clive arrived, I had directed enquiries to be made regarding the number of wells and other sources of supply, with the object of ascertaining approximately the wants of the population in different quarters of the town, and the extent to which these wants are now met, as well as the wishes of the people regarding any improvements that could be made to enhance the supply by clearing and deepening old wells, sinking new ones or constructing reservoirs when this could be done with advantage.

3. The Mutsaddis of the different Mohallas were accordingly directed to ascertain the number of wells and reservoirs, the quantity of the water obtained from each and whether the supply was constant. They also prepared returns compiled from the statements given by the residents of every house, shewing the source from which the inhabitants of each street obtained water, which were checked by counting the number of persons who drew water in a day from most of the principal wells, &c.

4. In an inquiry of this kind, accuracy is unattainable all that can be expected is, such information as will give a general view of existing circumstances, and to this extent I believe a fair estimate can now be formed of the actual condition of the town as regards water. I propose to mention first the present supply of the town in ordinary seasons, shewing this in detail for each Mohalla, proceeding then to review the results in a condensed form with some remarks on the means by which water is distributed, and on past seasons of actual scarcity. Some of these figures may be tedious, but are necessary to explain the subject. Finally, the proposals and requests of the inhabitants will be stated with such remarks as are required in each case. In order to render this intelligible, a map has been prepared, shewing the limits of each Mohalla, in which the streets have been grouped in convenient blocks and the sources of water-supply indicated according to the quality of the water. There are also 3 statements, A. B. and C., the first shewing the number of existing wells of all descriptions in the dwelling-houses, the second containing all the information that can be collected regarding the past history, &c., of the different reservoirs and wells, the water of which is capable of being used for drinking and cooking purposes, and the third the proposals of the inhabitants with my remarks.

5. I shall now, as proposed in para. 4, allude to each Mohalla separately.

6. Mysore is divided into the following Mohallas:—

1. Lashkar.	3. Devaraj.	5. Fort.
2. Mandi.	4. Krishnaraj	6. Nazarbad.

According to the last census and the returns of the municipal overseer, it contains 13,067 inhabited houses and 57,765 inhabitants on an average of 4·5 persons to a house.

7. The number of cattle is supposed to be about 15,000, exclusive of those belonging to the palace.

8. There are—

2 *Large Tanks.*—Dodkere with Bowen's well and others sunk round the margin. Karanji with wells below it.	3 *Kattes.*—Sub Rao, Siniru, Avaduta.
1 *Small Tank.*—Jivan Rao Katte.	1 *Gunta.*—In front of the summer palace.
	5 Ghâts in Purnaiya's channel.

Twenty-six public and 28 private wells, the water of which is considered good for drinking and cooking.

These all lie in the catchment basins of the Dodkere and Karanji and are within municipal limits.

In addition there are seven wells in the valleys running north, viz.—

North Valley.	*North-East.*
Jail Reservoir.	Julpuri.
Tololee Bowrie.	Christian.
Jailane.	Nawab.
Syed Ahmed Makan,	

Also a spring of excellent drinking water flowing down Chamundi Hill, and 2,398 wells scattered over different parts of the town, the water of which being either brackish or hard is only used for drinking and cooking when better is not procurable. The water of the majority is very inferior, and that of many useless for both purposes and only taken for ablution.

The case of the reservoir in the bed of Dodkere known as Bowen's Baoli is different: in consequence of its pollution the water has been only fit for washing cloths, &c.; but there is every prospect of its becoming fairly wholesome and drinkable when the silt is removed.

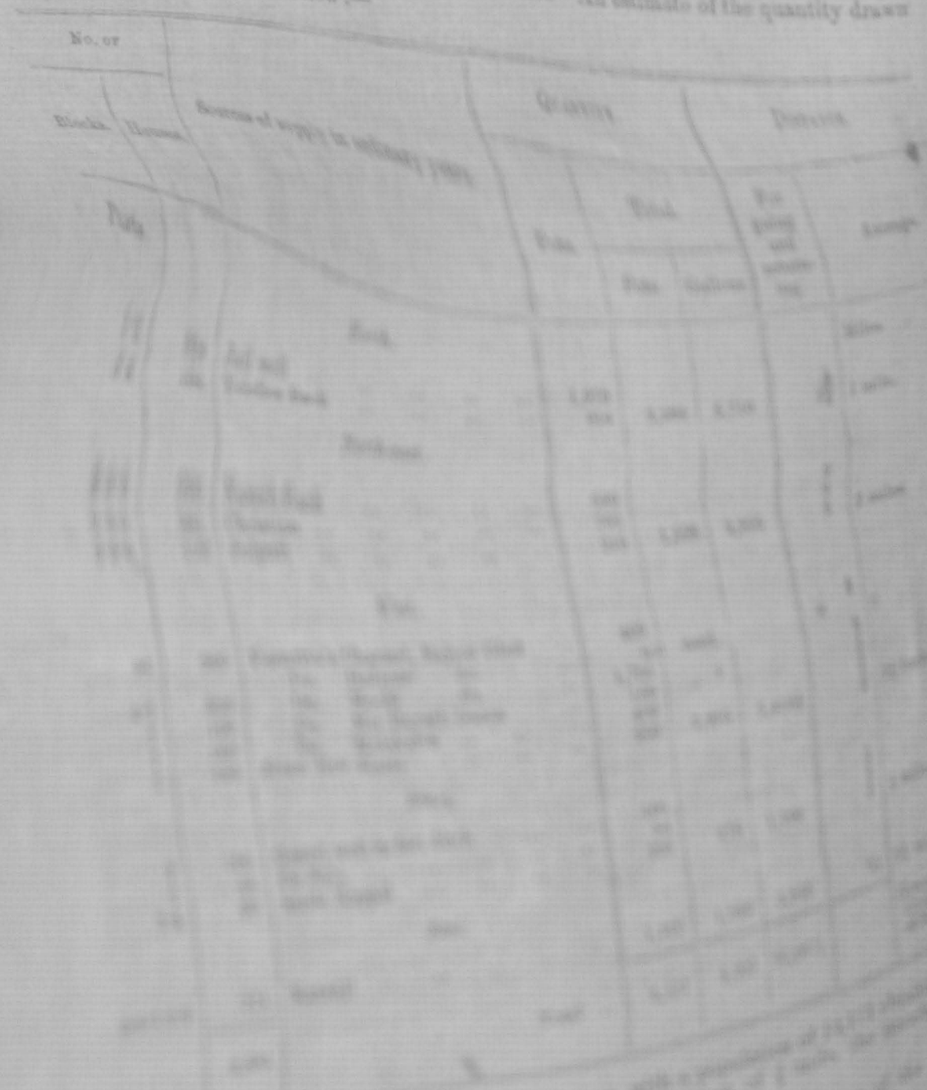
25

Lashkar Mohalla.

Houses.	*Population.*
3,581.	14,171.

9. This Mohalla contains three sub-divisions, Basvan, Lashkar, and Yirangere; the latter is believed to be the most ancient part of Mysore and the site of an old Polegar fort. Most of the ground remained unoccupied till the installation of His late Highness, when he is understood to have resided for a short time in a dwelling known as the "Durbin bungalow" in which his parents lived before they were removed to Setingapatam by Tippu. During the administration of Purnaiya, houses sprung up and troops were located there, whence the Mohalla got its present name.

10. No drinking water is procurable within the limits of the Mohalla, the people of which have to go either to the wells in the north-east or north valleys, to Purnaiya's Nalla on the west, or the two wells in the south and to the Karanji on the east. An estimate of the quantity drawn for this purpose only is given below:—



15. Water in the Telelee well never entirely fails, but is considered hard, and when water is procurable from the jail reservoir, it is only resorted to by pakalis who supply water to families for cooking and bathing purposes and carry it about for sale in the Mohalla.

16. With a rainfall of 21 inches and 63 cents in 1873 and 13¾ inches up to 4th August in 1874, the spring appeared to be capable of supplying at least 10 pakalis making 5 trips a day and drawing from it about 1,000 gallons.

17. The other wells in this valley contain good water, but owing to the distance, are not used till the supply in the jail reservoir fails. They are probably all kept up to some extent by a stone-built katte above used by dhobis, the water from which percolates through to the lower level.

North-east Valley.

18. The Julpuri is said never to run dry, but it is less drawn upon than the other two, the water of which is considered better; the steps are also very steep. The so-called Christian well, which is used by all lower castes, is the only well available for Holayars, and nearly failed last year. With the rainfall mentioned above, the supply from this well and the Nawab's is barely sufficient for the requisitions made on them. The pakalis of the detachment N. I. stationed in Mysore were in the habit of going before daylight to the latter, and by 8 A.M. the water was exhausted, and had to be scooped up half full of mud in saucers and shallow dishes, but was partially replenished during the day. Under those conditions the supply yielded daily by the well seemed to be about 1,500 gallons.

West.

Purnaiya's Channel and Jivan Rao Katte.

19. Though the Rajput Ghât contains more water, the Mochi Ghât is the most important to this Mohalla as it is nearer. The water never fails, but there is a general impression that it gives guineaworm, a circumstance to which I shall recur hereafter. It is unnecessary to give particulars regarding the wells on the south-east additional to those entered in the statement.

20. Part of the water so required is obtained from the wells first mentioned, and the remainder from draw-wells in different streets. As rock formation extends over this whole Mohalla, water is only reached at great depths, and all that is procured in the different wells being either salt, brackish or hard, is used only for domestic purposes, such as washing vessels and cloths and for bathing. The expense of sinking wells is also so great that the poorer inhabitants cannot afford to have private wells, and consequently the northern half of the Mohalla from the Yirangere gate to the taluk cutcherry and part of the south-western quarter possess very few. There are 61 public wells in different other parts of the Mohalla which were originally excavated by private individuals as acts of charity, and these are accessible to all classes. Two only are dry at present. In addition to these, 450 houses contain 489 private wells, of which 100 are dry. The owners of many of these allow their neighbours access, but the want of water for these purposes is often very severely felt, and the supply is never sufficient.

Mandi Mohalla.

Houses.	*Population.*
3,086.	13,981.

21. This Mohalla dates principally from the time of Purnaiya, who induced grain-merchants and other traders to settle at Mysore. Since the death of His Highness the late Maharaj good many houses in the western portion have been abandoned: it now contains 3,086 inhabited houses with a population of 13,981 persons.

22. The great majority are dependent on Purnaiya's channel, since out of 3,086 houses, it appears that 1,876 are supplied from the ghâts and 460 from three draw-wells, two in the centre and one at the northern extremity of the Mohalla. The residents of about 700 houses were returned as procuring water from the Karanji tank.

23. As regards distance, the inhabitants of this quarter are better off than those of the Lashkar Mohalla; but it is remarkable that according to their statements they procure less water. The explanation given for this is, that the approaches to some of the ghâts are steep and unsafe, and that the women do not bring more than is absolutely necessary. The people are generally poor, and employ neither pakalis nor carts. The households obtaining water from the Karanji are chiefly those of Brahmans and merchants who can afford to send to that distance.

24. Below is statement similar to that given for the Lashkar Mohalla. The estimate is that nearly 5 gallons per house are taken from an average distance of ¼ mile. In calculating the distance, the Karanji is excluded.

No. of Blocks.	No. of Houses.	Names of Wells, &c.	Quantity. Pots.	Quantity. Total Pots.	Quantity. Total Gallons.	Distance. For going and returning, miles.	Distance. Average.
		West.					
2·2	250	Chakkani Well	750	..	..	¼ + ¼	The average distance is ¼ of a mile excluding that of Karanji tank.
3·4	290	Bramasabhi	400	..	..	50 yds.	
5	10	Minakshi	50	..	..		
		Purnaiya's Channel.					
1·2·3	345	Rajput Ghât	1,035	..	..	¼ + ¼ + ¼	
2·3	70	Holiyar Ghât	140	..	..		
3·4·5	1028	Mochi Ghât	2,707	..	..		
4·5	83	Mir Hayath Gunta	259	..	..	200 yds. do. ¼	
4·5	350	Molakalve	700	..	..		
5	50	Jivan Rao Tank	50	6,091	15,227½		
		East.					
3·4·5·6	700	Karanji Tank	700	700	1,750	¼	
	3,026	Total ..	..	6,791	16,977½	..	

25. As in the Lashkar Mohalla, the water ascertained by counting to be drawn daily from the different sources includes a good deal of what is used for all domestic purposes, the rest being obtained from draw-wells. In this respect the Mandi Mohalla has no advantage over the Lashkar Mohalla, as there are only 67 wells the water of which is available for all, and 176 wells in private houses; out of the whole, 67 are dry.

Water for ablution, &c.

Devaraj Mohalla.

Houses.	*Population.*
2,271.	10,640.

26. Part of the Devaraj Mohalla is ancient, and part was founded by His Highness the late Raj. It is on the western side of Purnaiya's channel, of which the people make very little use though a few go to the Mochi Ghât.

Water for drinking and cooking.

As long as the Jivan Rao katte holds water it is much resorted to, and it is the accepted opinion that the water of the tank as it sinks into the soil feeds the wells below, of which several contain very good water. These are amongst the most valuable wells in the town, three of them (Advanaiya, Vire Gauda, and Venkatdikshit's well) have never failed, and afforded water to a large number of the inhabitants of other Mohallas when their own supply ceased. The estimated quantity of sweet water used daily in this Mohalla is about 5 gallons per house.

27. Half of the Mohalla from the Siledar's lines to Pindarkari Street (blocks 1 and 2—788 houses) is well supplied by the Jivan Rao tank, and 8 wells believed to be greatly dependent on it, which have never failed, but the other half from the Pindarkari to Sub Rao katte road containing 1,553 houses has only two wells and one small katte.

28. These wells are classed in the following statement in the order of their value:—

No. of Blocks.	No. of Houses.	Names of Wells.	Quantity. Pots.	Quantity. Total Pots.	Quantity. Total Gallons.	Distance. For going and returning.	Distance. Average.
		West.					
		Devaraj Mohalla.					
1·2·3·4	600	Jivan Rao Katte	800	..	..	½ mile.	The average distance is ¼ of a mile, excluding that of Karanji.
2·3	443	Advanaiya	890	..	..	200 yds.	
2·3	253	Vire Gauda	500	..	..	100 do.	
3	100	Nag Nayik	200	..	..	50 do.	
3	100	Narsaiya	160	..	..	50 do.	
1	83	Venkatdikshit	150	..	..	400 do.	
1·3	75	B. Venkatappa	150	..	..	100 do.	
1·4	75	Anjanaiya	132	..	..	100 do.	
1	66	A. Sub Rao's Well	130	..	..	100 do.	
1·2·3	67	Amrutheswara Temple	110	..	..	50 do.	
1·3	55	Avadatta Katte	100	..	..	1 mile.	
3	50	Narasswami	60	..	..	50 yds.	
2	30						
		Krishnaraj Mohalla.					
4·5	300	Sanjivaraj Urss	600	..	..	½ mile.	
		Mandi Mohalla.					
1	60	Purnaiya's Channel Mochi Ghât ..	120	4,102	10,255	200 yds.	
		South.					
		Dodkere	60	60	150	..	
		East.					
		Karanji Tank	200	200	500	..	
		Total ..	..	4,362	10,905	..	

29. It is represented that there is a great want of water for other purposes as the quantity procurable from wells, the water of which is not good to drink, is scanty and uncertain, nearly one-third out of 371 private wells, and 9 out of 72 public wells are dry, and it is said that the people do not obtain even half of what they need for domestic and personal use.

Water for ablution, &c.

Krishnaraj Mohalla.

Houses.	*Population.*
2,259.	9,603.

30. This Mohalla originated during the administration of Purnaiya, and now contains 2,259 houses with 9,603 inhabitants.

31. There are some very good sweet-water wells within its limits. Some have been constructed for the public and others are in private houses to which access is allowed.

32. In block No. 1, containing 1,055 houses, the supply appears to be tolerably plentiful and constant. The other 3 blocks rely to a great extent on the Siniru katte, a small pond for catching the rain-water on the high ground, to the south.

33. Lately two experimental wells have been sunk below the Dodkere bund, the water of which is considered fair and is taken for drinking and cooking purposes by the people of several streets in the vicinity.

The water of the Dodkere is not drunk but is taken by a few persons for cooking.

38. The average quantity taken daily in the Mohalla appears to be rather more than in the Fort Mohalla, being 6¼ gallons per house, ablutions, &c.

No. of		Description of Wells.	Quantity.			Distance.	
			Pots.	Total		For going and returning.	Average.
Blocks.	Houses.			Pots.	Gallons.		
		West.					
		Kalasanji Mohalla.					
		Kari Hulagiya	1172	..	..	700 yds.	
		K. Puttaiya	1146	..	..	250 do.	
		Bhagiratha Kalla	760	..	..	200 do.	
		Hanuma Kalla	472	..	..	½ mile.	
		Hanuma Kalla	219	..	..	½ do.	
		Hanuma Kalla	200	..	..	150 yds.	
		Hanuma Kalla	160	..	..	½ mile.	
		Hanuma Kalla	213	..	..	100 yds.	
		Hanuma Kalla	100	..	..	50 do.	
		Hanuma	100	5,135	12,837½	250 do.	
		K. Puttaiya					
		Mir Mahmood					
		Chattrappaji					
		South.	155	155	387½	300 do.	
1	155	Dodkere					
		East.					
1·2	488	Karanji Kere	400	..	..	2½ miles.	
	20	Spring at the foot of Chamundi	69	469	1,150	2 do.	
		Total ..	..	5,759	14,375	..	

The average distance is nearly half a mile, excluding that of Karanji.

35. The Dodkere tank provides all that is necessary in addition to what is obtained from wells * and kattes.

* Public wells 66, private wells 442.

Fort Mohalla.

Houses.	*Population.*
868.	5,755.

36. Tippu, with his usual policy of destroying every monument of the former Government, had razed Mysore and removed the stones of the palace and temples to the neighbouring height called by him Nazarbad, from its commanding an extensive view.

The present fort with the buildings in it date subsequent to the installation of the late Raja, with the exception of four temples, two on the west and two on the east, reputed to be ancient.

37. Water for cooking purposes is procured from 14 wells situated within it, and from the Dodkere tank. For drinking water the inhabitants have to go about 3 miles in all, to the Karanji tank, to the pipes by which this water was conveyed to the interior of the fort and (as is said) to 30 wells, constructed during the late Raja's administration, are now out of order.

38. When the supply in the Karanji tank is exhausted, the water of the fort wells, which is at present used only for cooking, is drunk by nearly half of the population of the fort; others resort to the springs at the foot of Chamundi Hill, and a few wealthy families obtain Cauvery water from Seringapatam.

39. The quantity at present supposed to be consumed for drinking and cooking purposes according to the statement of the people is 2,504 pots, or 6,510 gallons, at an average of 3 pots or 7½ gallons per house, obtained from the sources pointed out in the following statement:—

No. of		Description of Wells.	Quantity.			Distance.	
			Pots.	Total		For going and returning.	Average.
Blocks.	Houses.			Pots.	Gallons.		
		South.					
	81	Mudaljetti	168				
1	79	Venkat Subbaiya	140				
1·1	79	Bale Ars	140				
1·5	78	Sando Koppal	100				
1	88	P. Linga Shastri	100				
1	88	Garuwaiya	100				
2	88	Asaaiya Jote	100				
2	88	Kempanna	90				
2	88	S. Krishna Rao	90				
1	85	Pattiaji	80				
1	85	Balachari	80				
1	85	K. Puttaiya	80				
1	85	K. Linga Shastri	40				
1	28	Tippaiya	230	1,736	4,340	Within half mile.	Half a mile, excluding the distance of the Karanji tank.
1	155	Dodkere					
1·1		*East.*					
		Karanji Tank	868	868	2,170	2 miles.	
1·7		Total ..		2,604	6,510		
	868						

40. Except for drinking water, the fort seems in some respects to be better supplied than other Mohallas. In addition to the public* wells nearly half of the houses are provided, while the Dodkere tank is close to the walls.

* Public wells 31, private wells 390.

Nazarbad Mohalla.

Houses.	*Population.*
1,002.	3,585.

41. This Mohalla, as mentioned above, received its present name from Tippu. He had made considerable progress in the works of a fort on the spot when he began to consider that it afforded no water. He then dug an immense pit cutting down through the solid block rock to a great depth and width without success; and at the time of the siege of his capital the whole work was lying in a mass of confusion, with a few wretched huts in it for the accommodation of his workmen.

42. The Nazarbad Mohalla extends over a large area, but is thinly populated as compared with the others. It contains some of the palace buildings and a good many houses, occupied chiefly by the European and East Indian community; a considerable extent of ground is waste and unoccupied.

43. There are—

11 Minor wells.
3 Principal wells.
1 Tank—Karanji.
1 Gunta—in front of the summer palace within the limits of this Mohalla.

Of these, the 14 wells alluded to contain a moderate supply of water fit for drinking and cooking purposes, and are resorted to chiefly by the poorer native population; about ⅓ of the whole depending upon the Karanji tank for drinking water.

The gunta, which is a small pit originally dug for taking earth for preparing bricks, &c., catches the surface water of the high ground near the summer palace, but this lasts only for three or four months during the rainy season, and is drunk chiefly by Holiyars and others living in Higegud.

44. The estimated quantity of water at present obtainable from all sources for drinking and cooking purposes is 2,367 pots or 5,917 gallons, at an average of nearly 6 gallons per house, ablution, &c.

No. of Blocks.	No. of Houses.	Description of Wells.	Quantity. Pots.	Quantity. Total. Pots.	Quantity. Total. Gallons.	Distance. For going and returning	Distance. Average.
		East.					
14	35	Bahramsing					
2	10	Karanji Matt					
1	30	Hoitry Well	1,160	..	..	220 yds.	
5	13	Shama Shastri	120	..	..	1 mile	
8	19	Gunta	32	..	..	140 yds.	
1	28	Pullaiah	60	..	..	44 do.	
1	25	Mallaiya	24	..	..	100 do.	
2	15	Narasappa's Garden	56	..	..	150 do.	
1	15	Ahman Hoitray	30	..	..	50 do.	
4	5	Yakub Sab	60	..	..	100 do.	
4	5	Duvarasaiya	48	..	..	50 do.	
4	5	Lowry	32	..	..	150 do.	
3	10	Rudrayia	30	..	..	50 do.	
1.2.4.5.	5	Mr. Meyers	20	..	..	50 do.	
	308	Karanji Tank	20	..	..	50 do.	
			24	..	..	50 do.	
			358	2,657	6,317½	1 mile	
		South.					
5	140	Dodkere Wells	280	280	700		
		Total ..		2,937	6,917½		

One-fourth in salt, excluding the distance of the Karanji tank.

45. Regarding the water required for other purposes, the existing number of 236 private and 17 public wells suffices for the ordinary requirements of the people living in the Mohalla.

46. *Distribution.*—At least ⅓ths of this water is brought in the ordinary chatties (each containing 2½ gallons) by men or women on their heads, the rest in similar pots slung on addes (bamboos) by pakalis, in water carts, hand barrows or mankanies, which are panniers containing large vessels loaded on bullocks.

47. *Pakalis.*—There are 36 pakalis regularly employed; 9 of these draw water from the Telelee well and Purnaiya's channel for distribution in the Lashkar and Mandi Mohalla where it is sold at from one to two pies per pot of 2½ gallons. Seven supply the Barr, 11 the Siledars, one the detatchment, 30th native infantry, and 8 the palace stables. The principal places to which these resort are the jail reservoir in the north, Nawab Bowri in the north-east, Purnaiya's channel and Jivan Rao tank on the west, Gosayi well near the fort, and Dodkere tank on the south.

48. *Water Carts.*—Sixteen or seventeen wealthy inhabitants in the town send carts once or twice a day to bring water from the Karanji tank for their own use. In addition, 9 are engaged by the palace, each making three trips daily to the Karanji tank. Another cart brings daily 40 pots of Cauvery water from Seringapatam for the use of the Ranis. The water for ablution and domestic purposes is obtained from two or three brackish wells situated near the palace, as well as from the Dodkere tank and the well lately dug below the bund.

49. *Hand Barrows.*—These have been introduced within the last year or so, and the number at present employed is estimated at 37. They go twice a day to the Karanji tank and fetch 8 pots or 20 gallons of water each at a time.

50. *Mankanies or Panniers.*—These are used by oil-mongers: each mankani contains four pots or ten gallons of water and is conveyed by a single bullock.

51. *Cattle.*—It is necessary to say a few words regarding the cattle and horses, &c., kept by the people.

52. From an old account obtained from the taluk, there must be nearly 15,000 cattle in the town besides the palace cows and bullocks.

53. The cattle generally go to the marginally-noted places for drinking water, but when the supply is exhausted in the hot weather, brackish or hard water from the wells in the town is used. There are about 30 public tottis (stone and brick in chunam cisterns) constructed by private individuals in different places, which are daily filled by the owners as an act of charity for cattle, and especially cows which do not go to a distance daily to graze.

North.
1. Boppanhalli Tank.
2. Joginkere do.

West.
1. Jivan Rao Tank.
2. Purnaiya's Channel.
3. Pudvarhalli Katte.
4. Simiza Katte.
5. Subba Rao.

South.
1. Dodkere.
2. Halkoba.

East.
1. Devanur Katte.
2. Karanji Tank.

54. The total quantity of water required by the cattle is estimated at 60,000 gallons on an average of 4 gallons per head.

55. *Washermen.*—It is reported that there are nearly 200 washermen in Mysore, or at an average of one to 65 houses or 285 persons, who go to various * places for the purpose of washing clothes.

North.
* 1. Cauvery river, Seringapatam.
2. Boppanhalli tank.
3. Purnaiya's channel.

West.
1. Kukanhalli tank.

South.
1. Dodkere tank.
2. Bullikatte do.
3. Dairey do.

56. *Summary.*—I shall now proceed to review the returns for the whole town.

57. In addition to the Karanji and Dodkere tanks, there are Purnaiya's channel, the minor reservoirs, and the wells, public and private, all of which are resorted to by the people; but the peculiar difficulty at Mysore consists in the fact that only a few contain good and wholesome water, and that these are situated at a considerable distance from the occupied areas.

58. With some classes of natives the most important quality of water is that it should be palatable to drink; others consider it absolutely necessary that water should not be hard, for in that case dhall cannot be boiled owing to the coating found on it during the process, and hence they generally refer to this as the best test. For other domestic purposes and for bathing brackish or hard water suffices.

59. In Mysore the Karanji water is referred to as the type of purity and excellence; but the water of all the rain reservoirs except that of the Dodkere is good for every purpose. That in the wells in the north and north-east valleys, if not perfectly pure, is palatable and believed to be quite wholesome, and there are also a few wells in different places which are considered to furnish very good water.

60. The reservoir in the bed of the Dodkere tank, known as Bowen's bauri, contains a good spring, but owing to silt and other causes the water had hitherto been of no use; after the reservoir is cleared, it is believed that the water will be found fit for drinking and cooking purposes. The wells in the upper part of the bed have been found to yield very good water, and are regularly used by those living within a convenient distance from them.

61. The remaining wells give water of every degree of brackishness, that of some being almost salt and of others only slightly hard.

62. Opinions differ regarding the water in Purnaiya's nalla. The general impression is that the water of the channel and especially that of the Mochi Ghât produces guinea-worm; but many persons who suffer from it ascribe the complaint to other causes. Hindu doctors are of opinion that drinking stagnant water produces it, while Mussalman hakims do not attribute it to water at all, and many of the people consider it arises from filth, and can be remedied by clearing the reservoirs. Whatever the true explanation may be, it is demonstrable as a matter of fact that the population of the Mandi and Lashkar Mohallas who make use of that water suffer more than others. Within three or four years over 3 per cent. of the residents of the Mandi Mohalla and nearly 3 per cent. of those of the Lashkar Mohalla have been attacked by guinea-worm; 65 persons have migrated from these Mohallas elsewhere with the special object of getting rid of the disease.

63. The Civil Surgeon states that the general opinion that the drinkers of Purnaiya's nalla water are most liable to disease is correct. Mild cases of guinea-worm rarely come under hospital treatment, and the average ratio of guinea-worm cases to total sick in the hospital is, for the last five years, 4 per mille per annum.

64. By the statement given of the quantity of water fit for drinking and cooking purposes used daily, it appears that the whole amounts from 25,000 to 30,700† ordinary chatties or pots, each containing 2½ gallons, giving, if the higher figure be taken, about one and one-fourth gallons per head, or 6¼ per house.

† 76,750 gallons.

65. If we arrange the sources of supply according to the quantity of water obtained from each, their values are represented roughly by the following numbers:—

	GALS.
Public wells	28,985
Rain reservoirs	21,855
Purnaiya's channel	19,190
Private wells	6,720
Total ..	76,750

66. *North-East.*—The wells‡ in the north-east valley were returned as supplying 793 houses with an estimated quantity of 3,875 gallons; this was found to be tolerably accurate by the experiment of counting the number of persons resorting to each in a day.

‡ Relative importance of different wells.
Jalgiri, Chenniah, Nawab.

Hill reservoir and Tolelee bauri.

1. Chikni.
2. Biram.
3. A. Subba Rao.
4. Nunjaiya.
5. Venkatdikshita.
6. Advansiya.
7. Vera Gauda.
8. Sanjivarai.
9. P. Puttaiya.
10. Seppina or body guard.
11. Dod Holgere, 7,111 houses.

67. *North.*—In the north valley the quantity was 5,719 gallons to 628 houses.

68. *West.*—On the west there are 11 principal wells, Purnaiya's channel with five ghâts, the Jiwan Rao tank, the Shiru, and Subba Rao kattes with 13 minor wells, the whole returned as supplying water to about 20,000 people, the quantity being 45,730 gallons.

69. *South.*—The Dodkere on the south is scarcely used except for bathing, but there are two principal wells and twelve minor wells supposed to supply 1,267 houses, 6,772 gallons. Bowen's bauri, to which allusion is made in paragraphs 7 and 60, is now being cleared.

Soudi Koppal near the fort.
Munya Jettie well in the fort.

70. *East.*—On the east is the Karanji; by counting it was ascertained that 2,582 pots or 6,455 gallons were taken from this tank in a day. There are two or three * important wells and thirteen minor wells containing drinkable water. The total quantity consumed on the east is 14,642 gallons by 3,268 houses.

* Balram Sing, Rudrarajs, Karanji Matt.

71. It must be understood that all estimates made above have referred to the supply obtainable in ordinary seasons, and after a fair rainfall, when the tanks and wells have been partially filled. In the hot weather not more than half is said to be taken, and in seasons of drought the scarcity is very great.

72. Owing to the deficient rainfall in the last hot weather, viz., 21 inches and 63 cents, which was lower than that of 1871 and 1872, and far below 31 inches, the average of the previous years, the Karanji tank and rain reservoirs, with several wells and kattes upon which nearly one-third of the population of the town are dependent for drinking water, appear to have been actually dry. A large number of wells containing brackish water also failed, and the supply, in most, decreased considerably.

73. The scarcity was severely felt everywhere, for though the ghâts and some of the wells did not fail, there was very little water to be had, and what was procurable was often muddy and unwholesome.

The most valuable wells were those noted in the margin, and temporary wells were sunk by the palace and municipality in the tract of land between the Karanji and Dodkere, and even in the bed of the Boppenhalli tank, which proved of great service; but the people had to go long distances, and many incurred considerable expense in sending carts and barrows to fetch water from the places where it was to be got. A few wealthy families obtain water from Seringapatam.

North.
1. Tolelee bauri.
2. Syed Ahmed Makan. } Beyond the town.
3. Jailano.

North-East.
1. Julpuri. } Do.
2. Christian.
3. Nawab.

West.
1. Chikani.
2. Purnaiya's channel with its five ghâts. } Mandi Mohalla.
3. Asham Subba Rao.
4. Amruthesvara.
5. B. Venketappa.
6. Anjaniya.
7. Nanja.
8. V. Dikshit.
9. Adavanaiya. } Dasraj Mohalla.
10. Vire Gauda.
11. Sanjivarai.
12. P. Puttaiya.
13. Seppin well.
14. Dod Holgeri.

South.
1. Wells dug by the municipality near the end of Dodkere. } Krishnaraj.
2. Saudekoppal.
3. Channedi spring.
4. Muniya jettil.

East.
1. Karanji Matt. } Nasarbad.
2. Balram Sing.
3. Rudrarajs.
4. Shanker Das.

74. The total expenditure hitherto incurred on account of works carried out from the year 1859—60 by different departments in connection with the water-supply of Mysore is shown as Rs. 72,190-2-4, of which Rs. 9,444-3-5 were spent by the municipality, Rs. 13,000-12-8 by the Public Works Department, and Rs 49,745-9-3 by the Revenue authorities on various works, such as strengthening the bunds of the tanks of Dodkere, Karanji, and Jivan Rao katte, including repairs to their feeders and to several spring-fed wells. A great deal of the work to the Dodkere was undertaken at the special request of His Highness the late Maharaj, and had no effect in increasing the supply.

Measures adopted by Government towards water-supply of the town.

75. To increase the supply of drinking water the people desire the improvement of the following tanks and wells:—

West.
1. Clearing and improving Purnaiya's channel.
2. Improving the Jivan Rao katte tank.
3. Do. Suba Rao katte.
4. Deepening the well in the bed of Suba Rao katte.
5. Do. Sunjivaraj Arsu well.
6. Shiniru katte.

South.

7. Restoring the Karanji duct feeding the wells in the fort.

East.

8. Improving the gunta in front of the Summer Palace.
9. Karanji tank.

76. In addition to these the construction of reservoirs, one in the centre of the Lashkar and Mandi Mohallas, and the other in the Krishnaraj Mohalla, is urged.

77. In my opinion a careful examination should be made of the northern and north-eastern valleys containing the wells upon which so large a proportion of the inhabitants depend for water, and it should be ascertained whether the supply in the existing wells can be increased by deepening them, and whether others can be dug, as there are numerous wells in the valley just below them. The possibility of constructing small reservoirs to catch and retain the water so as to feed the wells should also be considered. There is an impression among the natives that the best spring in the Nawab's well has been suppressed by clay underlying the stone-work built to prevent the earth at the sides from falling in.

78. The steps to the Julpuri and Christian wells should be improved, as they are now too steep for women and children. Though the jail reservoir only holds rain-water, it is of the greatest value to the whole neighbourhood, and I should strongly recommend additional feeders being led to it, and if it is found that more water is brought than the reservoir will hold, another should be constructed below it.

79. Makan well in the north valley, dug by the municipality, should have stone revetments, and I believe another at an intermediate point could be sunk with advantage. The municipality have been instructed to do so as an experiment.

80. I understand that Major Johnson once recommended the construction of a katte or tank in the valley behind the jail, and the project though not emergent is worth further inquiry. A small reservoir for intercepting the water flowing from the Residency high ground might be formed at the bottom of the compound.

81. This great work failed in its original object, but has proved of an infinite service in tapping a number of excellent springs, the water of which though inferior in quality is indispensable and not objected to by a large section of the population.

Purnaiya's channel.

Apparently springs are to be met with throughout the whole length of the channel from the Rajpat Ghât to the fort walls, and many natives believe that there was once a continuous stream from the Rajpat Ghât downwards. Communication is, however, now entirely interrupted both by land slips and the general silting up of the bottom of the channel, as also by the excavation of the pits at the ghâts, the earth from which has been thrown up round them, and by the new road to the Civil Hospital. Everything has been done that could be done to render the channel a nuisance instead of a benefit. In parts it is overgrown with vegetation, it is used as a latrine and receptacle of filth, and the drainage of the market and several streets has been discharged into it contaminating the soil and stopping up one, if not more, of the springs. A professional officer is required to survey the channel and determine the best mode of remedying the damage, and also to decide on what should be done to the present ghâts, whether a continuous flow of water should be brought down, or the ghâts isolated and kept as separate wells. Considering the number of women, children and infirm persons who have to ascend and descend, the approaches to all the ghâts should be laid out with steps at easy slopes widened and protected by railings at the side.

82. It has been sometimes supposed that the Jivan Rao katte has been a failure, and it is in some respects defective, as the water does not remain at the tank; but there is little doubt that what disappears feeds the wells below, and that fresh wells could be sunk with success below it. The improvement of this work is in all respects desirable. I have heard that Sub Rao katte has been examined, but with what result I do not know. If it can be improved it should be, as the situation is convenient.

The Jivan Rao and other kattes.

83. This pond is situated a few yards above the Benne Hardanhalli feeder of the Dodkere, and the people in the neighbourhood have pointed out to me that it can possibly be filled from the feeder by making a small dam and a cut leading the water to the katte. Some years ago a project was proposed for constructing a second katte just below and filling it from the feeder, but this has passed out of notice. Both these proposals should receive attention, as it does not appear that the projects would be expensive and the people are much in favor of them. It may indeed be possible to find a still better site, but this is a point on which I am uncertain.

Shiniru katte.

84. The advantages of bringing water from the Karanji tank and distributing it at the cistern now under construction by the Public Works Department cannot be over-estimated

Karanji water.

when the great distance of the Karanji tank is considered; but it would be still better if the pipes could be continued from the fort to a reservoir on the open space now called the People's Park. It is not probable that the water in Bowen's well will be drank by any one who can get water from the Karanji cistern, but when purified the well will no doubt afford an excellent supply of water which will be quite drinkable, will probably be found good for cooking, and will be preferred to that of the Dodkere for all purposes.

85. The Dodkere must simply be regarded as the cess-pool of Mysore until the sewage which now pollutes it is cut off; when this is done there is no apparent reason why the water should not be tolerably good.

86. Having now reviewed the whole question, it must be evident that if all that is suggested was carried out, and every reservoir and well improved to its utmost capacity, Mysore would still have only an uncertain and often insufficient quantity of water at command. In dry seasons the people must suffer considerably, and in a year of drought undergo actual privation; and it is therefore necessary to look beyond the limits which have been referred to.

87. The possibility of bringing water from the Cauvery is a point to be decided by professional officers; but whatever may be the result the project for supplying some high level in the town with water from Benne Hardanhalli and Bogadi tanks, a scheme originally suggested by Major Johnson, should be carried out if found to be as good as it promises. The survey for this, the drainage project, Bowen's well, the Karanji tank feeders and duct, and the Jivan Rao katte, are either under survey or execution, and it only remains for me to recommend that a Public Works officer take up in succession the examination of the different valleys on the north and north-east, Purnaiya's channel, the Siniru and Suh Rao kattes, and the proposed continuation of the Karanji duct. The work of cleaning out and deepening wells of drinking water, sinking new ones within the town, improving others useful for any purpose, and the enforcing of conservancy, may be left to the municipality.

Sir Richard Meade, who has seen the principal wells and ghâts, considers that among the points for consideration by the municipality is the possibility of raising water from the main wells at the public expense and discharging it into cisterns from which it could be obtained by the people uncontaminated and without the risk and labor of descending to the level of the springs. I believe that with the information now collected, the municipality would have no difficulty in determining how money may be best expended for all these purposes.

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APPENDIX No. 10.

Table of Area of Water-spread and Capacity of the Halsur Lower and Upper Tanks.

Reduced level, M.S.D.	Survey contour level.	Gauge readings.	Area in millions of square feet.	Capacity: Between contours millions of cubic feet.	Capacity: At contours millions of cubic feet.	Remarks.
2920·97 ..	41·00	9·00	1·8504	0·489	1·628	The mean depth 0·88 below this contour has been taken from the cross sections shown on the survey, which is supposed to be that made in the early part of 1877 and referred to in Lieut. F. J. Romilly's report, dated 30th September 1879.
	41·25	8·75	1·988	0·514	2·108	
	41·50	8·50	2·126	0·551	2·622	
	41·75	8·25	2·286	0·591	3·173	
2921·97 ..	42·00	8·00	2·446	0·633	3·764	
	42·25	7·75	2·616	0·675	4·397	
	42·50	7·50	2·787	0·719	5·072	
	42·75	7·25	2·968	0·764	5·791	The areas at 41·00, 44·00, 47·00, and 50·00 have been measured from the contour lines shown on the survey.
2922·97 ..	43·00	7·00	3·149	0·811	6·555	
	43·25	6·75	3·341	0·859	7·366	
	43·50	6·50	3·533	0·909	8·225	The areas at each half foot between the above contours have been deduced on the supposition that each three feet layer is the frustrum of a cone.
	43·75	6·25	3·738	0·960	9·134	
2923·97 ..	44·00	6·00	3·9432	0·993	10·094	
	44·25	5·75	4·091	1·007	11·087	
	44·50	5·50	4·066	1·022	12·094	
	44·75	5·25	4·120	1·037	13·116	The areas at the quarter feet are the means of the areas at the half feet.
2924·97 ..	45·00	5·00	4·181	1·053	14·153	
	45·25	4·75	4·243	1·068	15·206	
	45·50	4·50	4·305	1·084	16·274	
	45·75	4·25	4·368	1·100	17·358	
2925·97 ..	46·00	4·00	4·431	1·116	18·458	The capacities between contour are found by multiplying the area of the mean contour by the depth. They are therefore only approximations, but are probably quite as accurate as the data will allow.
	46·25	3·75	4·495	1·132	19·574	
	46·50	3·50	4·560	1·148	20·706	
	46·75	3·25	4·624	1·164	21·854	
2926·97 ..	47·00	3·00	4·5884	1·176	23·018	
	47·25	2·75	4·720	1·184	24·194	
	47·50	2·50	4·752	1·192	25·378	
	47·75	2·25	4·782	1·199	26·570	
2927·97 ..	48·00	2·00	4·812	1·207	27·769	
	48·25	1·75	4·842	1·214	28·976	
	48·50	1·50	4·872	1·222	30·190	
	48·75	1·25	4·902	1·229	31·412	
2928·97 ..	49·00	1·00	4·932	1·237	32·641	
	49·25	0·75	4·962	1·244	33·878	
	49·50	0·50	4·993	1·252	35·122	
	49·75	0·25	5·023	1·259	36·374	
2929·97 ..	50·00	0·00	5·0533	1·267	37·633	Weir crest lower tank.
	50·25	..	5·083	1·274	38·900	
	50·50	..	5·113	1·282	40·174	
	50·75	..	5·143	1·290	41·456	
2930·97 ..	51·00	..	5·173		42·746	
	51·25	..	0·453	0·125	0·600	The area at the 50·00 and 53·00 contours have been taken from a survey signed G. B. Target, Exct. Engineer, No. 11, Tank Division, obtained from the office of the Secretary to Government of Mysore, Public Works Department, and those at 54·00 and 56·00 from a survey, dated 22nd November 1880, signed by Lieut. F. J. Romilly, R.E., the 54·00 contour being deduced from that at 54·08 shown on the survey.
	51·50	..	0·544	0·147	0·725	
	51·75	..	0·636	0·172	0·872	
2931·97 ..	52·00	..	0·742	0·197	1·044	
	52·25	..	0·848	0·237	1·241	
	52·50	..	0·970	0·258	1·468	
	52·75	..	1·092	0·296	1·726	
2932·97 ..	53·00	..	1·229	0·324	2·016	
	53·25	..	1·366	0·360	2·340	
	53·50	..	1·518	0·399	2·700	
	53·75	..	1·671	0·439	3·099	
2933·97 ..	54·00	..	1·839	0·431	3·538	
	54·25	..	2·007	0·508	4·019	Based on survey of 22nd November 1880.
	54·50	..	2·056	0·520	4·527	
	54·75	..	2·108	0·533	5·047	
2934·97 ..	55·00	..	2·158	0·545	5·580	
	55·25	..	2·207	0·561	6·125	
	55·50	..	2·284	0·582	6·686	
	55·75	..	2·372	0·604	7·268	
2935·97 ..	56·00	..	2·462	0·627	7·872	
	56·25	..	2·553	0·650	8·499	
	56·50	..	2·646	0·673	9·149	
	56·75	..	2·740	0·697	9·822	
2936·97 ..	57·00	..	2·837	0·721	10·519	Weir crest, upper tank.
	57·25	..	2·934		11·240	
	56·00	9·00	1·8504	0·480	1·628	
	41·00	8·75	1·988	0·514	2·108	
	41·25	8·50	2·126	0·551	2·622	
	41·50	8·25	2·286	0·591	3·173	
	41·75	8·00	2·446	0·633	3·764	
	42·00	7·75	2·616	0·675	4·397	
	42·25	7·50	2·787	0·719	5·072	
	42·50	7·25	2·968	0·764	5·791	
	42·75	7·00	3·149	0·811	6·555	
	43·00					

TABLE of Area of Water-spread and Capacity of the Halsur Tank prior to the Construction of the upper Tank in 1877.

Reduced level, M.S.D.	Survey contour level.	Gauge readings.	Area in millions of square feet.	Capacity		Remarks.
				Between contours, millions of cubic feet.	At contour, millions of cubic feet.	
	43·25	0·75	3·341			
	43·50	0·50	3·523	0·859	7·366	
	43·75	0·25	3·728	0·909	8·275	
	44·00	0·00	3·9432	0·960	9·134	
	44·25	5·75	4·001	0·993	10·094	
	44·50	5·50	4·060	1·007	11·087	
	44·75	5·25	4·120	1·023	12·904	
	45·00	5·00	4·181	1·037	13·116	
	45·25	4·75	4·243	1·043	14·153	
	45·50	4·50	4·305	1·068	15·206	
	45·75	4·25	4·368	1·084	16·274	
	46·00	4·00	4·431	1·100	17·358	
	46·25	3·75	4·495	1·116	18·468	
	46·50	3·50	4·560	1·132	19·574	
	46·75	3·25	4·624	1·148	20·706	
	47·00	3·00	4·6884	1·164	21·854	
	47·25	2·75	4·754	1·180	23·018	
	47·50	2·50	4·820	1·197	24·196	
	47·75	2·25	4·887	1·213	25·395	
	48·00	2·00	4·954	1·230	26·606	
	48·25	1·75	5·021	1·247	27·848	
	48·50	1·50	5·089	1·264	29·085	
	48·75	1·25	5·157	1·281	30·349	
	49·00	1·00	5·226	1·298	31·630	
	49·25	0·75	5·295	1·315	32·925	
	49·50	0·50	5·365	1·332	34·243	
	49·75	0·25	5·435	1·350	35·575	
	50·00	0·00	5·5002	1·368	36·925	
					38·293	

APPENDIX No. II.

Halsur Tank.

STATEMENT showing Particulars of Water-supply for the Year 1880.

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended.			Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
			Total, millions of cubic feet.	Used for troops, millions of cubic feet.	Lost, millions of cubic feet.			
January 1 ..	0·52	33·023	..	..	..	..	..	The zero of the gauge is level with the crest of the waste weir and its value is M.S.D. 2,929·97. Survey contour level 50·00.
,, 20 ..	0·92	..	..	..	..	..	..	
,, 21 ..	0·92	..	..	..	..	..	..	
,, 22 ..	0·94	..	..	..	..	..	0·62	
,, 31 ..	1·12	32·051	2·972	0·247	2·725	..	..	
February 1 ..	1·15	..	..	..	..	..	..	
,, 3 ..	1·29	31·658	0·393				..	
,, 4 ..	1·06	..	..				..	
,, 5 ..	0·67	..	..				..	
,, 6 ..	0·50	35·123	..	0·283	2·689	3·464	..	From upper tank.
,, 7 ..	0·51	..	..				..	
,, 29 ..	1·02	32·543	2·579				..	
	..	..	2·972	0·283	2·689	3·464	0·00	
March 1 ..	1·96	..	..			..	..	
,, 20 ..	1·66	..	..			..	0·17	
,, 21 ..	1·97	..	4·774	0·332	4·442	..	0·27	
,, 22 ..	1·70	..	..			..	..	
,, 31 ..	2·00	27·769	..			..	..	
	..	..	4·774	0·332	4·442	0·000	0·44	
April 4 ..	2·19	..	..	..	..	..	0·07	
,, 7 ..	2·17	..	..	..	..	..	0·07	
,, 11 ..	2·25	26·570	1·199			..	..	
,, 12 ..	1·83	28·390	..	0·237	3·693	2·020	1·20	
,, 19 ..	..	..	..			..	0·16	
,, 30 ..	2·42	25·759	2·831			..	..	
	..	..	4·030	0·337	3·693	2·020	1·50	

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Statement showing Particulars of Water-supply for the Year 1880—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended.			Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
			Total, millions of cubic feet.	Used for troops, millions of cubic feet.	Lost, millions of cubic feet.			
May 6 ..	2·50	..	..	..	..	..	..	
,, 7 ..	2·59	24·857	..	..	..	..	0·48	
,, 8 ..	2·61	25·759	0·902	..	..	0·902	..	
,, 9 ..	2·42	..	..	..	..	..	0·59	
,, 10 ..	2·42	..	..	..	..	..	0·23	
,, 11 ..	2·42	..	..	..	..	..	0·19	
,, 12 ..	2·44	25·569	0·190	..	..	..	..	
,, 13 ..	2·46	..	..	..	..	..	0·40	
,, 14 ..	2·38	..	..	0·279	1·538	2·828	0·60	
,, 15 ..	2·25	..	..	..	..	..	0·58	
,, 16 ..	2·17	..	..	..	..	..	0·79	
,, 17 ..	1·87	28·397	..	..	..	..	..	
,, 18 ..	1·90	..	..	..	..	..	0·15	
,, 19 ..	1·92	..	..	..	..	..	0·20	
,, 21 ..	1·96	..	..	..	..	..	0·09	
,, 23 ..	2·00	27·769	0·628	..	..	..	0·65	
,, 24 ..	1·71	..	..	..	..	1·693	0·47	
,, 25 ..	1·67	..	..	..	..	..	0·33	
,, 26 ..	1·65	29·462	..	..	..	..	..	
,, 27 ..	1·67	29·366	0·097	..	..	2·047	0·48	
,, 28 ..	1·67	..	..	..	..	..	1·27	
,, 29 ..	1·53	..	..	..	..	..	..	
,, 30 ..	1·53	..	..	..	..	..	0·66	
,, 31 ..	1·25	31·412	..	..	..	..	..	
	..	..	1·817	0·279	1·538	7·470	8·16	
June 6 ..	1·42	30·581	0·831			..	..	
,, 7 ..	1·38	..	..			..	..	
,, 8 ..	1·25	30·776	..			0·195	0·50	
,, 10 ..	1·42	30·581	0·195			..	..	
,, 11 ..	1·30	..	..			..	0·60	
,, 12 ..	1·25	..	..	0·254	1·756	..	0·14	
,, 13 ..	1·04	..	..			..	0·06	
,, 14 ..	1·03	..	..			1·913	0·14	
,, 15 ..	1·03	..	..			..	0·05	
,, 16 ..	1·02	32·494	..			..	0·09	
,, 17 ..	1·04	..	..			..	0·23	
,, 18 ..	1·25	..	..			..	..	
,, 20 ..	1·23	31·510	0·984					
,, 30 ..	..	..	2·010	0·254	1·756	2·108	3·11	
July 1 ..	1·19	31·707	..			0·197	0·35	
,, 2 ..	1·20	..	..			..	0·14	
,, 3 ..	1·21	31·609	0·098			..	..	
,, 4 ..	1·19	..	..			..	0·75	
,, 5 ..	1·00	32·641	..			1·032	0·71	
,, 6 ..	1·00	..	..			..	0·16	
,, 7 ..	1·01	32·543	0·098			1·335	0·03	
,, 8 ..	1·02	33·878	..			..	0·08	
,, 9 ..	0·75	..	..			..	0·99	0·94 in one hour.
,, 10 ..	0·77	..	..			..	0·46	
,, 18 ..	0·87	32·938	0·940	0·272	1·211	0·099	..	
,, 21 ..	0·94	33·037	..			..	0·50	
,, 22 ..	0·72	..	..			..	0·03	
,, 23 ..	0·93	..	..			..	0·33	
,, 24 ..	0·94	32·888	0·149			..	0·08	
,, 25 ..	0·93	..	..			0·396	0·41	
,, 26 ..	0·87	..	..			..	0·25	
,, 27 ..	0·87	33·254	..			..	0·02	
,, 28 ..	0·85	..	..			..	0·05	
,, 29 ..	0·59	33·086	0·198			..	0·15	
,, 30 ..	0·91	..	..			..	..	
,, 31 ..	..	..	1·483	0·272	1·211	3·059	5·49	
August 1 ..	0·93	33·037	0·049	..	..	..	0·35	
,, 8 ..	..	..	..	..	..	..	0·12	
,, 10 ..	1·03	32·494	0·543	..	..	..	..	
,, 11 ..	0·87	..	..	..	..	..	1·00	
,, 12 ..	0·87	..	..	..	..	..	0·60	
,, 13 ..	0·93	..	..	..	..	..	0·25	

Statement showing Particulars of Water-supply for the Year 1880—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Used for troops, millions of cubic feet.	Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
August 14..	1·60	* 37·633	..	..	..	..	..	* For gauge reading 6·00 Millions of C. F.
" 15..	0·75	..	..	..	..	5·139	5·18	
" 16..	0·25	..	..	..	..	..	0·43	
" 17..	0·25	..	..	..	..	..	..	
" 18..	0·17	..	..	..	..	..	..	
" 19..	0·12	..	63·476	0·302	0·296	..	0·37	
" 20..	0·30	..	..	..	63·476	..	..	
" 21..	0·68	..	..	..	..	..	..	
" 22..	0·68	..	..	..	..	63·476	0·01	
" 23..	0·67	..	..	..	..	..	0·13	
" 24..	0·66	..	..	..	..	..	..	
" 25..	0·64	..	..	..	..	..	..	
" 26..	0·63	..	..	..	..	..	..	
" 27..	0·54	..	..	..	..	..	..	
" 28..	0·42	..	..	..	..	..	..	
" 29..	0·30	..	..	..	..	..	0·25	
" 31..	0·66	37·633	..	..	..	..	0·13	
	..	..	..	..	..	..	0·22	
	..	..	..	..	..	..	0·10	
September 1..	3·95	37·633	64·988	0·302	63·746	68·615	2·13	
" 4..	0·63	..	..	..	..	..	0·03	
" 5..	0·33	..	..	..	..	..	0·07	
" 8..	0·66	..	..	..	..	..	0·02	
" 9..	0·64	37·633	0·502	..	..	..	..	
		37·633						
" 10..	0·62	..	..	..	..	..	..	
" 11..	0·62	..	..	..	..	0·393	1·69	
" 12..	0·60	..	..	..	..	..	..	
" 13..	0·62	..	..	..	..	..	..	
" 14..	0·47	..	..	..	..	..	0·03	
" 15..	0·47	..	..	..	..	..	0·05	
" 16..	0·34	..	0·274	0·569	..	..	0·15	
" 17..	0·36	..	..	..	..	..	..	
" 18..	0·36	..	5·394	..	..	..	..	
" 19..	0·34	..	..	..	..	1·394	..	
" 20..	0·32	..	..	..	..	..	0·03	
" 21..	0·32	..	..	..	..	..	..	
" 22..	0·19	..	..	..	..	..	..	
" 30..	4·19	36·724	9·667	..	..	..	..	
	..	..	..	..	..	..	..	
October 1..	0·21	..	7·163	0·274	6·889	0·196	2·69	
" 2..	0·22	..	..	..	..	..	0·11	
" 3..	0·35	36·724	0·502	..	..	..	0·18	
" 4..	0·25	37·633	..	..	..	1·559	0·03	
" 5..	0·17	..	..	..	..	..	..	
" 6..	0·09	..	..	..	..	..	..	
" 7..	0·21	..	..	..	..	..	0·72	
" 8..	0·13	..	..	..	..	..	..	
" 9..	0·08	..	..	..	..	..	..	
" 10..	0·04	..	..	..	..	..	..	
" 11..	0·02	..	..	..	..	..	..	
" 12..	0·04	..	..	..	..	..	..	
" 13..	0·04	..	..	..	..	..	..	
" 14..	0·17	..	..	..	..	..	0·16	
" 15..	0·12	..	..	..	..	..	0·04	
" 16..	0·06	..	..	..	..	..	..	
" 17..	0·06	..	..	..	..	..	..	
" 18..	0·06	..	0·245	0·569	63·677	65·622	..	
" 19..	0·04	..	..	..	..	..	0·06	
" 20..	0·04	..	..	..	..	..	..	
" 21..	0·02	..	..	..	..	..	1·00	
" 22..	0·02	..	..	..	..	..	..	
" 23..	0·02	..	..	..	..	..	..	
" 24..	0·02	..	..	..	..	..	0·12	
" 25..	0·02	..	..	..	..	..	0·06	
" 26..	0·02	..	..	..	..	..	..	
" 27..	0·02	..	..	..	..	..	..	
" 28..	0·02	..	..	..	..	..	..	
" 29..	0·02	..	..	..	..	..	..	
" 30..	0·02	..	..	..	..	..	0·06	
" 31..	0·02	37·633	..	..	..	..	..	
	..	..	65·622	0·813	63·677	65·622	2·69	

Statement showing Particulars of Water-supply for the Year 1880—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Used for troops, millions of cubic feet.	Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
November 1..	0·10	..	..	..	..	..	..	Millions of C. F. Discharged to waste .. 0·727
" 2..	0·08	..	..	..	..	..	..	Do. .. 0·529
" 3..	0·06	..	..	..	..	..	..	Do. .. 0·397
" 4..	0·04	..	..	..	..	..	..	Do. .. 0·198
" 5..	0·03	..	..	..	..	..	..	Do. .. 0·132
" 6..	0·02	..	..	..	..	..	..	Do. .. 0·079
" 7..	0·01	..	2·762	..	..	2·762	0·26	Do. .. 0·033
" 8..	0·04	..	..	..	..	..	..	Do. .. 0·086
" 9..	0·03	..	..	..	..	..	0·02	Do. .. 0·132
" 10..	0·02	..	..	..	..	..	0·18	Do. .. 0·079
" 11..	0·01	..	..	..	..	..	0·13	Do. .. 0·033
" 12..	0·01	..	..	..	..	..	..	Do. .. 0·086
" 13..	0·02	..	..	0·281	..	..	..	Do. .. 0·132
" 14..	0·02	..	..	..	..	..	..	Do. .. 0·079
" 15..	0·01	..	..	..	..	..	..	Do. .. 0·033
" 16..	0·00	37·633	..	..	..	..	0·12	Do. .. 0·097
" 17..	0·01	..	..	..	..	..	..	
" 18..	0·01	..	..	..	..	..	..	
" 20..	0·03	37·381	0·252	..	..	0·252	0·60	Do. .. 0·145
" 21..	0·00	37·633	..	..	..	..	0·37	Do. .. 0·198
" 22..	0·06	..	..	..	..	..	..	Do. .. 0·132
" 23..	0·04	..	..	..	..	..	0·05	Do. .. 0·132
" 24..	0·04	..	..	..	..	..	..	Do. .. 0·079
" 25..	0·03	..	1·182	..	..	1·182	..	Do. .. 0·033
" 26..	0·02	..	..	..	..	..	..	Do. .. 0·333
" 27..	0·01	..	..	..	..	..	0·33	Do. .. 0·033
" 28..	0·02	..	..	..	..	..	0·03	Do. .. 0·397
" 29..	0·01	..	..	..	..	..	0·60	
" 30..	0·12	37·633	..	..	..	..	..	Total .. 3·944
	..	..	4·196	0·281	3·915	4·196	2·69	
December 1..	0·08	..	..	..	..	..	0·02	Discharged to waste .. 0·595
" 2..	0·06	..	1·374	..	..	1·374	..	Do. .. 0·330
" 3..	0·04	..	..	..	..	..	..	Do. .. 0·198
" 4..	0·03	..	..	0·273	3·462	..	..	Do. .. 0·132
" 5..	0·02	..	..	..	..	..	..	Do. .. 0·079
" 6..	0·01	..	..	..	..	..	..	Do. .. 0·033
" 7..	0·00	37·633	2·361	..	..	..	..	Do. .. 0·007
" 31..	0·47	35·272						Total .. 1·374
	..	..	3·735	0·273	3·462	1·374	0·02	

Summary.

January ..	0·02	35·023	2·972	0·247	2·725	..	0·62
February ..	..	..	2·972	0·283	2·689	* 3·464	0·00
March	..	..	4·774	0·332	4·442	..	0·44
April	..	..	4·030	0·337	3·693	2·020	1·60
May	..	..	1·817	0·279	1·538	7·470	8·16
June	..	..	2·010	0·254	1·756	2·108	3·11
July	..	..	1·483	0·272	1·211	3·059	5·49
August	..	..	64·068	0·302	63·766	68·615	9·12
September ..	..	..	7·143	0·274	6·869	6·186	2·62
October ..	..	..	65·923	0·245	65·678	66·889	10·21
November ..	..	..	4·196	0·281	3·915	4·196	2·69
December ..	..	..	3·735	0·273	3·462	1·374	0·02
	0·47	35·272					
Difference ..	..	0·249	166·123	3·379	161·744	165·372	43·98

* From upper tank.

APPENDIX No. 12.

Habur Tank.

STATEMENT showing Particulars of Water-supply for the Year 1881.

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Volume expended. Used for troops, millions of cubic feet.	Volume expended. Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
January 1 ..	0·42	22·172	..		..	..	..	
.. 13 ..	0·68	..	..		..	..	0·23	
.. 18 ..	0·79	..	..	0·228	..	..	0·07	*
.. 31 ..	1·66	22·345	2·826		..	..	..	*
..	..	..	2·826	0·228	2·426	2·360	0·23	
February 1 ..	1·56	..	..		..	..	..	
.. 16 ..	1·44	..	..		..	..	..	Syphon over upper tank weir in work.
.. 22 ..	1·48	20·289	2·644	0·205	..	..	..	* From upper tank, exclusive of that which compensated from evaporation, &c.
.. 28 ..	1·43	20·434	..		* 0·246	..	..	
..	..	..	2·644	0·205	0·246	..	..	
March 1 ..	1·45	20·434	..		..	..	..	
.. 27 ..	1·62	..	..		..	..	..	
.. 28 ..	1·55	22·364	1·979	0·209	..	..	0·42	
.. 29 ..	1·50	20·189	0·134		..	..	0·04	
.. 31 ..	1·54	20·056	..		0·225	..	..	
..	..	..	1·264	0·209	0·225	0·236	0·46	
April 1 ..	1·56	..	..		..	..	..	
.. 17 ..	2·09	..	..		..	..	..	
.. 30 ..	2·49	23·344	1·434	0·232	..	..	0·45	
..	..	..	1·434	0·232	0·947	0·236	0·45	
May 1 ..	2·42	..	..		..	..	..	
.. 10 ..	2·70	..	..		..	..	0·07	
.. 11 ..	2·80	24·631	1·434	0·232	..	..	0·07	
.. 13 ..	2·82	23·378	..		..	..	0·29	
.. 14 ..	2·56	..	..		0·947	..	..	
.. 16 ..	2·58	..	..		..	..	0·07	
.. 30 ..	2·66	..	..		..	..	0·07	
.. 31 ..	2·71	23·618	2·869		..	..	0·29	
		24·243	..		..	..	..	
					1·368		0·61	
	..	..	3·284	0·232	2·405	2·313	1·23	
June 1 ..	2·72	..	..		..	..	..	
.. 4 ..	2·77	..	..		..	..	..	
.. 6 ..	2·81	23·913	0·471		..	..	0·24	
.. 7 ..	2·33	26·093	..		..	..	1·28	
.. 8 ..	2·25	..	..		2·181	..	..	
.. 9 ..	2·36	..	..	0·279	..	..	..	
.. 20 ..	2·60	..	..		..	..	..	
.. 25 ..	2·73	..	..		..	..	..	
.. 28 ..	2·78	..	..		..	..	..	
.. 29 ..	2·80	..	..		..	..	..	
.. 30 ..	2·83	..	..		..	..	..	
		23·618	3·276		..	..	..	
	..	..	3·746	0·279	2·476	2·181	2·14	
July 1 ..	2·85	..	..		..	..	..	
.. 3 ..	2·90	..	..		..	..	2·19	
.. 19 ..	3·02	23·923	0·833	0·276	..	..	..	From upper tank.
.. 17 ..	2·69	24·904	..		..	..	..	
.. 31 ..	2·60	23·918	1·886		1·979	..	..	
	..	..	2·779	0·276	2·503	1·979	0·19	

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Statement showing Particulars of Water-supply for the Year 1881—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Volume expended. Used for troops, millions of cubic feet.	Volume expended. Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
August 1 ..	3·00	..	..		..	..	0·23	
.. 3 ..	..	..	..		..	..	0·19	
.. 4 ..	..	..	..		..	..	0·08	
.. 5 ..	..	..	..		..	..	0·18	
.. 6 ..	..	..	..		..	..	0·15	
.. 8 ..	3·16	22·552	0·466		..	1·407	0·08	
.. 9 ..	2·80	23·959	..		..	..	0·37	
.. 10 ..	2·88	..	..		..	..	1·20	
.. 14 ..	..	..	..	0·264	..	..	0·09	
.. 19 ..	..	..	..		..	..	0·33	
.. 21 ..	..	..	..		..	..	0·10	
.. 22 ..	..	..	..		..	..	1·30	
.. 25 ..	2·92	23·394	0·565		..	..	0·13	
.. 25 ..	2·79	..	..		..	..	..	
.. 26 ..	2·75	..	..		..	..	1·00	
.. 27 ..	2·65	..	..		..	..	0·66	
.. 28 ..	2·59	..	..		..	..	0·70	
.. 29 ..	2·58	..	..		..	1·605	0·46	
.. 30 ..	2·58	24·999	..		..	..	0·37	
.. 31 ..	2·58	..	..		..	..	..	
..	..	..	1·031	0·264	0·767	3·012	7·02	
September 5 ..	2·69	..	..		..	..	0·12	
.. 11 ..	2·81	25·012	1·087		..	..	0·06	
.. 12 ..	2·78	24·053	..		..	0·141	0·21	
.. 13 ..	2·80	..	..		..	..	0·02	
.. 14 ..	2·82	..	..		..	..	0·04	
.. 16 ..	2·86	22·676	0·377		..	..	0·10	
.. 17 ..	2·71	..	..	0·302	..	..	1·25	
.. 18 ..	2·60	..	..		..	1·228	0·20	
.. 21 ..	2·60	24·904	..		..	..	0·37	
.. 22 ..	2·62	..	..		..	..	0·12	
.. 26 ..	2·73	24·289	0·615		..	..	0·05	
.. 27 ..	2·71	..	..		..	..	0·33	
.. 28 ..	2·71	..	..		..	..	0·10	
.. 29 ..	2·71	..	..		..	2·090	0·20	
.. 30 ..	2·29	26·379	..		..	..	2·10	
..	..	..	2·079	0·302	1·777	3·469	5·27	
October 1 ..	2·12	..	..		..	..	0·40	
.. 2 ..	1·87	28·397	..		..	2·018	0·94	
.. 5 ..	1·94	..	..	0·252	..	..	0·03	
.. 6 ..	1·94	..	..		..	..	0·10	
.. 31 ..	2·50	25·378	3·019		..	..	..	
..	..	..	3·019	0·252	2·767	2·018	1·47	
November 1 ..	2·52	..	..		..	..	0·06	
.. 3 ..	2·53	23·189	0·189		..	..	0·23	
.. 4 ..	2·34	25·426	..		..	0·237	0·32	
.. 5 ..	2·49	..	..		..	..	0·03	
.. 6 ..	2·50	..	..		..	..	..	
.. 7 ..	2·51	25·331	0·095		..	0·762	1·16	Probably evening of 6th. Duration, 7 to 11 P.M.
.. 8 ..	2·34	26·093	..		..	..	..	
.. 7 ..	2·49	25·855	0·238	0·222	..	..	1·64	
.. 14 ..	2·27	..	..		..	0·620	0·09	
.. 15 ..	2·27	26·475	..		..	..	0·06	
.. 13 ..	2·28	..	..		..	..	0·05	
.. 16 ..	2·32	..	..		..	..	0·04	
.. 17 ..	2·34	..	..		..	..	..	
.. 19 ..	2·30	25·378	1·097		..	..	..	
.. 30 ..								
	..	..	1·619	0·222	1·397	1·619	3·68	
December 9 ..	2·66	..	..		..	..	0·04	
.. 12 ..	2·69	..	..		..	..	0·05	
.. 23 ..	2·87	23·630	1·748	0·228	..	..	..	Sluice of upper tank opened on the 22nd.
.. 25 ..	2·48	23·173	..		..	1·843	..	
.. 31 ..	2·64	24·715	0·758		..	..	..	
	..	..	2·506	0·228	2·278	1·843	0·09	

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Statement showing Particulars of Water-supply for the Year 1881—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Volume expended. Used for troops, millions of cubic feet.	Volume expended. Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
January ..	0·49	35·172						
February ..	..	..	2·826	0·138	2·498	0·000	0·55	
March ..	..	..	2·648	0·265	1·753	*0·148	0·09	* From upper tank.
April ..	..	..	1·264	0·198	0·654	0·320	0·48	
May ..	..	..	4·141	0·213	3·669	0·000	0·45	
June ..	..	..	3·784	0·282	2·493	2·813	1·73	
July ..	..	..	3·716	0·276	2·479	2·181	2·14	
August ..	..	..	3·772	0·276	2·968	†1·079	0·10	† From upper tank.
September ..	..	..	1·931	0·264	0·767	3·613	1·62	
October ..	..	..	3·079	0·301	1·777	3·439	3·27	
November ..	..	..	3·419	0·153	2·747	2·918	1·47	
December ..	2·64	38·715	3·406	0·229	1·397	1·619	3·68	
Difference ..	..	10·457	39·452	3·268	26·582	19·355	23·28	‡ From upper tank.

APPENDIX No. 13.

Halsar Tank.

Statement showing Particulars of Water-supply for the Year 1882.

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Volume expended. Used for troops, millions of cubic feet.	Volume expended. Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
December 31 ..	2·64	38·715						
January 1 ..	2·65	38·562	..		..		..	
,, 2 ..	2·59	..	..		..		..	
,, 3 ..	2·49	..	..	0·206	..	0·237	0·48	
,, 31 ..	2·26	37·603	3·144		..		0·03	
..	..	..	..		..		..	
February 1 ..	2·28	..	3·144	0·206	2·939	0·237	0·52	
,, 28 ..	4·05	35·455	..		..		..	
..	..	..	3·550	0·253	..	..	..	
March 1 ..	4·03	..	3·550	0·250	3·300	0·050	2·05	
,, 31 ..	4·02	35·600	..		..		..	
..	..	..	3·803	0·253	..	..	..	
April 1 ..	..	..	3·956	0·166	3·790	0·000	0·00	
,, 13 ..	4·35	..	..		..	..	..	
,, 30 ..	4·22	36·160	4·722	0·278	..	..	0·42	
..	3·83	..	..		..	..	..	
..	..	..	4·731	0·279	× 3·445	0·000	0·42	
May 1 ..	3·85	..	..		..	..	0·02	
,, 9 ..	3·13	..	1·174	0·156	..	..	..	
,, 10 ..	4·13	0·156	..		..	..	0·19	
,, 11 ..	4·12	..	..		..	..	..	
,, 13 ..	3·91	..	..		..	..	0·41	
,, 14 ..	3·11	3·742	0·621	0·346	..	0·153	..	
,, 15 ..	3·06	3·973	..		..	..	1·37	
,, 16 ..	3·05	..	..		..	..	0·13	
,, 17 ..	3·00	..	..		..	..	0·16	
,, 19 ..	2·92	..	..		..	..	0·40	
,, 20 ..	2·74	..	..		..	..	0·07	
,, 30 ..	2·72	11·208	..		..	..	0·11	
,, 31 ..	2·94	..	..		..	1·338	0·01	
..	2·94	10·353	0·855		..	..	..	
..	..	..	3·209	0·259	2·927	1·491	3·24	

Difference 20 minutes, 1883.
Difference 12 minutes, 1883.
2 to 3 P.M.
3 P.M. to 4 A.M., 1883.

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Statement showing Particulars of Water-supply for the Year 1881—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Volume expended. Used for troops, millions of cubic feet.	Volume expended. Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
June 1 ..	5·98	..	..		..	..	0·07	
,, 2 ..	5·99	..	..		..	..	0·01	
,, 3 ..	6·01	..	..		..	..	0·01	
,, 5 ..	6·05	..	..		..	..	0·04	
,, 6 ..	6·07	..	..		..	..	0·05	
,, 7 ..	6·10	..	..		..	..	0·25	
,, 8 ..	6·12	..	..		..	..	0·03	
,, 10 ..	6·18	..	..	0·202	..	..	0·02	
,, 11 ..	6·20	..	..		..	..	0·05	
,, 12 ..	6·25	..	..		..	..	0·18	
,, 15 ..	6·31	..	..		..	..	..	
,, 22 ..	6·49	8·261	1·992		..	..	..	Sluice of upper tank opened.
,, 23 ..	6·23	..	..		..	..	0·33	
,, 25 ..	6·18	..	..		..	1·219	..	
,, 26 ..	6·16	2·480	..		..	..	..	
,, 29 ..	6·27	9·061	0·419		..	0·073	0·78	
,, 30 ..	6·25	9·134	..		..	..	..	
..	..	..	2·411	0·202	2·119	1·292	1·32	
July 1 ..	6·27	9·061	0·073		..	..	0·49	
,, 2 ..	6·25	9·134	..		..	0·073	0·09	
,, 3 ..	6·26	..	..		..	..	0·03	
,, 4 ..	6·27	9·061	0·073		..	..	0·18	
,, 5 ..	6·25	..	..		..	..	0·25	
,, 6 ..	6·25	9·134	..		..	0·073	0·16	
,, 7 ..	6·25	..	..		..	..	0·04	
,, 8 ..	6·26	..	..		..	..	0·02	
,, 9 ..	6·27	..	..		..	..	0·01	
,, 10 ..	6·23	..	..		..	..	..	
,, 13 ..	6·24	8·607	0·327		..	0·036	0·26	
,, 14 ..	6·23	8·843	..	0·241	..	..	0·04	
,, 15 ..	6·23	..	..		..	..	0·02	
,, 19 ..	6·14	..	..		..	..	0·02	
,, 20 ..	6·16	..	..		..	..	0·06	
,, 21 ..	6·15	..	..		..	..	0·09	
,, 23 ..	6·10	8·225	0·618		..	..	0·78	
,, 24 ..	6·08	..	..		..	..	0·21	
,, 25 ..	6·05	..	..		..	..	0·01	
,, 26 ..	6·05	..	..		..	..	0·35	
,, 27 ..	6·03	..	..		..	..	0·52	
,, 28 ..	6·07	..	..		..	..	0·58	
,, 29 ..	6·28	..	..		..	0·909	0·07	
,, 30 ..	6·25	9·134	..		..	..	..	
,, 31 ..	..	..	1·091	0·241	0·850	1·091	4·15	
..	..	..	..		..	..	..	
August 1 ..	6·25	..	..		..	..	0·07	
,, 2 ..	6·23	9·211	..		..	0·077	0·24	
,, 5 ..	6·24	9·028	0·113		..	..	..	
,, 6 ..	6·25	..	..		..	..	0·15	
,, 7 ..	6·26	..	..		..	..	0·75	
,, 8 ..	6·16	..	..		..	1·234	..	
,, 9 ..	6·13	12·332	..		..	..	0·62	
,, 10 ..	5·94	..	..		..	..	0·07	
,, 11 ..	5·95	..	..		..	..	0·15	
,, 12 ..	6·02	..	..	0·248	..	..	0·08	
,, 13 ..	6·03	..	..		..	..	0·02	
,, 20 ..	6·07	..	..		..	..	0·70	
,, 21 ..	6·00	9·748	0·584		..	..	0·66	
,, 23 ..	5·94	..	..		..	..	0·02	
,, 24 ..	5·94	..	..		..	..	0·28	
,, 25 ..	5·94	..	..		..	..	0·45	
,, 27 ..	5·94	..	..		..	1·021	0·60	
,, 28 ..	5·83	10·769	..		..	..	0·13	
,, 29 ..	5·85	..	..		..	..	0·03	
,, 30 ..	5·87	10·619	0·150		..	..	..	
,, 31 ..	..	..	0·856	0·248	0·608	2·332	3·02	
..	..	..	..		..	..	..	

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Statement showing Particulars of Water-supply for the Year 1881—*(Continued)*.

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Volume expended. Used for troops, millions of cubic feet.	Volume expended. Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
September 1 ..	5·52	..	..		..	..	0·02	
.. 3 ..	5·34	..	..		..	..	0·09	
.. 4 ..	5·26	..	..		..	..	0·03	
.. 6 ..	5·26	..	..		..	..	0·23	Duration 2 to 2½ P.M.
.. 7 ..	5·28	..	..		..	..	0·15	
.. 11 ..	6·04	..	..		..	..	0·06	
.. 15 ..	6·15	..	..		..	..	0·17	Duration 7½ to 9 P.M.
.. 21 ..	6·23	9·211	1·209	0·255	..	..	0·29	
.. 22 ..	5·06	10·315	..		..	1·042	0·68	
.. 25 ..	6·02	..	..		..	..	0·29	
.. 26 ..	6·04	9·949	0·313		..	..	..	
.. 27 ..	6·02	..	..		..	..	0·42	
.. 28 ..	6·02	..	..		..	..	0·11	
.. 29 ..	5·98	10·173	..		..	0·232	0·21	
.. 30 ..	6·00	10·094	0·079		..	..	..	
	..	..	1·791	0·255	1·536	1·274	2·75	
October 1 ..	6·00	10·094	..		..	..	0·01	
.. 2 ..	5·95	10·253	..		..	0·139	0·28	
.. 3 ..	5·95	..	..		..	..	0·02	
.. 4 ..	5·94	..	..		..	..	0·19	
.. 5 ..	5·96	10·173	0·080		..	..	..	Syphon working over upper tank weir.
.. 7 ..	5·94	..	..		..	..	0·25	
.. 8 ..	5·75	..	..		..	..	0·13	
.. 15 ..	5·67	..	..		..	..	0·08	
.. 13 ..	4·59	..	..		..	7·361	..	
.. 14 ..	4·33	..	..		..	..	..	
.. 15 ..	4·21	..	..		..	..	0·18	
.. 19 ..	4·21	..	..		..	..	0·75	
.. 21 ..	4·21	17·624	..		..	..	0·61	
.. 31 ..	4·22	..	..		..	..	0·10	
	4·42	16·021	0·913		..	..	0·25	
	..	..	..		..	..	0·13	
	..	..	0·993	0·263	0·730	7·536	2·57	
November 1 ..	4·44	..	..		..	..	..	
.. 4 ..	4·60	16·274	0·547		..	..	0·02	
.. 5 ..	4·44	..	..		..	..	..	
.. 6 ..	3·82	..	..		..	..	1·05	
.. 9 ..	3·50	20·780	..		..	..	2·33	
.. 15 ..	3·59	..	..		..	4·432	0·84	
.. 16 ..	3·68	20·253	0·453		..	..	0·08	
.. 17 ..	3·50	20·706	..		..	..	0·03	
.. 23 ..	3·59	20·209	0·497	0·231	..	0·452	0·25	
.. 24 ..	3·08	..	..		..	..	0·43	
.. 25 ..	2·87	..	..		..	..	1·88	
.. 26 ..	2·75	..	..		..	..	0·61	
.. 27 ..	2·71	..	..		..	..	0·25	
.. 28 ..	2·42	..	..		..	..	0·01	
.. 29 ..	2·88	..	..		..	..	0·70	
.. 30 ..	2·23	20·602	..		..	..	0·24	
	..	..	1·267	0·231	0·978	11·240	8·95	
December 1 ..	2·21	20·742	..		..	..	..	
.. 31 ..	3·62	24·810	1·952	0·251	..	0·956	..	
	..	..	1·952	0·231	1·721	0·206	0·00	
January ..	* 2·64	24·715	3·144	0·206	2·938	0·227	0·51	* 31st December 1881.
February ..	..	..	3·359	0·259	3·100	0·262	0·00	
March ..	..	..	3·966	0·256	3·700	0·603	0·00	
April	..	..	3·741	0·276	3·445	0·000	0·42	
May	..	..	2·365	0·264	1·937	1·580	4·04	Sluice of upper tank opened.
June	..	..	2·811	0·292	2·119	1·292	1·52	
July	..	..	1·921	0·241	0·850	1·971	4·15	
August	..	..	0·836	0·248	0·628	2·333	5·02	
September ..	..	..	1·791	0·255	1·536	1·275	2·72	Syphon working over upper tank weir.
October	..	..	0·993	0·263	0·730	7·329	2·57	
November ..	..	..	1·267	0·231	0·976	11·232	8·95	
December ..	2·62	24·810	1·952	0·251	1·701	0·956	0·00	
Difference ..	..	+ 0·095	26·089	3·089	23·040	26·784	31·13	

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APPENDIX No. 14.

Halsur Taluk.

Statement showing Particulars of Water-supply for the Year 1883.

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Volume expended. Used for troops, millions of cubic feet.	Volume expended. Lost, millions of cubic feet.	Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
1882.								
December 31 ..	2·62	24·810	..	0·264	..	..	..	
January 1 ..	2·65	..	..		..	..	..	
.. 31 ..	3·27	21·762	3·048		..	..	..	
	..	..	3·048	0·264	2·784	0·000	0·00	
February 1 ..	3·29	..	..	0·244	..	..	..	
.. 28 ..	3·96	18·637	3·125		..	..	..	
	..	..	3·125	0·244	2·881	0·000	0·00	
March 1 ..	3·99	..	..	0·289	..	..	0·07	
.. 2 ..	4·02	..	..		..	..	..	
.. 31 ..	4·83	14·869	3·768		..	..	..	
	..	..	3·768	0·289	3·479	0·000	0·07	
April 1 ..	4·87	..	..	0·341	..	..	0·16	
.. 24 ..	5·69	..	..		..	..	0·23	
.. 27 ..	5·67	..	..		..	..	..	
.. 29 ..	5·69	11·329	3·540		..	0·089	0·37	Duration 4 to 7 P.M., 29th.
.. 30 ..	5·67	11·409	..		..	..	..	
	..	..	3·540	0·341	3·199	0·089	0·76	
May 1 ..	5·70	..	..	0·323	..	..	..	
.. 2 ..	5·73	..	..		..	..	0·17	
.. 13 ..	6·03	..	..		..	..	0·19	
.. 15 ..	6·07	..	..		..	..	0·18	
.. 18 ..	6·17	9·441	1·968		..	..	..	
.. 19 ..	6·12	9·638	..		..	0·192	0·61	
.. 24 ..	6·29	..	..		..	..	..	
.. 25 ..	6·25	..	..		..	..	0·35	
.. 28 ..	6·30	..	..		..	..	0·17	
.. 29 ..	6·31	..	..		..	..	0·20	
.. 30 ..	6·33	..	..		..	..	0·005	
.. 31 ..	6·36	8·807	0·826		..	..	..	
	..	..	2·794	0·323	2·471	0·192	1·875	
June 1 ..	6·39	..	..	0·303	..	..	..	
.. 14 ..	6·75	..	..		..	..	0·13	
.. 21 ..	6·95	..	..		..	..	0·12	
.. 22 ..	6·96	..	..		..	..	0·26	
.. 23 ..	7·02	..	..		..	..	0·02	
.. 25 ..	7·06	..	..		..	..	0·09	
.. 28 ..	7·09	6·280	2·527		..	..	..	
.. 30 ..	..	..	2·527	0·303	2·224	0·000	0·62	
July 1 ..	7·11	..	..	0·296	..	..	..	
.. 2 ..	7·13	..	..		..	..	0·04	
.. 5 ..	7·31	5·913	0·367		..	..	..	
.. 6 ..	7·03	6·454	..		..	0·581	0·82	
.. 7 ..	7·03	..	..		..	..	0·08	
.. 8 ..	7·04	..	..		..	..	0·14	
.. 9 ..	7·04	..	..		..	..	0·10	
.. 10 ..	7·05	..	..		..	..	0·01	
.. 12 ..	7·07	..	..		..	..	0·02	
.. 13 ..	7·08	..	..		..	..	0·07	
.. 15 ..	7·10	..	..		..	..	0·28	
.. 16 ..	7·10	6·064	0·428		..	..	0·24	
.. 17 ..	7·12	..	..		..	..	0·38	
.. 18 ..	7·13	..	..		..	0·567	0·65	
.. 19 ..	7·13	..	..		..	..	..	
.. 20 ..	7·04	6·453	0·039		..	..	0·93	Duration 3 to 8 P.M., 21st.
.. 21 ..	7·04	6·403	..		..	..	..	Duration 3-15 to 3-45 P.M., 22nd.
.. 22 ..	6·94	..	..		..	1·032	0·63	
.. 23 ..	6·73	7·435	..		..	..	..	

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Statement showing Particulars of Water-supply for the Year 1883—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended.			Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
			Total, millions of cubic feet.	Used for troops, millions of cubic feet.	Lost, millions of cubic feet.			
July 24 ..	0·74	7·421	0·034		..	..	..	
.. 25 ..	0·73	7·409	..		..	0·503	0·23	
.. 26 ..	0·73	..	..		..	..	0·16	
.. 27 ..	0·73	..	..	0·235	..	..	0·16	
.. 28 ..	0·74	..	..		..	..	0·66	
.. 31 ..	0·80	7·204	0·365		..	..	..	
	..	..	1·134	0·236	0·838	2·046	4·87	
August 1 ..	0·83	..	..		..	..	..	
.. 4 ..	0·90	..	..		..	..	..	
.. 6 ..	0·94	..	..		..	..	0·39	
.. 7 ..	0·95	..	..		..	..	0·53	
.. 8 ..	0·97	..	..		..	..	0·06	
.. 9 ..	0·99	6·987	..		..	..	0·04	
.. 10 ..	0·55	..	0·617		..	..	..	
.. 12 ..	0·48	8·228	..		..	..	1·63	Duration from 7 p.m. 9th to 3 a.m. 10th.
.. 13 ..	0·47	..	..		..	1·711	0·23	
.. 14 ..	0·33	..	..		..	..	0·20	
.. 15 ..	0·39	..	..		..	..	0·11	
.. 16 ..	0·35	..	..		..	..	0·01	
.. 17 ..	0·38	..	..	0·285	..	..	0·15	
.. 18 ..	0·21	..	..		..	..	0·33	
.. 19 ..	0·17	..	..		..	..	0·15	
.. 20 ..	0·17	..	..		..	..	0·46	
.. 21 ..	0·15	9·818	..		..	..	0·01	
.. 22 ..	0·17	..	..		..	1·239	0·29	
.. 24 ..	0·13	..	..		..	..	0·08	
.. 26 ..	0·21	..	..		..	..	0·05	
.. 27 ..	0·22	..	..		..	..	0·02	
.. 28 ..	0·24	..	..		..	..	0·02	
.. 31 ..	0·26	9·605	0·430		..	..	0·05	
	..	..	1·637	0·285	0·782	2·953	4·64	
September 1 ..	0·27	..	..		..	..	..	
.. 5 ..	0·34	8·967	0·201		..	..	..	
.. 6 ..	0·13	..	..		..	..	..	
.. 7 ..	0·05	9·022	..		..	..	0·54	
.. 10 ..	0·09	..	..		..	1·035	..	
.. 12 ..	0·13	..	..	0·285	..	..	0·02	
.. 13 ..	0·16	..	..		..	..	0·02	
.. 25 ..	0·46	..	..		..	..	0·13	
.. 30 ..	0·58	7·950	1·302		..	..	0·05	
	..	..	2·243	0·285	1·985	1·035	0·74	
October 1 ..	0·60	7·881	0·069		..	..	..	
.. 2 ..	0·56	..	..		..	..	0·24	
.. 3 ..	0·56	..	..		..	..	0·39	
.. 4 ..	0·51	..	..		..	..	0·85	
.. 5 ..	0·12	..	..		..	..	0·05	
.. 6 ..	0·92	..	..		..	..	0·05	
.. 8 ..	0·82	10·703	..		..	..	0·05	
.. 9 ..	0·85	10·690	..		..	2·448	..	
.. 10 ..	0·23	12·992	0·079		..	..	0·10	
.. 11 ..	4·54	14·102	..		..	2·252	1·79	
.. 12 ..	4·33	..	..		..	2·141	1·89	
.. 13 ..	4·35	..	..	0·280	..	..	0·04	
.. 14 ..	4·13	..	..		..	..	0·19	
.. 15 ..	4·04	13·282	..		..	..	0·13	
.. 16 ..	3·43	..	..		..	2·179	0·07	
.. 17 ..	3·37	21·303	..		..	..	2·73	
.. 23 ..	3·60	20·253	1·050		..	3·021	0·07	
.. 30 ..	3·28	..	..		..	..	..	
.. 31 ..	3·23	21·634	..		..	..	0·27	
	..	..	1·129	0·280	0·215	13·102	11·88	

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Statement showing Particulars of Water-supply for the Year 1883—(*Continued*).

Date.	Gauge readings.	Contents, millions of cubic feet.	Volume expended.			Volume received, millions of cubic feet.	Rainfall, inches.	Remarks.
			Total, millions of cubic feet.	Used for troops, millions of cubic feet.	Lost, millions of cubic feet.			
November 1 ..	2·21	..	..		..	..	0·05	
.. 3 ..	2·17	..	..		..	..	0·85	
.. 4 ..	2·16	22·272	..		..	0·419	0·19	
.. 5 ..	2·16	..	..	0·281	..	..	0·07	
.. 7 ..	2·18	..	..		..	..	0·03	
.. 15 ..	2·33	..	..		..	..	0·05	
.. 19 ..	2·35	..	..		..	..	0·19	
.. 30 ..	2·53	20·570	1·703		..	..	..	
	..	..	1·703	0·281	1·422	0·419	1·43	
December 1 ..	2·35	..	..		..	..	..	
.. 4 ..	2·19	20·298	0·272		..	..	..	
.. 8 ..	2·31	23·441	..		..	3·143	..	From upper tank.
.. 13 ..	2·08	23·113	0·329		..	..	0·28	
.. 13 ..	2·03	..	..	0·272	..	..	0·20	
.. 14 ..	2·00	..	..		..	..	1·04	
.. 15 ..	2·05	..	..		..	..	0·21	
.. 18 ..	2·52	23·283	..		..	2·171	0·04	
.. 31 ..	2·70	24·147	1·136		..	..	..	
	..	..	1·737	0·272	1·464	5·314	1·87	

Summary.

January	2·62	24·810	3·045	0·264	2·784	0·000	0·00
February	..	..	3·133	0·244	2·891	0·000	0·00
March	..	..	3·768	0·289	3·479	0·000	0·07
April	..	..	2·794	0·323	2·471	0·192	1·876
May	..	..	2·927	0·303	2·224	0·000	0·02
June	..	..	1·124	0·296	0·828	2·048	4·87
July	..	..	1·637	0·285	0·782	2·931	4·64
August	..	..	2·243	0·258	1·985	1·095	0·74
September ..	..	..	1·198	0·280	0·918	14·102	11·88
October	..	..	1·703	0·281	1·422	0·419	1·43
November ..	..	..	1·737	0·273	1·464	5·314	1·87
December ..	2·70	24·147					
Difference ..	..	0·663	27·844	3·427	24·407	27·161	28·75

APPENDIX No. 15.

Halsur Tank.

SUMMARY of Particulars of Water-supply from 1880 to 1883 inclusive.

Years.	Gauge readings.	Contents, millions of cubic feet.	Volume expended. Total, millions of cubic feet.	Catchment-area, millions of cubic feet.	Lost, millions of cubic feet.	Volume required, millions of cubic feet.	Rainfall, inches.	Area of catchment basin, square miles.	Proportion of rain fall received.	Percentage of rain fall received.
1880	0·92	35·033								
	0·87	35·372	165·133	3·379	161·754	165·372	43·95	4·64	0·349	34·90
1881	0·69	35·172								
	2·04	34·715	29·532	9·300	20·532	29·832	29·28	Do.	0·027	2·70
1882	2·04	34·715								
	2·63	34·818	36·649	2·919	33·643	36·784	31·12	Do.	0·059	5·89
1883	2·62	34·819								
	2·76	34·147	27·944	3·437	24·497	27·131	28·75	Do.	0·067	6·70
	..	..	..	..	..	238·732	197·14	..	0·174	17·40
1880	..	..	..	..	..	..	Rainfall, Bowring Civil Hospital, inches.			
1881	..	..	..	..	..	..	31·69	..	0·297	29·72
1882	..	..	..	..	..	..	27·11	..	0·053	5·30
1883	..	..	..	..	..	..	27·92	..	0·067	6·72
	..	..	..	..	..	..	24·80	..	0·072	7·20
	..	..	..	..	..	238·732	150·85	..	0·146	14·60
Years 1881, 1882, and 1883, Halsur rock rain register	..	..	..	..	..	73·369	82·15	..	0·0713	7·13
Do. do. Bowring Civil Hospital rain register	..	..	..	..	..	Do.	99·25	..	0·0713	7·13

N.B.—A square mile = 3,097,600 square yards = 27·8784 millions of square feet; 4·64 square miles = 129·330 millions of square feet.

APPENDIX No. 16.

APPROXIMATE Abstract Estimate for diverting Drainage of Western Feeder from Halsur Tank.

Quantity.	Description.	Unit.	Rate.	Amount.	Work Totals.
		C. FT.	RS. A. P.	RS. A. P.	RS. A. P.
	Bund from culvert at south of western feeder to main bund of Halsur tank 10,95,446				
	Diverting drainage puddle wall 1,71,770				
789,195	Diverting drainage revetment 1,30,540				
	Diverting drainage gravel backing 63,360				
131,770	Puddle wall 3,56,370	1,000	3 7 6	3,736 0 0	
1,305·40	Revetment (formed of sized stones)	1,000	4 11 9	671 0 0	
639·60	Gravel backing	100	9 6 0	11,432 0 0	
	.. ..	100	2 0 0	1,279 0 0	18,039 0 0
	New Waste Weir—Crest, 93 feet.				
21·42	Concrete	100	12 9 0	265 0 2	
100·58	Rubble masonry	100	14 1 0	1,417 0 0	
24·44	Rough stone apron	100	9 9 0	232 0 0	
	Excavation and filling	100	.. ..	30 0 0	1,993 0 2
		..	.. ..		300 0 0
	Lowering old Waste Weir 4 feet.				
	Diverting North-west Drain into western feeder.				
42·126	Earthwork forming channel	1,000	2 14 3	122 0 0	
	A culvert under cross road	..	..	300 0 0	422 0 0
					18,754 0 0
	Contingencies	..	..	..	96 0 0
					18,850 0 0

N.B.—The rates were obtained from the office of the Executive Engineer, Presidency Division.

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ESTIMATE FORM.

ABSTRACT.

Quantity.	Description of Work.	Rate.	Per	Amount.	Total.
	Detailed Data for 100 Cubic Feet of concrete of the following proportions.	RS. A. P.	C. FT.	RS. A. P.	RS. A. P.
50	Broken stones, ½" to 1" cube	6 0 4	100	3 0 2	
8½	Screened and washed gravel	3 0 0	..	0 4 0	
16½	Slaked lime	0 4 3	C. FT.	4 6 10	
16½	Sookoo	0 1 9	..	1 13 2	
25	Sand	1 13 9	100	0 7 5	
4	Men coolies	0 3 0	Each.	0 12 0	
12	Women coolies	0 1 8	Do.	1 4 0	
	Contingencies	..	..	0 8 5	
	Total for 100 cubic feet ..	..	..	..	12 8 0
	Do. 1 cubic foot ..	..	..	..	0 2 0
	Grand Total of Estimate ..	..	..	..	..

NOTES.

REFERENCE TO MADRAS P.W.D. CODE.

PARAGRAPHS 1074, 1075, 1086, 1087, 1091 TO 1094, 1108, 1111 TO 1114, 1130 AND 1145 TO 1147.

1. Abstract of estimates should be prepared under such sub-heads as are to be separately shown in the accounts (register of works, work-vouchers, &c.) of the work. For repairs of buildings and roads, the classification of the budget estimate should be strictly followed, one estimate only being framed for each budget entry, and if a further estimate is required, it should be supplemental to the first; by this means, as the work abstracts follow the estimates, the register of works, the schedule of expenditure, and the books of the Central Office will show by one entry the entire outlay on repairs to each work for the whole year, which is not the case when several estimates are sanctioned for the repairs of one work in the course of the year.

2. Quantities are to be entered as so many units.

3. All rates are to be quoted in rupees, annas and pies.

4. Annas and pies are to be excluded from the abstract estimates, the cost of each item being brought to the nearest rupee. Totals of estimate need not be brought to round numbers.

SPECIFICATION for the Diversion of the Western Feeder of the Halsur Lower Tank.

1. A bund 2,460 feet in length, as shown on the survey, from which the table of waterspread and capacity was prepared, to be run from near the left wing of the 5 vent culvert at the lower end of the feeder, in a curve to near the point marked M, and thence nearly parallel to the road, at a minimum distance of 90 feet between the rear top edge of the bund and the top edge of the road, up to 50 from the site of the new weir whence the bund will curve to the eastward to connect with the weir wing.

Plan No. 11.

2. The ground to be cleared of all vegetation, and a trench 6 feet wide and 3 feet deep to be excavated and filled with puddle formed of well-tempered clayey soil taken from the bed of the tank before the formation of the bund is commenced.

3. The top width of the bund to be 8 feet, the interior slope 1½ to 1, and the exterior slope 2 to 1. The top of the bund will be 3½ feet above full tank level.

4. A puddle wall to be carried up simultaneously with the bund, and to terminate at 1½ feet below the top of the latter with a width of 2 feet. The faces to have a batter of 1 in 6.

5. The interior slope to be revetted to ½ a foot above full tank level with stones 1½ feet long laid at right angles to the slope on 1 foot of gravel backing. This height of revetment has been deemed sufficient because at the time of the year (March) when the easterly winds are strong, the water level will be from 3 to 3½ feet below the top of the revetment. The rear slope to be similarly revetted to the level 2,927·97. The revetments to be carried up simultaneously with the earthwork.

6. All earthwork to be well watered and rammed.

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7. The general arrangement of the channel between the bund and the road is shown on the section.

8. The present waste weir of the tank to be lowered 4 feet or to 2,925·97. This is supposed to be as low a level as can be secured without reconstructing the bridge, but it would be advantageous to lower it still further if found to be feasible.

9. A new waste weir with a crest 90 feet long and 1 foot above the present full tank level, Plan No. 12. *i.e.*, at 2,930·97 instead of 2,929·97, to be constructed a few feet from the present main bund in the line of the new bund, as shown on the survey.

It is calculated that the new weir will with a depth of 1½ feet passing over discharge 654 $D = 90 \times 3{\cdot}65 d\sqrt{d}$. cubic feet a second, whereas the present weir with a nominal length of 90 feet but actual only 76½ feet and with a wide irregular crest does not discharge more than 422 cubic feet. $D = 76\frac{1}{2} \times 3d\sqrt{d}$. Consequently maximum water level will not be more than 18 inches above the new crest level, and it probably will very rarely exceed 1 foot.

10. The drainage channel which now enters the tank at its north-west corner to be diverted along the west of the road forming the western boundary of the tank, and to be dropped into the channel now called the western feeder.

The diversion channel to be 4½ feet wide at bottom with side slopes of ½ to 1.

Its length will be 2,340 feet.

APPENDIX No. 17.

Approximate Estimate for constructing a Channel 5 Miles in length to bring into the Halsur Lower Tank the Drainage of 2·174 Square Miles to the Eastward.

Length.	Area of Cross Section.	Thousands of Cubic Feet.
5,280	48	253,440
5,280	$\frac{48+28}{2}$	200,640
5,280	$\frac{28+21}{2}$	129,360
5,280	$\frac{21+13}{2}$	89,760
5,280	$\frac{13+10}{2}$	60,720
		733,920

Quantities.	Description.	Unit.	Rate.	Amount.	Totals of Works.
			Rs. A. P.	Rs.	Rs.
733·920	Cutting channel and forming left bank ..	1,000 cubic feet ..	2 14 3	2,121	
	Rock cutting	Do. ..	..	309	
300	Waste weirs	Running foot ..	5 0 0	1,500	3,931
	Tail weir	..	..	334	1,500
	Culvert for cross road, Knorpett ..	..	..	200	334
	Do. for main road, Binnamangalam ..	..	..	302	
	Four other culverts for village tracks ..	..	120 0 0	480	
					982
	Contingencies ..	..	..	..	6,431
20	Compensation for land	Acres	50 0 0	..	20
					6,451
	Compensation for diversion of water ..	..	..	..	1,000
					6,451
					?

APPENDIX No. 17 A.

Approximate Estimate for constructing a Channel, 9½ Miles in length, to bring into the Halsur Lower Tank the Drainage of 3·10 Square Miles to the Eastward.

Length.	Area of Cross Section.	Thousands of Cubic Feet.
5,280	48	253·440
5,280	$\frac{48+40}{2}$	232·320
5,280	$\frac{40+36}{2}$	200·640
5,280	$\frac{36+30}{2}$	174·240
5,280	$\frac{30+26}{2}$	147·840
5,280	$\frac{26+22}{2}$	126·720
5,280	$\frac{22+18}{2}$	105·600
5,280	$\frac{18+14}{2}$	84·480
5,280	$\frac{14+10}{2}$	63·360
2,640	$\frac{10+8}{2}$	23·760
	Total ...	1,412·400

Quantities.	Description.	Unit.	Rate.	Amount.	Totals of Works.
			Rs. A. P.	Rs.	Rs.
1,412·400	Cutting channel and forming left bank ..	1,000 cubic feet ..	2 14 3	3,983	
	Rock cutting 6th and 7th mile	..	..	800	
	Rock cutting elsewhere	..	..	700	4,583
500	Waste weirs	Running foot ..	5 0 0	2,500	2,500
	Tail weir	..	..	330	330
	Culvert for cross road, Knorpett	..	..	225	
	Do. for main-road, Binnamangalam ..	..	..	335	
	Do. do. near 5th mile stone ..	..	..	220	
	Nine other culverts for village tracks ..	..	125 0 0	1,125	1,905
					9,318
	Contingencies	..	..	..	52
					9,370
35	Compensation for land	..	50 0 0	..	1,750
					11,120
	Compensation for diversion of water ..	..	..	..	?

APPENDIX No. 17 B.

DIMENSIONS, &c., of Channels for additional Catchment to eastward of Halsur Lower Tank.

(1) Channel for Catchment of 3·10 square miles.

Miles from Lower End.	Side Slopes.	Depth of Water.	Bottom Width.	Area of Waterway.	$\sqrt{R}$.	C. $\sqrt{RS}$.	$\sqrt{S}$. Feet per 1000.	Discharge. Cubic Feet per Second.	Area of Catchment approximate.	Discharge in Inches, deducting 10 per Day.
		ft.	ft.	sq. ft.					sq. mls.	
1	1 to 1	7·2	7·2	1·47	1·236	1·817	53·58	3·10		
2	do.	3	12	47·60	1·47	1·817	53·58	3·10	1	do.
3	do.	2½	11	30·62	1·34	1·817	53·58	3·10		
4	do.	2½	8	23·12	1·176	1·00	40·00	1·80		
5	do.	2½	8	23·12	1·159	1·159	46·36	2·32		
6	do.	2	8	20·32	1·125	1·106	44·24	2·14		
7	do.	2	8	19·00	1·30	1·074	42·96	2·04		
8	do.	2	6	14·00	1·18	1·074	42·96	2·04		
9	do.	1½	4½	11·06	1·10	1·043	41·72	1·94		
9½	do.	1½	4	9·53	1·04	0·999	39·96	1·78		
			3	5·62	0·91	0·857	34·28	1·42		

(2) Channel for Catchment of 2·174 square miles.

1	1 to 1	2½	12	1·37	1·180	1·817	53·68	3·10		
2	do.	2½	12	23·12	1·37	1·817	53·68	3·10	1	do.
3	do.	2	8	13·00	1·20	1·674	49·00	2·68		
4	do.	2	6	12·00	1·13	1·076	43·04	2·32		
5	do.	1½	4	7·12	0·98	0·915	36·60	1·76		

(3) Channel for Catchment of 1·07 square miles.

1	1 to 1	2½	12	1·37	1·180	1·817	53·68	3·10		
2	do.	2½	12	23·12	1·37	1·817	53·68	3·10	1	do.
3	do.	2	8	13·00	1·20	1·674	49·00	2·68		
4	do.	2	6	12·00	1·13	1·076	43·04	2·32		
5	do.	1½	4	7·12	0·98	0·915	36·60	1·76		

(4) Channel for Catchment of 0·217 square mile.

1	1 to 1	2½	12	1·37	1·180	1·817	53·68	3·10		
2	do.	2½	12	23·12	1·37	1·817	53·68	3·10	1	do.
3	do.	2	8	13·00	1·20	1·674	49·00	2·68		
4	do.	2	6	12·00	1·13	1·076	43·04	2·32		
5	do.	1½	4	7·12	0·98	0·915	36·60	1·76		

APPENDIX No. 17 C.

SPECIFICATION for Catchment Channels to bring in Drainage from the eastward to the Halsur Lower Tank.

The channels, whichever may be adopted, are intended to convey a quantity of water equal to 1 inch draining off the catchment in 24 hours; this is about the equivalent of a rainfall of 3 inches. Any supply in excess will be discharged towards by means of surplus weirs.

2. The surface fall throughout will be 2 feet a mile. The changes in depth, where such occur will be secured by raising the bed, or in other words increasing the bed-fall. Thus, in the 3rd mile, the bed-fall will be 2½ feet instead of 2 feet as in the 1st and 2nd miles.

3. The height of the banks above normal full supply level to be equal to the depth of water as a minimum.

4. The depth of water passing over the surplus weirs to be one-third of the depth of water (normal) in the channel as a maximum, the crests of the weirs being of course at normal full supply level.

5. Except in the part of the first mile, where the channel will run alongside a road, the alignment can be made so as to give approximately just about the quantity of cutting to make up the banks to the required section. Only one, the left bank will be required, and its top width may conveniently be made double the normal depth of water.

6. The estimated quantities of cutting and bank forming are necessarily approximations, as, until the channel is marked out and cross sections of the ground taken, the exact quantities cannot be determined. Generally the depth of cutting allowed is about 6 inches in excess of the depth of water.

7. Lump sums have been entered for rock cutting. There will be but little in the 5 miles channel; and only in the 6th mile and a short length of the 7th mile is much likely to be met with in constructing the 9½ miles channel, should that be selected for execution.

APPENDIX No. 18.

COMPARATIVE STATEMENT of Rainfall as gauged at the Halsur Rock and Bowring Civil Hospital.

Year.		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
		IN. C.	IN. C.	IN. C.	IN. C.	IN. C.	IN. C.	IN. C.	IN. C.	IN. C.	IN. C.	IN. C.	IN. C.	IN. C.
1880	Halsur Rock ...	0·62	...	0·44	1·50	8·16	3·11	5·49	9·125	2·62	10·21	2·69	0·02	43·985
	Bowring Civil Hospital.	0·670	...	0·410	2·160	9·350	3·905	6·680	11·740	2·780	10·950	2·840	0·210	51·695
1881	Halsur Rock ...	0·25	...	0·46	0·45	1·75	2·14	0·10	7·62	5·27	1·47	3·68	0·09	23·28
	Bowring Civil Hospital.	0·390	...	0·360	0 630	3·200	2·100	0·220	8·080	3·790	4·430	4·210	0·030	27·440
1882	Halsur Rock ...	0·51	...	...	0·42	4·04	1·82	4·15	5·02	2·75	3·57	8·85	...	31·13
	Bowring Civil Hospital.	0·680	...	...	0·530	4·410	1·690	5·600	5·720	4·050	4·475	9·870	...	37·025
1883	Halsur Rock ...	...	...	0·07	0·76	1·875	0·62	4·87	4·64	0·74	11·78	1·43	...	28·75
	Bowring Civil Hospital.	...	...	0·050	0·720	1·810	0·800	5·280	7·660	1·050	12·560	2·860	2·01	34·80

APPENDIX No. 19.

Comparison by Months of Rainfall as registered at the Halsur Rock and Bowring Civil Hospital.

Months.	Years.	Rainfall.		Difference.	Percentage.
		Halsur Rock.	Bowring Civil Hospital.		
		INCHES.	INCHES.	INCHES.	
January	1880 ...	...	...	...	...
Do.	1881 ...	0·62	0·67	+ 0·05	+ 8·06
Do.	1882 ...	0·25	0·39	+ 0·14	+ 56·00
Do.	1883 ...	0·51	0·68	+ 0·17	+ 33·33
		1·38	1·74	+ 0·36	+ 26·09
March ...	1880 ...	...	...	...	...
Do.	1881 ...	0·44	0·41	— 0·03	— 6·82
Do.	1882 ...	0·46	0·36	— 0·10	— 21·74
Do.	1883 ...	...	...	...	...
		0·07	0·05	— 0·02	— 28·57
		0·97	0·82	— 0·15	— 15·46
April ...	1880 ...	...	...	...	...
Do.	1881 ...	1·50	2·16	+ 0·66	+ 44·00
Do.	1882 ...	0·45	0·63	+ 0·18	+ 40·00
	1883 ...	0·42	0·53	+ 0·11	+ 26·19
		0·76	0·72	— 0·04	— 5·26
		3·13	4·04	+ 0·91	+ 29·07
May ...	1880 ...	...	...	...	...
Do.	1881 ...	8·16	9·35	+ 1·19	+ 14·58
Do.	1882 ...	1·75	3·20	+ 1·45	+ 82·85
Do.	1883 ...	4·04	4·41	+ 0·37	+ 9·15
		1·87	1·81	— 0·06	— 3·46
		15·82	18·77	+ 2·95	+ 18·65
June ...	1880 ...	...	...	...	...
Do.	1881 ...	3·11	3·90	+ 0·79	+ 25·56
Do.	1882 ...	2·14	2·10	— 0·04	— 1·87
	1883 ...	1·82	1·69	— 0·13	— 7·14
		0·62	0·80	+ 0·18	+ 29·03
		7·69	8·49	+ 0·80	+ 10·40
July ...	1880 ...	...	...	...	...
Do.	1881 ...	5·49	6·68	+ 1·19	+ 21·67
Do.	1882 ...	0·10	0·22	+ 0·12	+ 120·00
Do.	1883 ...	4·15	5·60	+ 1·45	+ 34·94
		4·87	5·28	+ 0·41	+ 8·42
		14·61	17·78	+ 3·17	+ 21·69
August	1880 ...	...	...	...	...
Do.	1881 ...	9·13	11·74	+ 2·62	+ 27·56
Do.	1882 ...	7·02	8·06	+ 0·46	+ 6·04
	1883 ...	5·03	5·72	+ 0·70	+ 13·94
		4·94	7·66	+ 2·72	+ 65·09
		26·40	33·20	+ 6·80	+ 25·76
September	1880 ...	...	...	...	...
Do.	1881 ...	2·62	2·78	+ 0·16	+ 6·10
Do.	1882 ...	5·27	3·79	— 1·48	— 28·08
	1883 ...	2·75	4·03	+ 1·28	+ 47·27
		0·74	1·05	+ 0·31	+ 41·89
		11·38	11·67	+ 0·29	+ 2·55

Comparison by Months of Rainfall as registered at the Halsur Rock and Bowring Civil Hospital—(*Continued*).

Months.	Years.	Rainfall.		Difference.	Percentage.
		Halsur Rock.	Bowring Civil Hospital.		
		INCHES.	INCHES.	INCHES.	
October ...	1880 ...	10·21	10·95	+ 0·74	+ 7·24
Do. ...	1881 ...	1·47	4·43	+ 2·96	+ 201·36
Do. ...	1882 ...	3·57	4·47	+ 0·90	+ 25·35
Do. ...	1883 ...	11·88	12·56	+ 0·68	+ 5·72
		27·13	32·41	+ 5·28	+ 19·46
November ...	1880 ...	2·69	2·84	+ 0·15	+ 5·57
Do. ...	1881 ...	3·68	4·21	+ 0·53	+ 14·40
Do. ...	1882 ...	8·85	9·87	+ 1·02	+ 11·53
Do. ...	1883 ...	1·43	2·86	+ 1·43	+ 100·00
		16·65	19·78	+ 3·13	+ 18·80
December ...	1880 ...	0·02	0·21	+ 0·19	+ 950·00
Do. ...	1881 ...	0·09	0·03	— 0·06	— 66·66
Do. ...	1882 ...	...	...	...	...
Do. ...	1883 ...	1·87	2·61	+ 0·74	+ 39·57
		1·98	2·85	+ 0·87	+ 43·94
		Summary.			
		43·98	51·69	+ 7·71	+ 17·53
	1880 ...	23·28	27·44	+ 4·16	+ 17·87
	1881 ...	31·13	37·02	+ 5·89	+ 18·98
	1882 ...	28·75	34·80	+ 6·05	+ 21·04
	1883 ...	127·14	150·95	+ 23·19	+ 18·24

Halsur Rock Rain Register, Monthly Fall and Number of Rainy Days.

Year.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Annual.		Remarks.
	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	
1873	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
1874	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
1875	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
1876	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
1877	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
1878	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
1879	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
1880	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
1881	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
1882	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
1883	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Mean ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	

N.B.—The rain-gauge is at the top of the Rock, and the record is on the seventh floor below it.
The Bowring Civil Hospital stood 1 mile distant.

(Signed) J. SMITH, C.E.,
Chief Engineer on Special Duty.

(Signed) J. SMITH,
Engineer in charge, Halsur Water Works.

Bangalore,
2nd January 1884.

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Register of the Rainfall gauged daily at 7 A.M., at the Halsur Rock for the Month of December 1883.

Month and Date.	Rainfall.		Remarks.
	Inches.	Cents.	
1st December 1883.	..	..	Rainfall to the end of December 1882 for the following years:—
2nd	..	..	
3rd	..	..	
4th	..	..	
5th	..	..	
6th	..	..	
7th	..	..	
8th	..	..	
9th	..	..	
10th	..	..	
11th	..	..	
12th	..	280	
13th	..	300	
14th	1	040	
15th	..	210	
16th	..	040	
17th	..	..	
18th	..	..	
19th	..	..	
20th	..	..	
21st	..	..	
22nd	..	..	
23rd	..	..	
24th	..	..	
25th	..	..	
26th	..	..	
27th	..	..	
28th	..	..	
29th	..	..	
30th	..	..	
31st	..	..	
Total ..	1	870	

Years.	Inches.	Cents.
1873	21	090
1874	45	005
1875	18	425
1876	17	175
1877	50	705
1878	34	055
1879	33	480
1880	43	055
1881	23	280
1882	31	130
1883	28	855

Bangalore,
2nd January 1884.

(Signed) J. SMITH,
Engineer in Charge, Halsur Water Works.

Halsur Rock Rain Register, Monthly Fall and Number of Rainy Days.

Year.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Annual.		Remarks.
	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	
1873	:	:	:	:	:	:	1·12	2	2·68	5	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	21·090	77	
1874	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	45·604	143	
1875	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	18·425	77	
1876	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	17·175	77	
1877	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	30·705	143	
1878	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	34·085	143	
1879	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	33·480	143	
1880	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	43·985	143	
1881	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	23·280	143	
1882	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	21·130	143	
1883	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	28·658	143	
Mean	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	3·12	11	30·000	110	

N.B.—The rain-gauge is at the top of the Rock, and the record is on the average about 1½ per cent. below that given by the gauge at the Bowring Civil Hospital, about 1 mile distant.

(Signed) J. SMITH,
Engineer in charge, Halsur Water Works.

Bangalore,
2nd January 1884.

1473

Register of the Rainfall gauged daily at 7 A.M., at the Halsur Rock for the Month of December 1883.

Month and Date.	Rainfall. Inches.	Rainfall. Cents.	Remarks.
1st December 1883.	..	..	Rainfall to the end of December 1882 for the following years:—
2nd " "	..	..	
3rd " "	..	..	
4th " "	..	..	
5th " "	..	..	
6th " "	..	..	
7th " "	..	..	
8th " "	..	..	
9th " "	..	..	
10th " "	..	..	
11th " "	..	..	
12th " "	..	·250	
13th " "	..	·300	
14th " "	1	·040	
15th " "	..	·210	
16th " "	..	..	
17th " "	..	..	
18th " "	..	..	
19th " "	..	..	
20th " "	..	..	
21st " "	..	..	
22nd " "	..	..	
23rd " "	..	..	
24th " "	..	..	
25th " "	..	..	
26th " "	..	..	
27th " "	..	..	
28th " "	..	..	
29th " "	..	..	
30th " "	..	..	
31st " "	..	..	
Total ..	1	·470	

Years.	Inches.	Cents.
1873	21	·090
1874	45	·604
1875	18	·425
1876	17	·175
1877	30	·705
1878	34	·085
1879	33	·480
1880	43	·985
1881	23	·280
1882	21	·130
1883	28	·658

Bangalore,
2nd January 1884.

(Signed) J. SMITH,
Engineer in Charge, Halsur Water Works.

APPENDIX No. 20.

Waste Weir.

LEVEL of Water below the Koday on the undermentioned dates.

Years.	31st January.	28th February.	31st March.	30th April.	31st May.	30th June.	31st July.	31st August.	30th September.	31st October.	30th November.	31st December.
	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.	FT. IN.
1873	0 11	1 5	2 2½	2 4	3 2½	3 5½	3 11	2 9	2 5	*	0 5½	1 2
1874	1 8½	2 3½	3 1½	3 9½	*	0 1½	*	*	*	*	*	0 6½
1875	1 1½	1 7½	2 0	2 7	2 7½	2 9½	2 11½	2 11½	3 2½	3 4½	3 10½	4 5
1876	4 11½	5 7	6 2½	6 10½	5 8	6 0	6 4½	6 6½	6 8½	6 9½	7 4	8 0
1877	8 10½	†	†	9 7½	9 6½	9 3½	10 1	9 8½	3 5½	1 1½	0 7½	1 1
1878	1 9	2 6½	3 5	3 0	3 0	3 3	2 4	*	*	0 ½	0 6½	1 1½
1879	1 2½	1 ½	0 8½	1 7½	1 5	1 5½	0 5	0 7½	0 5	*	0 3½	0 6
1880	1 1½	2½	2 0	2 5	1 3	1 2½	0 10½	*	0 2½	*	*	0 5½
1881	1 ½	1 5½	1 6½	2 4½	2 8½	2 10	3 0	2 7	2 3½	2 6	2 6	2 7½
1882	3 3½	4 0	4 11	5 10	5 11½	6 3	6 3	5 10½	6 0	4 5	2 2½	2 7½
1883	3 3½	3 11½	4 10	5 8	6 4½	7 1½	6 9½	6 3½	6 7	3 3	3 6½	2 9½
1884	...	...	...	...	...	...	...	...	...	...	...	...
1885	...	...	...	...	...	...	...	...	...	...	...	...

* Overflowing.

† Dried up.

APPENDIX No. 21.

STATEMENT showing the Quantity of Water pumped into Barracks from 1st January 1880 to 31st December 1883.

Months.	1880.		1881.		1882.		1883.		Remarks.
	Gallons.	Cubic Feet.	Gallons.	Cubic Feet.	Gallons.	Cubic Feet.	Gallons.	Cubic Feet.	
January	1,546,155	247,385	2,050,768	328,123	1,287,619	206,018	1,681,825	269,164	
February	1,768,848	283,016	1,909,111	305,454	1,560,997	249,760	1,525,511	244,097	
March	2,073,318	331,571	1,933,897	309,424	1,672,599	267,616	1,806,906	289,105	
April	2,103,776	336,604	1,573,369	251,739	1,728,029	276,485	2,129,982	340,797	
May	1,746,597	279,456	1,824,984	291,997	1,677,919	268,466	2,019,481	323,113	
June	1,585,168	253,627	1,687,072	269,932	1,525,481	292,077	1,896,280	303,405	
July	1,699,338	271,893	1,727,428	276,388	1,503,986	240,638	1,849,756	295,961	
August	1,689,605	302,337	1,651,321	264,211	1,548,497	247,756	1,779,623	284,740	
September	1,709,843	273,575	1,885,543	301,687	1,591,941	254,711	1,613,033	258,085	
October	1,531,657	245,065	1,575,696	252,111	1,641,803	262,688	1,751,046	280,167	
November	1,756,350	281,016	1,388,406	222,145	1,442,475	230,796	1,780,573	284,892	
December	1,704,696	272,751	1,426,109	228,175	1,567,219	250,755	1,704,318	272,691	
Total ..	21,114,354	3,378,301	20,633,695	3,301,391	19,048,547	3,047,786	21,507,633	3,441,217	

SUMMARY.

Years.	Millions of Cubic Feet.
1880	3·378
1881	3·301
1882	3·048
1883	3·441
Total ..	13·168
Average ..	3·292

Greatest monthly quantity, April 1883 .. .. 0·341 mls.

Greatest hourly quantity .. 2,960

Average hourly quantity .. 2,249

APPENDIX No. 22.

Register of Pumping Operations at No. 2 Well on right bank of Water-course, 760 yards south of South Station Hospital.

Date.	Pumping.						Times and Water-levels.			Revolutions of Fly Wheel.			Remarks.
	Time of Starting.		Time of Stopping.		Water-levels.		Times.		Water-levels.	Number per Minute.	Time at which taken.		
	Hours.	Minutes.	Hours.	Minutes.	Feet.	Inches.	Hours.	Minutes.	Feet.		Hours.	Minutes.	
1884.													
	11	50	..	..	5	4½	14	55	9·50	} 90	14	55	40 lb. steam.
17th March ..	..	..	..	..	..	..	14	57	7·83		14	56	
	..	..	..	..	..	..	15	1	8·50	} 72	15	2	25 lb. ,,
	..	..	..	..	..	..	15	4	9·83		15	3	
	..	..	..	..	..	..	14	7½	10·66	} 73	15	8	
	15	30	15	16½	13	..	15	11	11·66		15	9	
	11	7	15	22	13	6	15	14½	12·66	..	..	..	
	..	..	..	..	11	4	15	22	13·99	..	..	..	40 lb. ,,
18th ,, ..	..	..	..	..	..	..	11	9	12·00	..	..	..	
	..	..	..	..	..	..	11	13	13·00	..	..	..	
	..	..	..	..	..	..	11	16	14·00	..	..	..	
	..	..	..	..	..	..	11	19	15·00	..	..	..	
	..	..	..	..	..	..	11	23	16·00	} 94	11	19	
	..	..	11	30	17	10	11	27	17·00	} 92	11	27	
19th ,, ..	..	..	..	..	..	..	11	30	17·83		11	28	
	..	..	..	..	..	..	17	32	17·10	..	..	..	
20th ,, ..	..	..	..	..	..	..	6	25	15·75	..	..	..	
	..	..	..	..	..	..	10	30	15·08	..	..	..	
21st ,, ..	..	..	..	..	..	..	6	..	13·92	..	..	..	
24th ,, ..	..	..	..	..	..	..	10	30	13·08	..	..	..	
	..	..	..	..	..	..	6	..	12·17	..	..	..	
	..	..	..	..	..	..	6	..	9·34	..	..	..	

Diameter of well 9·00 from B.M. at top to 7·50 — 11·50 Area, Square Feet 161·87.
Do. 7·50 do. to 14·00 — 10·50 do. do. 86·39.
Do. 14·00 do. to 26·00 — 9·25 do. do. 67·19.

Summary of Results.—Engine 6-horse power, nominal, Clayton and Shuttleworth, Lincoln, No. 21199. Pump 4-inch centrifugal, Tangye Brothers and Holman. Suction and delivery pipes both 4 inches. Height from B mark to centre of delivery pipe 3·25 feet.

1st pumping.—First 7 minutes 211·89 c. ft. raised on the average 6·50 + 3·25 = 9·75 ft.
Afterwards.— 21½ do. 519·54 do. raised do. 10·50 + 3·25 = 13·75 ,,
2nd pumping.—First 9 do. 231·19 do. raised do. 12·66 + 3·25 = 15·91 ,,
Afterwards.— 14 do. 257·34 do. raised do. 15·92 + 3·25 = 19·17 ,,

$\frac{211·89}{7} = 30·27 \times 9·75 \times 62 = 18,298$ foot pounds per minute = 0·55 horse-power nominal.

$\frac{519·54}{21\frac{1}{2}} = 24·16 \times 13·75 \times 62 = 20,596$ do. do. = 0·62 do.

$\frac{231·19}{9} = 25·69 \times 15·91 \times 62 = 25,341$ do. do. = 0·77 do.

$\frac{257·34}{14} = 18·38 \times 19·17 \times 62 = 21,845$ do. do. = 0·66 do.

98·50	..	86,080	2·69
24·62	14·10	21,520	0·65
equivalent to	13·88	25·00	
do. to gallons	86·77	do.	

Messrs. J. and H. Gwynne put the duty of their centrifugal pumps of the same size at 250 gallons raised 25 feet with an expenditure of 25 × ·078 = 1·95-horse power. The duty was in

this case, about one-third of this standard, the chief cause being that the pump was too small for the engine; a 7-inch c. pump would have been more suitable.

Inflow between the two days' pumping = Rise 2·17 feet × 86·59 = 187·90 cubic feet.
Time 19·75 hours, or per hour .. .. = 9·51 ,,
Inflow after second day's pumping .. = Rise 3·83 ,, × 67·19 = 257·34 ,,
do. 1·83 ,, × 86·59 = 158·46 ,,
415·80
Time 66·50 hours, or per hour .. .. = 6·25 ,,
Equivalent to 39·06 gallons per hour
Average inflow in 138¼ hours, per hour .. .. = 5·37 ,,

APPENDIX No. 23.

Specification and Approximate Estimate for the Supply of the European Cavalry Regiment two Batteries of Field Artillery, and the South Station Hospital with Water for Drinking and Cooking from Wells in the Small Valley to the south of the Hospital.

1. *Wells.*—The wells to be seven in number and 20 feet in diameter.

The sump well to be in the centre and to be placed at or close to the present well No. 2, with its bottom at 2886·00.

Vide plan 12.

The remaining six wells to be arranged as a hexagon, at a distance of 500 feet from the sump well, centre to centre, and consequently 500 feet apart. Their bottoms to be at 2888·00. It is estimated that these wells will collect the water from 72 acres, or from a circle with a radius of 1,000 feet. The six wells to be connected with the sump well by 6-inch cast iron pipes laid with their ends at the external wells at 2890·00 and at the sump well at 2888·00. All the wells to be steined with stone in mortar from 1 foot above ground level to 5 feet below that level, and below this with dry stone. The space at the back of the masonry steining be filled in with red soil, like that used for compound walls, well puddled and carefully trodden in, so as to prevent any surface drainage getting into the wells.

The steining from the level 2902·00 or 10 feet below the top to be stepped in 4 inches for each course (of 8 inches) so as to reduce the top diameter of the wells to 10 feet, a width convenient for beam-stones.

The platform of the sump well to be at 2912·00, the beam-stones for the pump at 2909·33, and the rose of the suction pipe at 2890·00, the lowest level to which the water is to be drawn off being 2891·00, or 18·33 feet below the valve of the pump.

2. The water-supply required being taken at 400 gallons per hour, or 9,600 gallons a day, and the pumping time at ten hours, the pump should be capable of raising 960 gallons an hour. J. Taylor and Sons' treble barrel 3½-inch pumps with frame, Fig. $\frac{204}{2}$, price £31, are estimated to raise 940 gallons an hour to a height of 100 feet with four men.

The greatest lift required is from 2891·00 to about 2988·00 * or 97 feet.

* Floor of cistern of female hospital 2984·75.

Two sets of coolies, or eight men, taking turn and turn would be needed. The cost of this arrangement including suction pipe and fixing, freight and carriage may be taken to be Rs. 600. With bullock gear treble 5-inch pumps would be better, and the cost would be about Rs. 1,200. This latter will be entered in the estimate, as the work would be hard for coolies.

3. For laying the pipes connecting the outer wells with the sump well, a deep trench, 3 feet wide, will have to be cut and properly shored. The quantity of soil to be removed will be 6 × 500 × 3 × 23 = 207,000 cubic feet, costing about 1,500 rupees. The rest of the item of 3,000 rupees allowed is for planks and bars for shoring.

4. Pumping will be necessary in connection with the well sinking and the laying of the connecting pipes, and as it is difficult to estimate the time required, Rs. 3,000 will be allowed.

Approximate Estimate—

		Rs.
7 wells at Rs. 650		= 4,550
6 × 510 = 3,060 feet of 6-inch C. I. pipes, ⅝ inch, metal, at 23·4 lb. per foot, 71,604 lb. or	32 tons.	
4,500 feet of 3-inch C. I. pipe, ⅝ inch, at 12·4 lb. per foot, 55,800 lb. or	24 tons.	
1,000 feet of 2-inch C. I. pipe, ⅝ inch, at 8·7 lb. per foot 8,700 lb. or	4 tons	
	60 tons.	

							Rs.
60 tons of C. I. pipe, at Rs. 95	..	..	..	..	..	=	5,700
2,000 feet of 1¼-inch wrought iron pipe, at Rs. 0-8-4	..	..	..	..	..	=	1,063
Laying 1,060 yards of 6-inch pipe, at Rs. 0-10-0	..	637-8-0					
Do. 1,500 yards of 3-inch pipe, at Rs. 0-7-6	..	703-2-0					
Do. 1,000 yards of 2-inch pipe, at Rs. 0-4-0	..	250-0-0					
							1,591
Pump with gear							1,200
Trench for connecting pipes							3,000
Unwatering during construction							3,000
Taps and fittings							2,000
Contingencies							1,526
					Total	..	24,000

APPENDIX No. 24.

SPECIFICATION and Approximate Estimates for the Supply of the Troops from Agaram Tank.

1. *Data for Supply.*—The ordinary supply, on the average of four years, has been 56,376 gallons per day, the greatest 71,040 gallons. It is probable that 60,000 gallons would be sufficient, which are equivalent to 9,600 cubic feet, but to allow of a possible extension of the distribution, it is proposed to provide for a maximum quantity of 14,400 cubic feet a day.

It is desirable that this supply should be capable of delivery into the cisterns in 8 hours and the quantity per minute will then be 30 cubic feet.

The Agaram tank is about 3 miles from the old Race Course Barracks and nearly 4½ miles from the cistern which supplies the European Infantry Barracks.

This latter cistern is also at the highest level of the Agaram tank is 2873·35.

The present full tank level at which water has to be delivered, viz., 2039·62.

To obtain the required head for discharge through the pipes, the water must be lifted or forced over a stand pipe, the head (centre) of which is intended to be at 3015·00.

2. There are two alternative ways of obtaining water from the Agaram tank:—

(i) from a supply well sunk in the bed of the tank, in which case clear water would be obtained and artificial filters would not be needed;

(ii) from the tank direct, and in that case filtration prior to pumping would be requisite.

It would for this arrangement be necessary also to increase the capacity of the tank.

It is doubtful whether the quality of the water would not suffer from filtration through the soil into a supply well sunk in the tank bed, seeing that water taken from wells, not many yards from and above the tank, has been found to be inferior to that of the tank itself, though it remains to be determined whether a well sunk in the tank, or perhaps below the tank, would give similar results.

The maximum height to which water would have to be raised under this arrangement would be 161 feet.

With the alternative arrangement the maximum height is estimated at 151 feet.

3. *Engines and Pumps.*—The quantity of water being 30 cubic feet a minute, and the maximum lift 161 feet, the nominal engine horse power required is $\frac{30 \times 62 \times 161}{33,000}$ = just over 9-horse power.

It is intended therefore to provide two engines each of 12-horse power nominal, and these should be of the compound condensing type; there should be 3 boilers, each capable of supplying, with wood fuel, full steam to one engine. The three boilers to be fixed side by side and to be connected by means of the usual steam domes and pipes with valves, so that any one or two adjacent boilers may be used at a time.

Fuel being dear, the present price being Rs. 8·34 per ton equivalent to Rs. 33·36 a ton for coal, it is essential that, in designing the engines and boilers, economy of consumption should be specially studied.

Pumps.—These should be of the ordinary plunger kind, and there should be 4 set for each engine. Each set to consist of 3 barrels about 8 inches in diameter and from 20 to 24 inches stroke. The delivery with the former stroke would require 17·20 strokes a minute nearly, and with the latter 14·35 strokes a minute.

The other requirements will be noticed in connection with the alternative arrangements.

An air vessel of ample capacity to be provided to equalize the pressure and flow. The amount entered for engines and pumps is based on the cost of the machinery at Dhobies' wells, which is said to have been £1,135 in England.

4. *Stand-pipes.*—These to be three in number, and with 10 inches internal diameter, one up pipe and one down pipe connected by a bend at the top, and one waste pipe connected with a vertical pipe from the summit of the bend; such connection to be at 4 feet above the centre of the bend and 4 feet below the open top of the pipe. *Vide* plan 14.

The length of the pipes above the masonry platform will differ by about 7 feet in the two arrangements for the supply, but in either case the pipes are intended to be set up with a batter of 1 in 12, and to be strutted and braced at intervals of 2, or at most 3, lengths of pipe, *i.e.*, probably at every 18 or 27 feet, so as to make the whole structure quite rigid and able to withstand the severe gales at times experienced.

The pipes should rest on a base plate of suitable form, and they, as well as the connecting pipes below, should be securely bolted thereto.

The metal is supposed to be ⅝ inch thick, and a special rate is allowed to cover the subsidiary parts.

490 × 79 = 38,710 lbs. .. .. = 18 tons.
6 sets of struts and braces.

							Rs.
Bed plates—							
18 tons at Rs. 120	..	..	..	..	..	..	= 2,160
Erecting	..	..	..	..	..	..	340
					Total	..	2,500
Masonry foundation if water drawn from tank direct					..	..	1,430
Do. do. if drawn from supply well in tank					..	..	1,000

5. *Delivery Mains.*—The main from the foot of the stand-pipe to a short distance from the Race Course cistern, Cavalry Barracks, a distance of about 18,000 feet, will be of 10 inches diameter and ⅝ of an inch thick.

Flanged pipes are provided for. The working head, exclusive of the margin for bends, which will however be very slight, is arranged to give a gradient of 0·60 of a foot in a thousand feet.

By Nevilles' formula—

$$V = 140\sqrt{r.s} - 11\sqrt[3]{r.s.}$$

$$R = \frac{10}{4 \times 12} = \cdot2083 \qquad S = \cdot0006$$

$$\therefore V = 140 \times \cdot01118 - 11 \times \cdot05 = 1\cdot56 - \cdot55 = 1\cdot01$$

A = ·5454 and D = ·55 cubic feet a second = 33 cubic feet a minute.

By Jackson's Tables the discharge would be 29·64 cubic feet a minute.

The proportional discharge into the Race Course cistern will be 18·60 cubic feet a minute, and the gradient to this cistern being high, viz., 1·94 feet in a thousand, a 7-inch pipe will be ample.

The length of this branch will be about 500 feet.

The discharge of the other branch will, for 1,500 feet to the head of the Horse Artillery cistern branch pipe, be 11·40 cubic feet a minute; and for the rest of the distance, about 5,000 feet, to the E.I.B. cistern, 9 cubic feet a minute. Its length will be about 1,200 feet—the R.H.A. pipe 3 inches will be a suitable diameter.

18,000 feet 10-inch pipe, ⅝ inch thick, × 79 = 1,422,000 lb. = 635 tons.
7,000 feet of 7-inch pipe ⅝ inch thick × 46·7 = 326,900 lb. = 146 „
1,200 feet of 3-inch pipe, ⅜ inch thick × 12·4 = 14,880 lb. = 6½ „

							Rs.
							94,500
787½ tons of C. I. Pipe, at Rs. 120	..	..	..	..	..	..	6,750
Laying 6,000 yards, at „ 1-2-0	..	..	..	..	..	..	1,452
„ 2,333 yards, at „ 0-10-0	..	..	..	..	..	..	5,298
Contingencies							
							1,18,000

6. The cisterns and subsidiary distribution are intended to be left as at present.

7. *Arrangements at Agaram Tank and Pumping Station.*—First—With a supply well in or below the tank. In this case the only special works required would be a well in the bed of the tank at the deepest part of the small bay near the waste weir bridge, and a pipe therefrom to the engine at the pumping station.

The well would be 20 feet in diameter at top with its bottom at 2850·00, and its top a
2880·00, the excavated soil being arranged round that part of the steining which would be above
tank bed level, so as to prevent any surface water passing into the well. The steining to be
constructed in masonry down to 5 feet below
bed or ground level, * and below that in dry
stone.

* About 2868·43.

The steining above bed level may be arched as shown in the section, or it may be stepped
in 6 inches for each course, and then covered in
at top with slab stones.

Plan No. 14.

The well will be 20 feet in diameter for 8 feet below bed level, 27 feet for the next 7 feet,
and 24 feet for the last 7 feet. The contents of the well, from estimated L.W.L. 2855·63 to bed
level, are 7485·64 cubic feet, or rather more than half the supply required in the 24 hours.
The calculated required inflow of water is $\frac{14,400 - 7,485}{8 \text{ hours}} = 864\frac{1}{2}$ c.ft. per hour.

The surface for inflow is—

1st. The area of the bottom of the well	452·39 sqr. ft.	
2nd. The sides, where lined with dry stone, 1404·39 square feet which may be taken as ½ unobstructed	175·54	
	627·93	

so that 1·4 cubic foot per square foot per hour will be needed.

The probable cost of the well will be 9·309 earth-work, at Rs. 15-10-0 per 1,000 cubic feet 148
17·82 dry stone steining at Rs. 12-8-0 per 100 cubic feet .. 223
17·17 steining stone in mortar, at Rs. 18-12-0 322
Slab stones 50
Sundries 57
Contingencies 780
120
Total .. 900

Suction pipe, 12 inches diameter, ¾ inch thick, about 500 feet.

	Rs.
500 × 93·7 = 46,850 lbs. = say 21 tons of C. I. Pipe at Rs. 95 per ton =	1,995
Laying 167 yards at Rs. 1-4-0 per yard .. .. =	210
Trench to pumping station, for laying pipe, average depth about 12 feet, 500 × 4 × 12 = 24,000 cubic feet, at Rs. 10 per thousand	240
Sundries	125
Total ..	2,570

The suction pipe would have a connection, with a suitable valve, with each set of pumps
Secondly—If water be drawn off direct from the tank. The special works are—
(1) A suction pipe from the tank to the pumps;
(2) A pair of filters with a pure water well attached and a suction pipe therefrom to the pumps;
(3) An increase to the capacity of the tank;
(1) The suction pipe, which would be connected with each set of pumps to be 12 inches in diameter, and to be run out into the deep part of the tank, so as to be able to draw off water to about the 2866·63 level, or 6·72 feet below present full tank level. The length will be about 960 feet.

	Rs.
960 feet × 93·7 = 89,952 lb. = 40 tons.	
40 tons C. I. pipe at 95 .. .. =	3,800
Laying 320 yards at Rs. 1-4-0 .. .. =	400
Trench for pipe, average depth 6 feet, 960 × 4 × 6 = 23,040 cubic feet at Rs. 7 per thousand .. .. =	161
Sundries .. .. =	239
	4,600

Another suction pipe will be required from the pure water well: it will be 10 inches in
diameter, 150 × 79 = 11,850 lb. = 5 tons.

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	Rs.
5 tons of C. I pipe at Rs. 95 .. .. =	475
Laying 50 yards at Rs. 1-2-0 per yard .. .. =	56
Sundries .. .. =	29
	560

(2) The quantity of water to be filtered being 30 cubic feet a minute, or 1,800 cubic feet an hour, and the usual allowance being 2 square feet of filter bed for every cubic foot per hour, 3,600 square feet will be the area of each filter, or say 90 by 40 feet. The filters will be placed side by side, with a pure water well in connection with both. Depth of filters 10 feet and of well 13 feet; diameter of well 15 feet. Probable cost of the whole Rs. 15,000.

(3) The present capacity of the tank above the sill of the lowest sluice is 24·068 millions of cubic feet. It is proposed to raise the full tank level 3 feet, which will increase the capacity by 20·601 millions, or to 44·669 millions of cubic feet altogether. The present height of the bund varies considerably. There is only one waste weir, 119 feet in length, of which about 115 feet are effective, and this is not sufficient for the area of the catchment basin, 32·10 square miles. There was formerly a bywash at the other (east) end of the tank, but this was closed some time ago. The lowest estimate of the maximum discharge would be 2,646 cubic feet a second, viz.:—

$D = 350 \sqrt[3]{32^2} = 3{,}528$ cubic feet a second, with the time extended one-third by the action of the upper tanks.

The difference between full tank level and M. W. L. should be limited to 3 feet and the proper length of weir will then be 157 feet, say 160 feet, or 45 feet additional are required.

The revetment being out of section from settlements, will be rebuilt with a gravel and small stone backing, and the addition to the bund will be made, as is always desirable, on the inside, so far as may be practicable with due regard to securing a good alignment for the road.

The top of the bund will be 6·28 feet above full tank level, and the clear width of roadway 15 feet; a width of 18 feet has been allowed at road level, so as to admit of side ridging, which adds to the security of the traffic and tends to maintain the edges of the bank in good order.

There being a great length of bund at the east end with but very little water-spread, it will be cheaper and better to make a cross bund to the high ground immediately west of the village of Agara, and the connection of this bund with the main bund will be at about 2,920 feet on the longitudinal section, the zero of which is at the 7th furlong of the 6th mile. For this new bund a top width of 6 feet and slopes of 1½ to 1 inside and 2 to 1 outside have been allowed, and revetment 1½ feet thick up to 2 feet below the top, which is the height to which the revetment generally will be carried up.

The new weir will be built towards the south end of this cross bund. The estimate for it has been made out on the supposition that the crest will be at 3 feet above ground level, but it is probable that a good site may be found on a higher level, in which case the cost will be proportionately reduced.

There is a small irrigation sluice to the eastward of the position of the cross bund, and it is proposed to put a 6-inch pipe in or under the crest wall of the new weir to supply the lands under that sluice. The discharge of water through the pipe can be regulated by a wooden plug.

The surplus from the new weir will have to be passed across the road at the old outfall by lowering the road to about 1·28 feet about present full tank level with ramps of 1 in 25 at either end.

If the low level road be 200 feet in length, the maximum depth of water passing over will not exceed one foot, and if the lower side be well revetted with 3 or 4 feet of rough stone apron at the toe of the revetment, no other protection will be required. Moreover, if a cut, 9 feet wide, be made on the south side of the road to the two-vent culvert, which is on a low level, no water will pass over the road in ordinary seasons. Rs. 500 have been allowed for these alterations: sufficient stone will be obtainable from the present bund to the east of the cross bund.

8. The levels of the Agaram tank, as plotted, require an addition of 1·63 feet as noted on plans 13, 15 and 16. The levels were ordered to be taken from the floor at the south end of the cavalry part of the South Station Hospital, and they were actually started from an offset 0·96 feet above the floor. It has also been found that the levels on Lt. Romilley's section are not quite correct. His levels make the floor of the hospital 30·38 above datum which is 11·50 feet below Halsur tank waste weir, or the floor is 18·88 above the weir.

Vide section at end of paper on Halsur water-works, No. COLLL., in No. 45, July 1891, of Roorkee Professional Papers.

The zero of the tank gauge is 11·95 feet below the bench mark on the offset on the south face of the Rock engine house, and the difference between that bench mark and the floor of the cavalry hospital is 7·60 feet, so the latter is 19·55 feet above Halsur full tank level, or a difference of 0·67 feet.

48

The well would be 30 feet in diameter at top with its bottom at 2850·00, and its top a 2880·00, the excavated soil being arranged round that part of the steining which would be above tank bed level, so as to prevent any surface water passing into the well. The steining to be constructed in masonry down to 5 feet below bed or ground level,* and below that in dry stone.

* About 2868·63.

The steining above bed level may be arched as shown in the section, or it may be stepped in 6 inches for each course, and then covered in at top with slab stones.

Plan No. 14.

The well will be 30 feet in diameter for 3 feet below bed level, 27 feet for the next 7 feet, and 24 feet for the last 7 feet. The contents of the well, from estimated L. W. L. 2855·63 to bed level, are 7485·64 cubic feet, or rather more than half the supply required in the 24 hours.

The calculated required inflow of water is $\frac{14,400 - 7,485}{8 \text{ hours}} = 864\frac{1}{2}$ c.ft. per hour.

The surface for inflow is—

1st. The area of the bottom of the well	452·39 sqr. ft.	
2nd. The sides, where lined with dry stone, 1404·29 square feet which may be taken as $\frac{1}{4}$ unobstructed	175·54	
	627·93	

so that 1·4 cubic foot per square foot per hour will be needed.

The probable cost of the well will be 9·300 earth-work, at Rs. 15-10-0 per 1,000 cubic feet .. .. Rs. 148
17·82 dry stone steining at Rs. 12-8-0 per 100 cubic feet .. 223
17·17 steining stone in mortar, at Rs. 18-12-0 322
Slab stones 50
Sundries 57
Contingencies 789
129
Total .. 900

Suction pipe, 12 inches diameter, $\frac{5}{8}$ inch thick, about 500 feet.

	Rs.
500 × 93·7 = 46,850 lbs. = say 21 tons of C. I. Pipe at Rs. 95 per ton =	1,995
Laying 167 yards at Rs. 1-4-0 per yard .. .. =	210
Trench to pumping station, for laying pipe, average depth about 12 feet, 500 × 4 × 12 = 24,000 cubic feet, at Rs. 10 per thousand	240
Sundries	125
Total ..	2,570

The suction pipe would have a connection, with a suitable valve, with each set of pumps

Secondly—If water be drawn off direct from the tank. The special works are—

(1) A suction pipe from the tank to the pumps;
(2) A pair of filters with a pure water well attached and a suction pipe therefrom to the pumps;
(3) An increase to the capacity of the tank;

(1) The suction pipe, which would be connected with each set of pumps to be 12 inches in diameter, and to be run out into the deep part of the tank, so as to be able to draw off water to about the 2860·63 level, or 6·72 feet below present full tank level. The length will be about 960 feet.

	Rs.
960 feet × 93·7 = 89,952 lb. = 40 tons.	
40 tons C. I. pipe at 95 .. .. =	3,800
Laying 320 yards at Rs. 1-4-0 .. .. =	400
Trench for pipe, average depth 6 feet, 960 × 4 × 6 = 23,040 cubic feet at Rs. 7 per thousand .. .. =	161
Sundries .. .. =	239
	4,600

Another suction pipe will be required from the pure water well: it will be 10 inches in diameter, 150 × 79 = 11,850 lb. = 5 tons.

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	Rs.
5 tons of C. I pipe at Rs. 95 .. .. =	475
Laying 50 yards at Rs. 1-2-0 per yard .. .. =	56
Sundries .. .. =	29
	560

(2) The quantity of water to be filtered being 30 cubic feet a minute, or 1,800 cubic feet an hour, and the usual allowance being 2 square feet of filter bed for every cubic foot per hour, 3,600 square feet will be the area of each filter, or say 90 by 40 feet. The filters will be placed side by side, with a pure water well in connection with both. Depth of filters 10 feet and of well 13 feet; diameter of well 15 feet. Probable cost of the whole Rs. 15,000.

(3) The present capacity of the tank above the sill of the lowest sluice is 24·068 millions of cubic feet. It is proposed to raise the full tank level 3 feet, which will increase the capacity by 20·001 millions, or to 44·069 millions of cubic feet altogether. The present height of the bund varies considerably. There is only one waste weir, 119 feet in length, of which about 115 feet are effective, and this is not sufficient for the area of the catchment basin, 32·10 square miles. There was formerly a bywash at the other (east) end of the tank, but this was closed some time ago. The lowest estimate of the maximum discharge would be 2,645 cubic feet a second, viz.:—

$D = 350 \sqrt[5]{32^2} = 3{,}528$ cubic feet a second, with the time extended one-third by the action of the upper tanks.

The difference between full tank level and M. W. L. should be limited to 3 feet and the proper length of weir will then be 157 feet, say 160 feet, or 45 feet additional are required.

The revetment being out of section from settlements, will be rebuilt with a gravel and small stone backing, and the addition to the bund will be made, as is always desirable, on the inside, so far as may be practicable with due regard to securing a good alignment for the road.

The top of the bund will be 6·28 feet above full tank level, and the clear width of roadway 15 feet; a width of 18 feet has been allowed at road level, so as to admit of side ridging, which adds to the security of the traffic and tends to maintain the edges of the bank in good order.

There being a great length of bund at the east end with but very little water-spread, it will be cheaper and better to make a cross bund to the high ground immediately west of the village of Agara, and the connection of this bund with the main bund will be at about 2,920 feet on the longitudinal section, the zero of which is at the 7th furlong of the 6th mile. For this new bund a top width of 6 feet and slopes of 1¼ to 1 inside and 2 to 1 outside have been allowed, and revetment 1½ feet thick up to 2 feet below the top, which is the height to which the revetment generally will be carried up.

The new weir will be built towards the south end of this cross bund. The estimate for it has been made out on the supposition that the crest will be at 3 feet above ground level, but it is probable that a good site may be found on a higher level, in which case the cost will be proportionately reduced.

There is a small irrigation sluice to the eastward of the position of the cross bund, and it is proposed to put a 6-inch pipe in or under the crest wall of the new weir to supply the lands under that sluice. The discharge of water through the pipe can be regulated by a wooden plug.

The surplus from the new weir will have to be passed across the road at the old outfall by lowering the road to about 1·28 feet about present full tank level with ramps of 1 in 25 at either end.

If the low level road be 200 feet in length, the maximum depth of water passing over will not exceed one foot, and if the lower side be well revetted with 3 or 4 feet of rough stone apron at the toe of the revetment, no other protection will be required. Moreover, if a cut, 9 feet wide, be made on the south side of the road to the two-vent culvert, which is on a low level, no water will pass over the road in ordinary seasons. Rs. 500 have been allowed for these alterations: sufficient stone will be obtainable from the present bund to the east of the cross bund.

8. The levels of the Agaram tank, as plotted, require an addition of 1·63 feet as noted on plans 13, 15 and 16. The levels were ordered to be taken from the floor at the south end of the cavalry part of the South Station Hospital, and they were actually started from an offset 0·96 feet above the floor. It has also been found that the levels on Lt. Romilley's section are not quite correct. His levels make the floor of the hospital 30·38 above datum which is 11·50 feet below Halsur tank waste weir, or the floor is 18·88 above the weir.

Vide section at end of paper on Halsur water-works, No. COLLL., in No. 41, July 1881, of Roorkee Professional Papers.

The zero of the tank gauge is 11·95 feet below the bench mark on the offset on the south face of the Rock engine house, and the difference between that bench mark and the floor of the cavalry hospital is 7·60 feet, so the latter is 19·55 feet above Halsur full tank level, or a difference of 0·67 feet.

The reduced level (Karwar mean sea level) of the zero of the Halsur lower tank gauge is 2929·97, so the floor of the Cavalry hospital is 2949·52, and the bench mark on the offset 2950·48. In levelling to the Agaram tank the valve, 18·88 + 2929·97 — 2948·85 was used for this bench mark; hence the connection of 1·63 feet requiring to be added to the plotted levels above referred to. The levels entered on plan 14 have been corrected as regards the Agaram tank, but the levels of the several parts of the garrison distribution have been left as given in Lt. Romilley's section, as no connected series of check levels of the cisterns have been taken, and the stand pipe has been designed so as to secure ample head.

9. The following is an abstract approximate estimate of the cost of enlarging the Agaram tank :—

Quantities.	Description.	Unit.	Rate.	Amount.	Work Totals.
			Rs. A. P.	Rs.	
476,837	Earthwork to bund and forming cross bund.	1000 C.Ft.	3 7 6	1,634	
506.02	Rebuilding old revetment				1,634
337,35	Gravel backing to do.	100 C.Ft.	1 6 0	760	
		do.	2 0 0	675	
263,44	New revetment				1,435
242,29	Gravel backing to revetment	do.	2 5 0	3,453	
		do.	2 0 0	485	
	Alterations to waste weir and 11-vent culvert.				3,938
	Alterations to west sluice	S.	..	340	
		,,	..	340	
	New waste weir, 45 feet crest with sluice pipe				1,130
16,25	Rubble masonry				
12,24	Rough stone apron				
5	Feet sluice pipe 6 inches in diameter and ½ inch thick with elbow at tank end	100 C.Ft.	14 1 6	550	
	Sundries	do.	3 6 0	116	
				19	
	Lowering road to pass surplus from new weir, with cut on south side of road to two-vent culvert.			37	812
83·3	Land compensation for additional water-spread.	Acres.	60 0 0	500	500
	Contingencies			3,198	3,198
	Total				272
					12,000

The additional capacity being in round numbers 20½ millions of cubic feet, the cost of storage would be per million cubic feet Rs. 634, which seems reasonable, as the rebuilding of the old revetment and the new waste weir are works appertaining to the security of the present tank, and without these two items the cost per million would be under Rs. 525.

10. The ground selected for the pumping station measures 4·54 acres, and provision has been made for enclosing the whole with a wall of stone in mud pointed with mortar, and coped with stone in mortar. The wall to be 6 feet in height. The item, Rs. 4,000, is a considerable one, but it seems to be important to exclude all but employés, as otherwise perfect cleanliness cannot be ensured.

Vide plan 12.

11. Subjoined is a general abstract of the alternative arrangements for the supply of the troops from this source. As the present establishment at the Halsur rock water works would suffice for the Agaram works, and as the working expenses generally would be much the same, no provision has been made on this account.

Particulars.	Water drawn direct from Tank. Amount.	Water drawn from Supply Wells in or below Tank. Amount.
	Rs.	Rs.
Engines and pumps	30,500	30,500
Stand pipes	2,500	2,500
Masonry foundation pipes	1,430	1,000
Delivery mains	1,18,000	1,18,000
Suction pipe from supply well	..	2,570
Supply well	..	900

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Particulars.	Water drawn direct from Tank. Amount.	Water drawn from Supply Wells in or below Tank. Amount.
	Rs.	Rs.
Suction pipe from tank	4,600	..
Do. do. from pure water well	560	..
Two filters	15,000	..
Enlarging tank	13,000	..
Ground for pumping station	250	250
Engine house and chimney	12,500	12,500
Quarters for Engineer, &c.	3,000	3,000
Enclosure walls	4,000	4,000
	2,11,340	1,81,220
Contingencies	8,660	6,780
Total	2,20,000	1,88,000

CONDENSER LIST No. 1.

PURE COLD FRESH WATER FROM SEA-WATER WITH GREAT ECONOMY OF COAL.

For Yachts, Ships, or on Land.

Four-thousand and five-hundred Gallons, or 20 tons for 1 ton of Coal. (Results guaranteed abroad if required.)

Normandy's Improved Patent Fresh-Water Distilling Machinery.

This machinery converts sea, or other impure, water into *pure, cold, fresh water*, equal in appearance and taste to the best river or spring water, and fit for immediate use as it leaves the machinery, which will also force it to any distance, and to a height of 40 yards or metres, or more if desired.

It is well known that an *insufficient* or *impure* water-supply *is a constant source of danger from a sanitary point of view*. There are many places where such a state of things exists, and where the introduction of this machinery would at once provide a *cheap, pure, and abundant water-supply*. Over 1,000 machines have been supplied, and some of the land stations and ships supplied are given on the last page.

The process may be briefly stated as follows :—

Water distilled by the ordinary process, viz., by a boiler for generating steam, and a worm for condensing steam into water, is open to these objections:

1. *The entire heat of the condensed steam is lost.*

2. The water formed by the condensed steam contains organic impurities, which give it a disagreeable flavour.

3. This water is destitute of air, which it has lost in the process of boiling, and it is hence flat and vapid to the taste, besides being somewhat heavy if drunk in quantity.

These objections may be, to a certain extent, removed by exposing the water to air for a long time. *But on board ship, and in doubtful places, the water may absorb air which is not pure.*

Normandy's Improved Apparatus removes all these objections, by using over again the heat liberated by one or more successive condensations of steam, thus increasing the amount of distilled water to from 1½ to 2½ times the water evaporated by the boiler. The distilled water is aerated in the process of condensation and is cooled down to the temperature of ordinary water in the outer air, and the taint of organic matter is completely removed from the distilled water by passing it through a filter of prepared animal charcoal, from which it flows out cold, pure, well aerated, and equal in taste and appearance to the best river water as usually supplied to towns.

RESULT of the Trial of Normandy's Improved Patent Distilling Machinery, erected at Flushing for the Dutch Government, January and February 1877.

This machinery was supplied as suitable for producing 6,000 gallons of pure fresh water, per 24 hours, from sea water.

By the direction of Mr. Van Diesen, Chief Engineer of the Waterstaat, in the Province of Zeeland, Holland, this machinery was carefully tested by being worked under the inspection of officials appointed for the purpose, the result being that *in 19 hours' work* this machinery produced 28,500 litres of fresh water, and consumed 1,545 kilos. of coal. This is equal to 6,270 gallons (or 28 tons) of fresh water, produced with 1¼ tons of coal in 19 *hours' work.*

The fresh water produced, as it flowed from the machinery, *was bright-looking, clear, cold, and agreeable, without any peculiar taste, and, in fact, equal in appearance and taste to the best river or spring water.*

It will be seen, therefore, that this machinery, when worked *for* 19 *hours*, produced 33 *per cent. more water than it was said to produce* in that time, and yielded 4,100 *gallons (or* 18·3 *tons) per* 1 *ton of coal*; it would have produced more had the machinery been less overworked, as similar machines at Aden and elsewhere have yielded over 20 tons or 4,500 gallons of water per ton of coal.

In the above trial, the productive power and consumption of coal were ascertained as follows:—The machinery having been fairly started, *the coals were removed from the furnaces*, and the working was continued, under inspection, with *weighed coals*. After 19 *hours'* working, *the unconsumed coals were removed from the furnaces and weighed*, and their weight was deducted from the quantity of weighed coals put into the furnaces, the difference being taken as the weight consumed. The fresh water produced from the sea water was collected in an iron tank and carefully measured.

Reports on the Quality of the Fresh Water produced by Normandy's Improved Patent Machinery for producing from Sea Water, Pure, Cold, and Agreeable Fresh Water for Drinking Purposes.

Opinion of DON JOSE SOLER Y SANCHEZ, Licentiate in Pharmacy, Doctor in Sciences, late Professor of Chemistry to the Faculty of Sciences of University of Madrid, Professor of Chemistry and Physics to the Institute of Alicante, &c., &c.

Alicante, 11th September 1879.

I hereby certify that having analysed in my laboratory a sample of pure fresh water in order to see if the same was drinkable, and which sample was delivered to me by the President Alcalde (Mayor) of the most illustrious Municipality of Alicante, the said sample being drawn according to his declaration from Mr. Normandy's Distilling Engine.

This sample of fresh water was received in the presence of the Notary, Mr. Nemeo Albert, in two glass bottles duly sealed and stamped with the letters J.C.B., the result being as follows:—

1st. Its hyrotimatrical degree is 5°.
2nd. A litre of water contains 0·085 grammes of mineral substance.
3rd. Does not contain any organic matter.
4th. Contains 17·64 c.c. of air per litre of water.
5th. Does not prevent soap from dissolving.
6th. Is clear, without colour, limpid, and transparent.

Therefore, by its character and condition, it is to be considered *a most eminently drinkable water.*

Dr. J. SOLER Y SANCHEZ.

Report of Dr. NOAD, F.R.S., Professor of Chemistry at St. George's Hospital, London.

I find the water to be *absolutely free from organic matter*, which all river and well waters contain, more or less, and which is acknowledged to be a predisposing cause of disease. It is also bright, colourless, well aerated and agreeable, and it contains an exceedingly small percentage of saline matter, which is the case with all waters derived from the best natural sources.

From a sanitary point of view, I consider this water to be quite equal, and, in its absolute freedom from organic matter, superior to that obtained from the purest natural sources; it is therefore well suited for alimentary purposes.

Report of Dr. LETHEBY, M.B., M.A., Professor of Chemistry in the Medical College of the London Hospital, and Medical Officer of Health for the City of London.

The sample was colourless and well aerated and it was agreeable to the palate. It contained a very small proportion of saline matter, which I regard as an advantage, as it approximates the quality of the water to that derived from the best natural sources. For dietetical purposes, the proper aeration of the water is essential. *The water was absolutely free from organic matter*, and it is very soft.

I am of opinion, from these results, that the water is very wholesome and is well adapted for all domestic purposes.

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List of Particulars of Normandy's Improved Patent Distilling Machinery for converting Sea Water into Pure, Cold, Fresh Water, equal in appearance and taste to the best River or Spring Water, and fit for immediate use as it flows from the machinery, which will also force it to any distance and to a height of 40 yards (or metres) or more, if desired.

[See Reports and Result of Government Trial at Flushing, on other side.]

(Results guaranteed abroad if required).

	Quantity of Cold, Fresh Water produced from Sea Water in 24 hours. Under favorable circumstances the production will be about 30 per cent. more.		Quantity of Fresh Water produced by one Ton (or 1000 Kilos.) of Coal. Under favorable circumstances the Quantity will be about 10 per cent. more.					
			Single distilling Arrangement.		Double distilling Arrangement.		Treble distilling Arrangement.	
	Gallons.	Tons or Cub. Metres.	Gallons.	Tons or Cub. Metres.	Gallons.	Tons or Cub. Metres.	Gallons.	Tons or Cub. Metres.
These include as described Note A on next page.	1,000	4·5	1,560	7·0	..	..	..	..
	1,125	5·0	1,560	7·0	..	..	..	..
	1,250	5·6	1,560	7·0	..	..	..	..
	1,500	6·7	1,600	7·2	2,660	11·9	..	..
	1,750	7·8	1,600	7·2	..	..	..	..
	2,000	9·0	1,700	7·6	2,700	12.2	3,400	15·3
	2,250	10·0	1,740	7·7	..	..	..	..
	2,500	11·2	1,740	7·7	2,700	12·2	3,500	15·7
	3,000	13·4	1,790	8·0	2,950	13 2	3,500	15·7
	3,500	15·6	1,830	8·2	..	..	..	..
	4,000	17·9	1,830	8·2	3,000	13·8	3,650	16·3
	4,500	20·1	1,880	8·4	..	..	..	..
	5,000	22·3	1,950	8·8	3,100	14·0	3,900	17·7
	6,000	27·0	1,950	8·8	3,200	14·3	4,000	18·0
	7,000	31·2	..	..	3,200	14·3	4,000	18·0
	8,000	35·7	..	..	3,300	14·8	4,100	18·4
	9,000	40·2	..	..	3,400	15·4	4,200	18·8
	10,000	44·6	..	..	3,400	15·4	4,300	19·3
	11,000	49·1	..	..	3,400	15·4	4,400	19·6
	12,000	53·6	..	..	3,470	15·5	4,500	19·8
	13,000	58·0	..	..	..	..	4,500	20·0
	14,000	62·5	..	..	..	..	4,500	20·0
	15,000	67·0	..	..	..	..	4,500	20·0
These include as described Note B on next page.	100	0·5	1,000	4·5	1,680	7·5	..	..
	140	0·7	1,000	4·5	1,650	7·5	..	..
	225	1·0	1,000	4·5	1,680	7·5	..	..
	300	1·4	1,230	5·5	1,650	7·5	..	..
	420	1·8	1,230	5·5	1,900	8·5	..	..
	500	2·2	1,230	5·5	2,120	9·5	..	..
	615	2·8	1,230	5·5	..	..	..	..
	710	3·3	1,230	5·5	2,120	9·5	..	..
	878	4·0	1,230	5·5	..	..	..	..
	1,000	4·5	1,230	5·5	2,120	9·5	..	..
	1,134	5·0	1,340	6·0	..	..	2,800	12·5
	1,258	5·6	1,340	6·0	2,240	10·0	..	..
	1,500	6·7	1,340	6·0	2,350	10·5	2,800	12·5
	1,750	7·8	1,450	6·5	..	..	2,910	13·0
	2,000	9·0	1,450	6·5	2,350	10·5	..	..
	2,250	10·0	1,450	6·5	..	..	3,030	13·5
	2,500	11·2	1,450	6·5	2,350	10·5	..	..
	3,000	13·4	1,560	7·0	2,320	10·5	3,130	14·0
	3,500	15·6	1,560	7·0	..	..	3,130	14·0
	4,000	17·9	..	..	2,460	11·0	..	..
	5,000	22·3	..	..	2,680	12·0	3,130	14·0
	6,000	27·0	..	..	2,680	12·0	3,250	14·5
	7,000	31·2	..	..	..	..	3,360	15·0
							3,360	15·0

See Condenser List, No. 2, for particulars of Normandy's Improved Patent Double Distilling Condensers (without boilers) for steamships, yachts, and torpedo boats, for working with greasy steam from main boilers supplying the engines, so as to produce good, cold, fresh water for drinking, and also hot fresh water, to keep up the full supply of fresh water in those boilers, to prevent scale accumulating therein.

See Condenser List, No. 3, for particulars of Single Distilling Condensers (without boilers) for producing from sea water good, cold, fresh water for drinking, when worked with clean steam from boilers fed with sea-water, but with less economy of fuel.

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Estimate for complete sets of Normandy's Improved Patent Distilling Machinery for producing good, cold, drinking water from sea-water, and for forcing the fresh-water to a great height or distance, with letter, dated 21st *February* 1884, *to General Hyde.*

The drinking water as it flows from under-mentioned machinery is clear, cold, bright-looking and agreeable, without any peculiar taste, and equal in quality, taste and appearance, to the best river-water as usually supplied for drinking in towns. (See the reports on other side.)

Full instructions for putting together and working will be supplied with the machinery, and, if desired, special arrangements will be made for the machinery to be supplied and erected abroad, and also worked for an agreed time, the consumption of coal and the quantity and quality of the fresh-water produced being guaranteed.

Note A.—Under favorable circumstances, this machinery will produce from 20 *to* 30 *per cent. more water* per 24 hours, than is stated below, and the quantity of fresh-water produced by 1 ton of coal will be increased *by* 10 *to* 15 *per cent.* (*See results of Flushing trial on other side.*) For long continued working, however, the best results will be obtained by working so as not to produce much more than the quantity specified below, as the production per 25 hours.

Each *complete set of machinery* includes one of Normandy's Improved Patent Condensers with filter, suitable steam boiler and steam pumps for supplying sea-water to the condenser and boiler, and for *forcing the fresh-water produced to a great height or distance.* Also *all connecting parts and pipes in between above, the whole being arranged to a suitable plan, ready for putting together on a level surface abroad.* It also includes iron chimneys for the boilers, complete with guy chains, 40 yards of suction pipe from sea to machinery, 20 yards of waste sea-water pipe, and 20 yards of fresh-water delivery pipe. Also a quantity of useful stores and tools, such as spare fire bars, stoking and cleaning tools, spanners for tightening up, oil cans, gauge glasses and sundry useful stores, so that the whole may be *readily* set to work and kept in order without delay or difficulty. The surface on which the machinery stands should not be more than 6 yards (or 7 metres) above the sea-level.

The condenser tubes are of solid brass, tinned inside and outside. The pumps are of strong and simple construction, and easily adjustable to compensate for wear. The water is drawn and forced by plungers moving through stuffing boxes, easily packed and kept tight by an *external* gland, thus avoiding the troublesome and difficultly repaired leaks, which so frequently stop other kinds of pumps. They *work at a moderate speed*, so as to avoid the excessive wear and knocking about of the valves and other parts, always resulting from quick speed. They have fly-wheels, and have all valves, bearings, plungers and working parts in contact with water, made of *brass or copper, wrought-iron crank shafts, and steel piston-rods.* The *boilers* have furnace plates of *Low Moor or Bowling iron*, and have dampers, Bourdon's pressure gauges, safety valves, *and all necessary fittings.* They are proved to double the working pressure, and the working pressure is from ⅓ to ½ of the bursting pressure.

Note B.—If delivered in less than the maximum times stated below, then 4 per cent. extra on prices for every 10 per cent. less time.

Number of Estimate.	1	2	3	4	5	6	7	8
Number of complete and independent apparatus included in each estimate	2	1	1					
Type of the apparatus included in each estimate (single, double, or treble distilling)	Treble	do.	do.					
Type of boilers included in each estimate	Lancashire	do.	do.					
Fresh Water produced per 24 *hours* (See note A above). Gallons	12,000	6,000	12,000					
Tons, or cubic metres (1 cubic metre equals 1,000 litres or kilos)	53·6	26·8	53·6					
Economy of Coal and Wood (See Note A above). Wood or coals consumed for producing the quantities of water stated above as the production per 24 hours (weight in tons or 1,000 kilogrammes)	Coal 3 Wood 12	Coal 2·13 Wood 8·6	Coal 2·67 Wood 8·9					
Tons of water (or cubic metres) yielded per 1 ton (or 1,000 kilogrammes) of coal	Coal 18 Wood 4·5	Coal 12·6 Wood 4·7	Coal 20·6 Wood 6·0					

(*Continued.*)

Number of Estimate.	1	2	3	4	5	6	7	8
Time required from receipt of order for delivering the machinery in London.								
Days for delivering all the independent apparatus included in above estimates ... ... or else	45 to 120	45 to 100	45 to 120	do.	do.	do.	do.	do.
1st ... first	do.	do.	do.	do.	do.	do.	do.	do.
2nd ... second	do.	do.	do.	do.	do.	do.	do.	do.
3rd ... third	do.	do.	do.	do.	do.	do.	do.	do.
4th ... fourth	do.	do.	do.	do.	do.	do.	do.	do.
Prices, delivered packed and free on board in London.								
Prices for all the singular apparatus in each estimate as detailed above ... ... £	4,363	3,593	4,846					
Extras if required.								
Iron roofs supported on iron columns to contain the above machinery ... ... £								
Tanks of galvanized iron to contain the quantities of fresh water stated above as the production per 24 hours ... ... £								

REPORTS on Normandy's Improved Patent Machinery for producing from sea-water, pure, cold, and agreeable fresh-water for drinking purposes.

Result of the trial of Normandy's Improved Patent Distilling Machinery erected at Flushing for the Dutch Government, January and February 1877.

This machinery was supplied as suitable for producing 6,000 gallons, or 27 cubic metres, of good, cold, drinking water, per 24 hours, from sea-water.

By the direction of Mr Van Diesen, Chief Engineer of the Waterstaat, in the province of Zealand, Holland, this machinery was carefully tested by being worked under the inspection of officials appointed for the purpose, the result being, that in 19 *hours' work* this machinery produced 28,500 litres of fresh-water, and consumed 1,545 kilogrammes of coal. This is equal to 6,270 gallons (or 28 tons) of fresh-water, produced with 1½ tons of coal in 19 *hours' work.*

The fresh-water produced, as it flowed from the machinery, *was bright-looking, clear, cold and agreeable, without any peculiar taste, and, in fact, equal in appearance and taste to the best river or spring water.*

It will be seen, therefore, that this machinery, when worked *for* 19 *hours*, produced 33 *per cent. more water than it was said to produce* in that time, and yielded 4,100 *gallons* (*or* 18·3 *tons*) *per* 1 *ton of coal* (equal to 18·3 cubic metres per 1,000 kilogrammes of coal): the economy of coal would have been still greater had the machinery been less overworked, as similar machinery at *Adra and Alicante* has yielded over 20 *tons* of water per 1 ton of coal (or 20 cubic metres per 1,000 kilogrammes of coal).

In the above trial, the productive power and consumption of coal were ascertained as follows:—The machinery having been fairly started, *the coals were removed from the furnaces*, and the working was continued, under inspection, with *weighed coals*. After 19 *hours'* working, *the unconsumed coals were removed from the furnaces and weighed*, and their weight was deducted from the quantity of weighed coals put into the furnaces, the difference being taken as the weight consumed. The fresh-water produced from the sea-water was collected in an iron tank and carefully measured. The results were as above stated.

OPINION of DON JOSE SOLER Y SANCHEZ, Licentiate in Pharmacy, Doctor in Sciences, late Professor of Chemistry to the Faculty of Sciences of University of Madrid, Professor of Chemistry and Physics to the Institute of Alicante, &c., &c.

Alicante, 11th September 1879.

I hereby certify that, having analysed in my laboratory a sample of pure fresh-water in order to see if the same was drinkable, and which sample was delivered to me by the Presidente Alcalde (Mayor) of the most illustrious municipality of Alicante, the said sample being drawn, according to his declaration, from Mr. Normandy's Distilling Engine:

This sample of fresh-water was received in the presence of the Notary, Mr. Nerco Albert, in two glass bottles duly sealed and stamped with the letters J.C.B., the result being as follows:—

1st. Its hyrotimetrical degree is 5°.
2nd. A litre of water contains 0·085 grammes of mineral substance.
3rd. Does not contain any organic matter.
4th. Contains 17·64 c c. of air per litre of water.
5th. Does not prevent soap from dissolving.
6th. Is clear, without color, limpid, and transparent.

Therefore, by its character and condition, it is to be considered *a most eminently drinkable water.*

And in order that the interested party make use of this certificate as he may think fit, at his own request I grant the present document attaching my signature thereto.

REPORT of DR. NOAD, Ph.D., F.R.S., Professor of Chemistry at St. George's Hospital, London.

I find the water to be *absolutely free from organic matter*, which all river and well waters contain more or less, and which is acknowledged to be a predisposing cause of disease; it is also bright, colorless, well aerated and agreeable, and it contains an exceedingly small percentage of saline matter, which is the case with all waters derived from the best natural sources.

From a sanitary point of view, I consider this water to be quite equal, and in its absolute freedom from organic matter, superior, to that obtained from the purest natural sources. It is therefore well suited for alimentary purposes.

REPORT of DR. LETHEBY, M.B., M.A., Professor of Chemistry in the Medical College of the London Hospital and Medical Officer of Health for the City of London.

The sample was colorless and well aerated, and it was agreeable to the palate. It contained a very small proportion of saline matter, which I regard as an advantage, as it approximates the quality of the water to that derived from the best natural sources. For dietetical purposes, the proper aeration of the water is essential. *The water was absolutely free from organic matter*, and it is very soft.

I am of opinion, from these results, that the water is very wholesome and is well adapted for all domestic purposes.

KRASNOVODSK, 1st October 1880.

I, the undersigned, Doctor of Medicine, Doctor-in-Chief of the Trans-Caspian Expedition, certify that the water of the Caspian Sea rendered potable by NORMANDY'S DISTILLING APPARATUS has been submitted to me, by being taken as it flowed from the apparatus, and that after an examination of fifteen days I found it to have the following qualities:—

The water was *perfectly pure, free from all organic matters, contained a sufficient quantity of air*, was without any taste of machinery, or of any other unpleasant flavor. I personally used it, and found it suited me well. I consider it *perfectly suitable for alimentation, and for all domestic purposes.*

In consideration of which I have delivered the present certificate.

DR. OSCAR HEYFELDER,
Councillor of State.

All sizes supplied, producing from 120 to 15,000 gallons of water per 24 hours, and yielding up to 20 tons, or 4,500 gallons of water per 1 ton of coal consumed.

Notes and Remarks.

The price of the treble distilling arrangement exceeds that of the double, and that of the double exceeds that of the single distilling arrangement, but this *extra first cost is soon repaid by the great saving of coal.*

Applications for prices and further particulars should state size, kind of arrangement preferred, and whether required to convert sea-water into cold fresh-water for drinking, for a land station, or on board ship, or whether to produce hot or cold fresh-water for feeding locomotive boilers, or other manufacturing purposes, such as for saltpetre refining, dyeing works, brightening colors for calico printing, &c.

This machinery will force the fresh-water produced to *any distance* and to a height of 40 yards (or metres) or more if desired, and it may be placed at any convenient distance from the sea; but the surface on which it stands should not be more than 8 yards (or 7·2 metres) above the sea-level, which would necessitate special arrangements according to circumstances.

The attendance of one man will suffice to work one or more sets of this machinery, provided that the total quantity of fresh-water produced per 24 hours does not exceed 8,000 gallons if single distilling, 15,000 gallons if double distilling, or 20,000 gallons if treble distilling.

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Full instructions for putting together and working will be supplied with the machinery, and if desired, special arrangements may be made for the machinery to be supplied and erected abroad, *and also worked for an agreed time, the consumption of coal, and the quantity and quality of the fresh-water produced being guaranteed.*

Note A.—Each of these *complete sets of machinery* includes one of Normandy's Improved Patent Condensers with filter, suitable Cornish or Lancashire (double flue Cornish) steam boiler, and steam pumps for supplying sea-water to the condenser and boiler, and for *forcing the fresh-water produced to any distance, and to a height of* 40 *yards* (*or metres*) *or more if desired.* Also *all connecting parts and pipes in between above, the whole being arranged to a suitable plan, ready for putting together on a level surface abroad.* It also includes iron chimneys for the boilers, complete with guy chains, 40 yards of suction pipe from sea to machinery, 20 yards of waste sea-water pipe, and 40 yards of fresh-water delivery pipe. Also a quantity of useful stores and tools, such as spare fire bars, stoking and cleaning tools, spanners for tightening up, oil cans, gauge glasses and sundry useful stores, so that the whole may be readily set to work, and kept in order without delay or difficulty. The surface on which the machinery stands, should not be more than 8 yards (or 7·2 metres) above the sea level.

The condenser tubes are of solid brass, tinned inside and outside. The pumps are of strong and simple construction, and easily adjustable to compensate for wear. The water is drawn and forced by plungers moving through stuffing boxes, easily packed and kept tight by an *external* gland, thus avoiding the troublesome and difficultly repaired leaks, which so frequently stop other kinds of pumps. They *work at a moderate speed*, so as to avoid the excessive wear and knocking about of the valves and other parts, always resulting from quick speed. They have fly wheels, and have all valves, bearings, plungers and working parts in contact with water, made of *brass or copper, wrought-iron crank shafts, and steel piston-rods.* The *boilers* have furnace plates of *Low Moor or Bowling iron*, and have dampers, Bourdon's pressure gauges, safety valves, fusible safety plugs in crowns of furnaces, *and all necessary fittings.* They are proved to double the working pressure, and the working pressure is from $\frac{1}{6}$ to $\frac{1}{8}$ of the bursting pressure.

Note B.—Each of these complete sets of machinery includes the same as described under Note A, but the boilers included take up less room, and do not require setting in brickwork, being of the vertical, or return flue, type, and of simple construction so as to avoid difficulty in cleaning and working; they are, however, not so economical of coal, and boilers as described in Note A are generally preferable, especially for the larger sizes, as they are the most economical of coal, and easiest to clean, and keep in good working order, and are easily fixed in brickwork, concrete, cement, stone, &c.

Note C.—Tanks for containing the fresh water produced are supplied as extras. They are best made of galvanized iron, fitted with drawing-off cocks complete. It is convenient to have tanks large enough to contain at least the production per 24 hours, as per list on opposite page. For convenience of shipping, large sizes are made of flat or curved pieces, easily bolted together abroad.

Extra length of sea-water suction pipe, waste sea-water pipe, and fresh-water delivery pipe, including bends and joints to suit various positions, are supplied at per yard as required.

Iron roofs supported on iron columns for containing this machinery for land stations are also supplied as extras if required.

Some of the land stations supplied with various kinds of Normandy's Patent Distilling Machinery.

Aden, Red Sea.	Gibraltar.	Ismalia (Egyptian War).
Flushing, Holland.	Alicante.	Island of Ascension.
Abyssinian Expedition.	Peru.	Krasnovodsk, Caspian Sea.
Malta.	Chili.	Galapagos Islands.
Cape Coast Castle.	Australia.	China Hospital Ships.
West Coast of South America.	Brighton.	Heligoland.
Iquique.	Packam and Co., Croydon.	Fort Moultrie.
St. Vincent, Cape Verds.	Red Sea Lighthouses.	Pure Water Co., London.

Some of the above produce 20 tons or 4,500 gallons of good, cold, drinking water from sea water per 1 ton of coal.

Some of the Ships supplied with Normandy's Patent Distilling Machinery.

British Government.

H.M.S. Nelson	H.M.S. Rifleman	H.M.S. Forester
" Victor Emanuel	" Frolic	" Northampton
" Flying Fish	" Dee	" Foxhound
" Iron Duke	" Goshawk	" Foreward
" Lord Warden	" Swinger	" Emerald
" Lord Clyde	" Ready	" Medina
" Clarewitch	" Serapis	" Medway
" Crocodile	" Jumna	" Sabrina
" Euphrates	" Undine	" Spey
		24

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British Government—*cont.*

H.M.S. Audacious
„ Vanguard
„ Swiftsure
„ Encounter
„ Invincible
„ Magicienne
„ Assistance
„ Curacoa
„ Cleopatra
„ Conquest
„ Inflexible
„ Diamond
„ Moorhen
„ Sheldrake
„ Superb
„ Comus
„ Belle Isle
„ Triton
„ Himalaya
„ Sapphire
„ Pioneer
„ Rover
„ Fury
„ Lily
„ Arab
„ Investigator
„ Hecla
„ Hymalaya
„ Express
„ Contest
„ Cygnet
„ Daring
„ Samba
„ Pegasus
„ Dragon
„ Albatross
„ Modeste
„ Amethyst
„ Shah
„ Fantome
„ Egeria
„ Dromedary
„ Boadicea
„ Bacchante
„ Raleigh
„ Cormorant
„ Gannet
„ Leander
„ Arethusa
„ Phaeton
„ Ariel
„ Zephyr
„ Kestrel

H.M.S. Amphion
„ Caroline
„ Imperieuse
„ Malabar
„ Hydra
„ Briton
„ Rupert
„ Sultan
„ Volage
„ Active
„ Hecate
„ Hotspur
„ Mosquito
„ Don
„ Esk
„ Champion
„ Heroine
„ Hyacinth
„ Lark
„ Thetis
„ Barrosa
„ Odin
„ Gorgon
„ Druid
„ Merlin
„ Thalia
„ Glatton
„ Triumph
„ Magdala
„ Foam
„ Coquette
„ Cyclops
„ Decoy
„ Tourmaline
„ Slaney
„ Trent
„ Harrier
„ Raleigh
„ Ready
„ Pylades
„ Tweed
„ Iris
„ Griffin
„ Falcon
„ Firebrand
„ Firefly
„ Carrysfoot
„ Neptune
„ Starling
„ Stork
„ Raven
„ Humber
„ Fawn

H.M.S. Tay
„ Tees
„ Osprey
„ Condor
„ Flamingo
„ Temeraire
„ Turquoise
„ Ruby
„ Pelican
„ Penguin
„ Wild Swan
„ Dolphin
„ Wanderer
„ Sphinx
„ Calliope
„ Doterel
„ Mallard
„ Shannon
„ Euryalus
„ Garnet
„ Orion
„ Colossus
„ Conqueror
„ Sea Horse
„ Cordelia
„ Canada
„ Rambler
„ Ranger
„ Niger
„ Algerine
„ Kingfisher
„ Constance
„ Grappler
„ Banterer
„ Wrangler
„ Wasp
„ Espoir
„ Redwing
„ Bullfrog
„ Cockchafer
„ Swift
„ Linnet
„ Flying Fish
„ Agamemnon
„ Phœnix
„ Miranda
„ Satellite
„ Wyvern
„ Edinburgh
„ Majestic
„ Rodney
„ Warspite
„ Collingwood

German Government.

H.M.S. König Wilhelm
„ Kaiser Prinz
„ Kaiser
„ Arideln

H.M.S. Medusa
„ Vineta
„ Albatross
„ Nymphe

H.M.S. Deutschland
„ Leipzig
„ Sedan

Chilian, Danish, Brazilian, Portuguese, Argentine, Turkish, Spanish and Japan Governments.

H.M.S. Pizarro
„ Kongo
„ Hiyei
„ Fuyun
„ Independencia
„ Rainha de Portugal

H.M.S. Almirante Cochrane
„ Almirante Brown
„ Blanchoto
„ Mindelho
„ Mayrid Zafier
„ Northerbey

H.M.S. Florentia
„ Ingold
„ Mercur
„ Lotus
„ Orwina
„ Volcano
„

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Royal Mail Steam Packet Company.

S.S. Moselle
„ Atrato
„ Neva
„ Tagus
„ Nile
„ Boyne

S.S. Shannon
„ Esk
„ Rhone
„ Seine
„ Douro
„ Eden

S.S. La Plata
„ Tasmanian
„ Oneida
„ Elbe

Allan Line of Royal Mail Steamers.

S.S. St. Andrew
„ St. George
„ St. David
„ Germany
„ Peruvian
„ Moravian

S.S. Polynesian
„ Pomeranian
„ Norway
„ Nestorian
„ Circassian
„ Prussian

S.S. Scandinavian
„ Sweden
„ Sardinian
„ Nova Scotian
„ Assyrian
„ Austrian

Messrs. R. and H. Green.

S.S. Sultan
„ Viceroy
„ Shannon
„ Melbourne
Malabar

Roxburg Castle
Carlisle Castle
Newcastle
Clarence
Alnwick Castle

Agamemnon
Windsor Castle
Renown
Nile

Belonging to various Governments and Shipowners.

S.S. Torrington
„ Hampton
„ Harrington
„ Wyberton
„ Durham
„ Macassar
„ Bothnia
„ Synthia
„ Kingston
„ Spartan
„ Madeira
„ Nachimof
„ Serendib
„ Dacia
„ Russia
„ Pavonia
„ Padang
„ Royal Dane
„ Gelderland
„ Nepaul
„ Kate Fawcet
„ Servia
„ Lena
„ Kent
„ Friesland
„ Dreuthe
„ Royal Welsh
„ Black Watch
„ Cephalonia
„ Overyssel

S.S. Samarang
„ Zuid Holland
„ Aurania

Indus
Beaumaris Castle
Light Brigade
Eastern Empire
Southern Ocean
City of Melbourne
Marchesa
Southern Cross
Flying Cloud
Hugoumont
Young Australia
Lightning
Prince of Wales
Blue Jacket
Sir Robert Sale
Lansborough
Montmorency
Himalaya
Burlington
Caroline Coventry
Java
Maryborough
Matilda Atheling
Clairellen
Wambojeeg

Wellesley
Kent
Ellenborough
Harkaway
Atalanta
Aliquis
Canning
Samarang
Norman Morrison
Gresham
Howrah
Mermaid
Maori
Peeress
Lincoln
Zenobia
Canterbury
Gosforth
Avon
Clive
Siam
Zelandia
Wansfell
Philosopher
Thames
Poonah
Clara
Arcot
Dunbar Castle
Theresa

All sizes supplied and guaranteed to produce from sea-water from 100 to 15,000 gallons of best, cold, drinking water per 24 hours, and yielding up to 20 tons, or 4,500 gallons, of water per 1 ton of coal consumed, with the larger sizes.

See Condenser List No. 2 for particulars of Normandy's Improved Patent Double Distilling Condensers for steamships yachts, and torpedo boats, for working with greasy steam from main boilers supplying the engines so as to produce good, cold, drinking water, and also hot fresh-water for keeping up the full supply of fresh-water in these boilers and prevent scale accumulating therein.

See Condenser List No. 3 for particulars of single Distilling Condensers for producing good cold, drinking water from sea-water when worked with clean steam from boilers fed only with sea-water, these condensers are less economical of coal.

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From A. NORMANDY, Esq., for Normandy's Patent Marine Aerated Fresh Water Company (Limited), to General Hyde, India Office, Westminster, S.W., dated Custom House Station, Victoria Dock, London, 21st February 1884.

With reference to Col. J. Mullins' letter to you, dated Bangalore, 17th January 1884, which you were good enough to show me, respecting the water supply at Bangalore, I beg to observe as follows:—

Filtration will not make very foul water reasonably wholesome, and though filters may, at first, somewhat improve the quality of such impure water, they very soon lose this power, and get out of order.

Such impure water as Colonel Mullins describes may, however, be converted into good and agreeable drinking water by distillation with apparatus such as we have supplied for Aden and other places, and which are very economical of fuel.

Ordinary distillation converts salt-water into fresh-water, but such fresh-water is heavy and unwholesome, as well as unpleasant to drink, owing to want of proper aeration, and to its being tainted by an extremely small quantity of a very offensive oil.

If 25 gallons of ordinary distilled water be very slowly evaporated at considerably below the boiling point, at the end of several weeks the little platinum dish last used, will be found covered with a film of a most offensive oil, and if this film of oil is re-dissolved in 25 gallons of good drinking water, it will give it the unpleasant taste noticeable in the distilled water from which it was extracted as above.

The above film of oil results from as follows:—

The impure water to be distilled is evaporated in boilers, and the organic matter in such water coming in contact with the heated surfaces of the boiler is decomposed, thus creating a minute quantity of volatile oil, which mixes with the steam and is condensed therewith.

In our apparatus the distilled water, after being properly aerated, is passed through a large mass of prepared animal charcoal, which, without being acted upon itself, has the property of inducing some of oxygen dissolved in the water to oxydize the abovenamed offensive oil, so as to in effect burn it; the product of such oxydation being a minute quantity of water, and carbonic acid gas, and the consequence is, that the distilled water ultimately produced is purified from the above oil, and rendered *quite tasteless* and agreeable to drink as well as wholesome.

The reason why distilled water on board ship is often not palatable is, that the condensers are worked with *greasy* steam, which is good for driving the engines, but unsuitable for condensing into drinking water; but it is sometimes collected *separately* for washing with our improved for steamers such steam is sometimes so greasy that I have known pipes in our condensers more or less obstructed with a black fatty substance and the filter rendered impervious to water from the same cause. Sometimes this greasy steam yields an oil more or less volatile, and catches fire in the filter if a light is introduced.

With reference to the existing boilers, they are not large enough for distilling, and even if they were, they would not be suitable for obtaining good results as to quality of water and economy of fuel.

We should recommend working the proposed distilling machinery night and day, as they do at Aden, partly because it economises fuel, but principally because it saves 50 per cent of the price of the distilling machinery, as less powerful machinery is then sufficient.

There would be no difficulty in arranging for our boilers to burn wood instead of coal.

We therefore beg to submit the following estimates for consideration:—

No. 1 Estimate.—Two complete sets of Normandy's improved patent treble distilling machinery as supplied for Aden, producing together 12,000 gallons of good, cold, drinking water per 24 hours, with a consumption of 3 tons of coal, or 12 tons of wood (assuming 4 of wood equal 1 of coal as in Colonel Mullins' letter) price packed and delivered in London, £1,302.

No. 2 Estimate.—One complete set as above to produce 9,000 gallons per 24 hours, with 2·15 tons of coal or 8·6 tons of wood, price packed and delivered in London, £3,052.

No. 3 Estimate.—One complete set as above to produce 12,000 gallons per 24 hours, with 2·67 tons of coal or 10·7 tons of wood, price packed and delivered in London, £4,046.

In above estimates each complete set of apparatus includes distilling *condenser* and filter, steam boiler with iron chimneys, steam pumps for circulating water, and for forcing the distilled water produced wherever desired, and all connecting parts in between so that the whole may be readily erected abroad, also suction and delivery pipes and spare stores, all as described at length in annexed printed estimate form dated this day.

P.S.—In case some other size or kind of our apparatus should be preferred, we send herewith our No. 1 condenser list, giving particulars of all the sizes and kinds we make.

You will observe we only estimate for *treble* distilling arrangements, as the saving in fuel they effect soon repays their extra first cost as compared with the single and double distilling arrangements also described in our No. 1 condenser list herewith.

From A. NORMANDY, Esq., for Normandy's Patent Marine Aerated Fresh Water Company (Limited), to General Hyde, India Office, Westminster, S.W., dated Custom House Station, Victoria Dock, London, 1st March 1884.

In reply to your letter of the 29th ultimo, as the prepared animal charcoal is not acted upon itself, but acts as explained in paragraph 7 of our letter of the 21st ultimo, it does not require renewing for very many years.

2. What does occur is as follows:—When the machinery is first started, more or less rusty water is produced for a few minutes; this should be run off so as not to pass into the filter. A little rust, however, always finds its way in, and in the course of about a year may accumulate in the upper half-inch thick layer of charcoal; this should then be scraped off, and thrown away, and the rest of the charcoal should be removed from the filter to lighten it (it is apt to become dense by the constant flow of water through it); it is then simply replaced in the filter.

From the Commissary-General, to the Inspector-General of Railway Stores, India Office, Westminster, S.W., dated Bombay, 28th August 1883, No. E-25-5554.

With reference to your letter of 3rd instant, I have the honor to inform you that the two new condensers were tried at Aden in June last with the following results:—

The 6,000 gallons condenser was worked for 24 hours and the water produced during that period was 7,082 gallons with the expenditure of 1¼ tons of coal, which gives an outturn of 21 lb. of water to every pound of coal consumed.

The 9,000 gallons condenser was worked for 24 hours and the water produced during that period was 12,110 gallons with the expenditure of 2 tons 11 cwts. of coal, which also gives 21 lb. 3 ozs. of water to every pound of coal consumed.

2. I beg to append a copy of the statement showing the results of the working of these new condensers contrasted with those hitherto in use, and those of private companies, from which it will be observed that the result is very satisfactory.

CONTRACTED Statement of Water produced by the new and present Condensers belonging to Government and those of private Companies at Aden.

Particulars.	New Condensers.	Present Condensers on Flat Hydraulic.	Messrs. Lieb, Thomas and Co.'s Condensers.	Aden Water Co.'s Condensers.	Remarks.
Average outturn of water per 1 lb. of coal consumed	lb. 16	lb. 9	lb. 8	lb. 12	The outturn of water produced by the new condensers on the first trial was found to be 21 lb. of water per lb. of coal consumed, but this cannot be taken as an average of their outturn in future when worked continually; so the average outturn is taken at 16 lb. of water per lb. of coal consumed.
Taking the daily consumption of coal for each condenser at 3 tons, 18 cwts. or 6,496 lb. will produce	lb. 103,936	lb. 58,464	lb. 51,968	lb. 77,952	
At 10 lb. per gallon	10,393	5,846	5,196	7,795	
Difference in production of new and old condensers per day	..	4,547	5,197	2,598	
Profit to Government in using new condensers, per day	..	4,547	5,197	2,598	
Profit to Government in using new condensers, per month, taking 26 working days	.. gallons. 118,222	..	135,122	67,548	
Cost at Rs. 1-12-0 per 100 gallons	.. 2,066-14-2	..	$2,364-10-2	1,182-1-5	

N.B.—This is to be seen that the profit to Government per month in using the new condensers is Rs. 2,066-14-2 as compared with Messrs. Lieb, Thomas and Company's condensers, Rs. 2,364-10-2, and with the Aden Water Company, Rs. 1,182-1-5.

COMMISSARIAT OFFICE, ADEN,
31st July 1883.

Lieut.-Colonel,
Acting Commissary-General.

1473

APPENDIX No. 26-A.

STANDARDS of Impurity of Water.

——		Pure and wholesome water yields on analysis figures which do not exceed the following limits.	Usable water gives figures which do not exceed the following limits.	Suspicious water gives figures which do not exceed the following limits.	Bad water gives figures which exceed the following limits.
Total solids ..	Grms. per litre	0·114	0·428	0·714	0·714
Volatile solids ..	Do.	0·014	0·043	0·071	0·071
Chlorine ..	Do.	0·014	0·043	0·086	0·086
Total hardness ..	Clark's scale	..	..	..	..
Permanent hardness	Do.	2°	4°	6°	6°
Free ammonia ..	Migrms. per litre ..	0·02	0·05	0·1	0·1
Albuminoid ammonia	Do. ..	0·08	0·1	0·15	0·15
Nitric acid ..	Do. ..	..	..	..	..

APPENDIX No. 26-B.

ANALYSIS of Samples of Water received from the Engineer in charge of Ulsoor Water Works with his letter, dated 9th May 1883.

——		Sample of water taken direct from the Ulsoor tank.	Sample of water taken direct after passing through the filter bed.	Sample of water taken direct from the dhobies' wells.
		1	2	3
Total solids ..	Grms. per litre	0·27		
Volatile solids ..	Do.	0·12	0·26	0·23
Chlorine ..	Do.	0·081	0·06	0·09
Total hardness ..	Clark's scale	2°·4	0·078	0·053
Permanent hardness ..	Do.	0·4	1°·75	3°·15
Free ammonia ..	Migrms. per litre	2·45	0·45	0·08
Albuminoid ammonia	Do.	0·4	0·45	0·8
Nitric acid ..	Do.	2·6	3·0	2·3
Apparent quality of the water as inferred from the results obtained on examination.		Bad.	Bad.	Bad.

REMARKS—No. 1. Deposit abundant and composed of vegetable debris.
" 2. Deposit scanty and composed of vegetable debris and argillaceous matter.
" 3. Deposit scanty and composed of vegetable debris.
All three samples contain a very large amount of organic impurity.

(True Copy.)

MADRAS,
24th May 1883.

(Signed) T. K. ROGERS, M.B., F.R.C.S.,
Chemical Examiner.

APPENDIX No. 26-C.

N.B.—Nos. 1 to 4 from below Bund of New (Ooparhalli) Reservoir.

——		No. 1. Spring water below Sippers' well.	No. 2. Dhobies' well.	No. 3. Sippers' well.	No. 4. Spring directly below bund in centre of valley.	No. 5. Miller's No. 4. Reservoir
Total solids ..	Grms. per litre ..	0·2	0·14	0·19	0·22	0·24
Volatile solids ..	Do. ..	0·11	0·08	0·08	0·10	0·08
Chlorine ..	Do. ..	0·028	0·22	0·21	0·019	0·029
Total hardness ..	Clark's scale ..	5°·26	2°·45	1°·75	7°·7	2°·45
Permanent hardness	Do. ..	2°·4	1°·75	1°·05	1°·4	1°·75
Free ammonia ..	Migrms. per litre ..	0·16	0·08	0·05	0·88	0·2
Albuminoid ammonia	Do. ..	0·120	0·292	0·16	0·24	0·4
Nitric acid ..	Migrms. per litre (as ammonia) ..	1·920	1·050	1·8	2·4	2·1
Apparent quality of the samples as inferred from the results obtained on examination.		Usable.	Bad.	Usable.	Bad.	Usable.

These waters have been previously analysed and the results reported to the office docket, No. 1026, dated 12th June 1883, addressed to the Deputy Assistant Quartermaster-General, Bangalore, from whom the samples appeared to have been received.

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Comparative Statement of Water produced by the new and present Condensers belonging to Government and those of private Companies at Aden.

Particulars.	New Condensers.	Present Condensers on Flat Hydershed.	Messrs. Lake, Thomas and Co.'s Condensers.	Aden Water Co.'s Condensers.	Remarks.
Average outturn of water per 1 lb. of coal consumed .. .. lb.	16	9	8	12	The outturn of water produced by the new condensers on the first trial was found to be 21 lb. of water per lb. of coal consumed, but this cannot be taken as an average of their outturn in future when worked continually; so the average outturn is taken at 16 lb. of water per lb. of coal consumed.
Taking the daily consumption of coal for each condenser at 2 tons, 15 cwts. or 6,496 lb. will produce .. .. lb.	103,936	58,464	51,968	77,952	
At 11 lb. per gallon .. .. lb.	10,393	5,846	5,196	7,795	
Difference in production of new and old condensers ..	..	4,547	5,197	2,598	
Profit to Government in using new condensers, per day .. .. gallons.	..	4,547	5,197	2,598	
Profit to Government in using new condensers, per month, taking 26 working days .. gallons.	..	118,222	135,122	67,548	
Cost at Rs. 1-12-0 per 100 gallons ..	..	2,066-14-2	2,364-10-2	1,182-1-5	

N.B.—Thus it will be seen that the profit to Government per month in using the new condensers as compared with the present condensers on Flat Hydershed is Rs. 2,066-14-2 as compared with Messrs. Lake, Thomas and Company's condensers, Rs. 2,364-10-2, and with the Aden Water Company, Rs. 1,182-1-5.

Government Offices, Aden,
31st July 1883.

Lieut.-Colonel,
Acting Commissary-General.

1473

APPENDIX No. 26-A.

STANDARDS of Impurity of Water.

	Pure and wholesome water yields an analysis figures which do not exceed the following limits.	Usable water gives figures which do not exceed the following limits.	Suspicious water gives figures which do not exceed the following limits.	Bad water gives figures which exceed the following limits.
Total solids .. .. Grms. per litre	0·114	0·425	0·714	0·714
Volatile solids .. .. Do.	0·014	0·013	0·071	0·071
Chlorine .. .. Do.	0·014	0·043	0·086	0·086
Total hardness .. .. Clark's scale	2°	4°	6°	6°
Permanent hardness .. .. Do.	..	..	..	..
Free ammonia .. .. Mgrms. per litre ..	0·02	0·05	0·1	0·1
Albuminoid ammonia .. Do.	0·08	0·1	0·15	0·15
Nitric acid .. .. Do.	..	..	..	..

APPENDIX No. 26-B.

RESULTS of Samples of Water received from the Engineer in charge of Ulsoor Water Works with his letter, dated 9th May 1883.

	Sample of water taken direct from the Ulsoor tank.	Sample of water taken direct after passing through the filter bed.	Sample of water taken direct from the Shoppers' well.
	1	2	3
Total solids .. .. Grms. per litre	0·27	0·24	0·23
Volatile solids .. .. Do.	0·12	0·06	0·09
Chlorine .. .. Do.	0·081	0·078	0·033
Total hardness .. .. Clark's scale	3°·5	3°·5	2°·66
Permanent hardness .. .. Do.	2°·45	1°·75	2°·15
Free ammonia .. .. Mgrms. per litre ..	0·1	0·43	0·08
Albuminoid ammonia .. Do.	0·56	0·48	0·8
Nitric acid .. .. Do.	3·0	3·0	2·3
Apparent quality of the water as inferred from the results obtained on examination.	Bad.	Bad.	Bad.

REMARKS.—No. 1. Deposit abundant and composed of vegetable debris.
" 2. Deposit scanty and composed of vegetable debris and argillaceous matter.
" 3. Deposit scanty and composed of vegetable debris.
All three samples contain a very large amount of organic impurity.

MADRAS,
24th May 1883.

(True Copy.)
(Signed) T. K. ROGERS, M.B., F.R.C.S.,
Chemical Examiner.

APPENDIX No. 26-C.

N.B.—Nos. 1 to 4 from below Band of New (Ooparhalli) Reservoir.

	No. 1. Spring water below Shoppers' well.	No. 2. Dhobies' well.	No. 3. Shoppers' well.	No. 4. Spring directly below bund in centre of valley.	No. 5. Miller's No. 4, Reservoir
Total solids .. Grms. per litre ..	0·3	0·15	0·19	0·21	0·21
Volatile solids .. Do. ..	0·11	0·05	0·05	0·19	0·08
Chlorine .. Do. ..	0·028	0·22	0·03	0·019	0·029
Total hardness .. Clark's scale ..	9°·66	2°·45	2°·11	7°·7	2°·15
Permanent hardness .. Do. ..	7·5	1°·75	1°·75	1°·4	1°·75
Free ammonia .. Mgrms. per litre ..	0·16	0·08	0·08	0·08	0·2
Albuminoid ammonia .. Do. ..	0·120	0·09	0·16	0·24	0·4
Nitric acid .. Mgrms. per litre (at ammonia) ..	1·969	1·956	1·8	24	2·1
Apparent quality of the samples as inferred from the results obtained on examination.	Usable.	Bad.	Usable.	Bad.	Usable.

These waters have been previously analysed and the results reported in the office docket, No. 1038, dated 13th June 1882, addressed to the Deputy Assistant Quartermaster-General, Bangalore, from whom the samples appeared to have been received.

APPENDIX No. 26-D.

			Agram tank water.
Totals solids			
Volatile solids	Grms. per litre		0·25
Chlorine	Do.		0·10
Total hardness	Do.		0·043
Permanent hardness	Clark's scale		4°·2
Free ammonia	Do.		1°·75
Albuminoid ammonia	Milgrms. per litre		0·12
Nitric acid	Do.		0·16
	Do. (as ammonia)		3·0

Apparent quality of the water as inferred from the results obtained on examination.—Usable.

REMARKS.—An abundant deposit, composed chiefly of vegetable debris.

APPENDIX No. 26-E.

		Agram tank water.	Well water N.W. of Agram tank wat.
Total solids			
Volatile solids	Grms. per litre	0·25	0·78
Chlorine	Do.	0·10	0·32
Total hardness	Clark's scale	0·043	0·284
Permanent hardness	Do.	4°·55	19°·25
Free ammonia	Milgrms. per litre	1°·4	14°·0
Albuminoid ammonia	Do.	0·036	0·04
Nitric acid	Do. (as ammonia)	0·16	0·12
		3·0	4·8
Apparent quality of the water as inferred from the results obtained on examination.		Usable.	Bad.

REMARKS.—Both samples gave an abundant deposit chiefly composed of vegetable debris.

APPENDIX No. 26-F.

ANALYSES of Water in accordance with Deputy Surgeon-General's Memorandum, No. 930-E. of 14th March 1884.

Source and date of supply.	Physical character.	Qualitative tests. Nitrates with sulphuric acid	Nitrites with sulphuric acid	Sulphuric acid	Hardness, Clark's scale. Total degrees	Fixed.	Total solids in water.	Chlorine, grs. per gallon.	Remarks.
No. 2 well water to south of Cavalry Hospital, 13th March 1884.	A transparent water without sediment, taste or smell.	Nil.	Nil.	Nil.	7°·80	4·4	4	1·24	Usable water
Well side of Agram tank. No. 1 well water, 13th March 1884.	Do. do.	Nil.	Nil.	3 grains.	17°·95	16·5	2·50	29·26	According to the extent of present analysis these waters come under the hygienic sub-division of "impure."
No. 2 do. do.	Slight sediment.	Nil.	Nil.	½ do.	11°·20	8·2	1·6	6·04	
No. 3 do. do.	No do.	Nil.	Nil.	Traces.	10°·85	6·9	1·4	4·06	
No. 4 do. do.	No do.	Nil.	Nil.	Nil.	9°·80	6·2	1·	4·21	

BANGALORE,
17th March 1884.

(Signed) H. J. McLAUGHLIN, M.B.,
Surgeon, A.M.D.

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APPENDIX No. 26-G.

QUALITATIVE Analysis of Water.

Source and date of supply.	Physical characters.	Chlorides	Nitrates	Nitrites	Ammonia	Sulphates	Oxidisable matter by gold chloride.	Remarks.
No. I. Pool water under Agram tank, 26th March 1884.	A turbid water, colourless.	Slight.	Nil.	Nil.	Nil.	Nil.	Nil.	Apparently a pure water.
No. II. Pool water near sugar field under Agram tank, 26th March 1884.	Turbid, yellowish, probably from suspended clay. Sediment of clay.	Slight.	Nil.	Nil.	Nil.	Nil.	Nil.	Apparently a good water after filtration.

BANGALORE,
27th March 1884.

(Signed) H. J. McLAUGHLIN, M.B.,
Surgeon, A.M.D.

APPENDIX No. 27.

EXPLANATORY Memorandum regarding the Levels connected with Bangalore Water-supply *Investigations.*

There are at Bangalore three sets of levels referred to mean sea level, the one based upon the Madras Railway levels and their connection with De Havilland's bench-mark at Fort St. George; the second on the G.T.S. levels brought up from Karwar on the west coast, while the third were determined trigonometrically from Madras. The first and third each need an addition of 1 foot for the corrected level of De Havilland's bench-mark.

Apart from this the Madras Railway levels were said to be 8·06, and the trigonometrical determined levels 4·40 higher than the spirit levelling from Karwar. The revised differences would be 9·06 and 5·40, respectively. On sheet No. 42 of the topographical survey, issued in 1881, the difference between the G.T.S. spirit levelling from Karwar and the trigonometrical determination is shown to be 4·74, which would apparently be raised to 5·74 by the correction of De Havilland's bench-mark.

Memorandum of G.T.S. bench-marks, copy appended.

2. The value of the crest of the waste weir of the Halsur lower tank has been taken to be 2,929·97 above mean sea level at Karwar, as noted on a survey of the upper tank, dated 22nd November 1880, and signed F. J. Remilly, Lieutenant, R.E., Assistant Engineer. That this value is referred to Karwar is indicated by a list* of levels, dated 27th June 1879, by Overseer Patten, the reduction of which to that datum is given and afterwards the above value for the waste weir. That it is about right has been proved by the connections made with the G.T.S. B.M. on the step of the gunta at Subadar's chattram, the value of which is 2,996·29. As the Halsur waste weir crest is irregular, it has been thought best to take the zero of the gauge opposite the engine-house as F.T.L. corresponding to the reduced level 2,929·97 above mentioned, and a B.M. 11·95 feet above that zero has been cut on the offset at base of the south wall of the engine-house. The value of this B.M. is therefore 2,941·92.

* Office records, Executive Engineer, Presidency Division.

3. The waste weirs of the Bangalore water-supply reservoir (Ooparhalli) are nominally 104·00 feet above the Halsur tank weir. The west weir is slightly (0·10) the higher of the two. Their values as deduced from connection with the Subadar's chattram G.T.S. bench-mark, and by adding 104 to the Halsur waste weir value, are 2,929·97 + 104·00 = 3,033·97.

2,956·29 + 37·65 = 3,033·94 west weir.
2,996·29 + 37·45 = 3,033·74 east do.

4. The following levels have been taken by Mr. Simmons, Surveyor, and will be found in the same order in his level book, which is indexed: —

1. Levels to, and a contour of, a small hill S. by W. of Subadar's chattram; not checked.
2. Levels from the east waste weir of the Bangalore water-supply (Ooparhalli) reservoir to 6¾ miles on the Yelabanka road.
3. Levels from the above point to and round the hill to the west.
4. Levels from same point to Yelabanka tank.
5. Levels from a point, ⊙123 of the contour in No. 3, to and round Bettahalli hill.
6. Levels from a point, ⊙47 on this contour in No. 5, to Subadar's chattram.

With regard to the series of levels Nos. 2 to 6, the first point made was the mantapam on the hill to the north of the weir. There is a recorded G.T.S. value 3,116·90 for the floor, but no B.M. being distinguishable, it is uncertain whether Mr. Simmon's levels are to the same point.

His value is 3,117·65 or just 0·75 difference. At the Yelalanka tank the topographical survey shows a value 2,946, but no B.M. could be traced. These values are shown, by a footnote on the survey, to require a reduction of 4·74 feet to refer them to M.S.L. Karwar. Consequently the reduced value would be 2,935·26. Mr. Simmon's level of the waste weir at the south end of the tank is 2,939·75.

On closing at Subadar's chattram the apparent error was 4·37 feet, which is reduced by the corrected level of the reservoir east weir, his starting point, to 4·14.

For the purpose for which the levels were taken, viz., to see what ground, on a sufficiently high level to drain into the reservoir, could be found, they are sufficiently accurate. There are two field books connected with Mr. Simmon's levels.

5. The rest of the levelling work has been done by Mr. Andrews, surveyor. The levels are in two books and the surveys therewith connected in three field books. The following is the order in which the levels are recorded in the books:—

Book A—

1. Levels from Miller's tank No. 1 to Halsur (lower) tank weir.
2. Levels between Halsur (lower) tank weir and the B.M. on rock engine-house; between this last and the zero of tank gauge, and between the latter and crest of upper tank weir.
3. Levels from Halsur lower tank for a supply channel to the eastward with check levels between third and fifth milestones of road.
4. Levels from the end of contour for channel up water-shed northwards, and then along water-shed westwards to junction with eastern water-shed of Halsur tanks.
5. Levels along northern water-shed of Halsur tanks.
6. Levels of Miller's tanks Nos. 1 to 4.
7. Levels from South Station Hospital along water-course to southward, on water-shed of the valley, and to Agram tank waste weir.
8. Levels across the greater bends of the contour for eastern supply channel—Halsur tank.
9. Contour levels of the Agram tank, with levels of walls for house thereto.
10. Levels from Sulebele tank chattram northward along the water-shed between the Pinakini and Arkavatti rivers.

Book B—

11. Continuation of do.
12. Levels from Meiekote tank to a B.M. on the above, No. 11.
13. Check levels from Agram tank to the B.M. on South Station Hospital.
14. Cross sections of Agram tank bund.
15. Check levels from South Station Hospital to Halsur tank and back to hospital.
16. Check levels from B.M. at Subadar's chattram to west and east waste weirs of the Ooparhalli reservoir, and thence to P.W.D. B.M., 10, opposite railway station.

6. The levels of the first set are wrong. They make the weir of Miller's No. 1 tank to be 60·58 feet above the Halsur lower tank weir, and by set 6 the level of the former weir is 27·31 feet below the Public Works Department bench-mark, 10, opposite the cantonment railway station. The resulting reduced value would be 92·89 + (2929·97 — 0·09) = 90·69 + 2929·80 = 3020·77

Too G.T.S. value of the B.M., 10, Public Works Department, is .. .. .. 3021·30

Difference .. 0·47

In the Mysore Public Works office the value of Miller's No. 1 tank weir is 63·21 + 2929·97, to which adding 27·31 the Public Works Department B.M., 10, would be 3020·49, or 0·81 lower than the G.T.S. value.

It may therefore be concluded that Miller's No. 1 tank weir is 3021·30 — 27·31 = say, 2994·00, and that No. 1 set of levels is valueless.

In the levels, set 16, which connect the G.T.S. bench-mark at Subadar's chattram with the weirs of the new (Ooparhalli) reservoir and the Public Works Department B.M., 10, the value of the latter is shown as 3020·68, or 0·62 lower than the G.T.S. value of this B.M. This confirms the general correctness of the levels. The levels of the weirs have already been referred to in paragraph 3 above.

7. No. 2 set needs no explanation.

The value of the zero of the Halsur lower tank gauge is .. .. 2930·97

and that of the B.M. on the rock engine-house .. .. 2941·93

8. The levels of No. 3 set have been checked in two ways — first by a line between the third and fifth milestones of the road and, secondly, by a junction line along the east water-shed of the Halsur tanks to the upper tank weir.

The channel contour levels to B.M. on the fifth milestone made the value of the latter .. .. 2948·18

the check levels do. .. .. .. 2948·73

a difference of 0·55 feet, which in nearly 9 miles is unimportant.

The continuation to Halsur upper tank weir showed a difference of only—0·16 feet, the start being from the higher value of the fifth milestone above given. The fourth set are included in the above.

9. In the fifth set the levels ended at the mantapam near the G.T.S. base line station (No. 3, page 34) with a value of .. .. 2939·74

of R.L. .. .. 3118·71

The G.T.S. value of the floor of the mantapam is .. .. 3119·95

Difference .. 1·24

There is no G.T. bench-mark discoverable on the floor, so it is doubtful whether the levels are to the same point. The error if it be as shown is not of importance, as all the material levels have been determined.

10. The sixth set of levels are not needed in connection with any of the proposals for the supply of Bangalore.

The weir of Miller's No. 1 tank is as before mentioned .. .. 2994·00

.. .. 2 tank .. .. 2991·93

.. .. 3 tank .. .. No weir.

.. .. 4 tank (lowest) .. .. 2975·59

11. The seventh set of levels makes the difference between the B.M. on the south corner of cavalry part of South Station Hospital and the waste weir of Agram tank 77·13 feet.

The check levels, set 15, make this difference 77·30 feet.

The return levels, from the B.M. on rock engine-house, make the difference 20·51 feet.

The B.M. on South Station Hospital was originally taken, by mistake, to be at Lieutenant Romilly's value for the floor of the hospital on which, however, it is not situated, but is 0·95 feet above the floor.

The reduced value of the B.M. on the hospital is now taken to be 2950·48, and this raises the value of the Agram tank weir to 2873·35. Lieutenant Romilly's levels for this hospital floor appear to be wrong by (2950·48 — 0·95) — (30·38 — 11·50 + 2929·97) = 2949·53 — 2948·85 = 0·67, but the particular part of the floor referred to in his section is not known.

12. The levels, set 8, deal only with a detail, and in laying out the channel the alignment would be made as desired.

13. The levels of set 9 have not been connected or checked. The orders were to contour the tank and connect the two ends by levels along the bund. The water in the tank was but little below full tank level, as the levels were taken on the 4th February, and on the 29th January the water was 0·20 below full tank level, which is taken at 0·10 feet above the lowest part of the crest of the weir, which latter is higher at the ends than in the middle.

14. *Levels, sets* 10 *and* 11.—The levels along the water-shed to Nandidrug, southern spur, have not been checked. There are many levels along this line shown on the topographical survey, and as Mr. Andrews took levels to many stone bearing numbers it was hoped that these were the stones to which the levels shown on the survey referred.

As far as can be ascertained Mr. Andrews' levels have no connection with any of the topographical levels shown against a *C*, and in only two cases has it been possible to find the latter levels placed against a dot has a connection been made.

These latter are B.Ms. by stone numbered.

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and it will be seen that the difference is *plus* in the one case and *minus* in the other. The two sets of levels should probably differ by 4·74 feet — *vide* note at foot of sheet 42 of the survey.

If the idea of bringing water from Nandidrug should be entertained, check levels will be essential, and there are numerous B.Ms. which will admit of check being effected mile by mile.

MEMORANDUM of G.T. Survey bench-marks at or near Bangalore as determined by spirit levelling brought from approximate sea level * at Karwar (North Canara) in 1875 and previously.

	Height in feet above sea level.
1. Uyal-dinne Observatory, 25 yards north-west of the old mantapam about 2½ miles out, on the Nandidrug and Bellary roads; brass (⊙) mark 5 inches below the stone floor (see G.T.S. of India, spirit levelled heights, No. 2 S.G.)	3113·26
2. Plinth outside doorway of above, north side, about ground level. Notes.—The lower (⊙) mark defining the S.W. end of the Bangalore base line (measured in 1868) is 5 feet plumb below this ..	3113·63
3. Floor of the mantapam on top of the mound	3116·9
4. Lowest step at base of the Chief Commissioner's flag-staff (350 yards N.N.W. of public offices) about ground level. (A new flag-staff has been set up since)	3042
5. St. Andrew's Church, top step at central entrance under the tower (which is 80 feet high)	3006·42
6. Cistern of barometer 2·8 feet above floor of meteorological room at the (Bowring) Civil Hospital	2982·9
7. Flooring of the covered well under the new market clock tower of 1863 in the cantonment bazaar (just outside the parapet wall)	2955·5
8. Public Works Department bench-mark No. 10 $\left(\frac{\text{E.W.}}{\text{15}}\right)$ at the (cantonment) railway station, across the road and opposite the Central or booking office	3021·3
9. Madras Railway B.M. on coping stone at east end of south or arrival platform (cantonment station)	3023·91

*Mean sea level at Karwar was determined by 3 years of observations, but is still called "approximate," until the results obtained from the record of a self-registering tide gauge have been reduced. It is probably within a few inches of the true value.

(Initialled) J. F. W.

NOTE.—The Madras Railway levelled lights of this last point, as derived by spirit levelling from the G.T.S. B.M. on flush at N. gate of Fort St. George, Madras (using Colonel De Havilland's value of mean sea level, as 30·48 feet or 9·29 feet higher than above given.

The G.T. Survey preliminary trigonometrical values are 4·6 feet greater than the spirit levelled heights given above.

(Signed) B. R. BRANFILL, Lt.-Col.,
Dy. Supt., Survey of India, in charge
Madras Party.

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PUBLIC WORKS DEPARTMENT.

Buildings and Roads.
Military Works.

LETTER—from

COLONEL J. SHAW-STEWART, R.E.,

Secretary to the Government of Madras,

Public Works Department,

To

THE RESIDENT IN MYSORE.

SIR,

Adverting to my letter, No. 2705 W., dated 5th October 1883, I am directed to forward, for the information of the Government of His Highness the Maharajah of Mysore, the accompanying copy of proceedings of Government, No. 1473 W., dated 13th June 1884, with which is recorded Colonel Mullins' report on the question of water-supply to Bangalore, and to request that all needful assistance may be rendered to the officer who has been intrusted with the duty of working out the project which it has been decided to adopt.

I have the honor to be,

Sir,

Your most obedient servant,

Major, R.E.,
Under Secy. to Govt., P.W.D.

OOTACAMUND,
13th June 1884.

Fad. E. Fernandes
Spare Copies

BUILDINGS AND ROADS.
MILITARY WORKS.

Govt. of 1884

PUBLIC WORKS.

Dated June, 13th.

Read.

Read.

13th June 1884, No. 1474 W.

JUNE.

Bangalore Water Supply

Copy of orders on Colonel J. Mullins' report on the — forwarded, with remarks, to the Resident in Mysore.

Proceedings of the Madras Government, Military Department,—
21st September 1872.

Military.
Public Works.

Read the following letter :—

No. 343. From the Officiating Secretary to the Government of India, Military Department, to the Officiating Secretary to Government, Military Department, Fort Saint George ; dated Fort William, 2nd September 1872, No. 33.

The Government of India having had under its consideration the report showing the results of the analysis of the water used for drinking purposes in the stations of the Madras Presidency noted in the margin,

Fortress of Saint Thomas' Mount. | Surgeon, Secunderabad. | Bangalore.

I am desired to communicate, for the information of His Excellency the Governor in Council, the following expression of the views of the Right Honorable the Governor General in Council on the subject.

2. In regard to the first four stations, no special remarks seem to be necessary. The report on the important station of Secunderabad does not appear to be so full as could be desired ; but the plan of pumping up water from wells, (which should of course be properly protected from all sources of pollution) and forcing it into tanks for use in different lines is, it is understood, now being carried out. The Governor General in Council deems it of great importance that the arrangements should, so far as possible, be such as to ensure the supply of good water both to the town and cantonment, with reserves sufficient to meet, for a time, any failure of the ordinary means of supply. (the wells and the Ulsoor tank) except under circumstances, which will be sufficient to remark, that neither of the existing sources, with the Ulsoor water when filtered may be reasonably a good water, and the surface impregnations of the area from the drainage of which it is collected may be, as Assistant Surgeon Nicholson states, small compared with what would be the case in the vicinity of most Indian towns, His Excellency in Council is the daily of opinion that this mode of collection is very objectionable ; as any ground selected for the collection of water for drinking or even other purposes should be quite clear, and sufficiently removed from human habitation to ensure its freedom from the impurities which cannot be avoided when any portion of an Indian town or of its immediate neighbourhood is included in the area.

4. I am further to point out that the examination of so many as 81 sources of supply at one place, (Bangalore) which apparently occupied nine months, appears to the Government of India to be excessive. When the measure was first proposed in 1865, the Sanitary Commission expressed its opinion that the object would be attained by the examination of four, or at most six, selected wells at each station occupied by British troops ; the exception being that, if any well appeared liable to pollution from the proximity of cesspools or any other cause, or the water from it was regarded as in any respect peculiar or of inferior quality, it was the subject of additional and special enquiry and analysis.

5. In conclusion, as the analysis of water in the Bengal Presidency has now ceased, I am to inquire when that in the Madras Presidency may be expected to terminate.

Ord, file

Proceedings of the Madras Government, Military Department,
21st September 1872.

No. 344. Order thereon, 21st September 1872, No. 3022.

Communicated to departments concerned, and the following letter despatched in reply to the inquiry in the concluding paragraph.

(Signed) A. C. SILVER, *Colonel,*
Offg. Secretary to Government.

Sanitary.
Pollution, Wells.

No. 345. From the Officiating Secretary to Government, Military Department, Madras, to the Officiating Secretary to the Government of India, Military Department; dated Ootacamund, 21st September 1872, No. 3023.

With reference to the concluding paragraph of your letter No. 32, dated 2nd September 1872, I am directed to state that the Government of India, in their letter as per margin, were pleased to allow the analysis of waters at military stations in the Madras Presidency to be continued up to the end of the current year, when, it is hoped, the examination will be completed.

From the Under-Secretary to Government of India, Department of Agriculture, Revenue and Commerce, (Revenue), to the Acting Secretary to Government, Fort Saint George, dated Simla, 1st June 1872, No. 826.

Engd. V. Ramaswamy.

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Proceedings of the Madras Government, Military Department,
5th November 1873.

Cantonments, Water supply.

Read the following letter:—

No. 64. From Colonel H. K. BURNE, Secretary to the Government of India, Military Department, to Colonel A. C. SILVER, Secretary to Government, Military Department, Madras; dated Simla, 13th October 1873, No. 380.

With reference to your letter No. 1336 of the 18th April 1873, and previous correspondence on the subject of the water supply at Bangalore, I am directed to invite the attention of the Right Honorable the Governor in Council to paragraph 3 of military department letter, No. 32 of the 2nd September 1872, urging the necessity of an improved scheme for gathering and distributing good water both to the town and cantonment.

2. I am to remark that this is the more necessary, as the Sanitary Commissioner with the Government of India still considers that the Ulsoor Tank is fed from a filthy gathering ground, and that the water must therefore be dangerous, while there is a strong objection to passing waters of inferior quality through the same pipes as good water, which the Dhobies' well water is supposed to be.

No. 65. Order thereon, 5th November 1873, No. 3667.

Communicated to departments concerned, with reference to Proceedings of Government, 21st September 1872, No. 3022, and in view to the subject receiving early consideration.

(Signed) A. C. SILVER, Colonel,
Secretary to Government.

Engd. J. R. Cuthbert.

Proceedings of the Madras Government, Military Department,
7th March 1874.

Read the following papers :—

No. 83. From Surgeon-Major W. R. CORNISH, F.R.C.S., Sanitary Commissioner for Madras, to Colonel A. C. SILVER, Secretary to Government, Military Department, Fort Saint George; dated Madras, 18th November 1873, No. 1938.

With reference to order of Government as per margin, I have the honor to refer to the concluding portion of my report for 1872, in which I have expressed an opinion in accordance with that of the Sanitary Commissioner with the Government of India, that the water from the Ulsoor tank is, from the nature of the gathering grounds and of the pollution it receives, not a fit source for the supply of a large population. The impurities washed into the tank from the tanneries are very considerable, and during my recent stay at Bangalore, I have had ample opportunities of observing the fact that a large amount of surface filth finds its way into the tank, after every storm of rain.

G. No. 3667, of 5th November 1873, (Military.)

2. The filtration of the Ulsoor water has also been very imperfect for some time past, the filter bed being out of order and the second filter under repair. In consultation with Dr. Massy, C.B., we lately came to the opinion that, with the increase of typhoid fever in the Artillery and Hussars, there should be no further admixture of partially filtered water from the tank with that from the Dhobies' wells.

3. The Dhobies' wells, I may add, have not been increased to the extent suggested in my letter, No. 607, of 2nd May 1871. They now yield from 25 to 30,000 gallons per diem, enough for the drinking and domestic use of the troops, but insufficient for the plunge baths and for the horses of the cavalry.

4. The growing requirements of the cantonment of Bangalore, have long since impressed upon me the need of securing a more satisfactory water service for the whole place. In 1872, I inspected, with Colonel Sankey, R.E., and other gentlemen, the proposed site of the gathering ground for a water-supply. Colonel Sankey has, I believe, had the whole land surveyed and levelled and has framed estimates of the cost of constructing the necessary works; and I have the honor to suggest that the Mysore Government be communicated with, in view to an arrangement being made for a water-supply scheme that shall provide not only for the civil but the military population.

5. If the Government desire, I shall be prepared to place myself in communication with Colonel Sankey, so that all the essential sanitary points to be borne in view in the preparation of plans and estimates may be duly discussed, before the scheme is again brought forward.

Referred, through His Excellency the Commander-in-Chief, to the Surgeon-General, British Medical Service, in continuation of Proceedings of Government, No. 3667, dated 5th November 1873.

25th November 1873.

No. 84. From Lieutenant-Colonel R. H. SANKEY, R.E., Secretary to the Chief Commissioner of Mysore, to Colonel G. W. WALKER, R.E., Secretary to Government, Public Works Department; dated Bangalore, 7th January 1874, No. 27.

With reference to the request contained in the accompanying letter, addressed to the Chief Engineer of Mysore by the District Engineer of Bangalore, asking,

under instructions of the Madras Government, for information as to the schemes that may be under consideration for an improved water-supply both for the town and cantonment of Bangalore, I have the honor, by desire of the Officiating Chief Commissioner, to state that the Government of India, in August 1870, sanctioned an estimate amounting to Rupees 5,69,257, for a project based on the general principles laid down in the accompanying printed memorandum by the Chief Engineer, dated 9th September 1868; and that Her Majesty's Secretary of State confirmed the sanction thus accorded, in a despatch of the 31st January 1871.

2. The general scope of the scheme, as set forth in the accompanying memorandum, is to collect from ground now lying waste, and at sufficient height to command the station, without the intervention of pumping, a supply, during years of minimum rainfall, of ten gallons per head for a population of 90,000, the present population including European and Native troops, &c., being, by the last census, a little over 80,000 souls.

3. Hitherto, I am to state, no progress has been made in the execution of the project, owing to the difficulty of finding the requisite funds from the ordinary budget grant; but hopes are entertained that ere long the Government of India may be disposed to treat the works as extraordinary.

Transferred to the Military Department, with reference to the orders in that department, No. 3667, dated 5th November 1873.

FORT SAINT GEORGE,
12th January 1874.

(Signed) G. W. WALKER, Col., R.E.,
Secretary to Government, P.W.D.

No. 85. From Colonel H. H. O'CONNELL, Officiating Quarter Master General, to Colonel A. C. SILVER, Secretary to Government, Military Department, Fort Saint George; dated Head Quarter, Camp near Bangalore, 29th January 1874, No. 103-759.

With reference to your memorandum, dated 16th instant, I have the honor, by order, to acquaint you that at the time of writing this office letter, No. 8852, dated 13th December 1873, His Excellency the Commander-in-Chief was aware of the scheme for the water-supply of Bangalore, mentioned in the printed memorandum of the Chief Engineer of Mysore, forwarded with Proceedings of Madras Government, No. 3794, dated 28th September 1868. That memorandum, however, merely gives a sketch of the scheme proposed by Colonel Sankey, without details or estimates; and it was under the impression that the Madras Government would be called upon to meet a portion of the expense to be incurred, that His Excellency recommended the assembly of a committee, in order that full information on the subject should be laid before Government.

2. If, however, no call is made on the Madras Government, for funds to carry out this project, His Excellency has no wish to press his recommendation for the assembly of a committee; but he trusts it may be understood that any new works for water-supply to Bangalore may be carried out so as to include the wants of the military cantonment, as well as that of the civil population, and he further suggests that, based on the Sanitary Commissioner's recommendation, the Madras Government press on the Supreme Government the early commencement of the work.

3. The present water-supply from the Dhobies' wells is excellent and, with the filtered Ulsoor tank water, sufficient, and the Commander-in-Chief wishes it to be understood that he strongly advocates the maintenance of these works and their improvement. But the plentiful supply of good water to troops is a matter of such great importance that Sir Frederick Paul Haines would be glad to see a second scheme carried out, which would place the supply beyond all possibility of failure.

4. This office letter, No. 8852, dated 13th December, has been withdrawn. That from the Surgeon General British Medical Service, No. 268, dated 9th December 1873, and the Sanitary Commissioner, No. 1938, dated 18th November 1873, are herewith re-transmitted.

Cantonments.
Water supply.

No. 86. From Colonel A. C. SILVER, Secretary to Government, Military Department, Madras, to Colonel H. K. BURNE, Secretary to the Government of India, Military Department; dated Fort Saint George, 7th March 1874, No. 776.

With reference to the correspondence marginally noted, I am directed to forward, for submission to the Right Honorable the Governor General in Council, the accompanying papers, from which it will be observed that the military, medical and sanitary authorities in this presidency attach the greatest importance to an ample supply of pure and wholesome water being provided for the civil and military population of Bangalore.

Letter from the Government of India, No. 380, dated 13th October 1873.
From the Sanitary Commissioner, Madras, No. 1938, dated 18th November 1873.
From the Secretary to the Chief Commissioner of Mysore, Public Works Dept., No. 27, dated 7th January 1874.
From the Quarter Master General, No. 103-759, dated 29th January 1874.

2. The Right Honorable the Governor in Council is, therefore, desirous of urging upon the Government of India, the advisability of setting on foot measures for the early adoption of Colonel Sankey's scheme, which appears to be well calculated to meet the requirements both of the town and cantonment.

3. I am also to request that His Excellency Sir Frederick Haines' recommendation, in respect to the maintenance and improvement of the works connected with the Dhobies' wells and Ulsoor tank, may receive the early and favorable consideration of the Right Honorable the Governor General in Council.

Encl. P. Ranganathum.

No. 766. Proceedings of the Madras Govt., Public Works Dept.

Furnishing a copy of the Memorandum on the water-supply of Bangalore by Major R. H. Sankey, Royal Engineers, Chief Engineer of Mysore. } Here enter 22nd Sept. 1868, No. 55.

No. 767. ORDER, No. 3794, 28th September 1868.

Communicated to the Commander-in-Chief, (Quarter Master General's Dept.)

(Signed) C. S. ELLIOT, Lieut.-Colonel,
Offg. Deputy Secretary to Government.

Engd. F. R. Bentleman.

Cantonments, Water Supply.

Read the following papers :—

No. 269. From Colonel H. K. BURNE, Secretary to the Government of India, Military Department, to Colonel A. C. SILVER, Secretary to Government, Military Department, Madras; dated Fort William, 22nd April 1874, No. 1116.

With reference to your letter, No. 776, dated the 7th March 1874, on the subject of the water-supply at Bangalore, I am directed to request that the Right Honorable the Governor in Council may be moved to inform the Government of India, in what respect the maintenance and improvement of the works connected with the Dhobies' wells and Ulsoor tank require further consideration, as it was believed that the final estimates for that project were sanctioned in April 1872.

2. In regard to Colonel Sankey's scheme, I am to state, the papers will be transferred to the Public Works Department for consideration, as the project is a civil work.

Referred to His Excellency the Commander-in-Chief, with advertence to paragraph 3 of the Quarter Master General's letter, No. 103-759, dated 29th January 1874.

29*th April* 1874.

No. 270. From Brigadier-General A. HOWLETT, C.B., Quarter Master General, to Colonel A. C. SILVER, Secretary to Government, Military Department; dated Head Quarters, Ootacamund, 7th May 1874, No. 44-3497.

In returning letter from the Secretary to the Government of India, Military Department, No. 1116, dated 22nd ultimo, I have the honor, by order, to observe that the inquiry therein put, "in what respect the maintenance and improvement of the Dhobies' wells and Ulsoor tank require further consideration," is not understood.

2. His Excellency the Commander-in-Chief is not of opinion that they require further consideration, but, as stated in paragraph 3 of this office letter, No. 103-759, dated 29th January 1874, thinks that the supply is excellent and that the works should be maintained and improved. The improvement being chiefly the substitution of a better and more powerful engine for the old one now working the pumps at the Dhobies' wells, and the maintenance of the two filters in thoroughly good working order, a point to which they have never yet been brought.

3. I am directed to observe that the question of an additional source of water supply for Bangalore did not originate with the Commander-in-Chief, but with other authorities.—See paragraph 3 of letter from the Secretary to the Government of India, Military Department, published in Order of Government, 21st September 1872, No. 3022, and letter from the same in Order of Government, 5th November 1873, No. 3667.

4. Whilst His Excellency considers the supply of water from the Dhobies' wells and Ulsoor tank sufficient for the Military at Bangaloro, he looks upon the question of good and abundant water supply of such importance that he cordially advocates the carrying out of the scheme urged by the Supreme Government upon the consideration of the Madras Government, in the extracts given below.

Letter from the Officiating Secretary to the Government of India, Military Department, to the Officiating Secretary to Government, Military Department, Fort Saint George; dated Fort William, 2nd September 1872, No. 32, paragraph 5.

"The Governor General in Council, trusts that a well devised plan for gathering and distributing good water both to the town and cantonment will soon be undertaken."

Letter from the Secretary to the Government of India, Military Department, to the Secretary to Government, Military Department, Madras; dated Simla, 15th October 1873, No. 380, paragraph 1.

"I am directed to invite the attention of the Right Honorable the Governor in Council to paragraph 3 of Military Department letter, No. 32 of the 2nd September 1872, urging the necessity of an improved scheme for gathering and distributing good water both to the town and cantonment."

No. 271. DOCKET, 21st May 1874, No. 1610.

Copy of the Quarter Master General's letter, forwarded to the Secretary to the Government of India, Military Department, for the information of the Right Honorable the Governor General in Council, in reply to Colonel Burne's letter, No. 1116, Cantonments Water Supply, dated 22nd April 1874.

(Signed) A. C. SILVER, Colonel,
Secretary to Government.

Encl. R. Stephenson.

Cantonments, Water Supply.

Read the following papers:—

No. 249. From Colonel J. CROFTON, R.E., Deputy Secretary to the Government of India, Public Works Department, (Civil Works Miscellaneous), to Colonel H. K. BURNE, Secretary to the Government of India, Military Department; dated Fort William, 16th June 1874, No. 263-M.

The undersigned is directed to inform the Military Department, with reference to its endorsement, No. 568 of the 10th instant, that extract paragraph 2 of Brigadier-General Howlett's letter, No. 44-3497, suggesting the substitution of a more powerful engine at the Dhobies' wells at Bangalore, and the maintenance of the two filters in good working order, has been forwarded to the Chief Commissioner of Mysore for necessary attention.

2. With reference to paragraph 4 of the Brigadier-General's letter, the undersigned is instructed to add that Colonel Sankey's scheme of water-supply for the station of Bangalore was sanctioned by the Supreme Government some years ago, and that arrangements have lately been made in communication with the Foreign Department, for the provision of the requisite funds to proceed with the work.

MILITARY DEPARTMENT, FORT WILLIAM, THE 30TH JUNE 1874.

No. 1646.

Copy of the above forwarded to the Secretary to Government, Fort Saint George, Military Department, with reference to his docket, No. 1610, dated 21st May 1874, for the information of His Excellency the Governor in Council.

(By order.)

(Signed) W. M. LEES, Lieut.-Colonel,
Asst. Secy. to the Govt. of India.

No. 250. ORDER THEREON, 15th July 1874, No. 2232.

Communicated to His Excellency the Commander-in-Chief and the Public Works Department.

(Signed) A. C. SILVER, Colonel,
Secretary to Government.

Encl. P. Parthasarathy.

Proceedings of the Madras Government, Military Department,
22nd July 1875.

Cantonments—Water Supply.

Read the following papers :—

No. 384. From Lieutenant-Colonel R. H. SANKEY, R.E., Secretary to the Chief Commissioner of Mysore, Public Works Department, to Colonel A. C. SILVER, Secretary to Government, Military Department, Madras; dated Bangalore, 19th July 1875, No. 1665.

Adverting to the Resolution of the Madras Government, No. 431, dated 15th February 1875, in the memorandum appended to which by the Under Secretary in the Department of Public Works, it is observed that the supply by the General Water-supply Scheme, now under execution by this administration, can hardly be depended on for the filling of the various cisterns for the troops in the new barracks, I have the honor, by desire of the Officiating Chief Commissioner, to append a statement by the Executive Officer in charge of the works, showing that there has been a misapprehension on the point, owing chiefly to the better command of level that it has been found practicable to secure, and to solicit the favor of the same being brought under the notice of His Excellency the Commander-in-Chief.

MEMORANDUM with reference to Major SCOTT'S report, dated 22nd January 1875, No. 424.

1. The Bangalore water-supply cistern at Post Office will have a water surface level of 88·00 feet, not 80·00 as stated by Major Scott.

2. The distance thence to the Parade-ground barracks is less than one mile, and to the Agram and Artillery barracks about two miles.

3. The average water-supply from Ulsoor is about 33,000 gallons per day. But taking the daily supply at 36,000 gallons, *viz.* 12,000 gallons to the Infantry barracks and 24,000 gallons to the Horse barracks—

4. And assuming the levels of cisterns as given by Major Scott to be correct, the head given by the Post Office cistern is :

Above European Infantry cistern	18·35	feet.
Above Agram cistern	44·50	„
Above Royal Horse Artillery cistern	46·74	„
General Hospital cistern	33·52	„
Female Hospital cistern	29·88	„

5. With these heads, the supply in paragraph 3 would be given by one 3½-inch pipe from the Post Office cistern to opposite the Infantry barracks, then by a two-inch pipe to the latter and 2½-inch pipe to Trinity Church, whence the requisite smaller pipes would branch off to the Cavalry and the Royal Horse Artillery barracks respectively. No stand-pipe would be necessary.

6. Hence, so far as levels are concerned, the Bangalore water-supply is abundantly sufficient to supply the troops.

7. The data assumed by Major Scott, *viz.*, a head of 16·8 feet per mile, and a pipe diameter of 6 inches, would give a supply of more than 200,000 gallons per day, delivered at 2½ miles from the Post Office cistern, *i. e.*, six times the requisite supply, and delivered at an assumed distance nearly 1½ times the actual mean distance.

BANGALORE,
16th July 1875.

(Signed) W. HENDERSON, Executive Engineer,
Bangalore Water Supply.

Proceedings of the Madras Government, Military Department,
22nd July 1875.

No. 385. ORDER THEREON, 22nd July 1875, No. 3470.

No. 332, dated 19th February 1875.
*Proc. of Govt., No. 431, dated 15th Feb. 1875.

Communicated to His Excellency the Commander-in-Chief, and the Public Works Department,* with reference to Proceedings of Government, marginally noted.

(Signed) A. C. SILVER, Colonel,
Secretary to Government.

To the Quartermaster-General; Public Works Department; Sanitary Commissioner, for information.

(True Extract.)

Secretary to Government.

Exd./. Raitt.

Proceedings of the Madras Government, Military Department,
25th August 1875.

Cantonments—Water-supply.

Read the following papers:—

No. 516. *Proceedings of the Madras Government, Public Works Department, dated 13th August* 1875, No. 111.

(*Proceedings in the Military Department, dated 22nd July* 1875, *No* 3470.)

Ordered that the accompanying memorandum by the Under-Secretary to Government be communicated to the Military Department, with reference to order in that department, No. 3470, dated 22nd July 1875.

(True Extract.)

(Signed) J. O. HASTED, Major, R.E.,
Offg. Joint Secy. to Govt.

MEMORANDUM.

The information I was able to obtain when I visited Bangalore in December last, relative to the command of the new reservoir for the town water-supply, was not very definite, and I was under the impression that the details of the scheme were not sufficiently settled to enable the officers concerned to give more than approximate levels. The arrangements proposed for distribution were understood to be something of the nature of a conduit from the impounding reservoir to a stand pipe placed in the vicinity of what is called the high ground and distant from the barracks 2½ miles on the average; the level of the pipe being about 80 feet above the general datum.

2. As now explained by Mr. Henderson, the Executive Engineer, the details differ in an important degree from those assumed above. There will be a distributing cistern or reservoir at the post office at a mean distance of 1½ miles from the barracks instead of 2½ miles, and the water level in the cistern will be 88 feet instead of 80 feet above the datum. These conditions are of course much more favorable as regards the question of supply to the barracks.

3. It was stated in my memorandum of the 22nd January last, that it would require a head of about 42 feet with a 6-inch pipe to deliver water at the assumed distance of 2½ miles with a moderate velocity; and it was argued that since such a head could not be obtained and was not approached at several of the barracks, dependence could hardly be placed on the source of supply in question. The Executive Engineer, in his memorandum under reference, takes exception to this, because the theoretical discharge under such conditions from the pipe would in 24 hours be six times the average daily supply required for the troops, delivered at a much greater distance than is really necessary.

4. The distance was assumed from information available at the time, and is of course subject to correction in accordance with matured details of the scheme; but, as regards the other assumptions, it is necessary to point out that there are other and important considerations besides that of the mere discharge within twenty-four hours of the daily supply required, which need to be kept in view, and that a minimum velocity of motion of the water in the pipes, irrespective of the discharge, may reasonably be considered a condition of satisfactory supply. It is an object to guard against incrustation or deposit in the pipes as well as stagnation and putrefaction of the water. The source from which the water is obtained in the present case can hardly be considered unexceptionable, although the only one available. It is a pond; it must necessarily be full of animal and vegetal organisms, filtration is, when artificial, almost always imperfect; the detention of such water in pipes destroys the life present in it, putrefaction ensues, the products are oxidised with difficulty owing to the absence of light and air, and they continue to be offensive and pernicious. It is desirable that such or indeed any water should be passed rapidly into the cisterns; that it should be speedily drawn off thence for use and as frequently renewed. There is good authority for the assertion that a velocity of 70 feet a minute is the lowe

which will in temperate climates prevent water in an open conduit from stagnating. In a pipe the conditions are more unfavorable, and, while corruption is in the temperate zone an affair of days, it is here one of a few hours. A minimum velocity of from 116 to 120 feet per minute may therefore for this and the other reasons given be required and was satisfied with the head and dimensions of pipe quoted.

5. That these were not fanciful assumptions has, I think, been very recently shown by occurrences at Madras. The water drawn from the Red Hill reservoir has been condemned by the Chemical Examiner to Government as non-potable. Its substitution in the Fort for water from the seven wells has been prohibited. It issues from the town pipes in a state of putrefaction. There is no doubt whatever that its low velocity and long detention in the supply channel and town pipes is the cause of this decomposition. The presence of a large amount of animal and vegetable life in the tank water and imperfect filtration completing the necessary conditions.

6. There is another reason why the dimensions of the pipes supplying the barracks should not be limited so as to require twenty-four hours to discharge the daily supply. The question has been mooted of doing away with the cisterns on account of the stagnation of the water in them, and obtaining supplies on the constant pressure system. This is impracticable with a steam engine and stand pipe, and if adopted by aid of the new water-supply scheme the supply pipes must be calculated to deliver the whole daily supply within four hours in order to meet the maximum draft on them which recurs at certain periods each day. Again, in the event of accident occurring to a cistern or repairs being necessary, it would be desirable to have the power of obtaining the maximum supply required by direct connection with the post office cistern. To meet both cases described the pipes should be capable of discharging somewhat more than 200,000 gallons in twenty-four hours.

7. If the above views are endorsed, it will apparently be necessary that the arrangements proposed by the Executive Engineer for the supply to the barracks should be revised, since, judging from the information given of the proposed discharges and diameters, the maximum velocity will in no case exceed 90 feet per minute, while it will in some be as low as 65 feet per minute (under 14″ per second). A six-inch pipe to the junction at the Infantry barracks and a five-inch pipe thence to Trinity Church or the neighbouring parade would (under the arrangements as to position of reservoir and command now made known) fulfil the two conditions of a velocity of 120 feet per minute and a discharge in four hours of the supply daily used.

OOTACAMUND,
16th August 1875.

(Signed) A. DEC. SCOTT, *Major, R.E.,*
Under Secy. to Govt., P. W. D.

No. 517. ORDER THEREON, 25th August 1875, No. 4120.

Communicated to His Excellency the Commander-in-Chief, the Sanitary Commissioner, and the Chief Commissioner of Mysore, with reference to *Proceedings* of Government, No. 3470, dated 22nd July 1875.

(Signed) A. C. SILVER, Colonel,
Secretary to Government.

To the Quartermaster-General; Sanitary Commissioner; Public Works Department.

No. 518. From Colonel A. C. SILVER, Secretary to Government, Military Department, Madras, to the Secretary to the Chief Commissioner of Mysore, Public Works Department; dated Ootacamund, 25th August 1875, No. 4121.

With reference to your letter, No. 1665, dated 19th July 1875, I am directed to forward, for the information of the Chief Commissioner of Mysore, the accompanying copy of the Proceedings of this Government, in which is recorded a

No. 4120, dated 25th August 1875.

memorandum by Major A. deC. Scott, Under Secretary to Government in the Public Works Department, relative to the water-supply scheme for the cantonment of Bangalore.

(True Extract.)

Secretary to Government.

Ext. R. C. Shenkar.

Cantonments—Water-supply.

Read the following papers :—

No. 508. From Lieutenant-Colonel R. H. SANKEY, R.E., Secretary to the Chief Commissioner of Mysore, Public Works Department, to Colonel A. C. SILVER, Secretary to Government, Military Department, Madras; dated Bangalore, 16th September 1875, No. 2128.

I have the honor, by desire, to acknowledge the receipt of your No. 4121, of the 25th ultimo, forwarding, for the information of the Chief Commissioner, copy of Madras Government Proceedings, No. 4120, of the same date, in which is recorded a memorandum by Major A. deC. Scott, relative to the water-supply scheme for the cantonment of Bangalore.

2. In reply, Mr. Dalyell directs me to transmit, for the information of the Madras Government, the accompanying copy of a memorandum by Colonel Sankey, R.E., on the subject referred to.

MEMORANDUM by Colonel R. H. SANKEY, R.E., on the subject of water-supply scheme of Bangalore, to accompany letter, No. 2128, dated 16th September 1875, to the Secretary to Government, Military Department, Madras.

In the present memorandum, Major Scott recognizes that the conditions under which water can be delivered from the works now under execution would be sufficiently favorable if a 6-inch diameter pipe were employed up to the junction at the Infantry Barracks, and a 5-inch pipe thence to Trinity Church and the Agrain Barracks.

2. The relative velocities in a 3½-inch and 6-inch pipe, respectively, would, I calculate, be 91·8 and 117·6 feet per minute, which are very nearly those given by Major Scott; and I should think that the Madras Government might, at option, adopt the larger diameter, though possibly not precisely on the grounds now urged, as I am myself unable to see how particles in motion remaining 12½ minutes longer in a 3½ inch than they would in a 6-inch pipe, the distance to be traversed being only a mile, can, under any circumstances, make the difference between pure and impure water. Bangalore, moreover, possesses a fairly temperate climate, and if, as urged, 70 feet a-minute is the lowest velocity which in such will prevent water from putrifying, the velocity—91¾ feet—attainable in a 3½-inch pipe, should, on this datum, suffice here.

3. These are, however, only matters of detail which can readily be disposed of hereafter.

4. The only other point in Major Scott's memorandum which it is necessary for me to advert to, is the observation that the source from which our water-supply is obtained "can hardly be considered unexceptionable, although the only one available."

5. As His Excellency the Commander-in-Chief only a few days since inspected the catchment area, and satisfied himself on this point, it may perhaps suffice for me to observe that I am not aware of any sources of contamination, as the only two villages within the limits are to be bought out, and neither manuring nor cultivation of the ground (which is an upland of singularly clean granite soil) is to be permitted in future.

6. The storage will be in a reservoir of considerable depth, and in all respects under the most favorable circumstances.

No. 509. ORDER THEREON, 30th September 1875, No. 4745.

Communicated to His Excellency the Commander-in-Chief, the Public Works Department, and the Sanitary Commissioner.

(Signed) A. C. SILVER, Colonel,
Secretary to Government.

To the Quartermaster-General; Public Works Department; Sanitary Commissioner.

(True Extract.)

Secretary to Government.

Encl. A. Raitt.

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1423

MEMORANDUM.

The Resident has forwarded to me a copy of a Memo prepared by Major Maltby on the question of Water Supply to the Civil and Military Station of Bangalore and read by him at a Special Meeting of the Municipal Commissioners held on the 7th April 1883. The Resident has also asked me to make such arrangements as will secure a supply of water to Miller's No. 1 Reservoir, should rain fall within the next few days, reserving the question of the rights involved for future determination. I have accordingly arranged, as a temporary measure, to pass water from the Sampangi Channel to Miller's No. 1 Reservoir through the two existing covered drains, one at the Head Sluice behind the Palace Stables and the other in front of the Palace Gate, Mr. Henderson's dam constructed in 1877 some distance below the Head Sluice being removed, and the two feeders to the New Water-Supply Reservoir, also constructed in 1877 between the Head Sluice and the Railway, being closed. The existing covered drain in front of the Palace Gate will be either enlarged or a new one built by its side. These works have been ordered to be executed at once.

2. An immediate supply to Miller's Reservoirs being thus arranged for, the Government of Mysore now desire to place before the Resident the following facts in view as well to a final decision being arrived at on the general question of water supply to the Civil and Military Station, as to the issue of such orders as the action of the President of the Municipality and the language adopted by him and the Municipal Board with reference to the Mysore Government may seem to call for, upon a consideration of the real facts of the case.

3. Major Maltby in his Memo refers in the first place to the feeder to the Sampangi Tank and attempts to explain how this feeder used to bring a supply of water to Miller's Reservoir till alleged recent diversions by the Mysore Government. The branch of the Sampangi feeder north of the Mantapam on the Bellary Road was in existence before the year 1809. In that year the branch on the south side of the Mantapam was completed. Miller's Tank (*i. e.* No. 2 Reservoir) was not constructed till the year 1854. It must therefore be admitted that the Sampangi Tank has a prior claim to all the water received from the drainage area above the feeder in question and that Miller's Tank is entitled to receive from this feeder only such water as may not be required to fill the Sampangi Tank.

4. The natural drainage areas diverted by this channel in its course on the north and south sides of the Mantapam above referred to up to the saddle across the Cubbon Road near the Native Infantry Barracks are shown in the accompanying plan.

5. In 1859 the question of increasing the water supply of the Station appears to have arisen in connection with the new Cavalry Barracks. After a great deal of correspondence and inquiry into the matter, it seems that the construction of new high level reservoirs across the valley in which the Cantonment Bazaar is situated and the improvement of Miller's Reservoir were decided on. The works to these Reservoirs which are known as No. 1, 2, 3 and 4 were carried out during the years 1863 to 1867 as follows :—

(1.) The enlargement of Miller's Tank, (No. 2 Reservoir) completed in 1863.

(2.) The construction of the Railway or No. 3 Reservoir in 1864.

(3.) The construction of No. 1 Reservoir (above Miller's Tank) in 1866.

(4.) The construction of No. 4 Reservoir (below all the above) in 1867.

6. On the 18th September 1865, an estimate for the construction of a Head Sluice in the Sampangi Tank feeder was sanctioned. This Head Sluice is situated at the back of the Palace Stables, and it is here that the President of the Bangalore Civil and Military Station Municipality now

*Marked **E** in the accompanying Plan.

935

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*Marked **E** in the accompanying plan.

states that the supply to No. 1 Reservoir has been recently cut off, and he wishes to again restore this supply by re-constructing the bund which formerly existed at this point across the feeder.

7. The drainage of the Sampangi feeder above this point (E) is 143 acres consisting of—

52 acres in the watershed north-west of the Mantapam (See A in plan);
34.6 acres in the watershed north-east of the Mantapam (See B and C in the plan); and—
51 acres in the watershed south of the Mantapam (See D in plan).

Total 143 acres.

When the sluice at E was built, it was not intended to divert the whole of this drainage from the Sampangi feeder into No. 1 Reservoir; and the estimate sanctioned in 1865 did not provide for any dam across the feeder, but it did provide for a shutter, thus clearly showing that the intention was to keep under control the drainage of the Sampangi feeder above the Head Sluice (E). The object of this sluice appears to have been partly to prevent the Sampangi feeder from breaching and overflowing during seasons of exceptionally heavy rain-fall, and partly to give an additional supply of water to Miller's Tanks as a temporary measure and pending the completion of the Water-supply Scheme. The earthen bund just below this point E. was, as Major Maltby himself admits in para 27 of his Memo, a low one, which, while it diverted some water to Miller's Tank, allowed the rest to pass on to the Sampangi Tank. The bund was breached before 1875.

8. The surplus water passing through the Head Sluice at E used to spread over the adjoining waste ground, and some of it no doubt passed down to Miller's No. 1 Reservoir. The maps of the Cantonment (tracings attached) dated 1861 and 1866 show that no water courses existed close up to the Sampangi feeder, at the site of the Head Sluice. The soil here is very soft and friable, and within a short distance, some 150 yards or so, there were deep water courses which would have rapidly cut back to the feeder bank had any large quantity of water passed through the sluice. In 1875, when the work at the Palace was commenced, a large covered drain was constructed to carry off water from the Head Sluice down to the water course leading into Miller's No. 1 Reservoir; the soil had to be excavated before this drain was built and it will therefore be seen that 10 years after the construction of the Head Sluice, the water courses connected with this Reservoir were all at some distance from the Sampangi feeder and that no connection existed between the reservoir and the feeder till 1875, when the Engineer in charge of the Palace Works constructed the drain in question. If this drain had not been built and if the Head Sluice itself had been kept under control by means of shutters as intended in 1865, the Reservoir would scarcely get any water from the Sampangi feeder. But owing to the construction of the drain and the removal of the shutters of the sluice, the Reservoir, as a matter of fact, now receives a considerable supply from this source. This clearly proves the total unfounded nature of the allegation made by the Municipal Board that the Mysore Public Works Department cut off from Miller's Reservoir, the supply which it formerly used to get through the Head Sluice.

9. This now brings us down to about the year 1876 or 1877 when the contour channels of the New Water Works Reservoir were excavated. On their completion about 1877 or before, the Executive Engineer in charge, Mr. Henderson, had a dam (not the one which Major Maltby wishes to be reconstructed and to which reference is made in para 7 above) thrown up some 100 yards below the Head Sluice at the point marked F in the plan in order to divert the supply in the feeder into the new Reservoir. At this point F and at a lower point (G in the plan), the supply in the feeder has been diverted into the contour channel of the new Reservoir in accordance with the sanctioned project. These diversions, it is scarcely necessary to add, cannot appreciably affect the supply to Miller's Reservoir through the Head Sluice at E.

10. The condition of the Sampangi feeder from the Head Sluice up to the point H, near Dobbspet requires a few remarks. Just north of Melville House the feeder was cut through at the point J by the Railway about the year 1877 and consequently the supply received between the dam thrown up by Mr. Henderson and the Rail-

way, or a drainage of 7 acres, has since then discharged into No. 1 Reservoir instead of going into the Sampangi Tank. Further in April 1878, during a heavy rain-fall of 3", the water overflowed the road near the Native Infantry Lines and in order to prevent a breach in the road which here forms the bank of the feeder, the floorings of certain tunnels were lowered, but shortly after about September 1878, after another heavy fall of rain, when the water again overflowed the road and endangered the safety of the Native Infantry Lines, an opening was made at the point H to *temporarily* relieve the feeder just above Dobbspett and the drainage of 65 acres turned into No. 1 Reservoir. Miller's Tanks have consequently since then received the additional supply of some 70 acres formerly discharging into the Sampangi Tank.

11. It is therefore clear that since 1877, no supply has been cut off from Miller's Tanks, but that during 1878 and since then, these tanks received the drainage of 70 acres which used previously to go to the Sampangi Tank.

12. The contour channels of the New Water Works Reservoir have intercepted since 1876—77 the drainage areas of the Sampangi feeder and Dharmambudhi Tank as follows—

	Acres.
1. Sampangi feeder as it was formerly	143
2. Dharmambudhi tank	171
Total...	314

Of the 143 acres of the Sampangi feeder, as already explained in para 7, 51 acres belong to the watershed south of the Mantapam, that is, to the natural drainage of the Dharmambudhi Tank. About 38 acres of this drainage (*Vide* D in the plan) and about 21 acres from the watersheds N. W. and N. E. of the Mantapam (*Vide* A and B in the plan) making in all 59 acres, have been diverted from the Sampangi feeder by one of the upper contour channels of the New Reservoir, marked K, L, M in the plan. This is the only loss of drainage area which can in any way affect the supply in the Sampangi feeder at the Head Sluice at E, but it is so small that it cannot appreciably affect the supply to Miller's Reservoir from this point. Major Maltby has evidently not examined the Sampangi feeder all along its course, for he does not refer to this loss of drainage area.

13. The real cause of none of these reservoirs filling during the last two years is the almost total absence of tank-filling rain. The Sampangi Tank, although its feeder has been in action only as far as the point H near Dobbspett since 1878, admittedly received ample supplies in that and in the two following years. This is attributable to good tank-filling monsoons and also to its very much silted condition; whereas the non-filling of the Miller's Reservoirs in 1881 and 1882, although in those years they received the additional drainage of 70 acres from the Sampangi feeder at the point H, was due to the absence of tank-filling rain, and more particularly to the fact that they were considerably increased in capacity between 1863 and 1867 and again during the Famine, without any corresponding increase being made to their drainage areas. This latter matter was never apparently considered during the Famine, and, if so, was not feasible, without tampering with prior rights. It is not therefore surprising that when a somewhat short tank-filling monsoon occurs, these tanks receive but very poor supplies as exemplified last year, when a large quantity of water was passed into them from the New Reservoir. It should, moreover, be here mentioned that the lowest Reservoir No. 4 has never discharged since its last increase in capacity during 1877, though, as admitted by Major Maltby, the Sampangi Tank which is said to fill very seldom, received full supplies in 1879 and 1880. This clearly shows that the capacity of Miller's Reservoirs is very much in excess of the supply available even in good monsoons.

14. To sum up the facts connected with these feeders, it seems that 70 years ago or earlier, the Sampangi feeder was excavated, that it diverted the natural supply of 314 acres from other drainages of which 51 acres belonged to the natural drainage of the Dharmambudhi Tank; that long after, in 1865, when several New Reservoirs had been constructed in the Cantonment Bazaar valley and the existing one increased in capacity, a Head Sluice was built in the feeder, but till 1875, (when the Engineer in charge of the Palace Works built the covered drain at E) little or no

supply was received from this sluice, and this diversion of the Sampangi feeder was therefore practically inoperative; and that in 1876 or 1877, the contour channels of the New Reservoir diverted the drainage of 171 acres which belonged at the time of diversion to the Dharmambudhi feeder and that of 143 acres which belonged then to the Sampangi feeder. Nevertheless it is stated that the Miller's Reservoirs received ample supplies up to 1880 and failed to do so in 1881 and 1882, though during the latter two years they were under exactly the same conditions of drainage area as they were in 1878, 1879 and 1880. This clearly proves the want of tank-filling rains during 1881 and 1882, and a reference to the rain-fall registers of the New Water Supply Reservoir and the Bowring Hospital confirms this conclusion.

15. Under these circumstances it will be seen that the statements made in Major Maltby's Memo of the 7th instant are without any foundation, as shown below:—

1st'y. Major Maltby in para 26 of his Memo states that "after the Palace was established and the grounds enclosed, the old nullah was changed into an underground channel." There was no such "old nullah," and the "underground channel" near the Palace Stables was constructed in 1875 by excavation. (See para 8 of this Memo.)

2ndly. In para 28 of his Memo Major Maltby states that the dam across the Sampangi Nullah near this underground channel was recently breached. This was not the case. It was thrown up probably in aid of the Head Sluice at **E** which itself was a temporary expedient as explained in para 7 of this Memo, and it was breached before 1875, because it was an obstruction to the flow of water in the Sampangi Channel which had to be diverted into the New Reservoir in accordance with the project sanctioned and executed by the British Government. Major Maltby infers that the dam was recently breached merely because it was only during the past two years that Miller's Reservoirs failed to fill!

3rdly. Major Maltby makes a similar unreasonable inference in paras 4, 5, 15 of his Memo. He concludes that the contour channels of the New Reservoir did not, as originally made in 1877, interfere with the Sampangi Channel, because Sampangi Tank used to fill till 1880. Because the tank did not fill in 1881 and 1882, he at once arrives at the conclusion that His Highness' Government tampered with the channel in 1881.

4thly. In paras 8 and 9 of his Memo Major Maltby refers to the dam and channels to the New Reservoir at the points **F** and **G** in the accompanying plan. These works were constructed in 1876 or 1877 by the British Government as part of the Water-Supply scheme, and not *recently* by His Highness' Government, as seems to be too readily assumed.

5thly. In para 7 of his Memo Major Maltby says that the Railway filled up the channel about the time Mr. Rangacharlu filled up the portion of the channel which was within his compound. This was not the case. The Railway cut through the channel in 1877; on the north of the Railway, part of the channel was filled in to protect the Railway: as no water could, owing to this cause, come down the channel to pass through Mr. Rangacharlu's compound, that gentleman had the portion within his compound filled in.

6thly. In para 10 and elsewhere, in his Memo, Major Maltby proposes to carry the channel under the Railway. A careful examination of the spot would have convinced him that no such proposal was feasible, for the level of the Railway is much lower than that of the channel on either side: an aqueduct above the Railway or a syphon under it would therefore be required, and either work would be attended with great practical difficulty.

7thly. In para 10 of his Memo Major Maltby says "I have followed this channel (Sampangi feeder) well past the Palace grounds and almost up to its source, and except that it is much silted up, there is nothing more required to fill the Sampangi Tank again than to have an archway put for the water to flow under the Railway." An inspection of this channel "almost up to its source" must have revealed the fact that part of its drainage has been

diverted by the upper contour channel of the New Reservoir (marked **K L M** in the accompanying plan). This contour channel is no recent construction by His Highness' Government. It was excavated in 1876—77 as part of the Water-Supply scheme.

It will be seen from the foregoing summary that the Memo which Major Maltby read at the Special Meeting of the Municipal Board was full of statements not founded upon fact. The Board were misled by this Memo into making unwarranted statements as to the intention and action of His Highness' Government. To all such statements, a conclusive answer is furnished by the fact that whatever was done to interfere with the supply of water in the Sampangi Channel was all done in and before 1877 and in accordance with a scheme initiated and carried out by the British Government; and that since the Rendition, nothing whatever has been done by the Mysore Government calculated to interfere in the smallest degree with the supply of water to any Reservoir within the Civil and Military Station.

16. I now come to consider the means whereby an ample supply of water may, in future, be insured to the Civil and Military Station. The New Water Works Reservoir has not fulfilled the expectations formed of its capability. Major Maltby seems to regard it as a mistake, for in para 16 of his Memo he writes as follows:—"It would be a clear waste of labor, &c., to make new contour channels to divert our water supply into a new tank to be thence run into Bangalore by a new feeder, when the experience of years has shown that our old channel did its work so well." In para 2 he says that the Miller's Reservoirs and the Sampangi Tank used to receive till two years ago "a regular and unfailing supply every year," and in para 24, he adds that Miller's Reservoirs filled regularly "under old conditions," and that in 1881 they held a two years' supply. Under such circumstances, it would be right to restore the "old conditions" by revising the arrangements made in 1876 and 1877 in connection with the New Water-Supply Project, and by restoring to the Civil and Military Station all sources of water supply it could possibly have had before the construction of the New Reservoir and its contour channels. Such a revision of the arrangements of 1876 and 1877 would, judging from the opinion of Major Maltby, be acceptable to the Municipal Board: it would also be convenient to the Mysore Government, for the recent proceedings of that Board show that it would be extremely undesirable to recognise any joint claim on the part of the Mysore Government and the Civil and Military Station to the water of the New Reservoir. The Durbar is accordingly prepared to revise at once the arrangements of 1876 and 1877. With this object the whole of the drainage on the north side of the watershed from the Mantapam (*Vide* **A**, **B** and **C** in the plan) will be restored to the Sampangi feeder by breaching the upper contour channel of the New Reservoir at **L**. Out of the 51 acres belonging to the natural drainage of the Dharmambudhi Tank formerly diverted by the south branch of the Sampangi feeder, the 13 acres below the new contour channel will still drain into that feeder, the remaining 38 acres alone draining into the New Reservoir which will hereafter supply the Dharmambudhi Tank. The Head Sluice at **E** will be either removed and the feeder bank blocked up, or it will be kept under control by means of shutters as originally intended. Then the existing dam (100 yards below the Head Sluice and at the point **F** in the plan) thrown up by Mr. Henderson will be removed, and the channels near the points **F** and **G** leading from the Sampangi feeder to the New Reservoir Channels will be closed. The Sampangi feeder will thus be led *without any diversion of its supply* to the point **N** in the plan, whence it will be taken by an underground masonry drain across the entrance to the Palace to the Railway at **O** under which it will pass through the existing opening (to be enlarged if necessary) after which it will cross the road at **P** and be dropped into a natural watercourse of No. 1 Reservoir at **Q**. In addition to the *whole* supply of the 105 acres situated above the point **E**, about 7 acres of drainage between this and the Railway, and about 12 acres between the Railway and Mr. Rangacharlu's house belonging formerly to the Sampangi feeder, will be also given to Miller's Reservoir. The drainage area thus allotted to Miller's Reservoir is about 124 acres instead of the 143 acres above the sluice at **E** which the Municipality apparently claim.

17. The above work will be carried out and the supply through the feeder given on the understanding—

1st That the Civil and Military Station has hereafter no right whatever to the water in the New Reservoir;

2*nd*. That they allow the lowering of certain tunnels across the Infantry and Cubbon Roads and the deepening of the channel connected therewith to enable the Sampangi Tank to receive the whole supply from the area above its feeder situated between Mr. Ranganadhiah's house and the saddle across the ridge in Cubbon Road near the Native Infantry Barracks. This work is moreover necessary for the safety of the road and the Native Infantry Lines; and—

3*rd*. That the work of removing the silt from the Sampangi Channel and clearing its drainage area of grass, &c., be carried out from time to time by the Mysore Government upon the requisition of the Station Municipality and at their cost.

18. His Highness' Government do not wish to make the smallest difference between the Civil and Military Station and the Pettah in the question of water supply, for they consider it to be their duty to supply as much water as possible to both places. But the New Reservoir which was intended for both the Civil and Military Station and the Pettah has not hitherto filled to such an extent as will justify the Government undertaking any elaborate scheme of distribution; nor is there any prospect of its filling better in future years, especially if the work referred to in para 16 above be, as is proposed, carried out immediately. It has already been stated that a large extent of the natural drainage of the Dharmambudhi Tank which used to supply the Pettah has been diverted into the New Reservoir which is above it. There is thus an obligation upon the Government to restore the water supply of the Pettah containing a population of 52,317 souls, at least to the condition it was in before the construction of the New Reservoir. On the other hand, it will be seen that the New Reservoir has not deprived the Civil and Military Station of any sources of water supply, except perhaps the drainage of 38 acres belonging to the natural watershed of the Dharmambudhi Tank diverted many years ago into the Sampangi feeder, and intercepted in 1876-77 by the contour channel L. M. of the New Reservoir. This drainage area is so small that it can make no appreciable difference, but, if required, even this can be restored to the Sampangi feeder. When this is done, not one drop of water which formerly used to find its way either into the Sampangi Tank or into Miller's Reservoirs will go into the New Reservoir. Upon this ground alone it would be just to decide that when the Mysore Government carry out the work specified in para 16, the Civil and Military Station shall cease to have any claim for a supply of water from the New Reservoir. The Durbar of course will be always willing to open out the sluices of this Reservoir and to let into Miller's Reservoirs all water which may not be required for the legitimate wants of the large population of the Pettah; but any arrangement recognizing a joint claim in a matter of this kind must be more or less unsatisfactory, and it is only with the object of avoiding such an arrangement that the present proposal is made.

19. Copies of correspondence which took place between the Mysore D. P. W. Officers and Major Malthy are attached, and it will be seen from them that the latter officer took upon himself without any reference to the Mysore Government the construction of a dam across the Water-Supply Feeder situated at a considerable distance outside the limits of the Civil and Military Station. His action was unauthorised and naturally provoked the resistance of the Mysore D. P. W. Officers. If Major Malthy wished to have had any work done within Mysore Territory, and had had the ordinary courtesy of asking the Mysore Government for permission to do it, such permission would doubtless have been given, or at any rate some alternative work calculated to secure the object in view would at once have been executed. This obvious course was not adopted, nor was any intimation given to the Mysore Government through the British Resident. As it was, the first intimation that the Durbar received of what the Municipality wished to be done in connection with the water supply of the Station was through the newspapers which published a report of the proceedings of a Special Meeting of the Municipal Commissioners.

20. It may not be out of place here to make a few observations on what was said at the Special Meeting of the Municipal Commissioners held on the 7th instant, regarding the powers of the Municipal Board under Sections 163, 164 and 194 of the Municipal Regulation of the Civil and Military Station passed in 1883. The Municipal Regulation of 1871 applied to both the Town and Cantonment of Bangalore, but when after the Rendition, His Highness the Maharaja granted a portion of the old Cantonment to form the Civil and Military Station, for the purpose of a British Cantonment being maintained therein, it was found necessary to make several verbal alterations in the old Regulation of 1871, so as to adapt it to the altered system of administration. One of the alterations thus made substituted the words "Resident in Mysore" for the words "Chief Commissioner of Mysore." The result is that, Sections 164 and 194 of the revised Regulation of 1883 (corresponding with Sections 165 and 195 of the old Regulation) give to the Municipal Commissioners of the Civil and Military Station the necessary powers to construct dams, aqueducts, drains, &c., *outside Municipal limits*, with the sanction of the Resident and in accordance with plans approved by him. The old Regulation required the Chief Commissioner's previous sanction and approval of plans, and as the authority of the Government of India which passed that Regulation extended till Rendition over the whole Province, the Municipal Commissioners' jurisdiction for the purpose indicated could till then be exercised in any part of the Province. But since the Rendition, direct British jurisdiction is restricted to the Civil and Military Station, and the revised Regulation of 1883 can therefore have operation only within the Civil and Military Station; the jurisdiction beyond Municipal limits, vested in the Municipal Commissioners by Sections 164 and 194 of this Regulation, can thus be exercised only in such portions (if there be any) of the Civil and Military Station as may be beyond Municipal limits, and these sections cannot confer on Municipal Commissioners or others any power of action within the Territories under the Maharaja's direct Administration.

Para 9 of the Instrument of Transfer requires the Maharaja to carry out in the lands adjoining British Cantonments, such sanitary measures as the Governor-General in Council may declare to be necessary. It looks to the Maharaja to do what is required, and does not authorize the Municipal Commissioners or others to do it. As regards works required to be carried out in Mysore Territory for the purpose of supplying water to British Cantonments, the Instrument of Transfer makes no provision, but the Maharaja's Government are always willing to do whatever may be required by the British Government in this matter. They only object to the Municipal Commissioners of the Civil and Military Station or their President arrogating to themselves any powers of action and interference within Mysore Territory, when such powers have not been vested in them by His Highness the Maharaja.

21. In conclusion, it is only necessary to add that the Durbar very much regret that Major Malthy's action in this matter was such as called for the just resistance of the Mysore D. P. W. Officers, and that imputations against the Mysore Government have been made and published without proper enquiry and upon incorrect information, both by that officer and by the Members of the Board present at the Special Meeting at which he presided. The Durbar will therefore feel much obliged if the Resident will issue such orders as will prevent a repetition of similar occurrences in future.

K. SHESHADRI IYER,
Dewan of Mysore.

OOTACAMUND,
28*th April* 1888.

From the tail end of the Esplanade
Sewer, however enlarged
& improved.

The proposed supply of the
troops from the Ejeerum Tank,
the water

1473

No. 54

Col. J. Mullins R.E.
Chief Engineer on Spl. duty

The Secretary to Government
Public Works Department
Madras

Bangalore 2nd April 1884.

I have the honor with reference
No. 3101 W. of the 1 November 1883
and a Report on the water supply
Bangalore, together with 27 appendices
& Plans.

Para 51 of the Report the results of
investigations will be found summarized.

I have the honor to be
Sir
Your most obedient Servant

Mullins Col. R.E.
Chief Engineer on Spl. duty.

83

from the tail end of the Oxford Middle
Terrace, however enlarged
& improved.

The proposed supply of the
troops from the Egremont Ford
the water

1473

Eng. Papers

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and demands for compensation

This source of supply seems
to offer the most promising,
if not the only practicable
solution of the difficult question
of water supply to the Cantonment
Garrison and Town of

opinion that it would be well to appoint a qualified officer for the special duty of elaborating the scheme in the necessary detail & of preparing plans & estimates. This would I presume have to be done in communication with the Mysore Govt.

In paragraph 46 of his report, Col. M. remarks that, to avoid the expense & complication of artificial filtration, "in my opinion it would be desirable to make an experiment by sinking in the bed of the tank a test, through the water therefrom drawn, the character of the soil through which the water has filtered, and its effect upon the potable qualities of the supply." This should be done although I greatly doubt the possibility of dispensing with artificial filtration in the case of the Agrahara tank water.

JA
23-5-84

2Vb

C.A.W. 88

C.A.W. 87

Please have this E.R. Note copied fair for my signature, as soon as possible, with the Note for riders, & we will add a few words. The papers should go to the Hon: Members, & the C in C. & the Governor -

I think the may proceed not go ?

1473

23.5.24

Cric: 23/5/24.

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S.A.W. 88

Report on Bangalore
water Supply W.B

The Govt. of India called
on the Military Dept. of
this Govt. for a report on
the above subject. The
Mily: Dept. are now sending
copies of our Govt. and
Colonel Mallet's Report.
Please attach the latter
to the original draft
for future reference.

M.S.
24.6.84

RK

Please attach to
file of G.O. No. 1478 W/S
13.6.84.

Ch
26/6/84

229 S.P.
26/6/84

89

Secy

1473

Bangalore Water Supply

Please inform S.E.IV Circle to whom this order has been sent in Mfo of the No. and date.

The plans are sent to Madras as directed by Col. Hart Stewart to be available for Capt. Romilly who has been requested demi-officially to call at the Madras Office for them.

Ed S 25.
11/6/84.

Attended to. Plans have been forwarded according to [illegible]
12/6/84

No 54

From

Col. J. Mullins R.E.
Chief Engineer on Spl. duty

To.

1423

The Secretary to Government
Public Works Department
Madras

Bangalore 2nd April 1884.

Sir.

I have the honor with reference to G.O. No 3101 W. of the 1 December 1883 to forward a Report on the water supply of Bangalore, together with 27 appendices and 19 Plans.

2. In para 51 of the Report the results of the investigations will be found summarized.

I have the honor to be
Sir
Your most obedient Servant

W. Mullins Col. R.E.
Chief Engineer on Spl. duty.

20

Maps to follow Railway Parcel

Appendices in Separate Cover

Rec'd 3035

Rec'd 4/4/02

C.A.W. 74

These papers should be printed cheap — the Report first — the appendices afterwards. Plans, in receipt, will be lithographed. —

I think it might be well to print the whole in the form * the adopted for Committee's Report — the Harbours

1473 CW

Reg'd in Rec'd 3035

Registered 3035

203

CORS 14/5/94

...ndleton Col. R.E.
...Chief Engineer on Special duty.

3035
3039
3087

C. a. W.

Col. Mullins' report on the ~~Dam~~ water supply of Bangalore, with note by Dy. C. file.

The plans & ten transcripts have been detached in separate packets — 1473

The enclosures mentioned in Cn. 3087 have been retained at Madras, as Dy. does not consider it necessary to put them before Govt. If however they are required, I shall at once send them up.

J. W. 20/1 14/5/84

The remaining papers had been sent up. 16.5.84

Govt 14/5/84

No. 59 From. 76

Col. J. Mullins R.E.
Chief Engineer on Spl. duty.

To. 14 27

The Secretary to Government
Public Works Department

Dt. Bangalore 5th April 1884.

Sir.

I have the honor to request that the following words may be added at the end of the concluding paragraph of the Report on the water supply of Bangalore, which accompanied my letter No. 54 of the 2nd instant.

52.

No. 3035-

"and to the President of the Madras Municipal Commission for particulars of the consumption of water, cost of distribution and maintenance, and of pipes and fittings &c."

I have the honor to be
Sir
Your most obedient Servant

J. Mullins Col. R.E.
Chief Engineer on Special duty.

Oct, 14/5/84

P.W.Ch. No. 3087

Recd 7-4-84.

No. 62

Office of the Chief Engineer
for Special duty

Bangalore 5th April 1884

To The Undersecretary to Government
Public Works department
Madras

Memorandum.

The undersigned has the honor to forward the undermentioned papers connected with the investigation of the water supply of Bangalore.

1. Reservoir and main pipe registers, appended to Bangalore water supply project
2. Table of water spread over the Reservoirs
3. Statement of volumes of water contained by the Reservoirs
4. Means of observations of dec. 1880 to 1883 by Captain Renaing for R.E.
5. Rainfall Registers, Halasur Lake.
6. Gauge Readings Halasur (Lower) Tank
1st January 1880 to 31 December 1883.
7. Statement of Quantity of water pumped up to Barracks from Halasur water works
1st January 1880 to 31st December 1883.
8. Rainfall gauged at the Bowring Civil Hospital
1880 to 1883.
9. Letter R.D. No. 203 of 20-2-84 Resident to the Municipality containing particulars of [illegible] water, cost of distribution

The numbers marked in red pencil

Yearly letters & Railway Fund

of weight and cost of C. Iron pipes, fittings &c
P. Proceedings Government of Bengal, 6 June 1883 No 1075-5.

2 Level books marked A+B. and 3 Survey
books marked C. D+E. of the N. Indrani
1 Level Book & 2 — do marked #2 of the Hemavathi.

Col. R. Co.
Chief Engineer on special duty.

No. D. 78
GOVT. OF MADRAS. } 188 . { P. W. DEPT.

SECRETARY.

1477

Chepák, 14th May 1884.

OFFICE NOTE.

To

Col. Mullins' Report on the Bangalore Water-supply.

The conclusions derived fr— the full investigations instituted are briefly:-

(1) The Goparhalli Reservoir, in other words the scheme generally spoken of as General Sankey's, is a failure. It is not and cannot be made capable of supplying the station or the troops.

(2) The Halsur tanks cannot afford a satisfactory water supply for the tropps.

(3) Wells may be sunk which would give a sufficient supply to the barracks for drinking and cooking purposes, but the quality of the water will ever be doubtful.

(4) The Agaram Tank offers a favorable source of supply, having an ample and sufficiently clean catchment basin. Estimate would be Rs.2,20,000 or Rs. 1,00,000 - according as the water is drawn direct from the tank or from a well below it.

(5) Water of unexceptionable quality is to be obtained only by distillation. Annual expenditure for this would be about Rs.40,204.

In dealing with the Coparhalli Reservoir and the possible means of augmenting its capabilities, Col. Mullins has not noticed Genl. Sankey's proposal to sink a line of wells below the bund, which would catch up all the leakage from the reservoir and the sub-soil drainage, and from which the water, naturally filtered, would be pumped up to the rear cistern, thence to be delivered by gravitation. Probably Col. Mullins was not aware of this proposal.

I venture to remark the omission is of some importance

as regards the Civil Station, but not as regards the Military, for it is pretty evident that the European troops could not be supplied from the tail-end of this source, however enlarged and improved.

But as regards the Civil Station alone, for which 47·45 millions of cubic feet are required yearly, some remarks strike me in connection with the proposed wells and pumping.

The average quantity of water received into the tank for the 6 years 1878 to 1883 was 26·258 millions of cubic feet, only an average of 4·60 inches of rain having drained in, out of an average of 35·30 inches that fell.

Now if we take the natural catchment basin only, may we not assume that a line of wells sunk across the valley behind the bund would in time intercept the whole of the rainfall on this portion, less loss only by evaporation from the surface?

If so, there would then be available for supply on the

average 4·60 inches run off 1340 acres (=area of artificial drainage) and a full rainfall of 35·30 inches (less evaporation from the land) from 260 acres (=area of natural basin). In all, these two amount to about 55 millions of cubic feet.

If the assumption be correct that there would thus be stored for pumping 55 millions of cubic feet, all water below the surface being available, we would still have to make allowance for evaporation off the Tank surface. What might this be?

In 1883 the "balance loss" from the water stored is shown to be 19·351 millions of cubic feet, and it is reported that in November, when the water level was 6½ feet below waste weir, that part of the leakage which came to the surface was gauged to measure 1·77 millions of cubic feet a month (para 27). May not then 12 millions be taken as the whole leakage loss in 1883, leaving 7 millions as the loss by evaporation?

1423

Deducting 7 millions for this probable loss there would remain 48 millions available for delivery to the Civil Station.

In para 29 the population to be supplied is put down as 130,000, which at 6½ gallons a head, would require 47·45 millions of cubic feet yearly, and 48 millions of cubic feet are available for requirements.

And I would here add that the low average of 4·60 inches run off, as shown in para 24, page 8, may have been brought about to some extent at least, by the bad condition of the channels in some of these years, which fact has not been touched on.

As against the above assumption that all the drainage from the natural basin would eventually filter through to the wells, through the Tank or below the Tank bed or round the sides, I note that in his para 40 Col. Mullins estimates that with a bund across the valley therein alluded to, which valley contains 358 acres, 6 connected wells of

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*20 feet diameter each, would afford probably 400 gallons an hour (=·56 millions of cubic feet). This is very very far short of what I have calculated on above.

But all this affects directly only the state of Mysore and has no interest for the European Troops. To proceed further with this portion of the question may ~~therefore~~ perhaps be considered superfluous.

Agaram Tank. The supply of the troops from this source, the water from which is reported by the Chemical Examiner to be "usable", is estimated to cost Rs.2,20,000, if the water is drawn direct from the tank, and Rs.1,88,000, if water is taken from a well within the influence of the tank. Rs.~~15,000~~ 18,000 should be added to the last, however, as enlargement of the tank is apparently advocated, even if the supply is pumped from the well.

These amounts do not include compensation. It is not clear whether any would be necessary.

B'

1473

In the concluding sentence of para 48 Col.Mullins recommends that the tank be enlarged even if the water be taken from a well, "as by so doing all question of injury to landholders under the tank would be avoided". It is likely, however, there are lands round the border, which might, in such a case, be injured, and raising the weir 3 feet will affect the supply of tanks lower down the valley. So there is sure to be a cry of injury in some shape or form, and demands for compensation.

Distillation. The remarks on this system speak for themselves.

C.J.

D.W.

14-5-42.

24

E.W. 83

Complete report Vol. 2
Complaints & the
matter referred to
Mysore Legislature &
to be laid on the table

82

Public Works Department.

Bangalore 3 April 1883

Meyher Bowen

I return with many
thanks the 2 papers you sent
me last November relating
to the Bangalore Water Supply
Project. The Report goes in to
day

Yours sincerely
C Hawksley

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E.W. 83

82

Public Works Department,

Bangalore 3 April 1883

Meyhew Bowen

I return with many thanks the 2 papers you sent me last November relating to the Bangalore Water Supply Project. The Report goes in to day

Yours sincerely
[illegible]

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In this conclude report, Col. Ludlow considered of the various matters referred to him for investigation in connection with the Croton Supply of Canterbury. 1473

The results are summed up in para 510 the report, and may be briefly stated as follows:—

(1) The Ostrandville project is incapable of supplying the station or the troops.

(2) The Jackson Farm project is capable of being made a satisfactory source of supply for the troops.

(3) Wells may be sunk which would yield a sufficient supply to the troops for drinking & cooking purposes, but the quality of the water must remain doubtful.

(4) The Ogdram Tank if form a ~~permanent~~ new source of supply of suitable water, having an ample & efficient storage catchment basin. 213

(5) Water if conveyed from the Jackson project is probably ~~the~~ capable of [illegible]

Major Malbey's Memo.

March 1883.

814 2.

Allusion is also made in the
report to the possibility of
supplying Bangalore by
gravitation from a reservoir
to be constructed near Nandidroog
but the expense would probably
be prohibitive, being roughly
estimated at from 25 to
29 lakhs of rupees - 1473

The conclusions arrived
at on these points may
think be accepted.

With respect to the Cyclostyle
proposal to supplement the supply
by sinking a line of wells below
the bund of the reservoir, by
means of which the leakage
from the reservoir and the
sub soil drainage would be
caught & pumped thence to
be distributed by gravitation.
The question may prove to
be of importance with respect
to the civil station,
but not with respect to the
troops: for the
investigations have placed
beyond doubt that the troops
could not be properly supplied

92

...ume that Mr. Thos
...c. connected
...a Bangalore
...ll project

91

+ remainder of the
Plans & sent
separately
by Bangalore
1423 11/6.

227

227

93

...or Major Malleys Memo:

...th March 1883.

92

293

...on Major Mallby's Memo.

...th March 1883.

I presume that all the plans &c. connected with the Bangalore water supply project have been sent to Madras.

If not, they should be sent there at once, to be available for Captain Donnithy.

M.

1-6-84

1423

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Note on Major Malby's Memo: of 1st March 1883.

1483

As I observe from this Note that a good deal is here stated on an insufficient acquaintance with the fact as to Sampangi Tank at Bangalore and the position it occupies in regard to the general water supply of the cantonment, it may be as well at once to say that, till at least the rendition of Mysore, it was a purely military work, that no irrigation was ever allowed to take place from the Lake, and that it was only on sufferance on the part of the Military Authorities that a few people residing in the Vill-

were allowed to draw water from it at the west end and to fill pone water carts from the S. E. corner.

Nobody from the Cantonment Bazaar to the best of my knowledge ever drew a drop of water from it even in the most severe scarcity.

Notwithstanding the facts above mentioned that water was never permitted to be drawn from the sluice and that but little was drawn for domestic purposes by the few inhabitants of the Settlement in the immediate neighbourhood, the tank to my personal knowledge (Extending over some 17 years) never once filled excepting in the year 1874 (probably the year of most Exceptional rainfall in the ~~century~~ century) when for a few days the small ditch at the S.E. corner which serves as a waste weir

channel, (not over a yard wide) was cleared out and a little surplus water flowed off. All cultivation below the tank depends on wells alone

It is not too much to say that probably there is no tank in Mysore whose supply has so constantly failed and been altogether so unsatisfactory.

Till 1861, the supply channel from the Mundapam Hill, originally made in the early part of the century, had remained untouched, but in that year owing to the insufficient supply of Miller's Tank as derived from its own proper catchment, the late General Sawford as an act of grace to the Cantonment Bazaar had a sluice constructed at a point immediately S. W. of what is now known as "Jobbs Settie" — [In the

old S.W. Grounds (the one always alluded to as "Sluice A")]

No further draughts were made on the Sumpunje Supply Channel, but when the general scheme for supplying water by gravitation from the new reservoir came up for consideration, it was held that when this was once in full operation the claim and relative importance of the chain of tanks at head of the Cantonment Bazaar (Nos I II & III and certainly of Sumpunje) would necessarily become of very secondary consideration. A full supply was to be provided for at 10 gallons per head for the whole population of the Cantonment Bazaars and this was thought would suffice for all practical purposes.

Till however the scheme was completed it was decided to feed the chain of reservoirs Nos I II & III partly through a new sluice (now called the "Head Sluice") immediately above the Maharajahs' Stables and partly through the old sluice A above adverted to at least till it should be interfered with by the

In aid of the action of this new Head Sluice a low earthern bund was thrown across the Sumpunje Channel immediately to the South, but as the flow of water cut a very deep nalla through the Maharajah's Palace grounds the bund was breached. Subsequently on my own orders the nalla was taken advantage of to construct the masonry drain (alluded to in the papers) with the object partly of answering the original purpose for which the Head Sluice had been made, and partly to supply a ready means for dealing with drainage of the very steep ground forming the Palace Park on that side. Contour drains were in fact to be led into it and thus prevent the soil being unduly washed off

The next dam adverted to, viz. Mr Henderson's, was made by that officer on completing his feeding channel for the new general reservoir. Its action it will be seen from the foregoing observation would while arresting ~~upon~~ supplies which had previously reached the old sluice A and the Lumpungi Tank, left the Head Sluice as it was.

From the above it will be clear that

(1) The Lumpungi Tank has never played the slightest part in the water supply of the Cantonment Bazar (the special province of the Municipal Board) and only affects such few interests that if arrangements are made

9b

gontahs which exist a
three angles nothing furth
needed

(2) The chain of tanks
as Nos I. II & III had never a
recognized right to receive a
supply from the old Lumpungi
channel, but as an act of
grace a supply was given in
by the then Chief Engineer, it
is believed on his own personal
authority

(3) Subsequently ~~as a temporary~~
~~arrangement~~ the so called Head
Sluice was built to answer as
far as possible the same purpose
as a temporary measure till the
general water supply Scheme should
be completed

As I understand that the
Mysore Government are prepared
to not only utilize the Head Sluice

1273

rookeries nor any of the
that have been carried
the Maharajahs Park can
way interfere with or arrest
flow. The singular statemen
which have appeared in rela
to this matter are in fact
on a misapprehension of the
ordinary physical laws, and on
complete ignorance of the form of
the ground.

The paper I am comment-
-ing on contains a number of
other misleading remarks; but
it is needless to deal with these.

With reference to the works
of the new reservoir and the
general supply of water for the
Bangalore Cantonment Bazar I
hope to have an opportunity ere

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e purpose for which it was
ally constructed by me, but
er divert any further supplies
may reach the channel
n to the point where cros
d by the Railway, not only are
the previous rights of supply
the chain of Reservoirs secured,
but also the additional supply
to which as shewn they had no
interest right will be maintained.

To any one acquainted with
the conformation of the ground it
is needless to say that water
obeying the ordinary laws of
gravitation must after leaving
the Head Sluice or other opening
in the Sampunji Channel take
its lowest level in the chain
of tanks and that neither the

of stating any views in
manner which I hope may
of some service to the
ic.

R. A. Lawley
Lieutenant
C&S Rly

30/4/83

Papers, plans &c connected with the Bangalore
Water Supply Scheme, handed to Captain
Rowilly R.E. on 28th June 1882.

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1. Report by Executive Engineer. Mr. Henderson
dated Bangalore 8th October 1869.

2. Letter from the officiating Secretary to the Chief
Commissioner for the Govt of the
Territories of His Highness the
Maharajah of Mysore No 95
dated 8th May 1870.

3. Memorandum by Rev. J. Puckle President,
Municipal Board dated 20th April 1883

4. Reservoir and Rain gauge register

5 Table of water spread and Capacities.

6 Statements showing Volumes of water received

7 Captain Kennington's Memo of Corrections in
water receipts at Reservoir 1880 & 1877

8. A Demi-Official by Captain Kennington forwarding
the above.

9. Register of Rainfall at the Halsur Rock
from 1st January 1880.

10. Statements Showing the water Level in the Ulsoor
tank from 1st January 1880, to 16th
December 1883.

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from 1st January 1880.

10. Statement showing the water Level in the Ulsoor
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11. Statement showing the quantity of water pumped into Barracks from 1st January to 31st December 1880

12 Rainfall gauged at the Bowring Civil Hospital 1880 to 1883.

13. Particulars of consumption of water, Cost of distribution & Maintenance and of pipes & fittings - Madras Municipals (with President's Letter)

14. Proceedings of the Municipal Commissioner relative to the water supply of the Civil and Military Stations and of the Town of Bangalore

15. Surveying Book No. 2. } Do
Do No. 1 } Do } Tied together
Levelling Book Do

16 Levelling Book A Mr. Mc. Cutcheon
Do Do B Do Do
Do Do C Do Do
Do Do D Do Do
Do Do E Do Do
} Tied together

Plans &c.

1 General plan of Bangalore reduced from plan of Cantonment of Bangalore on scale of 6 inches to a mile signed by Hon. L. Prendergast Major R.E. Commandant Sappers & Miners dated in pencil 1874 with additions from the Topographical survey

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3. Abstract Longitudinal Sections of the Foundry Catchment channels of the Coparhalli reservoir Plan No. 3 in 2 sheets

4 Plan of drainage of Sampage feeder water works & new reservoir Plan No. 4

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7. Plan of Survey from Subedar's Choultrum near Bangalore along the water shed between the Pinakini & Arkavatti River to the South spur of Nundidroog to the Melekote Tank. Plan No. 7 in 7 sheets

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13. Survey and levels of the Agaram Tank
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14. Water supply from Agaram Tank &
Particulars of Levels of Tanks and of
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bution. Plan No. 14.
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and Levels thereto to the
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16. Longitudinal and Cross sections of the
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17. New waste weir Agaram Tank to be built
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Hospitals. Plan No. 17

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if the F.T.L. be raised 3 feet
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Survey. Plan No 19 in 3 Sheets

Plan of Part of Ramanagaram Cy/No Attached to Original
G.O. No 1474 W. dated
13th June 1884 — D.D.
3 Sheets

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References.

G. O. No: 2794 W. 5th October 1883
Letter " 2795 W. " do "
G. O. " 3101 W 1st November 1883
Memorandum No 2174 C dated 10th Nov 2/83
by the Chief Engineer C. W.D with memorandum
dated 10th December 1879 by Major C Bowen R.E.

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The total outlay against the sanctions - - - - 7

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8. Particulars of approximate cost of supplying Bangalore
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15 Summary of do ——— do ——— do.
16. Abstract estimate and Specification for diverting all
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17. Approximate estimate for a channel 5 miles in length

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17C. Specification for - - - - do - - - -
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27. Explanatory Memorandum regarding the Levels.

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2. Drainage area and Contour channels, Bangalore new water works Reservoir (Coparhalli) Scale 10 chains to an inch.

3. Sheet 1. Longitudinal Section of Boundary Catchment Channels

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4. Drainage area of Sampagi feeder and new Reservoir (Coparhalli).

5 Survey of ground the drainage of which could be diverted into Bangalore water supply — " Reservoir (Coparhalli)

6. Section from Subedari chuttrum along watershed towards Bettahalli

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15. Survey of ground S. South East of Royal Artillery Barracks, with the wells therein and levels of the Agaram Tank.

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18. Rough Plan and Section of Tunnel and waste weir Agaram Tank.

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Report on the Water Supply of Bangalore 1867

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1. The investigations ordered to be made — relate to the following distinct sources of water supply;

1st The scheme for the supply of the Troops, the Civil and Military Station and a portion of the population of the Pettah with water from the Agaram Tank reservoir which was constructed in 1864-70. The project having been drawn up when Major General (then Major) Sankey was Chief Engineer of Mysore.

2d The Haleur Tank the object being the improvement of the quality of the water of the Tank by excluding from the Cantonment Bazaar and other thickly populated localities, which now enters the Tank by the Western feeder.

The Troops are at present supplied with water from this Tank, the water being either naturally filtered in the case of that drawn from the Pholies' wells, or artificially filtered by passing it through the usual media, rag, sand, charcoal, gravel and stone.

3d Well water; the intention being, failing other means of obtaining sufficiently pure water, to construct a series of wells in the vicinity of the European Barracks for the supply of the

* The spelling of the name varies in reports and plans of different dates: that here adopted is taken from the Topographical Survey, and is understood to be the proper — transliteration of the — native name.

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garrison.

2. These several proposals will be dealt with in the above order in this report.

3. General Sankey's scheme is much the most important project which has been taken up in connection with the water-supply of Bangalore, because it was designed to effect a radical improvement of the supply of the whole military and civil population excepting the Pettah, which has hitherto been generally fairly well supplied. Moreover a partial supply of the Pettah has been proposed to be provided for;

1st the construction of a reservoir in the 3rd mile of the Bellary or Tumkur road, at a level giving what was deemed to be a sufficient command of the whole station to secure water distribution by gravitation.

2nd the supply of this reservoir by the formation of channels to intercept the drainage of approximately the whole area of ground available on a level higher than that of the tank itself.

3rd the distribution of the water to the several parts of the station by means of conduits, pipes &c. The further detailed distribution was not included in the project, but was to be left to the municipality and, so far as the troops

might be concerned, to the Government to carry out.

The instructions of the Chief Engineer Public Works Department in connection with this scheme are

(1) to ascertain exactly the extent to which the original scheme sanctioned by the Government of India has been carried out;

(2) to definitely determine from the experience gained since the work was discontinued, to what extent the completion of the works in their integrity, as per the sanctioned designs, would meet the requirements now considered necessary;

(3) to prepare a project for such modification or development of the existing works, as will ensure the needful water supply.

4. The first estimate of Rupees 5,09,257 for this scheme was sanctioned by the Government of India on the 23 August 1870, and was made up of 3 Sections.

1. The Reservoir	Rs 1,03,903	
2. Channels of supply 11,850 and subsidiary works (Moderate Tanks)	7,112	18,962
3. Distribution works		
water Tower or shine	8,635	
outlet pipe	1,605	

Filter and store basins 72,603
Distribution reservoir 24,123
Delivery pipes &c 2,89,426 3,96,302
Compensation for land 5,19,257
50,000
5,69,257

work was commenced on this sanction in October 1874.

5. An estimate amounting to Rs 5,36,363 for a revised project was sanctioned by the Government of India in July 1876, the items of the 8 sections being:

1. The Reservoir Rs 2,31,207
2. Channels of supply 51,758
Moderator Tanks
3. Distribution works
Water tower or sluice including tunnel through the bund 11,768
Filter and stone basins 39,123
Distribution reservoir
Delivery channels 115,552 166,443
Surveys and Rainfall Registration 5250
Inspection Lodge, Barracks and huts 12,705 17,955
Land compensation 4,67,363
69,000
5,36,000

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6. There was a supplemental sanction given in October 1876 for

1. The Reservoir Rs 3329
2. The Delivery channels 7632
10,961
Compensation for land 2000
12,961.

7. The total outlay up to date is shown thus

1. The Reservoir 3,14,868
2. Channels of supply 71,289
Moderator Tanks 71,289
3. Distribution works
Water Tower or sluice 729
outlet pipe
Filter & stone basins
Distribution reservoir
Delivery channels 89,454 90,183
Extra. Surveys & Rainfall Regr:
Inspection Lodge, Barracks
and huts 4285 4285
480625
Compensation for land 64,140
Rupees 5,44,765

8. The several sanctions and the outlay will be found side by side in appendix

9. The greatly increased cost of the reservoir was due to difficulties encountered in getting in the concrete wall which was used instead of puddle; to an

augmentation of the section of the embankment and to sundry minor causes. As the present enquiry is not concerned with the cost of the work, except in so far as this is directly connected with the efficiency of the water supply, it need only be mentioned here that the embankment has but imperfectly answered its purpose of retaining water. The extent of the imperfection will be dealt with later or when showing what water has been received and what became of it.

10. The channels of supply or catchment — channels will require to be dealt with at some length, as upon their efficiency the success of the project was supposed mainly to depend. They were a special feature in the scheme, because the natural catchment basin of the reservoir is but small or indeed — insignificant, and the channels were intended to collect and bring into the tank the drainage of an area rather more than 5 times greater, which naturally would flow in other directions.

These channels as provided for in the estimate of 1869 (sanctioned in 1870) are described in paras 16 & 17 of the Report, and

vide para 27

† 260 acres.

† Description indefinite.

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and in paras 154 of the Specification. They were to consist of two sets, the lower to embrace the 105.00 contour line, and the upper set a 125.00 Contour.

These sets were practically to be divided into 8 channels, having an aggregate length of about 23 miles, and with nominal sectional areas varying from 15 square feet near the discharge to 2½ square feet at the upper ends. The inclination or fall of the lower series was to be made small so as to embrace the largest available area, while that of the upper series was to be made steeper, so as to obtain a quick delivery of the rainfall on the contained area. In the specification for the lower series the fall prescribed is not less than 9 inches a mile at the lower ends, and not more than 18 inches a mile at the upper ends. The — Corresponding falls of the upper series were to be 2½ feet a mile at the lower, and 10 feet a mile at the upper ends. In neither case are the starting levels given. The channel — through the Mantapam hill ridge, by which the water collected by the north East upper and lower, and the South West upper and lower,

Catchment

catchment channels was also conveyed into the Tank was shewn a bottom width of 6 feet, side slopes of 1½ to 1 and a uniform fall towards the Tank.

The total Cost of these channels were to be Rupees 1,800 or Rupees 515 a mile, equivalent to just under 10 pence the yard run.

The quantity of earth work provided for was 56,191 Cubic yards, or just under 1.40 Cubic yards to the yard run.

11. Of all the plans, eleven in number, enumerated in para 2 of the Executive Engineer's (Mr Henderson) Report on this project, only one* is now to be found. It is not practicable therefore to give any further details of these channels as designed, save the first scheme that was sanctioned. This is however of little consequence, because in the revised estimate sanctioned in July 1876, a considerable extension of the catchment Channel System was provided for.

12. The Report singularly makes no allusion to the alteration of development of these channels generally, or to their very greatly increased Cost: but it does under the head of "watershed area" notice the intended extension of the South East Boundary or lower contour a temporal [illegible] the drainage [illegible]

dated 8th October 1869.
* No 9.a. Plan of Cantonment.

Initialled W.A
9/3/76.

additional was also brought into the Tank.

The estimate however indicates a very greater extension of the system, the main items being for:

33	.	63,000 feet or 11.93 of Boundary or lower main channel (average section 19.7 sq. ft.)	
16	do	49,000 do or 9.28 of upper mains.	
8	do	58,000 do or 11.00 of Secondaries	
2	do	90,000 do or 17.04 of Catch drains	

159,055 Cub. yds against 56,191 do

The first two in the above list corresponds with the two sets of the first sanctioned scheme, but they had been found, or were supposed, to need nearly 3 times as much work.

13. The position and extent of the Boundary or lower main channels have always been fairly well defined, and for this see the plan shows the location, and gives the direction that the slope or fall was the 1 in 5,000. For the upper mains and Secondaries nothing is prescribed except that the upper mains were to have a fall of 1 in 500, and the Secondaries 1 in 100. These channels do not seem to have at any time been surveyed or laid down on paper, and for none of them is the intended level at the commencement shown. Regarding the catch drains there are no directions or any indications as to what was

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was intended.

14. The extent to which the system of Catchmanh channels has been actually carried out up to the present time is shown in the accompanying plan*, which has been prepared under Captain Hensingtin's instructions.

The following summary compares the work executed with the scheme of 1876.

	Scheme of 1876	Executed
Boundary or lower main channels, miles	11·93	9·85
Upper Mains	" 9·28	7·42
Secondaries	" 11·00	2·31
Catch drains	" 17·04	4·25
	49·25	23·83

15. The Boundary (or Gathering ground) channels have been completed as far as intended, but the extension of the South East channel has not been carried out, because it was found that to carry it round the Goolahalli hill would involve much greater expense than had been anticipated, while the yield of the 170 acres to be drained by it would be extremely small, the ground being flat, and very absorbent. There is a gentle depression on the line which, small as it is, very seldom gets filled, consequently the extension for a length of 2·75 miles of the channel has been deemed undesirable - apart from this extension the length

* Plan No 3 Sheet 1
Tabulated levels appendix No 2.

11·93
2·75
9·18
9·85
Differ 0·67

1423

length executed is rather greater than provided for in the Scheme of 1876, and this is due to an extension of the South West channel by which an additional area of 22·30 acres has been brought into the gathering ground.

As regards the arrangement of these channels, as already stated, the intention was in general terms to give a fall of 1 in 6,000 or rather more than 1 foot a mile. In this respect a departure from the intention of 1869-70 was made as then the fall was to be not less than 9 inches a mile at the lower ends, and not more than 18 inches a mile at the upper ends.

From levels recently taken, and from which the accompanying sections have been plotted, it will be seen that the falls actually given are irregular, but that generally they are in excess of those specified at any time. With the exception of the South East channel, the work was done in a fairly satisfactory manner, but the irregularities in the case of that channel are sufficient to affect its efficiency.

16. Since last, with a view to improve the efficiency of these channels, orders were issued for the following arrangements to be adopted and the work has been partially carried out.

All 4 channels to have bed widths as follows

Lower half mile . . . 9 feet
alinie this 6 "
with gradual reduction to at
extreme upper ends, . . 3 "

The average section as provided for in the estimate of 1876 allowed a bottom width of 8 feet. These as well as the revised dimensions are much in excess of the quantity of water to be carried

North West channel
Level of bed at lower end . . 98.00
Rise in 1st mile from lower end . 3 feet
do 2nd do . . do . . 4 do

North East channel
Level of bed at lower end . . 98.00
Rise in each mile from lower end 3 feet

South West channel
Level of bed at the lower end 98.00
Rise in 1st mile from . . do . . 3 feet
do 2nd do . . do . . 4 "

South East channel
Level of bed at lower end . . 99.00
Rise throughout per mile 4 feet

The effect of these alterations will be to increase the velocity of the water, and so lessen the loss by absorption, and as the increased fall is obtained by deepening the lower ends without diminishing the area

Level of waste weir 104.00.

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area drained, the result is likely to be unimportant. When the tank is nearly full the surface fall will be diminished in the lower parts, but as the depth will be increased the rate of discharge will probably not be affected. The estimated cost of these improvements is Rupees 7,605.

The original (1876) intended average depths of cutting was 6 to 3 feet. The intended depth of water is not shown. The actual depth of excavation is much in excess of that proposed which latter however does not appear to have been based on levels taken along the selected line. The accounts do not show what the quantity of work done and the cost have been.

17. Upper main channels. The levels of these as executed are shown in Appendix No. 2, and longitudinal sections plotted therefrom will be found on Plan No. 3, Sheet 2.

The fall specified for these channels was 1 in 500 or 10.56 feet a mile.

The average falls given are.

North East channel 10.15 feet a mile
South West — do — 14.45 do
South East — do — 14.92 do
North West — do — 10.58 — do.

but in each case the lower part of the channel

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reasu much steeper slope than
the upper, the result apparently of having to
drop the channel into the Boundary channel.
The average fall however is 6.13 feet
a mile in the case of 2 miles of the North
East Channel.

With regard to the difference of length,
7.42 miles against 9.28 miles, it will
be readily seen from Plan No 2 that
these channels could not well have been
made longer, and for the reason that
they were not surveyed and laid down
on paper for the project, it is not practicable
to say how the 9.28 miles were distributed
in the estimate the entry is 49,000 feet in one
item for the 4 channels, so probably the length
was not based on measurement.

The channel, the South East, is excavated not
only from its head at a deep ravine, and
drains much further down: the water is
caught by the Boundary channel which
runs at a distance of from 558 to 576 yards.
So either of these channels was superfluous.

Secondaries. Regarding these channels
there is nothing specified in the project papers
as to number or position, but in one of the
plans (No 8) the average Section is given
viz.

viz 2 feet bottom width and 2 feet depth.
The length excavated is less than one fourth
of that shown in the estimate, which shows
a single entry for 58,000 feet. Only 2 channels
have been cut viz one in the South West and
one in the North West portions of the catchment
and it is doubtful whether they are of
much use. Perhaps the catch drains
4.25 miles should be considered as
belonging to the designation Secondaries,
but there is nothing to show what constitutes
the difference between the two classes.

19. Catch drains. For these no specification,
beyond an average Section 1 foot wide at bottom and 1 foot deep, was given.
The estimate shows one entry for 90,000 feet
of channel. About one fourth of this length
has been carried out.

20. In addition to the catchment channels,
there are the road side channels and
numerous tracks and footpaths all of
which act as quick delivery channels.
Altogether, even from the point of view of the
rapid collection and delivery into the
reservoir of the drainage, the development
of the channels seems to be excessive, while
viewed economically the cost has been

out

out of proportion to the quantity of water the
conveyed. Had the Boundary channels been
laid out originally with the fall now the
given to them, and been aligned so as to
make the depth of cutting about 2 feet,
the upper main channels might with
advantage have been dispensed with
altogether, and probably about half a
lakh of Rupees would have been saved.
21. In the revised project of 1876 the provision
for moderator tanks on the line of the supply
channels was omitted. Owing to the plans
of the original project not being forthcoming,
it is not known exactly what the arrangements
were to have been, and the ground does not
present any special facilities for the formation
of even small tanks. Had any such been
formed they would have tended to diminish
the quantity of water reaching the Reservoir
by increasing the loss from evaporation and
absorption en route.

22. Distribution works. In the original
scheme the main distribution was to have
been effected by iron pipes. The greater part
of the Reservoir and of the supply channels
led however to the substitution of concrete
or masonry for iron, and the channels were

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in the project of 1876 designed as open ducts,
but shortly afterwards supplemental sanction
was obtained for covering in the ducts with
slate stones. The only works done under this
head are the construction of the sluice at
the reservoir, and the formation of a channel
thence to Cantonment road, a distance of 1 mile,
5.57 furlongs or 1.70 miles, where it ends in a
square cistern on the lower side of the road.
By the time the work had so far progressed
it had become evident that no such supply
of water, as had been supposed to be available,
could be relied on, and in June 1880, in applying
to the Government of India to sanction the
deviations and excesses, which had occurred,
it was recommended that the work should
not be proceeded with further. From the
delivery channel at its present terminus water
can be run into the tanks near the Cantonment
Railway Station whenever the water in the
Reservoir may be above the level of the sluice
sill, and a supply has in this way been
recently passed into those tanks which are
of much importance to the population of
that part of the Station.

* usually called Miller's Tanks.

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23. Reservoir Catchment or gathering ground.
Before dealing with water supply, it may

be convenient to explain the circumstances of the gathering ground, which form a distinctive feature of the project. Owing to the high level of the Station, and to the necessity therefore of placing the Reservoir at a level which would command it, no site having a natural catchment-basin of considerable area could be found, and that selected has an area of only 260 acres naturally draining into it. The rest of the catchment consists of ground the natural drainage of which runs in other directions, and comprises an area of 1340 acres, the drainage of which is diverted into the Reservoir by the series of supply channels already described. The total area is thus 1600 acres or 2½ square miles.

Of the above mentioned 1340 acres, the drainage from 367 acres went, prior to the construction of the Reservoir supply channels, into tanks connected with the water supply of Bangalore viz.

To Sampangi Tank, above the sluice connected with Miller's Tank - - acres 143

To Halasur Tank, via the Baderhalli valley - 53

To

vide Plan No 4

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To Dharmambudi Tank between the Sampangi Tank channel and the South East supply channel of the Reservoir - - - - - 171

Total acres 367.

The rest of the diverted drainage formerly flowed away from Bangalore.

It will be of interest to note here that the Sampangi tank has from a period at any rate earlier than the year 1809, been supplied to a material extent from ground outside its own proper catchment basin viz.

Diverted from Rajanna tank acres 52.

do do Halasur Tank above the sluice connected with Miller's tanks - 40.

do - below - do - - 171 - 211

do. Dharmambudi tank 57

Total acres 314

P. Govt of Mysore 6th June 1883.

It has to be noted also that, recently it was decided to discontinue the diversion of the drainage of 84 acres out of the 143 acres which had belonged to the Sampangi tank feeder, but the water so relinquished has been sent into Miller's tanks.

Via

The area now draining into the Reservoir is therefore 1516 acres. The Sampangi feeder has from a point where the extension of the Madras Railway crossed its line to the Cattlecartroad, been more or less filled up and water cannot be sent that way, while the tank itself has been long considered of less importance than the Miller's tanks.

It is recommended that all the drainage which formerly ran into the apportion of the Sampangi feeder, ie of the 59 acres not yet restored, and also of the 51 acres, which drained into the Southern branch of the feeder, which had its head at the Bangalore and Mundidroog road at a small Gunta or pond, should be allowed to run into Miller's tanks, because it is less wasteful to allow it to flow direct into those tanks than to divert it into the Reservoir and then send it back by the delivery channel, even should the water level in the Reservoir admit of this being done.

24. Water supply. From the Register of water at the Reservoir the actual quantity received has been calculated in the Imperial Public Works office, and a copy has been taken. the

the results are shown in the subjoined statement.

Year	Rainfall Inches	Quantity of water received Mg. Gl. 24	Rainfall in inches over Catchment	Proportion of rainfall draining into Reservoir	Area of Catchment Acres	Area of Catchment Million Sqr Feet	
1878	41.03	42.340	7.34	0.18			
1879	37.75	22.804	3.95	0.10			
1880	39.56	26.478	4.69	0.11	1600	69.696	
1881	24.63	16.920	2.96	0.14			* In the latter part of this year the area was reduced to 1516 acres.
1882	36.92	23.100	3.98	0.11			
1883	34.91	27.508	4.77	0.13 *			
	211.80	159.160	27.59	0.77			
	35.30	26.525	4.60	0.13			

An abstract from the Rainfall Register showing the rainfall in each month from 1876 to 1883 will be found in appendix 23. Up to October 1883 2 of the 3 gauges were situated below the bund of the Reservoir, and the third at the Reservoir Bungalow. The latter gauge has been retained and the others removed to positions near the Boundary Channels North West and North East, as shown on Plan 22, to obtain a better average for the gathering ground generally.

It will be seen that the yield of the Catchment in 1878 was in a very marked degree better than in either of the other years. This was due to exceptionally heavy rainfall in August viz 5.69 inches on the 20th and 3.48 inches on the

24. The Reservoir received from these two falls nearly two fifths of the total of the year, and the proportion of the rainfall which found its way into the tank was 0.31 or not far short of one third.

16.541 millions out of 42.344 millions of cubic feet.

It was anticipated when the project for this Reservoir was first brought forward that the yield from a part of the catchment would be one third of the rainfall, and from the remainder two fifths. So far the actual yield has been on the average just over one eighth (0.13), and even from the very exceptionally heavy rainfall of August 1878, the yield was less than the smallest proportion estimated as receivable on the whole annual rainfall. From the records it appears that the direct effective rainfall was in each year as below shown, the balance not producing any rise of water in the Reservoir, though of course it contributed to increase the effect of that which did cause a rise.

Vide para 62 of major Sankey's memorandum dated 9 September 1868. P. W. Cy. No 2794 W. 50 Oct: 1883. P.W. Page 23.

Years	Total Rainfall in inches	Effective	Non Effective	
1878	41.03	33.41	7.62	
1879	37.75	26.85	10.90	
1880	29.56	28.28	1.28	
1881	21.63	17.91	3.72	
1882	36.92	29.06	7.86	
1883	34.91	27.27	7.64	
Total	211.80	162.78	49.03	
Average	35.30	27.13		

13. The effective rainfall yielded nearly 1 million of cubic feet for each inch

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The anticipated yield of the Catchment was estimated at 62.125 millions of cubic feet from a rainfall of 28.2 inches, the average of the two years of lowest consecutive rainfall out of 20. How greatly the yield was overestimated is now sufficiently evident, for even the best year, with a rainfall more than 45 per cent in excess of that taken as the basis of the calculation, yielded but little more than two thirds of the quantity, and the result of an average rainfall, during the 6 years of 25 per cent in excess, shows a shortcoming of nearly 58 per cent.

On what data the estimated yield was based is not stated. It will be seen on referring to the appendices containing particulars of the water supply of the Halcon Tank, that the water received by the new Reservoir, so far from being exceptionally small, is considerably greater, in proportion to the area drained and the rainfall, than that obtained by the Halcon Tank.

* No.

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Major General Sankey's Memo of 23 Septr. 1883, paras 16 & 17 P.W.S. No. 2794. W. 50 Oct. 1883. P.W. Page 25

25. This great difference between the estimated and actual yield of the Catchment has been attributed chiefly to the following causes.

1. The presence of a tufted grass (andropogon) over very nearly the whole area of the Catchment

2. the absence of certain quick delivery channels which were intended to expedite the off-flow. With regard to the first of these causes, the grass referred to is very thick and luxuriant in the Catchment basin proper of the Reservoir, but it is by no means general elsewhere. There is much of the area covered with short grass, than which nothing better could be desired, and it will be advantageous if the long, can be generally superseded by the short grass. Probably burning the grass annually, or as frequently as it may be dry enough, will tend to the production of a better kind. To get rid of it by weeding would be expensive, even if it were likely to be effectual; and it may well be doubted whether it would be successful for this particular grass propagates itself rapidly wherever certain kinds of soil are thrown out of cultivation, and it will continue to grow in the Reservoir Catchment unless it can be ousted by some other form of vegetation.

As the quick delivery channels, if by these were meant the catch drains, were never planned in detail, or any specification as

to the manner in which they were to be laid out from it is not clear what the intention was. Above the lower part of the Lower Basin channels there are some cuts which may have been formed as catch drains. The general tendency of all such drains with steep falls is to cause rapid erosion of the soil, and were the whole scheme of catch drains viz 17.04 miles or 6.81 miles of drain to the Square mile of Catchment carried out in this manner, the effect would be a rapid silting up of the larger channels or of the bed of the Reservoir to a certain extent this latter might be beneficial as tending to reduce Subsoil leakage; but the process once started could not be stopped at will, and it might end in the destruction of the greater part of the storage capacity, and consequently of the utility of the Reservoir.

* exclusive of these 4½ miles of regular catch drains which have been formed.

26. Capacity of the Reservoir - a condensed table of capacity and water spread of the Reservoir is given in Appendix No 4. Below 75.00 the contents are estimated to be 6.273 millions of Cubic feet. Between that level and that of the sluice sill which is at 90.00, the contents are 16.330 Mill. so that below the level at which water can be drawn off the capacity is or was 22.603 millions of Cubic feet. Certainly a good

deal of silt has been carried into the tank and probably the quantity of water below 75.00 is not considerable.

The waste weir crests are at 104.00 and the contents to that level, above the sluice sill, are 28.617 millions of cubic feet. The full tank level was originally intended to be at 105.00 and water was to be retained above the crests of the waste weirs by small bunds thereon: at the higher level 31.381 millions of cubic feet would be retained above the sills of the sluice. The sluice sill was placed at the lowest level which would command the higher parts of Bangalore which it was intended to supply and as regards the troops the highest point is the cistern of the European Infantry Barracks, the floor of which is 16.35 and the necessary level of delivery about 19.35 feet below the Reservoir sluice sill, which leaves not more than sufficient head, and indeed less than conveniently sufficient were filtration provided for. It would not be practicable therefore to lower the sluice, even if it would be worthwhile to incur the expense of cutting another channel through the Goottahalli ridge.

27. The Reservoir has not once filled above the 104.00 level. The highest and lowest gauge readings in the several years have been as shown below

Years	Dates	Highest Gauge Reading	Contents Millions Cubic Feet	Dates	Lowest Gauge Reading	Contents Millions Cubic Feet
1878	21st October	100.25	19.299	15 April	81.42	Nil
1879	5th November	96.75	11.792	17 May	90.33	0.634
1880	28 October	97.85	14.045	12 April	88.62	Nil
1881	13th November	93.12	5.220	8 June	87.67	Nil
1882	20 May	92.87	4.671	13 May	84.69	Nil
1883	17 October	96.00	11.353	10 August	84.53	Nil

The contents shown are above sluice sill level

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From these figures it will be seen that in the first year the Reservoir contained, when at its highest level, but little more than one third of the supposed quantity annually required apart from wastage by evaporation and other causes, while in other years the proportion was very much less.

The wastage or loss by evaporation etc was estimated at 9.125 millions of cubic feet. What it has been is as follows:

	Mns. Cc. Ft.	Difference to be accounted for	Quantity drawn off	Balance Loss.	Remarks
1878. Contents 1 January	0.000				No contents here shown are total contents. The small loss in this year is partly due to there having been but little water in the Reservoir prior to April from the 1st of which month the Register commences
Receipts during year	42.340				
	42.340				
Contents end of year	33.055	9.285	—	9.285	
1879 Contents 1 January	33.055				
Receipts during year	24.568				
	57.623				
Contents end of year	27.532	30.091	—	20.091	
1880 Contents 1 January	27.532				
Receipts during year	22.738				
	50.270				
Contents end of year	29.698	20.572	—	20.572	

* 52.50 millions of Cubic Feet.

1881. Contents 1 Janry	29.698					
Receipts during year	16.920					
	46.618					
Contents end of year	24.306	22.312	*		22.312	
1882. Contents 1 Janry	24.306					
Receipts during year	23.100					
	47.406					
Contents end of year	23.303	24.103	2.870		21.233	
1883 Contents 1 Janry	23.303					
Receipts during year	27.507					
	50.810					
Contents end of year	25.654	25.156	5.302		19.854	
		131.619	8.795		122.824	
				Average	20.471	

* As small quantity is believed to have been pumped out: channel and spill, but there is no record of the quantity and the gauge registers in decalitres not cubic feet.

The evaporation is probably greater than the Reservoir figures which is 1/3 of an inch a day, but the total loss at the Halcon Tank, but the tank is accountable to any material extent for the rate at which the water surface falls. In November 1883 when the gauge readings were 97 the actual quantity of water in the reservoir was 1.77 millions of cubic feet a month's pumping would account for 0.355 of a foot of fall in the water surface in a month, or quick enough one third of an inch a day, between the levels 98.00 + 97.00. The actual total fall was three quarters of an inch a day, and there seems still an inch to be accounted for. Evaporation and leakage not covering the loss at Halcon Tank. If the fall in the surface, in which the water drawn off, was 0.208 of an inch a day the net result to that time water works have in the six years, in addition to about 9 millions drawn off, been about 26.554 millions of cubic feet for the supply of Bangalore, but of this quantity only 2.907 millions were at the end of December, above the level of the sluice sill, and this proved not sufficient to work the distributing works & operating pressure. There above 12 inch from the Reservoir contained no water, above the level of the sluice sills for the following months. The details will be found in Appendix to 1878 Number of days = 198

1878	do	
1880	do	77
1881	do	167
1882	do	184
1883	do	268
	Total	894
	Average	149

Had the supply of Bangalore been attempted the above periods would of course have been largely increased and the days in which anything like a full supply could have been

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been afforded would have been extremely few. No doubt it was foreseen that it might be necessary to pump water occasionally into the distributing mains, but the project was essentially a gravitation scheme, and it was not contemplated that pumping would have been needed otherwise than as an exceptional arrangement. It may be added that even with pumping the circumstances are altogether hopeless. In 1883 there would have been no water above the 75·00 level between the middle of May and the middle of October, had the supply of the place been started at the beginning of that year. With an empty start the balance of water at the beginning of the year would have been about 10 millions. On the 30th October moreover there would have been a deficit of upwards of 11 millions of cubic feet, not until the 13 October would the supply have balanced the expenditure, and at the last time of the year viz in November, when at least 6 months' consumption should have been [illegible] there would have been 6 ft less than one

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level it will be capable of supplying the supply of that part of the Pettah which is paid for indifferently provided with water. It is clearly out of the question to think of supplying the Station generally or the troops from so precarious and inadequate a source as the Reservoir now is.

28. With regard to the possibility of adding to the catchment or gathering ground of the Reservoir, it may be desirable first to consider what area might reasonably be expected to supply the Reservoir adequately, and prevent risk of failure of supply in at any rate all but remarkably arid and exceptionally dry years such as, for instance, 1876. The data now available show first that the total Rainfall amounts to about 20½ inches per annum; secondly that the quantity last would have been very much greater if the water level had been such as would have admitted of the proper supply of Bangalore; thirdly that the receipts cannot safely be taken at more than one eighth of the rainfall at most, while even this would be a safer assumption; thirdly that no material addition to the water stored can be depended on between November and May or say for 5½ months, so that the Reservoir

should, at the end of November, contain enough water to meet the losses and provide the supply of 5½ or 6 months, from the losses by evaporation in these 5½ months have amounted on the average of 6.55 feet.

Further the minimum level at which it would be prudent to allow the water in the Reservoir to fall may be taken at 95.00, at which level the contents above sluice sill are 8.380 millions of Cubic feet.

It follows then that the Reservoir on the 30th November should, to be efficient for its intended duty, contain 26.25 millions of Cubic feet above the level 95.00 plus 6.55, or 101.55. And at 101.55 the contents are 72.374 millions, and at the present weir crest level they are 78.617 millions, consequently the Reservoir would have to be enlarged to hold 26.25 minus 6.243 or 20.007 millions of Cubic feet more than at present. To effect this the weir, and the land in proportion, would have to be raised about 6.62 feet, and the contents at this higher level would be 48.741 millions of Cubic feet. On the average the Reservoir has held on the 30th November only

vide appendix No 6.

× Tally of 52.50 millions, vide preceding page 4th

78.617
72.374
6.243

7.997 millions, and the additional supply required is 40.714 millions, to obtain which an increase to the area of the gathering ground of at least 3.78 Square miles would be necessary, taking into account the great distance from which water would have to be brought probably 5 Square miles would be **none** too much; or in other words the present area would need to be trebled.

29. In the above calculation the scope of the original project has been adhered to, but in his memorandum of the 23rd September 1883, paras 40 and 41, General Sankey proposes to reduce the unit of supply from 10 to 6½ gallons a head per diem, and on the other hand estimates that the number to be supplied may be taken not to exceed 130,000 instead of the 90,000 previously to be provided for. The quantity required at 6½ gallons a head for the larger population would be 47.45 millions of Cubic feet yearly, which does not differ very greatly from the supply originally intended to be distributed. With regard to the unit of supply it may be assumed that the quantity of water consumed will, under similarly more or less complete arrangements for the

prevention of waste, depend chiefly upon the facilities afforded the population for getting at the water. If the people can get the good water with as much facility as that of more or less indifferent quality heretofore used, they will use it freely and exclusively so far as it may be available: but unless the old sources of supply be very bad they will not go a much greater distance to get the better water. Of course it would be an advantage if the people were able to get even a gallon or two of really good water daily, but where the supply small and at the same time inaccessible, the inevitable result would be that some would have to go without any. When the circumstances are such as to make it desirable in the interests of the public health to introduce a purer supply of water, it is obviously also desirable to make that supply ample and to place it within easy reach of the people, so that it may be freely and universally used. Statistics of actual consumption by native populations are not to any great extent available:

President's letter
P.W.H. No 203
25th February 1881

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At Madras it is believed that 300 out of 400 thousand of the population are now supplied and the consumption is stated to be 11 gallons per head per diem.

In appendix No 7 will be found some particulars of most of the water works which have been carried out in India, and it will be seen that the unit of supply varies greatly and in some cases it was based rather on the quantity of water that had, than on what would have been desirable.

In support of his proposal to reduce the unit of supply from 10 gallons to 5 gallons or "to err on the side of liberality to 6½ gallons or 1 cubic foot per head per diem, General Scaife mentions that "investigations of a very painstaking character in the town of Mysore brought out the fact that for those (drinking and culinary) purposes the average amount actually used by natives only amounted to 1¼ gallons per head per diem, or just one fifth of the quantity proposed to be given at Bangalore

The paper whence this information was obtained is a letter from the Commissioner of

† Memorandum dated 23 Sept. 1883 paras 41-42.

General No. 257/73 d/25 Aug. 74 vide appendix No.

the Ashtagram Division and of the investigations Colonel Hay remarks that accuracy is unattainable" and the object of the enquiry was to give a "general view of existing circumstances" The general result arrived at was that 25,000 to 30,000 pots of water, estimated to contain 2½ gallons each, were used daily the population being 57,765. The larger quantity 1,762,500 gallons makes the average just under 1½ gallons a head, but (para 68) 2,000 people are supposed to have used 45,730 gallons, so 37,765 people were left with 31,920 gallons and hence it would appear that in an extremely hilly & ill supplied locality the people took as much water to their homes. The population of Bangalore obtain water for domestic purposes with very great difficulty, and a more abundant and accessible supply has been deemed to be of so much importance that a water supply scheme calculated to afford 6½ gallons per head per diem has been drawn up and will, it is hoped, be carried out at an early date. The unit adopted is no doubt based on General Sankey's revised estimate of requirements, but on the other hand a wide margin has been left to prevent disappointment, for the main distributing channel is capable of discharging the above supply in 6 hours; and the Reservoir is to hold 100 millions of cubic feet or nearly 5 times as much as the estimated yearly consumption. Consequently should the quantity used be double that of the assumed unit, the water will be available, as also the means of distributing it.

Under any circumstances the European troops could not be supplied from the tail end of a system based on a unit of 6½ gallons a day per head. The Hesserghatta reservoir is at, or rather beyond the extreme Western limits of Bangalore, and the troops are at the Eastern end, and some at the extreme Eastern limits. As it is there are sometimes complaints of want of water though their supply is specially provided on a sufficiently liberal scale. What would be the result of attempting to supply them from the tail end of a system based on a low unit may easily be imagined.

vide Appendix No. 7.

(Should the Tank fail)

30. Result of examination of the country to the north of Bangalore. The country to the north has been examined, and the additional catchment area a little to the South of Yellalanka, which was supposed to be available, has been contoured. There is first a hill to the West of the 7th mile stone of the road, and this would afford an area of about 0.43 of a Square mile: then proceeding Westward there is the Bettahalli hill of which the part sufficiently high measures 0.70 of a square mile. A mile South of the Western side of the above hill there is a small hill with an available area of 0.04 of a square mile, or altogether 1.17 square miles could be obtained in this locality. The distance the water would have to be brought would be between 9 & 10 miles, and the Section shows what the circumstances would be. The most favorable line, using the watershed between the Pennakini and Arkavatti rivers, has been selected, but this at Sulledars Chuttrum is about 40 feet below the necessary level, at 1 mile and 50 yards therefrom is the lowest point, which is 23½ feet lower, for nearly 4½ miles a continuous and for the most part lofty aqueduct would be needed, and in the 8th mile and again to the back of the Bettahalli hill aqueducts would be required.

* Memo of 23 Sept 1883 para 34 Plan No 5

Plan No 6.

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Plans Nos 7 & 8.

The expense of aqueducts for so small a catchment would be prohibitive, and it is certain therefore that no addition to the gathering ground of the Reservoir in this neighbourhood is feasible. In order moreover to ascertain the circumstances of the country on the vicinity another set of levels has been run from Sulledar's Chuttrum along the watershed to the Southern spur of Nundidroog, and thence to the Pilkola Tank which was, in the earlier discussions, supposed to be a possible source of supply, but which is not on a sufficiently high level, its waste-weir being at 3046.49 or only 1.52 feet above the weir of the Ooparhalli Reservoir. From these levels it will be seen that there is no considerable extent of ground, which is on a level high enough to supply the reservoir nearer than the sloping ground at the foot of Nundidroog itself, or at 2 miles from Sulledar's Chuttrum. Also that to bring in water by a channel would involve some 2 miles altogether of aqueducts, owing to the low level of the watershed. It is therefore economically impracticable to bring in water to the Reservoir from gathering ground to the North by means of a Channel. If water is to be

(2)

other respects can be indicated.

1- the extent of gathering ground available would probably be about 9 sqr. miles, would probably be about 9 sqr. miles, but whether any reservoir site could be found into which the whole of this drainage could be conveniently conducted is problematical. The above area is on the West of Irundidroog, on which side. Judging by the Topographical Survey a site is the more likely to be found. On the Eastern slopes there is an area of about 3 square miles which is probably high enough to allow of the drainage being diverted into a reservoir on the mucktade. Altogether it is certainly disappointing to find that, even at this distance from Bangalore, no large area is to be met with at a sufficiently high level.

2- The supply required for a population of 135,000 at 10 gallons a head per diem being 216,000 cubic feet a day and as it would be desirable in a project of this kind to allow for an increase of the population to say, 150,000, 240,000 cubic feet a day may be taken as the quantity needed.

3.. The head available would probably be about 60 feet, and the length of main not

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not less than 150,000 feet. As the water would be delivered into a service reservoir it could run continuously, and the diameter of the main would be 2 feet.

4. The proper capacity of the storage reservoir would be not less than 60 millions of Cubic feet.

5. The capacity of the service reservoir near Bangalore would be 5 days supply or 1.20 millions of Cubic feet. The desirable level for its floor would be 100 feet above the Halasur Tank datum, equal 15 feet above the sill of the Ooparhalli reservoir sluices, or reduced level 3029.97. With a depth of water of 10 feet it would have an interior superficial area of 120,000 Square feet. The form would be influenced by the site chosen, which would be somewhere between Subedars Chuttrum and the Ooparhalli Reservoir, but probably a rectangle, affording clear room 600 by 200 feet, would be found convenient, and to make it fully satisfactory as a pure water reservoir it would have to be covered in by arches over which some 3 feet of soil would be laid.

6. The water would in all probability have to be filtered either near the storage reservoir or before entering the service reservoir.

The following summary gives an approximate estimate of the cost of the project. For mains of 24 inches in diameter a thickness of 1 inch of metal is usual, but as far as head is concerned 3/4 of an inch would be ample so estimates are given for each thickness, and in appendix No 8 further details will be found.

Storage Reservoir	45,000	45,000
Filters	75,000	75,000
Main between Storage & Service Reservoirs, 24 inch	17,70,000	13,77,000
Service Reservoir	2,40,000	2,40,000
Distribution mains &c at 6 Rupees a head	7,62,000	7,62,000
Rupees	28,80,000	24,87,000

Assuming that 10 per cent on these sums would be required to cover interest, maintenance and deterioration, and that establishment for regulating the supply and looking after the works would cost Rs 6,000 a year, the annual cost of the water supply would be either Rs 294,000 or Rs 2,54,700 equivalent to Rs 1.960 or Rs 1.698 per head of a population of 15,000 or Rs 2.262 or Rs 1.96 a head of the present population of 13,0000.

This

This would not, under the circumstances, be at all an extravagant charge, and ab Lahore with an abundant supply of water at a distance of half a mile from the service reservoir, the charges based on the same percentage, but with pumping, amount to Rs 1.258 per head of the population of 130,000.

Capital outlay a little over 15 lakhs.

There 25 & 30 Square miles of gathering ground available, as also a good site for a reservoir, it might be made worthwhile to incur the considerable outlay indicated for the purpose of supplying the whole of Bangalore with good water. As it is in years of scanty rainfall there would be a risk of partial failure of supply, though it is probable that, even in a year like 1876, a sufficient quantity for essential requirements would be forthcoming.

32. Halsur Tank. This tank the present source of water supply for the European Troops, had naturally a catchment basin of about 8½ miles . . . . . 5·50

A small portion of the Western part of this area was diverted prior to the early part of the century into the Sampangi tank 0·33

5·17

and

and between the years 1854 and 1867 the construction of the 4 tanks known by the name of Millers tanks, near the Madras Railway (Cantonment) Station, further curtailed the area by . . . . . 0·53

Present effective area 4·64

In 1877 an upper Halsur tank was formed by throwing a bund across the northern margin of the old tank, and the catchment is now divided therefore into two sections of 2·54 and 2·10 Square miles, respectively, for the supply of the upper and lower tanks. The upper tank discharges its surplus into the lower, and its contents are also from time to time turned into the lower tank to supplement the supply of the latter when required.

33. The greater part of the catchment or gathering ground of the lower tank, with the exception of less than one fifth of a square mile of the eastward, is occupied by the large population of the Cantonment Bazaar, and until the completion of the main sewer in 1864, most of the filth from a population of about 75,000 was washed down into the tank whenever a heavy fall of rain occurred. The Sewer has much improved matters, as it is capable of carrying off all the bazaar drainage

drainage provided the rainfall does not exceed about one tenth of an inch an hour. There is no doubt however that the water flowing into the tank, after a considerable period of dry weather followed by heavy rainfall, is decidedly foul and unsuitable for drinking & culinary purposes.

The whole of the drainage of the 1.66 Square miles which reaches the tank by the Western feeder, which runs from pick below the lowest of Millers tanks through the Bazaar, might without difficulty be diverted from the tank by running a bund across from the culvert by which it passes into the tank, & the main bund a little to the north of the present Surplus weir, which latter would be lowered, and a new weir built in the new bund; this tank receives drainage from foul ground at its North West Corner, and this also would need be diverted into the Western feeder above the Culvert just refered to.

However the water supply of the upper tank is far from pure. There is a large

1473

large population in this part of the gathering ground, and there are tanneries and a large native cemetery, which are quite sufficient to account for the quality of the supply.

34. It has been ascertained that a considerable area of fresh ground could be drained into the lower tank by running a supply channel at a gradient of 2 feet per mile to the Eastward.

The position and general circumstances of this area are shown on the general plan,* and on a larger scale and in more detail on Plan No 9. This ground measures 3-10 Sq. Miles and the soil is generally of the light sandy character which is common to the neighbourhood. The water supply from it would be of a better character than that now received by the tank, but it certainly would not be even approximately pure for, though the land is for the most part under dry cultivation, it is extensively manured with all the nastiness and filthy material which is conveyed from the Barracks, the Station, and the Bazaar by the conservancy carts. There is further the additional objection that the construction of such a channel would

* No 21.

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interfere with and diminish the supply of a great many small tanks some of which belong to the Impore Government, while others are privately owned.

The settlement of Compensation would be difficult and troublesome, because there are not only the tanks of which the supply would be directly diminished to a demonstrable extent, but many others which get water from the surplus of the former, and no reliable estimate could be formed of the extent to which the supply of these lower tanks would be affected. On the whole then, promising though the plan of bringing in a supply from the open country to the East and appeared in the first instance, it is considered that the circumstances are too unfavourable as regards quality of the supply to warrant relief being sought in this direction.

To secure the drainage from the 3.10 square miles above mentioned, a channel 9½ miles in length would be needed, but a fresh area of 2.17 square miles would be secured by stopping the channel at 5 miles, and as this would more than compensate for the 1.68 plus 0.22, equal to 1.90 square miles of the present catchment which would

(3) (30)

would be diverted from the tank and as the shorter channel would interfere with but four existing tanks, it would be the better arrangement.

The cost of diverting the Western and North West feeders of the tank would be about Rs. 850

The supply channel 10½ miles in length for the catchment of 3.10 square miles would cost about Rs. 11,120

The channel 5 miles long for the catchment of 2.17 square miles would cost about Rs. 6,460

So that the larger scheme would require an expenditure of Rupees 29,970 and the smaller of Rupees 25,310, exclusive of compensation for waste direction. Approximate abstract estimates and specifications are given in appendices Nos. 16 & 17 c

In either case it is proposed to raise the Full Tank Level 1 foot, and so increase the storage by 5.113 millions of Cubic Feet.

35. The Halaur Tank, prior to the formation of the upper tank, held, when full, Mn. C. Ft. 38.293

At present the capacities of the two tanks are

Upper Tank holding C. Ft. 11.240

Lower do 37.633 48.973

Increase 10.680

A table of capacities has been drawn up and will be found in appendix No. 10.

Statements of particulars of water supply

have

became been worked on from the Registers
for the years 1882 & 1883 including Appendices
Nos. 11 & 14, and a Summary is given in
Appendix No 15. From the latter it will
be seen that the year 1880 was one of
exceptionally heavy rainfall, and the tanks
received no less than 165.372 millions of C. Feet,
but in neither of the three years was the
yield of the basin equal to the capacity of
the tanks. The average receipts of these
3 years were indeed only just one half
of that capacity.

36. It has been alleged that the falling
off in the supply of the Halsur Tank
has resulted from the diversion of
part of the drainage by the Catchment
Channels of the new (Coparhalli) Reservoir,
but the area of drainage so diverted
is only one twelfth of a square mile, and
would account for only 1-32 millions
of C. Feet in the last 3 years, or on the
average 0.44 millions per annum or
1-8 per cent.

Compared with the period prior to 1864 the
supply has no doubt suffered material
reduction by the construction of the main
sewer, but the idea of the prejudicial effect

× 53 acres vide para 23

of the Bangalore water supply project took
its origin in the contrast between
the abundant supply of 1850, when the waste
weir discharged surplus on no less than 88 days
between the 14th August and the 7 December,
and the short supply of subsequent years.
The real cause is explained by the rainfall
register, and a reference to the statistics of
the Halsur water works, Appendix No 20, will
show that the water level in the tank on the
31 December was much the same in 1878,
the first year in which the new Reservoir held
water, as in 1877, and that in 1879 and 1880
it was at a higher level than in any year
after 1872.

37. It will be noticed that the rainfall
registered at the Halsur rock is about
18 per cent less than that registered at
the Bowring Civil Hospital, which is
1,900 yards. distant but little more than a mile. This
is due chiefly to the gauge at the Rock being
on the top of the rock, or indeed one foot
higher than the latter.

Appendix No 19. On examination of the monthly abstract of
the registers shows that, on the other hand, in
February the rainfall gauged at the Rock
has always been higher than that at the
Hospital

Hospital, but for the 1880 Mer 44 months this
was the case in only 6 months.
It is further noticeable that the Rainfall
registered at the Bowring Hospital is not
always a guide to the rainfall over the
catchment of the Hesperhalli Reservoir,
distant about 3 miles, for 1880 was an
average year in the latter locality, the
rainfall being 39.56 inches against 51.69
at the Hospital; and again in 1881 the figures
are 21.63 and 27.44 respectively. In 1882
and 1883 the two sets of registers agree nearly

38. The yield of the Halsur catchment basin
for the 4 years averaged 0.174 and 0.146 of the
rainfall registered at the Rook and Hospital
respectively. The proportion at the Hesperhalli
Reservoir averaged 0.12 for the same period.
Omitting 1880, the proportions for the Halsur
catchment are 0.083 and 0.071, and for the
Hesperhalli Reservoir 0.127.

39. Wells. These as a means of procuring water
are in very general use, and seeing how small
a proportion of the rainfall runs off the ground
it might be expected that a fairly abundant
supply would be met with below the surface.
The ordinary surface soil is very deep, and

below this, at varying depths, a subsoil impervious
to rain rock in a more or less advanced state
of disintegration and decomposition is met with;
this overlies gneiss in either the massive or detached
state. In many places the rock comes to the
surface, but more generally it is at a considerable
and sometimes at a very considerable depth
therefrom. Many houses possess wells which are
said to yield water of excellent quality, but there
is no certainty that two wells, though only a short distance
apart will contain water of at all similar character.
The wells of the station which
has for a long time been thickly populated is
generally indifferently bad, as is to be expected,
but besides these there are many wells the
water of which is unfit for domestic use
because it is impregnated with salts which
render it brackish or bitter.
There is at Bangalore ample space on fairly clear
ground for a sufficient number of wells to
produce collectively a much greater quantity
of water than is required, but while it is
certain that a very considerable proportion of these
wells would contain brackish water, there
would be no means of determining beforehand
where wells of good water would be obtained.
Borings would afford prima facie evidence

of the character of the soil at the spot and
the water drawn therefrom could be tested,
but even then it would not be demonstrable
that the water taken from a large well on
the same spot would be of the same quality for
directly the quantity taken out became considerable
the area drawn from would be extended
horizontally, and new conditions would be
met with.

There is no generally distributed water bearing
stratum, containing good and pure water, into
which wells can be sunk, and a supply of
such character obtained with certainty.
To the South of the South Station Hospital
there is a small water course on the banks of
which some wells were sunk in the Famine
year 1876-77. One of these wells, No 2, at 760 yards
from the Hospital, and conveniently situated
as regards the Field artillery and European
Cavalry Barracks, has been tested, and
the partial (qualitative) analysis made
under the direction of the Deputy Surgeon
General, is fairly favourable.
If an abundant supply of such water
could be obtained this source might be
considered satisfactory, but the experiment

Plan 15

made

vide Sanitary Commissioner's
Appendix No 26.

made in March with an engine and pump
sent for the purpose by the Secretary to the Imperial
Government, P.W. Department, shows that at
a time when the yield of a well is certainly
not at its minimum, the inflow averaged
during 138½ hours only 5.37 cubic feet or 33.56
gallons an hour. On the average of 24 years
the hourly consumption of water by the troops
has been 2,349 gallons.

Appendix No 21.

It would therefore require 70 such wells
to supply the total quantity required, and
probably not less than 40 larger wells
distributed so as to drain the greater part
of the basin of the water course, which has
an area of 258 acres, would suffice, while
there would be always the possibility of the
failure of the supply towards the end of the
dry season. With a bund across the valley
above the road, it is probable that sufficient
water would be obtainable for cooking
and drinking purposes for the Cavalry
Regiment, the 2 Field Batteries and the Hospital
as this part of the supply might be taken from
the one side of the whole or say 100 gallons
an hour, which quantity might be
obtained from say six connected wells
of 20 feet diameter each, and the supply

could be lifted by a pump worked by bullocks or buffaloes, which would be less expensive than a steam engine, the cost of which would not exceed Rupees 1000 per annum.

41. Similar arrangements might be made for the supply of the Horse Artillery and the European Infantry at a cost of about Rs 1,500 per annum, but for other purposes two thirds of the present supply would still have to be pumped up from the Talaw water works, and the cost of these two thirds would be but little less than the Rupees 10,000 expended at present on the whole supply of the Troops.

The Register of the pumping operations at Nos well will be found in appendix No 22.

42. Some of the data - eg: the number and length of the connections with the several buildings - for an approximate estimate of the cost of the arrangements above indicated, would require more time for their collection than is now available, but the following summary will give a tolerably good idea of the probable outlay required. The way in which the calculation has been

been made will be found in appendix 23.

37 wells	Rs 4550
Pumps with gear	1200
Pipes & laying	8,354
Trench for connecting pipes	3,000
Irrigating during construction	3,000
Taps and fittings	2,000
Contingencies	1896
	24,000

About an equal amount would be required to supply the Horse Artillery and the European Infantry Regiment with water from wells, or say Rs 50,000 altogether. The current charges being estimated at Rupees 1500 plus 5% annum on this capitalized at 25 years purchase would represent Rupees 62,500, so the entire cost of supplying well water for drinking and cooking purposes only, to the European troops, would be about Rupees 112,500.

43. Some of the heretofore considered sources of supply being likely to be acceptable and also adequate, attention has been given to those which it seemed possible might be better suited to meet the requirements. Necessarily there could be no adequate supply obtainable without pumping, and all that could be hoped for was sufficient water at a level not very

much below that of the Station, and at a moderate distance the Hosbla tank, which is much the largest in the neighbourhood visited. It has a catchment basin of 540 sq miles, and is the terminal of a very large group of tanks of which at present only one subsidiary has been surveyed, so the statistical information is incomplete. Notwithstanding the large number of tanks above it, the supply is said to be good: in 1876 there was some water but not enough for cultivation: in 1877 the tank got a good supply. About 200 years ago (probably 1680) the tank was entirely emptied in 1875 the supply was so great that it was feared the tank would breach. The extent of irrigation is about 2000 acres and the revenue about 5000 Rupees: the assessment has been reduced since 1877. The season of cultivation is from December to August or September. Only one crop is cultivated this is commenced from December to April, the harvest being from June to September. The tank is from 12 to 13 miles from the Barracks, and it is about 104 feet lower than the Halavan Tank. There is a small hill, 2 miles west of the 14th mile stone, which would be a convenient site for a stand pipe as this

190 feet above the tank level. Neither the quality of the water in January, when the tank was nearly if not quite full, was not promising, the native opinion of it as unfavorable the expression used being that they would not give it to a horse to drink, and they say that to bathe in it is apt to produce fever.

The inhabitants of the town use the water of a small tank, which lies immediately East of the large tank and North of the town, and its water is altogether different in appearance. Under these circumstances it seemed unnecessary to carry the investigations further. The information above given was obtained from the native Accountant of the Amani tanks.

4th. About 3 miles from the head of the Race Course, is Cavalry and Field Artillery Barracks. There is the appearance of tank, which on the whole affords the best prospect of being a suitable source for the supply of the troops. It has a catchment basin of 32·18 square miles, of which however a considerable part is rendered ineffective, or only partially effective, by the upper tanks in the same basin. It receives no drainage from the Pettah or Cantonment. It is said

has generally well supplied Bangalore in 1876 it was in common with nearly every tank in the Country, for a time dry.
This season, though the rainfall was below the average, the tank was filled up by the 19th January or 4½ weeks after the last considerable rainfall. In the 5th month the water had fallen 0·96 of a foot, so that including if the water dropped off for all time the water surface would fall less than one quarter of an inch a day.
The position of the tank with regard to Remarks, and that of its catchment basin will be seen on referring to Plan 1 sheets 1 & 2, and the Survey of the tank is given in plan 13.
The area of the water spread at Full Tank Level is 131 acres or 5·706 millions of Square feet.
The sill of the lowest sluice is 7·18 feet below Full Tank Level, and the area of water spread at this sill level is computed to be about 1·017 millions of Square feet. The capacity between sluice sill and Full Tank Level is therefore 24·068 millions of Cubic feet, and it has been assumed that more than Full tank level record 3 feet 20 by 5 Millions of

of Cubic Feet would be added to the contents. There are 280·17 acres of land cleared not under the tank, and of these 129·10 acres are usually cultivated and yield a Revenue of Rupees 617-8-0.
The Full Tank Level is 58·25 feet below that of the Halasur Tank and the water must be pumped at least as much higher in order to secure as much command as at present.
45 Samples of the water have been analysed by the Chemical Examiner with the result shown in Appendix No 26. It will be seen that the water has obtained only the qualified character "Potable", but that is the highest character given in any of the analyses of Bangalore water, and it seems to be more than doubtful whether anything more favorable is likely to be found.
The Agaram water is slightly clouded, but it is good wholesome looking water and very different indeed from that which even at the best of times is to be found in the Halasur tank. It will be noticed that the analysis differs

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somewhat in the case of the two samples, through the water was all taken from the tank at one time and at one place.

46. It was at first intended to get rid of all matter, capable of removal by filtration, from the water by sinking a large well in a convenient spot near the North West corner of the tank, and allowing no water to enter the well except through several feet of soil. The analysis by the Chemical Examiner appendix No 26E
shows one of the waters of one well to the North West of the Tank, and the partial analysis of the water of 4 wells at Bangalore of the same kind do - do 26F
but a short distance from its waterspread on the west side, which, more especially Nos 3 & 4, were chosen to serve as an Index to the probable quality of the soil through which a supply well would be sunk, render it more than probable that such an arrangement might materially injure the quality of the water. The fixed hardness, for instance, is 6.2 degrees in the tank, No 4, of these 4 wells, against 1.4 & 1.75 degrees for the tank water, while in other respects the well water is considerably less pure than that

that in the tank, though the former is far clearer.

It would be desirable if possible to avoid the expense and complication of artificial filtration, and so in any case it would be desirable to have an experimental well sunk in the bed of the tank to test, through the water therefrom drawn, the character of the soil through which the water has filtered, and its effect upon the potable qualities of the supply. Samples of water have been taken from 2 wells or pools in rear of the Western end of the bund, and their analyses will be found in appendix No 26G. The results are satisfactory as the turbidity of the water is no doubt due to the wash of the water on the soil, the pools or wells being used for irrigation.

47. On Plan 14 are shown the relative levels of the tank and the several service cisterns attached to the Barracks, Hospitals &c. Also the proposed height of the standpipe, which is intended to be rather more than 15 feet above the water surface, when full, of the highest cistern to be filled.

Appendix No. 24 Contains specifications and approximate estimates for the work done, and a short summary of the latter is subjoined. It appears the essential & increase the capacity of the tank by the water drawn direct from the latter only, in the estimate for this arrangement such increase has, it will be seen, been provided for. The average consumption of water by the troops has been 3·292 millions of Cubic feet per annum or less than one seventh of the contents of the tank, and probably not more than one twentieth of the quantity received: the estimated maximum consumption also has been taken as 5·256 millions of Cubic feet in the year, or perhaps one twelfth of the supply coming into the tank. There would correspondingly extent of land, viz about 5 acres, thrown out of cultivation and compensation on that account paid, there would still be much risk of the storage proving insufficient at times with an addition to the storage capacity of nearly 3 times the maximum offtake there is every probability of there being always in the tank an ample reserve to meet the contingency of an unusual interval between successive receipts from rainfall.

It is indeed recorded in consideration whether it would not be the better plan, even if water be drawn from a well within or below the tank, to enlarge the tank, as by so doing all question of injury to land holders under the tank would be avoided, and that is a matter of importance.

Particulars	Wells	
	Water drawn direct from Tank	Water drawn from supply well in or below Tank
	Rupees	
Engines and pumps	36,500	36,500
Standpipes, including masonry	3930	3500
Delivery mains	1,18,000	1,18,000
Suction pipe from supply well		
Supply well	—	2570
Suction pipe from tank	—	900
do from pure water well	4600	—
2 Filters	560	—
Enlarging tank	15,000	—
Ground for pumping station	13,000	—
Engine House and Chimney	250	250
Quarters for Engineer &c	12,500	12,500
Enclosure walls	3,000	3,000
	4,000	4,00
	2,11,340	1,81,220
Contingencies	8,660	6780
	2,20,000	1,88,000

any of the pumping plant at the present water works would be suitable and available for transfer to the Agaram water works. The engine at the Rock is an old one, but with new boilers it would be serviceable for some years to come. The engine at the Oholiers wells is comparatively new, and it ought to be capable of a much higher duty than has so far been obtained from it. At present it is weak as regards fuel consumed as compared with work done but it seems probable that this is in a considerable measure due to the use of a small delivery pipe.

However the chief difficulty would lie in the necessity for continuing the present water supply arrangements until other and better arrangements have been carried out and are perfectly ready to be substituted. The troops cannot be left without water for 2 or 3 weeks or perhaps longer, and as the engines and pumps must be kept where they are, and others be provided for the new works. It may be taken as certain however

however that it will in the long run be the more economical and satisfactory plan to get complete machinery, suited in all respects to the work to be done, from a Firm which understands the special requirements of such works. Water works need to be well carried out in all respects and all the parts should be in harmony. The old plant will fetch something considerable when done with though much less than its value. The pipes now in use ought to fetch their full value. or some of them might with advantage be used for extending the distribution arrangements to the lines occupied by the officers of the Regiments supplied.

50. It is nearly certain that water of perfectly satisfactory quality could be obtained at Bangalore only by distillation, and it seemed desirable therefore to complete the water supply investigations by ascertaining the cost of the necessary apparatus, and the expense of producing potable water in this way. General Hyde of the India Office has obligingly furnished the

requisite information. In appendix No. 25 will be found a statement giving the results of the working of the new and old Government Condensers at Aden, as well as those of 2 private owners. The new Condensers were made by the Normandy Company, and are considered the best and most economical known. Also 2 letters from the Normandy Company to General Hyde, and estimates for 3 sets of apparatus. It will be seen that the cost of 2 sets of apparatus to produce together 12,000 gallons in 24 hours would be £4,362

1 Set to produce 9000 gallons £3,052

1 Set to produce 12,000 " £4,046

These prices are free on board in London, and the corresponding prices at Bangalore would probably be Rs 65,430; 45,780; and 60,690.

The smaller or 6000 gallon size has, in an experimental trial at Aden, produced 7,082 gallons in 24 hours.

The larger, or 9000 gallons size, — do — 12,113 — do —

but the average yield is shown by the statement to be about four fifths of the above. Coal is the fuel used at Aden,

14473

and one pound of coal is equivalent to four pounds of wood, the fuel available at Bangalore.

The yield is 16 lbs of Condensed water for one lb of coal, and therefore 4 lbs of water would be obtained for one pound of wood fuel.

The Company's estimate of out turn is higher than the above, and varies slightly according to the size of the apparatus, the yield being 18·0; 18·8 and 19·8 lbs of water to 1 lb of coal for the 3 sizes, respectively.

The Aden experience may, it is considered, be accepted as a safe guide.

No better water than that of the Wholies' wells could be obtained for distillation.

Assuming that 9000 gallons a day would meet the requirements of the troops, if the use of the condensed water were restricted to drinking and cooking purposes, one set of apparatus at a cost of Rs 45,780 would suffice if kept constantly at work, but as at any rate it would be advisable to stop the machinery on Sundays, it would be desirable to have a 12,000 gallon set which would produce in 6 days enough water for 8 days consumption, and its cost

cost would be Rs 60,690- The weight of 12,000 gallons is 120,000 lbs, and the wood fuel required would be 30,000 lbs. The present price of wood is 1 Rupee for 268½ lbs, therefore the daily cost of fuel would be Rupees 112 nearly, and the annual cost 52×6×112 = Rs 34,344

Small stores &c . . . 256

working expenses 34,600

The apparatus includes pumps capable of delivering the water where required. It is stated that the attendance of one man will suffice to work the apparatus, and therefore the existing establishment at the Dhobies' wells would suffice; and as the engine and pumps there would not be required, the buildings would be available for the Condensers.

The only other outlay would be for pipes, cisterns at the Barracks, &c say 25,000 and the total annual outlay may be thus estimated.

15 per cent interest and depreciation on the cost of the condensers . . . 9,104

10 per cent. down rest of outlay 2,500

working expenses 34,600

46,204

or about 15.40 Rupees annually per head.

The present cost, about Rupees 10400 a year, for the working expenses of the Halsur water works would remain unaffected, as water for other purposes would have to be pumped up by the Halsur Rock water works.

51. The results of the investigations that have been made are briefly these.

(1) The Bangalore water Supply project was designed and has been, with the exception of the greater part of the distribution works, carried out, to supply the population generally with good water.

The (cooparhalli) reservoir is inadequately supplied. It has never been full or nearly so: for nearly 5 months in the year, on the average of 6 years, the water level there in has been below the sill of the off take sluice. The cause of this failure is the very small extent of the gathering ground, 2½ square miles, which is not more than about one third of the area necessary to enable the reservoir to perform the duty for which the works were constructed.

There is but an insignificant extent of additional ground, the drainage of which could be brought into

Para: 27.

Para: 28.

× a little over 1 sq mile

para: 30.

the tank, within a distance of 2 or 3 miles,
and owing to the low level of the intervening
country, the cost of bringing in the water
therefrom would be out of all proportion to
its quantity and value.

The Bangalore water Supply project is therefore
incapable of supplying the Station or the troops,
and its utility will necessarily be confined
to the improvement of the supply of a part of
the Pettah or native town, and to occasionally
supplementing the supply of Millers Tanks,
which are of much importance to the
inhabitants of the Cantonment Bazaar.
The high ground at Hundidroog is the
nearest and indeed only, locality in which
there is any considerable extent of ground
on a sufficiently high level to command
Bangalore, and even there the area, between
9 and 12 Square miles, is much less than
would be desirable. It is not yet certain
that a suitable site for a reservoir in
that neighbourhood can be found, but
if there be such a site, the cost of
supplying Bangalore generally, including
the garrison would be between 24,87,000
and 28,80,000 Rupees, depending upon
the

Para 31.

the thickness of the Cast iron mains. These
amounts represent, together with an allowance
for working expenses, annual charges of
from Rs. 1.698 to 1.960 per head of a population
of 150,000, and of from Rs 1.960 to 2.262 per head
of the present population of 130,000

(2) The Halsur Tanks, the present source of supply
for the Troops, are supplied from, for the most
part, a densely populated watering ground,
and the quality of the water is therefore —
unsuitable for drinking and cooking purposes.
It would be possible to exclude the whole of
the foul drainage from the lower and larger
of the Tanks, and to compensate for this exclusion
by bringing in the drainage of open —
cultivated country to the Eastward. This
new watering ground however though
comparatively clean, is manured with the
dirt and refuse of the cantonment Bazaar
Barracks, &c, and is therefore not capable of
yielding any thing like pure water. This —
however not practicable to get rid of the foul
supply of the upper tank, which receives
drainage not only from ground carrying a
considerable population, but from the —
occupied by Tanneries, a large nature —
On the

the Halsur

The Halsur Tanks therefore are not capable of being made a really satisfactory source of water supply for the Troops.

The cost of such improvements as are feasible would be from 25,310 to 29,970 Rupees, the former for a new catchment of 2·174, and the latter for one of 3·10, square miles.

para 39.

(3) The proportion of the annual rainfall which does not run off the surface of the ground, but which is absorbed thereby, is in favour of wells as a source of water supply, and there is still a large extent of open, and fairly clean, ground in the neighbourhood of the Barracks occupied by the Troops, in which wells could be sunk to obtain the water supply required for drinking and cooking purposes.

The nature of the subsoil, composed of fissile rock in a more or less advanced state of decomposition, makes it difficult to find subsoil water of suitable quality, and there is great uncertainty as to the quality of the water which wells sunk in any given locality would yield.

Separate sets of wells would moreover be needed to supply

1st The European Barracks

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The 2 Field Batteries

a South Station Hospital

2nd The Horse artillery

3. The European Infantry Regiment

in North Station Hospital.

The water supply of one well, No 2. about 760 yards South of the South Station Hospital, has been tested as regards both quantity and quality. The latter is satisfactory, and the former indicates that, for drinking and cooking purposes only, 6 supply wells each 20 feet in diameter, would be required for the first section above mentioned of the Garrison.

The total cost of supplying the Troops from wells is estimated at Rupees 1,12,500, representing

Para 42.

the following annual expenditure.

Interest and depreciation on cost of works at 10 per cent	Rupees 5,000
Working expenses.	2,500
total Rs.	7,500

which would be in addition to present charges on this account.

The difficulty of forecasting the quality of the water, and the uncertainty as to the maintenance of that quality if found suitable in the first instance, render it

it unadvisable to resort to wells as a source of supply, if any better arrangement can be made.

(4) A new source of supply for the troops has been found in the Agaram Tank, a reservoir situated about 3 miles to the South of the South station Hospital, and having a catchment basin of 32·10 square miles. Of which however a considerable part is rendered non effective by a number of tanks in the upper part of the valley. The tank is well supplied; it receives none of the drainage of Bangalore, and the quality of the water, which has been analysed by the Chemical Examiner, is described as "usable", the highest character given to any water, from the neighbourhood of Bangalore, which has been examined. The surplus weir is 56·62 feet below that of the Halsur (lower) tank, and water would have to be pumped up to a level sufficiently higher than at present to cover this difference, and the head due to the greater distance. The water could either be drawn direct from the tank, filtered, and then pumped into the existing service cisterns, or it could be drawn from a supply well in or below the tank, in which case artificial filtration might not be needed.

Para 44.

para 45

The tank at present has a capacity of 24·068 millions of cubic feet, and by raising the weir 3 feet an additional storage capacity of 20·601 millions would be secured, making the total 44·669 millions of cubic feet. The estimated outlay required is Rupees 2,20,000 if water be taken direct from the tank, and Rupees 1,88,000 if it be drawn from a supply well within the influence of the tank. These amounts would represent an annual expenditure as follows.

	No 1.	No 2
Interest and depreciation on cost of engines, pumps & boilers &c.		
at 15 per cent.	5475.	5475
do - do. on other outlay at do. do.	18350	15150
	23,825	20,625

Troops & families 3,000 or from Rupees 7·94 to 6·87 per head.

The present working expenses, for pumping &c amounting to about Rs 10,500 per annum, would suffice for the new pumping station, and the engines and pumps at the Halsur Rock and Dhobies' wells could, after the new arrangements had been completed, be disposed of.

(5) Water of unexceptionable quality is —

probably obtainable at Bangalore only by distillation.

It has been ascertained that the best known apparatus for this purpose is the Normandy Company's Condenser, which is that recently introduced for the Government water supply at Aden.

Paras 50

Taking 9000 gallons or 3 gallons a head as the quantity essential for the use of the troops, for drinking and cooking purposes, the annual expenditure on this account would be about Rs 46,204 or Rupees 15-40 per head.

The working expenses of the present water works would be unaffected, as all the rest of the supply would have to be obtained from the Halsur tanks.

The Obalies well water would be the best for distillation, and the buildings there would be suitable for the Condensing apparatus.

The Normandy Condenser produces pure, cold, palatable and well aerated water.

52. The thanks of the undersigned are due to Captains Karsington R.E. the ... assistan

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Secretary to the Mysore Government, P.W.D.; to Lieutenant-Colonel Burton R.E. Executive Engineer, Presidency Division, and to Mr. J. Smith, the Engineer of the Halsur water works, for much valuable assistance given in carrying out the investigations referred to in this Report; as also to Dr. T. Jarrant, Deputy Surgeon General, Bangalore Division, for the very useful information afforded, at short notice, as to the quality of samples of water taken from several wells.

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Bangalore
31st March
1884

Colin Mackenzie Col. R.E.
Chief Engineer on Special duty

201

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Report
on Bangalore Water
Supply.

1473

Comparative Statement of Sanctions and outlay, ...

Heads	Original Estimate Sanctioned by the Government of India on the 23rd August 70	Revised Estimate sanctioned by the Government of India		Total Revised Estimate	Total outlay.	~~Total Capacity of Reservoirs available for~~
		July 1876 Revised Estimate	October 1876 Supplemental Estimate sanctioned by the Government			
Embankment and Weir	1,03,903	2,31,207	3329	234536	314868	
Catchment channels	11,850	51,758	.	51,758	71289	
Moderator Tanks	7,112	"	.	"	"	
Waster Sewer	8,635	11,768	.	11768	729	
Filter and store Basins	72,603	39123	.	39123	"	Design modified & then given up.
Distribution Reservoir	24,123	"		"		This part of scheme abandoned
Delivery Channels	2,91,031	1,15,552 x	7632 xx	123184	89454 xx	x open masonry channels instead of Iron pipes.
Compensation for land &c	50,000	69,000	2000	71,000	64140	xx Covering the channels
Surveys & Rainfall Registration	"	5250		5250		xxx Nothing done beyond earth-work.
Inspection Lodge Barracks & Huts	"	12705		12705	4.285 xxx	
Total Rupees	5,69,257	536363	12961	549324.	544,765.	

Reservoirs { Total Capacity. Available.

Appendix No. 2.

Levels of the Boundary Catchment channels—Ogharahalli Reservoir

Bangalore Water Supply Project

Taken in April & May 1883.

Mileage Mile.	Ft.	Bed levels &c.	Remarks	Revised Bed level may 1883
			N. East. Channel	
0	0	99.87	Newly excavated bed at grade stone	98.00
0	1	101.42	on grade stone	
0	2	101.43	do	98.75
0	3	101.33	do	
0	4	101.57	on bed	99.50
0	5	102.08	do	
0	6	102.44	do	100.25
0	7	103.23	do	
1	0	102.50	do Rise 1.23 per mile	101.00
1	1	102.18	do	
1	2	102.42	do	101.75
1	3	102.80	do	
1	4	103.07	do	102.50
1	5	103.21	do	
1	6	103.26	do	103.25
1	7	104.02	do	
2	0	103.70	do Rise 1.20 in mile	104.00
2	1	104.21	do	
2	2	104.35	do	104.75
2	3	104.00	do	
2	4	104.44	do	105.50
2	5	104.60	do	
2	6	105.01	do	106.25
2	7	105.42	do	
3	0	107.84	do Rise 1.14 in mile	107.00
3	1	120.11	do	
			North West Channel.	
0	0	99.38	Newly excavated bed	98.00
0	1	101.49	on grade stone	
		100.98	" bed newly excavated	
0	2	101.65	on grade stone	98.75
0	3	101.80	" do	
0	4	101.82	" do	99.50
0	5	102.17	" do	
0	6	102.29	" do	100.25
0	7	102.51	" do	
1	0	102.72	" do	101.00
1	1	102.91	" do	
1	2	103.25	" bed of channel	102.00
1	3	103.33	" grade stone	
1	4	103.46	" bed of channel	103.00
1	5	102.74	" do	
1	6	104.06	" grade stone	104.00
1	7	104.49	" bed of channel	
2	0	104.76	" grade stone	105.00
2	1	106.08	" bed of channel	
2	2	108.19	do	

Mileage Mile.	Ft.	Bed levels &c	Remarks	Revised Bed level may 1883
			North West channel	
0	0	100.26	bed of channel & floor of culvert No. 1 under rail = 104.11	98.00
0	1	101.04	on grade stone	
		99.34	Bed newly excavated	
0	2	101.48	on grade stone	98.75
		99.98	Bed newly excavated	
0	3	101.64	on grade stone	
		100.44	Bed newly excavated	
0	4	101.89	on grade stone	99.50
		101.26	Bed newly excavated	
0	5	101.97	on grade stone	
0	6	101.65	Bed newly excavated	100.25
0	7	102.38	on grade stone	
1	0	102.67	on bed	101.00
1	1	103.18	" do	
1	2	103.11	" do	102.00
1	3	103.41	on grade stone	
1	4	103.29	on bed	103.00
1	5	103.61	on grade stone	
1	6	103.95	" do	104.00
1	7	104.36	" do	
2	0	104.57	" do	105.00
2	1	105.48	" do	
2	2	106.43	" do	
			South East channel	
0	0	99.76	Floor of Culvert	99.00
		100.39	on grade stone	
		97.99	Bed newly excavated	
0	1	102.75	on grade stone	
0	2	102.09	" do	100.00
0	3	102.27	" do	
0	4	102.60	" do	101.00
0	5	100.85	" bed	
0	6	103.01	on grade stone	102.00
0	7	103.24	" do	
1	0	104.04	" bed	103.00
1	1	103.97	" do	
1	2	103.81	" do	
1	3	104.19	" do	

December 1883.

Copied from Level Book lent by Inspector P. W. Office.

Appendix No 2.

Levels of the Boundary Catchment Channels. Ooparahalli Reservoir Bangalore Water Supply Project

Levels of the Upper main (No 2) Catchment channels - Ooparhalli Reservoir
Taken in October & November 1883. Bangalore Water Supply Project.

Mileage Miles	Mileage F.	Bed Levels &c.	Remarks.
			North East channel
0	0	100.62	Bed
0	1	105.48	do
0	2	110.31	do
0	3	112.24	do
0	4	112.46	do
0	5	113.95	do
0	6	114.21	do
0	7	114.14	do
1	0	114.96	do
1	1	115.50	do
1	2	116.09	do
1	3	118.65	Grade stone
1	4	118.13	do
1	5	118.40	do
1	6	119.35	do
1	7	119.67	do
2	0	120.98	Bed
2	1	121.52	Grade stone
2	2	122.84	Bed
2	3	124.72	
			South West channel
0	0	100.84	
0	1	104.33	
0	2	107.70	
0	3	110.75	
0	4	114.66	
0	5	117.31	
0	6	118.07	
0	7	118.74	
1	0	119.15	
1	1	119.84	
1	2	120.52	
1	3	121.29	
1	4	122.52	
		123.82	end of channel

Mileage Miles	Mileage F.	Bed Levels &c.	Remarks
			South East channel.
0	0	101.90	
0	1	106.33	
0	2	111.96	
0	3	113.36	
0	4	114.39	
0	5	115.22	
0	6	115.39	
0	7	117.38	
1	0	118.09	
		118.69	end of channel.
			North West channel
0	0	102.30	
0	1	104.64	
0	2	107.44	
0	3	109.61	
0	4	111.68	
0	5	112.76	
0	6	113.43	
0	7	113.65	
1	0	114.04	
1	1	114.64	
1	2	115.42	
1	3	116.47	
1	4	117.44	Grade stone
1	5	117.94	do
1	6	118.04	do
1	7	120.02	do
2	0	121.24	do
2	1	122.77	do
2	2	124.62	do
		126.95	end of channel.

Copied from the Level Books in the office of the Secretary to the Improvement Government P.W.D. on the 7th January 1884.

Appendix No. 3

Abstract of the Rainfall Registered at Stations of the Bangalore Water Supply Works.

Months	1876		1877		1878		1879		1880		1881		1882		1883		Days		Inches.	
	Days	Inches	Days	Inches	Days	Inches	Days	Inches	Days	Inches	Days	Inches	Days	Inches	Days	Inches	Total	Average	Total	Average
January	-	-	-	-	-	-	1	0·27	-	-	-	-	1	0·75	-	-	2	0·28	1·02	0·13
February	-	-	-	-	-	-	2	1·24	-	-	-	-	-	-	-	-	2	0·29	1·24	0·15
March	-	0·88	2	0·60	-	-	2	1·56	1	0·57	2	0·63	-	-	-	-	7	1·00	4·24	0·58
April	-	0·48	2	1·08	1	2·13	2	0·60	3	1·44	1	0·74	1	0·39	1	0·09	11	1·57	6·95	0·87
May	-	5·69	6	2·68	5	8·31	9	6·05	10	5·29	2	1·64	10	6·77	5	2·83	47	6·71	36·16	4·52
June	-	1·89	7	1·83	5	2·23	4	2·02	15	4·20 ×	2	2·06	5	0·62	7	1·24	45	6·43	17·17	2·15
July	-	2·38	6	1·03	11	5·33	14	8·49	17	6·84 ×	-	-	16	4·89	18	3·94	82	11·71	37·00	4·11
August	-	3·11	8	2·78	13	12·77	15	3·82	10	8·06	13	5·56	15	7·29	14	6·92	88	12·57	50·31	6·29
September	-	1·11	21	12·33	15	6·93	7	4·32	4	1·63	14	6·47	12	3·39	4	0·96	77	11·00	37·14	4·64
October	-	0·56	14	9·95	11	5·11	10	7·48	11	8·78	1	0·14	10	4·73	14	12·96	71	10·14	49·71	6·21
November		0·42	3	2·07	1	0·23	2	1·90	6	2·09	5	1·38	12	8·09	6	3·94	35	5·00	23·12	2·89
December	-	-	-	-	-	-	-	-	1	0·58	-	-	-	-	3	2·03	4	0·57	2·61	0·33
Total	-	16·52	69	34·25	62	41·03	68	37·75	78	39·56	40	21·63	82	36·92	72	34·91	471	67·28	262·57	32·82

× as registered at the Bangalore Observatory, Browning Civil Hospital

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Appendix No 5.

Table showing the periods during which water was above or below the sill of the Esparhelli Reservoir, Sheet No 2 of Dr. 3019-97.

Years	Months	Days above Sill	Days below Sill		
1878	January		31		
	February		28		
	March		31		
	April		30		
	May		31		
	June		30		
	July	14	17	Highest W.L. 91.28 on 19th;	Lowest W.L. 87.68 on 1st
	August	3		do 99.68 on 26th;	do 98.48 on 10th
	September	30		do 100.12 on 29th;	do 98.69 on 2nd
	October	31		do 100.25 on 24th;	do 99.33 on 1st
	November	30		do 99.62 on 1st;	do 97.97 on 3rd
	December	31		do 97.77 on 18th;	do 95.10 on 31st
	Total	167	198		
1879	January	31	—	Highest W.L. 96.07 on 1st;	Lowest W.L. 92.60 on 31st
	February	28	—	do 94.58 on 1st;	do 93.57 on 28th
	March	31	—	do 93.82 on 14th;	do 92.50 on 31st
	April	30	—	do 92.44 on 14th;	do 91.12 on 30th
	May	31	—	do 92.83 on 22nd;	do 90.29 on 18th
	June	30	—	do 92.92 on 18th;	do 91.90 on 30th
	July	31	—	do 92.08 on 29th;	do 91.17 on 16th
	August	31	—	do 94.83 on 18th;	do 93.79 on 23rd & 24th
	September	30	—	do 94.81 on 15th;	do 93.75 on 1st
	October	31	—	do 96.42 on 11th;	do 93.42 on 10th
	November	30	—	do 96.75 on 6th;	do 94.93 on 30th
	December	31	—	do 96.85 on 1st;	do 96.12 on 31st
	Total	365			
1880	January	31	—	Highest W.L. 92.08 on 1st;	Lowest W.L. 91.69 on 31st
	February	29	—	do 91.63 on 1st;	do 90.29 on 29th
	March	5	26	do 90.25 on 1st;	do 89.17 on 31st
	April	—	30	do 89.10 on 1st; Register incomplete.	
	May	—	21	do 92.33 on 27th;	do —
	June	30	—	do 92.17 on 2nd;	Lowest W.L. 91.04 on 30th
	July	31	—	do 92.09 on 11th;	do 90.83 on 5th
	August	31	—	do 96.92 on 16th;	do 91.04 on 11th
	September	30	—	do 95.93 on 1st;	do 94.33 on 20th
	October	31	—	do 97.85 on 28th;	do 94.08 on 20th
	November	30	—	do 97.58 on 1st;	do 95.83 on 30th
	December	31	—	do 96.04 on 1st;	do 94.33 on 31st
	Total	289	77		

Years	Months	Days Alive	Days Abs'tee	
1878	January	31	—	Highest M.L 94·25 on 1st; Lowest M.L 92·75 on
	February	28	—	do 92·31 on 1st; 91·37 on
	March	31	—	do 91·33 on 1st; 90·06 on
	April	1	29	do 90·04 on 1st; Register incomplete
	May	—	31	do 89·25 on 31st; Lowest M.L 87·96 on 28
	June	11	19	do 92·42 on 8–9th; do 87·00 on 7
	July	—	31	do 89·37 on 10th; do 88·08 on 31
	August	4	27	do 91·42 on 29th; do 87·96 on 7th
	September	13	17	do 90·78 on 28th; do 89·65 on 15
	October	22	9	do 90·71 on 6th; do 89·67 on 31
	November	26	4	do 93·12 on 13–14th; do 89·58 on 2
	December	31	—	do 92·12 on 10th; do 91·17 on 31st
	Total	198	167	
1879	January	29	2	Highest M.L 91·12 on 1st; Lowest M.L 89·94 on 31
	February	—	28	do 89·94 on 1st; do 88·77 on 28
	March	—	31	do 89·72 on 1st; do 87·29 on 31
	April	—	30	do 89·21 on 1st; do 85·48 on 30
	May	12	19	do 92·28 on 20th; do 86·69 on 15
	June	26	6	do 92·29 on 18th; do 89·93 on 30
	July	—	31	do 89·79 on 12th; do 89·17 on 20
	August	21	10	do 91·46 on 11th; do 89·35 on 8
	September	11	19	do 90·92 on 1st; do 89·67 on 28
	October	22	9	do 90·92 on 14–15th; do 89·28 on 9
	November	30	—	do 91·79 on 30th; do 90·08 on 5
	December	31	—	do 91·75 on 12th; do 91·50 on 21st
	Total	181	184	
1880	January	31	—	Highest M.L 90·06 on 1st; Lowest M.L 89·21 on 31st
	February	—	28	do 89·7 on 12th; do 88·50 on 28
	March	—	31	do 88·47 on 18th; do 87·37 on 21st
	April	—	30	do 87·34 on 14th; do 86·27 on 30
	May	—	31	do 86·24 on 18th; do 85·68 on 31st
	June	—	30	do 86·95 on 3rd; do 84·97 on 30
	July	—	31	do 84·93 on 10th; do 84·88 on 17
	August	—	31	do 89·40 on 19–20th; do 84·52 on 10
	September	—	30	do 88·96 on 10th; do 88·02 on 30
	October	25	6	do 98·00 on 17th; do 87·95 on 2nd
	November	30	—	do 97·96 on 3rd; do 95·33 on 30
	December	31	—	do 95·15 on 10th; do 91·90 on 31st
	Total	97	268	

Years	Days Alive	Days Abs'tee
1878	167	198
1879	365	—
1880	289	77
1881	198	167
1882	181	184
1883	97	268
Total	1297	894
Average	2·16	1·49

5

...es of Periods of M.L. abo...
...or below Sluice Gate.

Asparhalli Reservoir

—		
77		
78		
79		

...showing the ... of water level & contents on the 30th & ...
...ch year and the 15th May of the ... following. Asparhalli Reservoir.

Year	30th ...		15th May.		Difference Millions of Cubic Feet.
	Gauge Reading	Contents Millions of Cubic feet.	Gauge Reading	Contents Millions of Cubic Feet.	
1878 / 1879	97·87	14·086	90·42	0·635	13·451
1879 / 1880	94·93	8·262	87·67*	0·484	8·736
1880 / 1881	96·83	9·968	88·58	2·046	12·013
1881 / 1882	92·48	3·880	85·69	5·808	9·691
1882 / 1883	91·79	2·775	85·74	5·747	8·522
1883	95·33	9·018			
		47·982			
Average		7·997			

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* An approximation, the Register not giving the water level between 24 April and 22 May.

Fall of Surface = 1878 / 1879 { 7·45
do 1879 / 1880 { 5·26
do 1880 / 1881 { 7·25
do 1881 / 1882 { 6·77
do 18[illegible] / 18[illegible] { 6·05
32·76
Average 6·55

do

Abstract

Name	Number of Supply Gallons per head per day		Description of works.
Valeur water-works	14	European	Water pumped into service cisterns
Bangalore	1	Native followers	holding 3 mn 7 & 33 days supply
	12	Horses	Source of supply – a tank and wells
			below the tank.
			Cost about Rs 328,000
			Population 2460 European
			1302 Native followers
			834 Horses
Alwarpet water-works	2		Population 800; Cost Rs 21,000
			Supply collected from ravines and springs
			and conveyed in a concrete channel
			from an extreme distance of 3½ miles
			to a storage reservoir holding 12,000
			cubic feet or 62,500 gallons.
Ahmedabad water-works	5⅓		Distribution by water posts.
			Population supplied 26,000 out of
			111,880 – consumption 133,000 gal.
			daily – water pumped from the
			Sabarmati by engines of 546 horse
			power in 10 hours daily to a height
			62 feet, into a settling tank holding
			but little more than ½ a days
			supply. Distribution by covered
			tanks and stand pipes.
Karundwad &c adjunction of Kunda-punja & Krishna pipes	5		Cost prior & subsidiary to adoption of pumps Rs 99583.
			Population 6000 Cost Rs 23,807
			water pumped by a windmill
			from well on bank of river, into
			standpipe 20 feet high and thence
			into a storage tank (Pontoon)
			holding 2.4 millions of gals.
			No distribution.

Name	Limit of supply gallons per head per diem		Description of works
			Works not successful owing to wind engine not working properly
Chalkarapi water works	5		Population 8000: cost Rs 1,00,174 Lift 80 feet – Source of supply the river Punchganga – water pumped up and conveyed to storage tank holding 120 millions of gallons. Distribution by pipes to 4 dipping wells and 2 cattle troughs.
Secunderabad water works	16 80	European troops Officers	European troops, men 3719 officers 140. The women and children not included in the above. Source of supply – wells. Water pumped by engines into service reservoirs. Quantity 79,704 gallons per diem. Maximum height of delivery above water in well, 139 feet. Total cost Rs 3,12,913. Cost of machinery & piping Rs 1,75,000 South supply 24 to 30 gallons per diem one well 30 feet diameter and 55 feet deep from ground surface. Cost of this part of system Rs 88,060. Monthly cost of working Rs 380. North supply 26 to 30 gallons per head. Main well and Quarter guard well which are connected – dimensions not stated. Cost of this part of system Rs 2,27,851 Monthly cost of working Rs 60 The service reservoir holds 3 days supply. Results satisfactory. North supply 300,000 gallons per a
Colaramund water Supply	30	Domestic 12 General baths 4 Steam & trade 4 waste 10	Source of supply reservoir. Capacity 1 million gallons, catchment 2 to 3 square miles. Supply insufficient and intermittent. Supplemented by a second reservoir with capacity about 24 millions of gallons at catchment 1 to

Name	Limit of Supply gallons per head per diem	1873	Description of works
			Cost ——— Rupees 28,629
			Proposed additions 102,940 131,569
			South Supply — Reservoir, capacity — 3 millions of gallons — Catchment 184 acres. Reservoir too small as the supply would fill one holding 30 millions of gallons So far supply not satisfactory and extensive improvements contemplated
Royal Aliba[g] water works	16		Population 5,500 — Reservoir, capacity 22·50 millions of gallons, fed by a stream which can fill the reservoir in 48 hours. Distribution by pipes to about 20 dipping wells or service reservoirs. Cost Rupees 34,000 — Reservoir has a small Command over town.
Pen water works Kolaba Collectorate	26⅔		Population 6,000 Cost 28000 Rupees of which Reservoir 18000 and distribu 10000 Rupees. Catchment basin 100 a Annual rainfall 113 inches Estimated yield of catchment 120 millions of gallons or 19·20 millions of cubic feet equivalent to 52·8 inc draining off the catchment or nearly half the rainfall. Estimated maximum consum of water 160,000 gallons per diem equal to 26⅔ gallons per he per diem. Distribution below filter by cast iron mains to 15 t or cisterns, with option of house connections at owners expen
Kolhapur water works.	10		Population 40,000 Cost — Head works Rs 15309 alterations & duct 40,486 Reservoir 18,403 Pipes 1,09,377 Fountains etc 10,099 Total Rs 2,54,2

Name	Quantity of water per head per diem.	1873	Description of works.
			Source of supply – Springs in a water course 4½ miles South West of town – Catchment basin of water course above dam 4 square miles. Water drawn from well 10 feet below bed of stream, and flows into duct which has a fall of 16 feet per mile and can discharge when running full 262 cubic feet per minute or 2½ millions of gallons a day or 5 times the daily requirement at 10 gallons per head. Duct discharges into service reservoir a circular masonry tank 100 feet in diameter and 6 feet deep, holding 294,500 gallons. Distribution by cast iron pipes and 267 standpipes. Rainfall 40 to 45 inches. Works only partially successful, as the supply has been as little as 117,000 gallons a day in the hot season, or 7·8 gallons per head per diem. It is intended to form a impounding reservoir above the head works.
Jalgaon water works	89	3 Prepa. 5500 gallons daily for 6 months. 1 Factory 6000 gallons daily for 12 months.	Population (July 1879) 8,406. Source of supply Mehrun large and small tanks with a catchment of 3·45 square miles. Rainfall 7·68 to 35·92 inches. Average of 8 years (1868 to 1875) 22·20. Capacity of large tank 142 millions of gallons – Depth of draining off catchment
	70		

Name	Daily supply allowed per head per diem		Description of works
Lahore water work	10		Catchment & filter tank & reservoir Tank filled & overflowing in 1878 & in 1879, but rainfall not stated Supply available by gravitation, after deducting allowance for evaporation, 378 millions of gallons for the year, of which 360 millions used by pedestrians &c, and 270 millions, remain for distribution among population or over 87 gals per head per day. Cost of works-Service tank & 27 87 Pipes £ 16,000 Loop tank 700 17 37 or Rs 1743 per million cubic feet stored and Rs 10 monthly per head of population. Population 130,000 - Source of supply wells in Khadir of River Ravi. Supply practically inexhaustible, the Khadir having formerly been the bed of the river and having a constant subsoil flow. Extreme lift 140 feet Length of pumping main 2 miles Water pumped into enclosed reservoir with a capacity of 381,600 C. Feet or 2 days supply and distributed thence by iron pipes. Greatest quantity of water pumped 60,000 gals per hour.

Name	Limit of supply Gallons per head per diem		Particulars
			Cost of works ... Rs 16,00,935 working expenses per mensem Engine establishment Rs 356 Fuel &c ... 763-8-0 Total Rs 1119-8-0 The outlay is just under Rs 11-8-5 per head of the population, and the cost of pumping just under 1⅛ annas a head per annum. Allowing 10 per cent on outlay for cover interest, maintenance and deterioration the whole cost of the water supply would be 1·155 + 0·103 = 1·258 Rupees per head per annum.
Mysore Water works	6¼ terminal		Population 57,765. Estimated Cost 9 Lakhs, of which Distribution = Rs 60,000 + Filters Rs 30,000. Source of supply a Reservoir about 2 miles from the Town. Natural Catchments/Reservoir area Sq Total — do — do —— = 4,300 Water spread — of do —— = 165 Storage Capacity of do M.C.ft —— 100 Level of waste weir 2491·00 -do. Sill of sluice (bottom of lowest opening) 2469·00 -do. Centre of do. 2470·00 Rainfall 20 inches of which one eighth expected to drain into the Tank.

Depth draining off required to fill the tank 6.40 inches.

The water is then conveyed in a covered masonry or concrete channel, designed to carry the nominal supply in 6 hours, to 2 settling basins, each to hold 60,000 cubic feet.

The loss by evaporation is estimated at nearly 40 per cent.

The Reservoir was ready before water in March 1881. No water had been drawn off up to October 1883, when the water stood at 24'74·85 or 16·15 feet below sill level, and the contents were 10·80 millions of c. ft. The highest water level so far reached appears to be 9½ feet above sluice sill.

Depth draining off required to fill the tank 6.40 inches.

The water is blue conveyed in a covered masonry or concrete channel, designed to carry the nominal supply in 6 hours, to 2 settling basins, each to hold 60,000 cubic feet.

The loss by evaporation is estimated at nearly 40 per cent.

The Reservoir was ready to store water in March 1881. No water had been drawn off up to October 1883, when the water stood at 247.85 or 16.15 feet below sill level, and the contents were 10.80 millions of C. Ft. The highest water level so far reached appears to be 9½ feet above sluice sill.

Appendix No 7.

Abstract particulars of water Works.

Rs 2 9 / 3035/10

1473

Appendix No 8. 105 8/6 15

Particulars of the calculation of approximate cost of supplying Bangalore with water from near Hundidroog.

1. Storage Reservoir — The estimate, Rupees 45,000, has been, in the absence of any data for a definite estimate, been calculated at Rupees 750 per million cubic feet. The actual cost of storage ranges from Rs 300 upwards.

2. Filters — The quantity of water being 10,000 cubic feet an hour, and the usual allowance being 2 square feet of filter bed for every cubic foot per hour, the area will be 20,000 Square feet or 200 by 100 feet. A second filter will be necessary to admit of alternate cleansing; so 40,000 square feet of filter bed may be taken as the requirement. The estimated cost of the Service Reservoir, a covered work, is 2 Rs a cft. so Rs 75,000 will probably suffice for the filters.

Plan No 4

3. Cast iron main — The length 15,000 feet is that indicated as probable by Mr Andrews' survey. The assumed required discharge being 240,000 cubic feet a day or 2·778 cu feet a second and the head 60 feet, it was found from Jackson's Tables that the discharge of a 24 cast iron pipe would, with a regular gradient be 3·51 cubic feet a second, while Neville's for

$v = 140\sqrt{r.s.} - 11\sqrt[3]{r.s.}$ makes the discharge 5.786 cubic feet a second - The main moved have the laid with many variations of gradient and it was considered therefore advisable to use the formula which gives the lowest discharge and to allow a moderate margin.

The length of 150,000 feet has been divided into 149,000 feet of straight pipe and 1,000 feet of bends &c. The bends or changes of direction both vertical and horizontal will for the most part be so gentle that straight pipes will suffice.

The rates are based on information obtained from the Madras Municipality viz Rs 80 a ton for straight pipes, and Rupees 120 for bends &c; the corresponding rates for the neighbourhood of Bangalore are Rs 95 and Rs 135 thus made up.

Rate per ton at Madras - - - -	Rs 80
Rail to Bangalore - - - -	10
Cartage & work - - - -	5
	95

The weight per foot is for 1 inch thickness of metal taken from the Madras Municipal table, but that for the $\frac{3}{4}$ inch thickness has been calculated therefrom and checked by Beardmore's table.

The cost of laying the pipes is that paid at Madras and includes all the necessary materials.

Main with 24 inch C.I. Pipe, 1 inch thick.

149 000 feet × 245 lbs = 36,505,000 lbs = 16297 tons.	
1000 do × 245 " = 245,000 " = 109½ "	
16297 tons of straight pipe at Rs 95 =	Rs 1548205
109½ do . . . do . . . 135 =	14,782½
Laying 5,000 yards at 2½ Rupees =	1,25,000
Contingies	82,012½
	17,70,000.

Main with 24 inch C.I. Pipe, $\frac{3}{4}$ inch thick.

149000 × 186 = 27,714,000 lbs =	12732 tons
1000 × 186 = 186,000 " =	83 "
12732 tons of Straight pipe at 95 =	Rs 11,75,340
83 " do . . 135 =	11,205
Laying 5,00,000 yards at 2½ =	1,25,000
Contingies	65,455
	13,77,000

4. Service Reservoir. The capacity is intended to be 1·20 millions of cubic feet or 5 days supply, the depth of water 10 feet and in making the estimate, it has been supposed that a clear space for water 600 by 200 will be the form adopted. The length is to be divided into 2 equal parts by a pier 4 feet thick and each part into 20 bays of 15 feet by piers 2½ feet thick. The abutments and side walls to be 6 feet thick at bottom and 3 feet at top. The foundation to be of concrete 5 feet deep for the

the springing of the inverts, which are to have a versed sine of 1½ feet and a thickness of 1½ feet, the concrete under the inverts will therefore be 2 feet thick.

The 2½ feet piers will have openings in them, arched both below and above, to allow of the free circulation of the water. The central 4 feet pier will have no opening, and there will be no communication between the two parts of the reservoir except by pipes with regulating valves. The piers and abutments will be 40 feet high and will carry arches with a versed sine of 3¾ feet, and thickness of 1½ feet. The abutments, handrils and side walls will be carried up to the level of the tops of the arches, and over all 2 feet of earth will be placed with slopes of 2 to 1 down to ground level on all sides, except where the value house &c. may be placed.

The abutment faces, side walls, and inverts will be plastered with Surki mortar for a thickness of half an inch, and the surface will be rendered with Portland cement of good quality to be used for all work above the concrete.

The concrete platform will project 3 feet beyond the base of the walls.

Total

1473 135 8/12/17

Total length between abutments.

40×15 + 38×2½ + 1×4 = 600 + 95 + 4 = 699 feet.

Length of concrete platform.

699 + 2×6 + 2×3 = 717 "

Width of do

200 + 2×6 + 2×3 = 218 "

Concrete 717×218×5 = 781,530

do 600×200×$\frac{2\times1\frac{1}{2}}{3}$ = 120,000

" 40×200×16½×1½ = 198,000 318.000 463,530 C.F.

Brickwork.

Inverts		198,000	
abutments	2×200×4½×10	18,000	
Centre pier	200×4×10	8,000	
Piers	38×200×2½×10	190,000	
Arches	40×200×19×1½	228,000	
Backings abutments	2×200×$\frac{10\times5\frac{1}{2}}{2}$	11,000	
Spandrils	38×200×$\frac{16\times4}{2}$	243,200	
do	1×200×$\frac{17\frac{1}{2}\times4}{2}$	6,000	
Sidewalls	2×711×4½×10	63,990	967,190 C.F.

Excavation 720×220×say 6+5 = 1742400.

Concrete in reservoir 705×205×3 = 433575

do 2×200×24×$\frac{12}{2}$ = 57,600

do 2×705×24×$\frac{12}{2}$ = 203,040 694,215 2,436,615 C.F.

Plastering 2×200×10 = 4000

2×600×10 = 12,000

40×16×200 = 128,000 144,000 93.7

4635.30 Concrete at Rs 9-8-0 per 100 Rs 44,035

9671-90 Brickwork at 16-8-0 " do 1,59,586

2436.600 Earthwork at 4-0-0 per 1000 9,746

1440.00 Plastering at 4-0-0 per square 5,760

Contingencies 14,883

2,34,000

Pipes, valve house, dwellings
for Establishments &c 6000

2,40,000

5. Distribution mains &c. This head includes all the works below the Service Reservoir, viz the mains, branches, stand pipes, dipping wells, fountains &c which may be needed for bringing the water within easy reach of the population. The rate of Rupees 5 a head of the population is the actual cost at Madras. If the Service reservoir floor can be placed as high as 3029.97, the distribution will probably cost less than the sum allowed.

1473 18 77

166

Appendix No 8.

Particulars of approximate Cost of Supplying Bangalore with water from near Irundidroog.

No 10
30 3/4 70

General No. 327 / 73.

ASSTTACHAR COMMISSIONER'S OFFICE,
DATED MYSORE, 25th *August* 1874.

To

The Secretary to the Chief Commissioner of Mysore,
Public Works Department.

SIR,

I have the honor to acknowledge the receipt of your No. 1494 of 18th July, forwarding copy of a Memo to Captain Clive regarding the drainage and water-supply of the town of Mysore.

2. Before Captain Clive arrived, I had directed enquiries to be made regarding the number of wells and other sources of supply, with the object of ascertaining approximately the wants of the population in different quarters of the town, and the extent to which these wants are now met, as well as the wishes of the people regarding any improvements that could be made to enhance the supply by clearing and deepening old wells, sinking new ones or constructing reservoirs when this could be done with advantage.

3. The Mutsaddis of the Different Mohallas were accordingly directed to ascertain the number of wells and reservoirs, the quantity of the water obtained from each and whether the supply was constant. They also prepared returns compiled from the statements given by the residents of every house, shewing the source from which the inhabitants of each street obtained water, which were checked by counting the number of persons who drew water in a day from most of the principal wells, &c.

4. In an enquiry of this kind, accuracy is unattainable, all that can be expected is, such information as will give a general view of existing circumstances, and to this extent I believe a fair estimate can now be formed of the actual condition of the town as regards water. I propose to mention first the present supply of the town in ordinary seasons, shewing this in detail for each Mohalla, proceeding then to review the results in a condensed form with some remarks on the means by which water is distributed, and on past seasons of actual scarcity. Some of these figures may be tedious, but are necessary to explain the subject. Finally the proposals and requests of the inhabitants will be stated with such remarks as are required in each case. In order to render this intelligible, a map has been prepared shewing the limits of each Mohalla, in which the streets have been grouped in convenient blocks and the sources of water-supply indicated according to the quality of the water. There are also 3 statements A. B. and C., the first shewing the number of existing wells of all descriptions in the dwelling houses, the second containing all the information that can be collected regarding the past history, &c., of the different reservoirs and wells, the water of which is capable of being used for drinking and cooking purposes, and the third the proposals of the inhabitants with my remarks.

5. I shall now, as proposed in para 4, allude to each Mohalla separately.

6. Mysore is divided into the following Mohallas :—

1. Lashkar.	3. Devaraj.	5. Fort.
2. Mandi.	4. Krishnaraj.	6. Nazarbad.

According to the last Census and the returns of the Municipal Overseer, it contains 13,067 inhabited houses and 57,765 inhabitants on an average of 4·5 persons to a house.

7. The number of cattle is supposed to be about 15,000, exclusive of those belonging to the Palace.

8. There are—

2 *Large Tanks.*—Dodkere with Bowen's well and others sunk round the margin. Karanji with wells below it.

1 *Small Tank.*—Jivah Rao Katte.	1 *Gunta.*—In front of the Summer Palace.
3 *Kattes.*—Sub Rao, Siniru, Avaduta.	5 Ghats in Purnaiya's Channel.

26 Public and 28 private wells, the water of which is considered good for drinking and cooking.

These all lie in the catchment basins of the Dodkere and Karanji and are within Municipal limits.

In addition there are seven wells in the valleys running north, *viz.*—

North Valley.	*North East.*
Jail reservoir	Julpuri.
Telelee Bowrie	Christian.
Jaffane	Nawab.
Syed Ahmed Makan.	

Also a spring of excellent drinking water flowing down Chamundi Hill, and 2,398 wells scattered over different parts of the town, the water of which being either brackish or hard is only used for drinking and cooking when better is not procurable. The water of the majority is very inferior, and that of many useless for both purposes and only taken for ablution.

The case of the reservoir in the bed of Dodkere known as Bowen's Baoli is different: in consequence of its pollution the water has been only fit for washing cloths, &c.; but there is every prospect of its becoming fairly wholesome and drinkable when the silt is removed.

LASHKAR MOHALLA.

Houses.	*Population.*
3,581.	14,171.

9. This Mohalla contains three sub-divisions, Rasvan, Lashkar, and Yirangere; the latter is believed to be the most ancient part of Mysore and the site of an old Polegar fort, most of the ground remained unoccupied till the installation of His late Highness, when he is understood to have resided for a short time in a dwelling known as the "Durbin Bungalow" in which his parents lived before they were removed to Seringapatam by Tippu. During the Administration of Púrnaiya, houses sprung up and troops were located there, whence the Mohalla got its present name.

10. No drinking water is procurable within the limits of the Mohalla, the people of which have to go either to the wells in the north-east or north valleys, to Púrnaiya's Nalla on the west or to the two wells in the south and to the Karanji on the east. An estimate of the quantity drawn for this purpose only is given below:—

No. of Blocks.	No. of Houses.	Sources of supply in ordinary years.	Quantity. Pots.	Quantity. Total. Pots.	Quantity. Total. Gallons.	Distance. Going and returning.	Distance. Average.
		North.					Miles.
1·2	524	Jail well	1,970				
3·4	104	Telelee Baoli	314	2,284	5,710	1½	1 mile.
		North-East.					
2·3·5	290	Nawab Baoli	590			2	
2·3·5	881	Christian	762			2	
3·5·6	123	Julpuri	216	1,568	3,895	2	2 miles.
		West.					
4·4	200	Púrnaiya's Channel, Rajput Ghat ...	400			¾	
		Do Holiyar do ...	not used.				
4·7	525	Do Mochi do ...	1,765			¾	
7	100	Do Mir Hayath Ganta ...	150			¾	
7	200	Do Molakalve	400			¾	3½ furlongs.
7	125	Hras Rao Katte	250	2,965	7,413½	¾	
		South.					
7	100	Gonayi well in fort ditch ...	100			½	
7	40	Pir Sahi	80			½	
7·8	99	Sauce Koppal	298	478	1,194	½	½ mile.
		East.					
5·6·7·8·9	771	Karanji	1,542	1,542	3,855	2½	2½ miles.
	3,581	Total.....	8,827	8,827	22,067½		General average excluding the distance of Karanji is ¾ mile.

11. This statement represents 3,581 houses, with a population of 14,171 obtaining per house about 6½ gallons of water per day from an average distance of ¾ mile, the maximum distance being 2½, and the minimum ¼ mile.

12. The returns obtained by counting shew larger quantities, part of the water being required for other purposes.

13. With the exception of the Karanji tank, the jail reservoir and the original cutting of Púrnaiya's Nalla, it may be said that all these are the work of private individuals; though some have been deepened and the approaches to others improved at different times by the Government and the Municipality.

North Valley.

Constancy of Supply.

14. The Jail reservoir is excavated in rock, and contains a spring of brackish water which is not drinkable. The value of the work consists in its catching and retaining the rain water flowing off the slopes above it, and as it is the only reservoir of this description in the neighbourhood it is much prized. I understand that the Executive Engineer is employed in examining this reservoir and it is therefore unnecessary to give further details.

15. Water in the Telelee well never entirely fails, but is considered hard and when water is procurable from the Jail reservoir, it is only resorted to by Pakalis who supply water to families for cooking and bathing purposes and carry it about for sale in the Mohalla.

16. With a rain-fall of 21 inches and 63 cents in 1873 and 13¾ inches up to 4th August in 1874, the spring appeared to be capable of supplying at least 10 Pakalis making 5 trips a day and drawing from it about 1,000 gallons.

17. The other wells in this valley contain good water, but owing to the distance are not used till the supply in the Jail reservoir fails. They are probably all kept up to some extent by a stone built katte above used by Dhobis, the water from which percolates through to the lower level.

North East Valley.

18. The Julpuri is said never to run dry, but it is less drawn upon than the other two, the water of which is considered better, the steps are also very steep. The so called Christian well, which is used by all lower castes, is the only well available for Holayars, and nearly failed last year. With the rain-fall mentioned above, the supply from this well and the Nawab's is barely sufficient for the requisitions made on them. The Pakalis of the detachment N. I. stationed in Mysore were in the habit of going before day light to the latter, and by 8 A. M. the water was exhausted, and had to be scooped up half full of mud in saucers and shallow dishes, but was partially replenished during the day. Under those conditions the supply yielded daily by the well seemed to be about 1,500 gallons.

West.

Púrnaiya's Channel and Jivan Rao Katte.

19. Though the Rajput Ghat contains more water, the Mochi Ghat is the most important to this Mohalla as it is nearer. The water never fails, but there is a general impression that it gives Guinea-worm, a circumstance to which I shall recur hereafter. It is unnecessary to give particulars regarding the wells on the south-east additional to those entered in the statement.

Water for Domestic purposes and Ablution.

20. Part of the water so required is obtained from the wells first mentioned, and the remainder, from draw-wells in different streets. As rock formation extends over this whole Mohalla, water is only reached at great depths, and all that is procured in the different wells being either salt, brackish or hard, is used only for domestic purposes, such as washing vessels and cloths and for bathing. The expense of sinking wells is also so great that the poorer inhabitants cannot afford to have private wells, and consequently the northern half of the Mohalla from the Yirangere Gate to the Taluk Cutcherry and part of the south-western quarter possess very few. There are 61 public wells in different other parts of the Mohalla which were originally excavated by private individuals as acts of charity, and these are accessible to all classes. Two only are dry at present. In addition to these, 450 houses contain 489 private wells, of which 100 are dry. The owners of many of these allow their neighbours access, but the want of water for these purposes is often very severely felt, and the supply is never sufficient.

MANDI MOHALLA.

Houses.	*Population.*
3,086.	13,981.

24. This Mohalla dates principally from the time of Pûrnaiya, who induced grain-merchants and other traders to settle at Mysore. Since the death of His Highness the late Maharaja good many houses in the western portion have been abandoned; it now contains 3,086 inhabited houses with a population of 13,951 persons.

Water for Drinking and Cooking.

22. The great majority are dependent on Pûrnaiya's Channel, since out of 3,086 houses, it appears that 1,876 are supplied from the ghats and 460 from three draw-wells, 2 in the centre and one at the northern extremity of the Mohalla. The residents of about 700 houses were returned as procuring water from the Karanji Tank.

23. As regards distance, the inhabitants of this quarter are better off than those of the Lashkar Mohalla; but it is remarkable that according to their statements they procure less water. The explanation given for this is, that the approaches to some of the ghats are steep and unsafe, and that the women do not bring more than is absolutely necessary. The people are generally poor, and employ neither pakalis nor carts. The households obtaining water from the Karanji are chiefly those of Brahmans and merchants who can afford to send to that distance.

24. Below is a statement similar to that given for the Lashkar Mohalla. The estimate is that nearly 5 gallons per house are taken from an average distance of ¼ mile. In calculating the distance, the Karanji is excluded.

No. of Blocks.	No. of Houses.	Names of Wells, &c.	Quantity. Pots.	Quantity. Total. Pots.	Quantity. Total. Gallons.	Distance. For going and returning.	Distance. Average.
		West.					
2·3	250	Chakkani well	750	...	...	...	
3	200	Bramsala	400	...	...	...	
3	10	Minakshi	50	...	...	50 yds.	
		Pûrnaiya's Channel.					
1·2·3	345	Rajput Ghat	1,035	...	...	...	
2·3	70	Holiyar Ghat	140	...	...	...	
3·4·5	1028	Mochi Ghat	2,707	...	...	...	
4·5	83	Mir Hayath Gunta	255	...	...	200 yds.	
4·5	350	Molakalve	700	...	...	Do	
3	50	Jivan Rao Tank	50	6,091	15227½	½	
		East.					
3·4·5·6	700	Karanji Tank	700	700	1,750	½	
	3,086	Total ...		6,791	16977½		

The average distance is ½ of a mile excluding that of Karanji Tank.

25. As in the Lashkar Mohalla, the water ascertained by counting to be drawn daily from the different sources includes a good deal of what is used for all domestic purposes, the rest being obtained from draw-wells. In this respect the Mandi Mohalla has no advantage over the Lashkar Mohalla, as there are only 67 wells the water of which is available for all, and 176 wells in private houses, out of the whole, 67 are dry.

Water for Ablution, &c.

DEVRAJ MOHALLA.

Houses. 2,271.

Population. 10,640.

26. Part of the Devraj Mohalla is ancient, and part was founded by His Highness the late Raja. It is on the western side of Pûrnaiya's Channel, of which the people make very little use though a few go to the Mochi Ghat.

Water for Drinking and Cooking.

As long as the Jivan Rao katte holds water it is much resorted to, and it is the accepted opinion that the water of the tank as it sinks into the soil feeds the wells below, of which several contain very good water. These are amongst the most valuable wells in the town, three of them (Advanaiya, Vire Gauda, and Venkatdikshit's well) have never failed, and afforded water to a large number of the inhabitants of other Mohallas when their own supply ceased. The estimated quantity of sweet water used daily in this Mohalla is about 5 gallons per house.

27. Half of the Mohalla from the Siledars' lines to Pindarkari Street (blocks 1 and 2—788 houses) is well supplied by the Jivan Rao Tank, and 8 wells believed to be greatly dependent on it, which have never failed, but the other half from the Pindarkari to Sub Rao Katte road containing 1,553 houses has only 2 wells and one small katte.

28. These wells are classed in the following statement in the order of their value.

No. of Blocks.	No. of Houses.	Names of Wells.	Quantity. Pots.	Quantity. Total. Pots.	Quantity. Total. Gallons.	Distance. For going and returning.	Distance. Average.
		West.					
		Devaraj Mohalla.					
1·2·3·4	400	Jivan Rao Katte	800	...	...	½ mile.	
2·3	445	Advanaiya	890	...	...	200 yds.	
3	250	Vire Gauda	500	...	...	100 do	
3	100	Nag Nayik	200	...	...	50 do	
1	80	Nanjaiya	160	...	...	50 do	
1·3	75	Venkatdikshita	150	...	...	400 do	
1·4	75	B. Venkatappa	150	...	...	100 do	
1	66	Anjanaiya	132	...	...	100 do	
1·2·3	67	A. Sub Rao's well	130	...	...	100 do	
1·3	55	Amruthesvara Temple ...	110	...	...	50 do	
3	50	Avaduta Katte	100	...	...	1 mile.	
2	30	Narnaswami	60	...	...	50 yds.	
		Krishnaraj Mohalla.					
4·5	300	Sanjivaraj Ursu	600	...	...	½ mile.	
		Mandi Mohalla.					
1	60	Pûrnaiya's Channel Mochi Ghat ...	120	4,102	10,255	200 yds.	
		South.					
		Dodkere	60	60	150	...	
		East.					
		Karanji Tank	200	200	500	...	
		Total.....	...	4,362	10,905	...	

The average distance is ½ of a mile, excluding that of Karanji.

29. It is represented that there is a great want of water for other purposes as the quantity procurable from wells, the water of which is not good to drink, is scanty and uncertain, nearly ½ out of 371 private wells, and 9 out of 72 public wells are dry, and it is said that the people do not obtain even half of what they need for domestic and personal use.

Water for ablution &c.

KRISHNARAJ MOHALLA.

Houses. 2,259.

Population. 9603.

30. This Mohalla originated during the Administration of Pûrnaiya, and now contains 2,259 houses with 9,603 inhabitants.

31. There are some very good sweet water wells within its limits, some have been constructed for the public and others are in private houses to which access is allowed.

32. In block No. 1 containing 1,055 houses, the supply appears to be tolerably plentiful and constant. The other 3 blocks rely to a great extent on the Siniru Katte, a small pond for catching the rain water on the high ground, to the south.

33. Lately two experimental wells have been sunk below the Dodkere bund, the water of which is considered fair and is taken for drinking and cooking purposes by the people of several streets in the vicinity.

The water of the Dodkere is not drunk but is taken by a few persons for cooking.

34. The average quantity taken daily in the Mohalla appears to be rather more than in the Devaraj Mohalla, being 6½ gallons per house, ablutions, &c.

No. of—		Description of wells.	Quantity.			Distance.	
Blocks.	Houses.		Pots.	Total. Pots.	Total. Gallons.	For going and returning.	Average.
		West.					
		Krishnaraj Mohalla.					
3	393	Dod Holagere					
1·2	300	P. Puttaiya	1572			200 yds.	
1·3	250	Soppina Kola	1105			200 do	
1	155	Sanjivaraj Urus	700			300 do	
1	100	Bale Mutisaiya	675			¾ mile.	
2·4	80	Halgaiya	310			¼ do	
1·2	71	V. Patti	200			150 yds.	
1	50	Mir. Mahomed	160			¼ mile.	
1	60	Chamappaji	218			100 yds.	
			100			50 do	
			100	5135	12837½	250 do	
		South.					
1	155	Dodkere	155	155	387½	500 do	
		East.					
1·3	400	Karanji Kere					
4	30	Spring at the foot of Chamundi ...	400			2½ mile.	
			60	460	1150	2 do	
		Total.....	...	5750	14875	...	

The average distance is nearly half a mile, excluding the distance of the Karanji.

35. The Dodkere Tank provides all that is necessary in addition to what is obtained from * wells and kattes.

* Public wells 28, private wells 442.

FORT MOHALLA.

Houses. 868.

Population. 5785.

36. Tippu with his usual policy of destroying every monument of the former Government, had razed Mysore and removed the stones of the Palace and temples to the neighbouring height called by him Nazarbad, from its commanding an extensive view.

The present fort with the buildings in it date subsequent to the installation of the late Raja, with the exception of four temples, two on the west and two on the east, reputed to be ancient.

37. Water for cooking purposes is procured from 14 wells situated within it, and from the Dodkere Tank. For drinking water the inhabitants have to go about 2 miles in all, to the Karanji Tank, as the pipes by which this water was conveyed to the interior of the fort and (as is said) to 30 wells, constructed during the late Raja's Administration, are now out of order.

38. When the supply in the Karanji Tank is exhausted, the water of the Fort-wells, which is at present used only for cooking, is drunk by nearly half of the population of the Fort; others resort to the springs at the foot of Chamundi Hill, and a few wealthy families obtain Cauvery water from Seringapatam.

39. The quantity at present supposed to be consumed for drinking and cooking purposes according to the statement of the people is 2604 pots or 6,510 gallons, at an average of 3 pots or 7½ gallons per house, obtained from the sources pointed out in the following statement.

No. of—		Description of Wells.	Quantity.			Distance.	
Blocks.	Houses.		Pots.	Total. Pots.	Total. Gallons.	For going and returning.	Average.
		South.					
1	83	Muniajatti	166				
1·2	70	Venkat Subbaiya	140				
1·2	70	Bale Ars	140				
1	50	Saude Koppal	100				
1	50	P. Linga Shastri	100				
2	50	Guruvaiya	100				
2	50	Annaiya Joia	100				
2	50	Kempanna	100				
1	45	S. Krishna Rao	90				
1	45	Puttiaji	90				
1	40	Balachari	80				
1	40	K. Puttaiya	80				
1	40	K. Linga Shastri	80				
1	20	Tippaiya	40				
1·2	165	Dodkere	330	1,736	4,340		
		East.					
1·2		Karanji Tank	868	868	2,170	2 miles.	
	868	Total.....		2,604	6,510		

Within half mile. ½ of a mile, excluding the distance of the Karanji Tank.

40. Except for drinking-water, the Fort seems in some respects to be better supplied than other Mohallas. In addition to the public *wells nearly half of the houses are provided, while the Dodkere Tank is close to the walls.

* Public wells 31, private wells 380.

NAZARBAD MOHALLA.

Houses. 1,002.

Population. 3585.

41. This Mohalla, as mentioned above, received its present name from Tippu. He had made considerable progress in the works of a Fort on the spot when he began to consider that it afforded no water. He then dug an immense pit cutting down through the solid block rock to a great depth and width without success; and at the time of the siege of his capital the whole work was lying in a mass of confusion, with a few wretched huts in it for the accommodation of his workmen.

42. The Nazarbad Mohalla extends over a large area, but is thinly populated as compared with the others. It contains some of the Palace buildings and a good many houses, occupied chiefly by the European and East Indian community; a considerable extent of ground is waste and unoccupied.

43. There are—

11. Minor wells.
3. Principal wells.
1. Tank—Karanji.
1. Gunta—in front of the Summer Palace within the limits of this Mohalla.

Of these, the 14 wells alluded to contain a moderate supply of water fit for drinking and cooking purposes, and are resorted to chiefly by the poorer native population; about ⅓ of the whole depending upon the Karanji Tank for drinking water.

The Gunta which is a small pit originally dug for taking earth for preparing bricks &c., catches the surface water of the high ground near the Summer Palace, but this lasts only for three or four months during the rainy season, and is drunk chiefly by Holiyars and others living in Itigegod.

44. The estimated quantity of water at present obtainable from all sources for drinking and cooking purposes is 2,867 pots or 5,917 gallons, at an average of nearly 6 gallons per house, ablution &c.,

No. of— Blocks	Houses	Description of wells.	Quantity. Pots.	Total. Pots.	Gallons.	Distance. For going and returning.	Average.
		East.					
1.4	25	Balramaig					
2	10	Karanji Matt					
1	30	Holiay Well	1,160			200 yds.	
5	13	Shama Shastri	100	...	...	1 mile	
5	10	Gunta	90	...	...	100 yds.	
1	25	Pailandi	60	...	...	50 do	
1	25	Mallaiya	54	...	...	100 do	
2	15	Narasappa's Garden	50	...	...	150 do	
1	15	Aleman Holiay	50	...	...	50 do	
4	5	Yakub Sab	45	...	...	100 do	
4	5	Davarasaiya	30	...	...	50 do	
4	10	Lovery	80	...	...	150 do	
3	5	Rudraraju	20	...	...	50 do	
1.3.4.5	308	Mr. Meyers	20	...	...	50 do	
		Karanji Tank	20	...	...	50 do	
		... ...	308	2,037	5,217½	1 mile	
		South.					
5	140	Dodkere Wells.	280	280	700		
		Total.....		2,867	5,917½		

45. Regarding the water required for other purposes, the existing number of 226 private and 17 public wells suffices for the ordinary requirements of the people living in the Mohalla.

46. *Distribution.*—At least ⅔ ths of this water is brought in the ordinary chatties (each containing 2½ gallons) by men or women on their heads, the rest in similar pots slung on addes (bamboos) by pakalis, in water carts, hand barrows or monkanis, which are panniers containing large vessels loaded on bullocks.

47. *Pakalis.*—There are 36 pakalis regularly employed; 9 of these draw water from the Telelee well and Púrnaiya's Channel for distribution in the Lashkar and Mandi Mohallas where it is sold at from one to two pies per pot of 2½ gallons: Seven supply the Barr[illegible] the Siledars, one the detachment 30th N.I. and 8 the Palace stables. The principal places to which these resort are the Jail Reservoir in the north, Nawab Bowri in the north-east, Púrnaiya's channel and Jivan Rao Tank on the west, Gossyi Well near the Fort, and Dodkere Tank on the south.

48. *Water carts.*—Sixteen or seventeen wealthy inhabitants in the town send carts once or twice a day to bring water from the Karanji Tank for their own use. In addition, 9 are engaged by the Palace, each making three trips daily to the Karanji Tank. Another cart brings daily 40 pots of Cauvery water from Seringapatam for the use of the Rams. The water for ablution and domestic purposes is obtained from two or three brackish wells situated near the Palace, as well as from the Dodkere Tank and the well lately dug below the bund.

49. *Hand Barrows.*—These have been introduced within the last year or so, and the number at present employed is estimated at 37. They go twice a day to the Karanji Tank and fetch 8 pots or 20 gallons of water each at a time.

50. *Monkanis or Panniers.*—These are used by oil-mongers; each monkani contains 4 pots or ten gallons of water, and is conveyed by a single bullock.

51. *Cattle.*—It is necessary to say a few words regarding the cattle and horses, &c, kept by the people:

52. From an old account obtained from the taluk, there must be nearly 15,000 cattle in the town besides the palace cows and bullocks.

53. The cattle generally go to the marginally noted places for drinking water, but when the supply is exhausted in the hot weather, brackish or hard water from the wells in the town is used. There are about 20 public Tottis (stone and brick in chunam cisterns) constructed by private individuals in different places, which are daily filled by the owners as an act of charity for cattle, and especially cows which do not go to a distance daily to graze.

North.	*South.*
1. Boppanhalli Tank.	1. Dodkere.
2. Joginkere Do.	2. Halkola.
West:	
1. Jivan Rao Tank.	*East.*
2. Purnaiya's Channel.	
3. Pudvarhalli Katte.	1. Devanur Katte.
4. Sinira Do.	2. Karanji Tank.
5. Subba Rao Do.	

54. The total quantity of water required by the cattle is estimated at 60 thousand gallons on an average of 4 gallons per head.

55. *Washermen.*—It is reported that there are nearly 200 washermen in Mysore, or at an average of one to 65 houses or 285 persons, who go to various places for the purpose of washing clothes.

North.
1. Cauvery river, Seringapatam.
2. Boppanhalli Tank.
3. Purnaiya's Channel.
West.
1. Kukanhalli Tank.
South.
1. Dodkere Tank.
2. Bohlikatte Do.
3. Dalvoy Do.

56. *Summary.*—I shall now proceed to review the returns for the whole town.

57. In addition to the Karanji and Dodkere tanks, there are Purnaiya's channel, the minor reservoirs, and the wells, public and private, all of which are resorted to by the people; but the peculiar difficulty at Mysore consists in the fact that only a few contain good and wholesome water, and that these are situated at a considerable distance from the occupied areas.

58. With some classes of natives the most important quality of water is that it should be palatable to drink; others consider it absolutely necessary that water should not be hard, for in that case, dhall cannot be boiled owing to the coating found on it during the process, and hence they generally refer to this as the best test. For other domestic purposes and for bathing, brackish or hard water suffices.

59. In Mysore, the Karanji water is referred to as the type of purity and excellence; but the water of all the rain reservoirs except that of the Dodkere is good for every purpose. That in the wells in the north and north-east valleys, if not perfectly pure, is palatable and believed to be quite wholesome; and there are also a few wells in different places which are considered to furnish very good water.

60. The reservoir in the bed of the Dodkere tank, known as Bowen's Bauri, contains a good spring, but owing to silt and other causes, the water had hitherto been of no use; after the reservoir is cleared, it is believed that the water will be found fit for drinking and cooking purposes. The wells in the upper part of the bed have been found to yield very good water, and are regularly used by those living within a convenient distance from them.

61. The remaining wells give water of every degree of brackishness, that of some being almost salt and of others only slightly hard.

62. Opinions differ regarding the water in Púrnaiya's Nalla. The general impression is, that the water of the Channel and especially that of the Mochi Ghat produces guinea worm; but many persons who suffer from it ascribe the complaint to other causes. Hindu doctors are of opinion that drinking stagnant water produces it, while Mussalman hakims do not attribute it to water at all, and many of the people consider it arises from filth, and can be remedied by clearing the reservoirs. Whatever the true explanation may be, it is demonstrable as a matter of fact that the population of the Mandi and Lashkar Mohallas who make use of that water suffer more than others. Within 3 or 4 years over 3 per cent of the residents of the Mandi Mohalla, and nearly 3 per cent of those of the Lashkar Mohalla have been attacked by guinea worm: 65 persons have migrated from these Mohallas elsewhere with the special object of getting rid of the disease.

63. The Civil Surgeon states that the general opinion that the drinkers of Púrnaiya's Nallah water are most liable to disease, is correct. Mild cases of guinea worm rarely come under hospital treatment, and the average ratio of guinea worm cases to total sick in the Hospital is, for the last 5 years, four per mille per annum.

64. By the statement given of the quantity of water fit for drinking and cooking purposes used daily, it appears that the whole amounts from 25,000 to *30,700 ordinary chatties or pots each containing 2½ gallons, giving, if the higher figure be taken, about one and one fourth gallons per head, or 6¼ per house.

*76 750 gallons.

65. If we arrange the sources of supply according to the quantity of water obtained from each, their values are represented roughly by the following numbers.

Public Wells ...	...	28,985 Gallons.
Rain Reservoirs ...	...	21,855 Do.
Purnaiya's Channel ...	...	19,190 Do.
Private Wells ...	...	6,720 Do.
	Total.....	76,750

66. *North East.*—The *wells in the north east valley were returned as supplying 793 houses with an estimated quantity of 3,875 gallons; this was found to be tolerably accurate by the experiment of counting the number of persons resorting to each in a day.

Relative importance of different wells.

*Julpuri Christian Nawab.

67. *North.*—In the north valley the quantity was 5,710 gallons to 628 houses.

Jail Reservoir and Telelee Bauri.

68. *West.*—On the west there are 11 principal wells, Purnaiya's Channel with five ghats, the Jiwan Rao Tank, the Sinira, and Subba Rao Katte with 13 minor wells, the whole returned as supplying water to about 20,000 people, the quantity being 45,730 gallons.

1. Chikni.
2. Biram.
3. A. Subba Rao.
4. Nunjaiya.
5. Venkatdikshita.
6. Advanaiya.
7. Vera Gauda.
8. Sanjivaral.
9. P. Puttaiya.
10. Soppina or body guard.
11. Bod Holgere 7, ill housed.

69. *South.*—The Dodkere on the south is scarcely used except for bathing, but there are two principal wells, and 12 minor wells supposed to supply 1,267 houses, 6,772 gallons. Bowen's Bauri, to which allusion is made in paras 7 and 60 is now being cleared.

Soudi Koppal near the fort.
Manya Jettis well in the do.

70. *East.*—On the east is the Karanji, by counting it was ascertained that 2,582 pots or 6,455 gallons were taken from this tank in a day. There are two or three *important wells, and 13 minor wells containing drinkable water. The total quantity consumed on the east is 14,642 gallons by 3,263 houses.

*Balram Sing, Rudraraju, Karanji Matt.

71. It must be understood that all estimates made above, have referred to the supply obtainable in ordinary seasons, and after a fair rainfall, when the tanks and wells have been partially filled. In the hot-weather not more than half is said to be taken, and in seasons of drought the scarcity is very great.

72. Owing to the deficient rainfall in the last hot weather, *viz*, 21 inches and 63 cents, which was lower than that of 1871 and 1872, and far below 31 inches the average of the previous years, the Karanji tank and rain reservoirs, with several wells and Kattes upon which nearly ⅓rd of the population of the Town are dependent for drinking water, appear to have been actually dry. A large number of wells containing brackish water also failed, and the supply, in most, decreased considerably.

73. The scarcity was severely felt everywhere, for though the ghats and some of the wells did not fail, there was very little water to be had, and what was procurable was often muddy and unwholesome.

The most valuable wells were those noted in the margin; * and temporary wells were sunk by the Palace and Municipality in the tract of land between the Karanji and Dodkere, and even in the bed of the Boppenhalli tank, which proved of great service; but the people had to go long distances and many incurred considerable expense in sending carts and barrows to fetch water from the places where it was to be got:—a few wealthy families obtain water from Seringapatam.

North.
1. Telelee Bauri.
2. Syed Ahmed Makan.
3. Jailane.

Beyond the Town.

North-east.
1. Julpuri.
2. Christian.
3. Nawab.

Do.

West.

1. Chikani.	Mandi Mohalla.
2. Purnaiya's Channel with its 5 Ghats.	Mandi Mohalla.
3. Asham Subba Rao.	Mandi Mohalla.
4. Amrathesvara.	Mandi Mohalla.
5. B. Venketappa.	Mandi Mohalla.
6. Anjaniya.	Mandi Mohalla.
7. Ranja.	Devraj Mohalla.
8. V. Dikshit.	Devraj Mohalla.
9. Adavanaiya.	Devraj Mohalla.
10. Vire Gauda.	Devraj Mohalla.
11. Sanjivaral.	Devraj Mohalla.
12. P. Puttaiya.	Krishnaraj.
13. Soppin well.	Krishnaraj.
14. Bod Holgeri	Krishnaraj.

South.

1. Wells dug by the Municipality near the end of Dodkere.
2. Saudekoppal.
3. Chamundi Spring.
4. Manya jetti.

East.

1. Karanji Matt.	Nazarbad.
2. Balram Sing.	Nazarbad.
3. Rudraraju.	Nazarbad.
4. Shanker Das.	Nazarbad.

74. The total expenditure hitherto incurred on account of works carried out from the year 1859—60 by different departments in connection with the water supply of Mysore, is shewn as Rs. 72,190—9—4, of which Rs. 9,444—3—5 were spent by the Municipality; Rs. 13,000—12—8 by the Public Works Department; and Rs. 49,745—9—3 by the Revenue Authorities on various works such as strengthening the bunds of the tanks of Dodkere, Karanji, and Jivan Rao Katte, including repairs to their feeders and to several spring-fed wells. A great deal of the work to the Dodkere was undertaken at the special request of His Highness the late Maharaj, and had no effect in increasing the supply.

Measures adopted by Government towards water supply of the town.

75. To increase the supply of drinking water, the people desire the improvement of the following tanks and wells.

West.

1. Clearing and improving Purnaiya's Channel.
2. Improving the Jivan Rao Katte Tank.
3. Do Suba Rao Katte.
4. Deepening the well in the bed of Suba Rao Katte.
5. Do Sunjivaraj Arsu well.
6. Shinira Katte.

South.

7. Restoring the Karanji duct feeding the wells in the Fort.

East.

8. Improving the Gunta in front of the Summer Palace.
9. Karanji Tank.

76. In addition to these, the construction of reservoirs, one in the centre of the Lashkar and Mandi Mohallas, and the other in the Krishnaraj Mohalla, is urged.

77. In my opinion, a careful examination should be made of the northern and north eastern valleys containing the wells upon which so large a proportion of the inhabitants depend for water, and it should be ascertained whether the supply in the existing wells can be increased by deepening them, and whether others can be dug, as there are numerous wells in the valley just below them. The possibility of constructing small reservoirs to catch and retain the water so as to feed the wells, should also be considered. There is an impression among the natives that the best spring in the Nawab's well has been suppressed by clay underlying the stone work built to prevent the earth at the sides from falling in.

78. The steps to the Julpuri and Christian wells should be improved, as they are now too steep for women and children. Though the Jail reservoir only holds rain-water, it is of the greatest value to the whole neighbourhood; and I should strongly recommend additional feeders being led to it, and if it is found that more water is brought than the reservoir will hold, another should be constructed below it.

79. Makan well in the north valley, dug by the Municipality, should have stone revetments, and I believe another at an intermediate point could be sunk with advantage. The Municipality have been instructed to do so as an experiment.

80. I understand that Major Johnson once recommended the construction of a Katte or tank in the valley behind the Jail, and the project though not emergent, is worth further enquiry. A small reservoir for intercepting the water flowing from the Residency high ground might be formed at the bottom of the compound.

81. This great work failed in its original object, but has proved of an infinite service in tapping a number of excellent springs, the water of which though inferior in quality is indispensable, and not objected to by a large section of the population.

Purnaiya's Channel.

Appendix No. 9

Apparently springs are to be met with throughout the whole length of the Channel from the Rajput Ghat to the fort walls, and many natives believe that there was once a continuous stream from the Rajput Ghat downwards. Communication is, however, now entirely interrupted both by land slips and the general silting up of the bottom of the channel, as also by the excavation of the pits at the ghats for the earth from which has been thrown up round them, and by the new road to the Civil Hospital. Everything has been done that could be done to render the channel a nuisance instead of a benefit. In parts, it is overgrown with vegetation; it is used as a latrine and receptacle of filth; and the drainage of the market and several streets has been discharged into it contaminating the soil, and stopping up one, if not more, of the springs. A professional officer is required to survey the Channel and determine the best mode of remedying the damage, and also to decide on what should be done to the present ghats, whether a continuous flow of water should be brought down, or the ghats isolated and kept as separate wells. Considering the number of women, children and infirm persons who have to ascend and descend, the approaches to all the ghats should be laid out with steps at easy slopes widened and protected by railings at the side.

The Jivan Rao and other Kattes.

82. It has been sometimes supposed that the Jivan Rao Katte has been a failure; and it is in some respects defective as the water does not remain at the tank; but there is little doubt that what disappears feeds the wells below, and that fresh wells could be sunk with success below it. The improvement of this work is in all respects desirable. I have heard that Sub Rao Katte has been examined, but with what result I do not know. If it can be improved, it should be, as the situation is convenient.

Siniru Katte.

83. This pond is situated a few yards above the Benne Hardenhalli feeder of the Dodkere, and the people in the neighbourhood have pointed out to me that it can possibly be filled from the feeder by making a small dam and a cut leading the water to the Katte. Some years ago a project was proposed for constructing a second Katte just below and filling it from the feeder, but this has passed out of notice. Both these proposals should receive attention, as it does not appear that the projects would be expensive and the people are much in favor of them. It may indeed be possible to find a still better site, but this is a point on which I am uncertain.

Karanji water.

84. The advantages of bringing water from the Karanji tank and distributing it at the cistern now under construction by the Public Works Department, cannot be overestimated, when the great distance of the Karanji tank is considered; but it would be still better if the pipes could be continued from the fort to a reservoir on the open space now called the Fowler's Park. It is not probable that the water in Bowen's well will be drunk by any one who can get water from the Karanji cistern, but when purified, the well will no doubt afford an excellent supply of water which will be quite drinkable, will probably be found good for cooking, and will be preferred to that of the Dodkere for all purposes.

85. The Dodkere must simply be regarded as the cess pool of Mysore until the sewage which now pollutes it is cut off; when this is done, there is no apparent reason why the water should not be tolerably good.

86. Having now reviewed the whole question, it must be evident that if all that is suggested was carried out, and every reservoir and well improved to its utmost capacity, Mysore would still have only an uncertain and often insufficient quantity of water at command. In dry seasons the people must suffer considerably, and in a year of drought undergo actual privation; and it is therefore necessary to look beyond the limits which have been referred to.

87. The possibility of bringing water from the Cauvery is a point to be decided by professional Officers; but whatever may be the result, the project for supplying some high level in the town with water from Benne Hardenhalli and Bogadi tanks, a scheme originally suggested by Major Johnson, should be carried out if found to be as good as it promises. The survey for this, the drainage project, Bowen's well, the Karanji tank feeders and duct, and the Jivan Rao Katte, are either under survey or execution, and it only remains for me to recommend that a Public Works Officer take up in succession the examination of the different valleys on the north and north-east, Furnaiya's Channel, the Siniru and Sub Rao Kattes, and the proposed continuation of the Karanji duct. The work of cleaning out and deepening wells of drinking water, sinking new ones within the town, improving others useful for any purpose, and the enforcing of conservancy, may be left to the Municipality.

Sir Richard Meade, who has seen the principal wells and ghats, considers, that among the points for consideration by the Municipality, is the possibility of raising water from the main wells at the public expense and discharging it into cisterns from which it could be obtained by the people uncontaminated, and without the risk and labor of descending to the level of the springs. I believe that with the information now collected, the Municipality would have no difficulty in determining how money may be best expended for all these purposes.

I have the honor to be
Sir,
Your most obedient Servant,
A. C. HAY.
Commissioner, Mysore Division.

1873 173 Appendix

Water spread & Capacity of the Halsur Lower & Upper Tanks.

Gauge Readings	Area in Millions of Sq feet	Capacity Between successive Contours Mn. Gs. Ft.	Capacity at various Contours Mn. Gs. Ft.	Remarks.
9·00	1·8504		1·628	The mean depth 0·88 below this
8·75	1·988	0·480	2·108	contour has been taken from the
8·50	2·126	0·514	2·622	Cross Sections shown on the Survey
8·25	2·286	0·581	3·173	which is supposed to be that made
8·00	2·446	0·591	3·764	in the early part of 1877 and re-
7·75	2·616	0·633	4·397	ferred to in Lt. F. J. Romilly's Rep
7·50	2·787	0·678	5·072	dated 30th September 1879.
7·25	2·969	0·719	5·791	The areas at 4·00; 4·50; 4·75 were measured
7·00	3·160	0·765	6·556	by planimeter from the plan of the Halsur
6·75	3·360	0·810	7·366	Lake in the Survey Office. The depth
6·50	3·570	0·857	8·223	of foot above the Sill of the Sluice have
6·25	3·790	0·905	9·128	been taken from the Longitudinal Section
6·00	4·020	0·955	10·083	shown on the Survey Plan.
5·75	4·260	1·006	11·089	
5·50	4·510	1·059	12·148	
5·25	4·770	1·115	13·263	
5·00	5·040	1·171	14·434	
4·75	5·320	1·230	15·664	
4·50	5·610	1·291	16·955	
4·25	5·910	1·354	18·309	
4·00	6·220	1·419	19·728	
3·75	6·540	1·486	21·214	
3·50	6·870	1·555	22·769	
3·25	7·210	1·626	24·395	
3·00	7·560	1·699	26·094	
2·75	7·920	1·774	27·868	
2·50	8·290	1·851	29·719	
2·25	8·670	1·930	31·649	
2·00	9·060	2·011	33·660	
1·75	9·460	2·094	35·754	
1·50	9·870	2·180	37·934	
1·25	10·290	2·268	40·202	
1·00	10·720	2·359	42·561	

1873 173 2nd

Papers which General Cantley remarks that the actual consumption of water in Mysore for drinking & cooking purposes is 1½ gallon per head in Colonel A. C. Hay's letter No 357/73 of 25 August 1874.

1473/83

He says "accuracy is unattainable" & the object of the enquiry was to give a "general view of the existing circumstances."

The general result arrived at was that at 25000 to 30000 persons 1½ gallons each per head daily the population being 57,765 the larger quantity 76,750 gallons makes the average just under 1⅓ gallon. A check list (para 68) 20000 people are supposed to have used 45,750 gallons & 37765 people were left with 31,020 gallons only.

Even with the data available they would only show that in an extremely badly supplied locality the people under favourable circumstances took a much smaller

Main creek Lower Tank

Apparently springs are to be met with throughout the whole length of the Channel from the Rajpu Ghat to the fort walls, and many natives believe that there was once a continuous stream from the Rajpu Ghat downwards. Communication is, however, now entirely interrupted both by land slips and the genera silting up of the bottom of the channel, as also by the excavation of the pits at the ghats, the earth fro which has been thrown up round them, and by the new road to the Civil Hospital. Everything ha been done that could be done to render the channel a nuisance instead of a benefit. In parts, it is over- grown with vegetation; it is used as a latrine and receptacle of filth; and the drainage of the market and several streets has been discharged into it contaminating the soil, and stopping up one, if not more, of the springs. A professional officer is required to survey the Channel and determine the best mode of remedying the damage, and also to decide on what should be done to the present ghats, whether a continuous flow of water should be brought down, or the ghats isolated and kept as separate wells. Considering the number of women, children and infirm persons who have to ascend and descend, the approaches to all the ghats should be laid out with steps at easy slopes widened and protected by rail- ings at the side.

82. It has been sometimes supposed that the Jivan Rao Katte has been a failure; and it is in some respects defective as the water does not remain at the tank; but

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drinking water, sinking new ones within the town, improving others useful for any purpose, and the enforcing of conservancy, may be left to the Municipality.

Sir Richard Meade, who has seen the principal wells and ghats, considers, that among the points for consideration by the Municipality, is the possibility of raising water from the main wells at the public expense and discharging it into cisterns from which it could be obtained by the people uncontaminated, and without the risk and labor of descending to the level of the springs. I believe that with the information now collected, the Municipality would have no difficulty in determining how money may be best expended for all these purposes.

I have the honor to be
Sir,
Your most obedient Servant,
A. C. HAY,
Commissioner, Ahmednagar Division.

Table of area of water spread & capacity of the Watson Lower & Upper Tanks.

Reduced Level from S.O.	Survey Contour Level	Gauge Readings	Area in Millions of sqr feet	Capacity Between Contours in Millions of Cubic Feet	Capacity Contour in Millions of Cubic Feet	Remarks.
2920.97	41.00	9.00	1.8504			The mean depth 0.88 below the
	41.25	8.75	1.988	0.480	1.628	contour has been taken from the
	41.50	8.50	2.128	0.514	2.108	cross sections shown on the drawing
	41.75	8.25	2.296	0.554	2.662	which is supported that made
2921.97	42.00	8.00	2.446	0.591	3.173	in the early part of 1877 and
	42.25	7.75	2.616	0.633	3.760	reported to in Lr No. J. Revenue dated 30th September 1879.
	42.50	7.50	2.787	0.675	4.337	
	42.75	7.25	2.968	0.717	5.072	The areas at 9.00; 8.00; 7.00
2922.97	43.00	7.00	3.149	0.764	5.791	and some have been measured
	43.25	6.75	3.341	0.811	6.555	from the Contour Lines shown on
	43.50	6.50	3.523	0.859	7.368	the drawing.
	43.75	6.25	3.739	0.909	8.228	
2923.97	44.00	6.00	3.9432	0.960	9.184	The area at each half foot
	44.25	5.75	4.121	0.998	10.094	between the above contours have
	44.50	5.50	4.343	1.058	11.152	been derived on the supposition
	44.75	5.25	4.560	1.107	12.259	that each 3 feet length is the
2924.97	45.00	5.00	4.720	1.022	13.294	frustum of a cone.
	45.25	4.75	4.181	1.037	14.348	
	45.50	4.50	4.343	1.053	15.422	The area at the gauge heights are
	45.75	4.25	4.505	1.069	16.548	the means of the areas at the adjacent
2925.97	46.00	4.00	4.668	1.084	17.574	The capacities between contours
	46.25	3.75	4.431	1.100	18.858	are found by multiplying the area
	46.50	3.50	4.495	1.116	19.974	of the mean contour by the depth.
	46.75	3.25	4.560	1.132	21.106	They are therefore only approximate
2926.97	47.00	3.00	4.624	1.148	22.254	but are probably quite as accurate
			4.6984	1.164	23.418	as the data will allow.
	47.25	2.75	4.772	1.176	24.594	
	47.50	2.50	4.782	1.196	25.790	
	47.75	2.25	4.792	1.196	26.986	
2927.97	48.00	2.00	4.812	1.198	28.184	
	48.25	1.75	4.842	1.207	29.391	
	48.50	1.50	4.872	1.214	30.605	
	48.75	1.25	4.902	1.222	31.827	
2928.97	49.00	1.00	4.932	1.229	33.056	
	49.25	0.75	4.962	1.237	34.293	
	49.50	0.50	4.993	1.244	35.537	
	49.75	0.25	5.023	1.254	36.791	
2929.97	50.00	0.00	5.0532	1.259	38.050	
	50.25		5.083	1.267	39.317	
	50.50		5.113	1.274	40.591	
	50.75		5.143	1.282	41.873	
2930.97	51.00		5.173	1.290	43.163	

Main creek Lower Tank

Reduced Level M.S.D.	Survey Contour Level	Gauge Reading	Area in Sq. Feet	Capacity between contours Mg. Ft.	Capacity at contour Mg. Ft.	Remarks.
	50·00					
	50·25		0·453		0·600	The area at the 50·00 + 53·00 contour has
	50·50		0·544	0·125		been taken from a Survey signed C.B. Joyce, Esq.
	50·75		0·626	0·147	0·725	Engineer & Water Works Division obtained from
	51·00		0·742	0·172	0·872	the Office of the Surveyor General of Penang R.W.D. & dated
	51·25		0·848	0·197	1·044	at 54·00 + 56·00 from a Survey dated 22nd Nov.
	51·50		0·970	0·227	1·241	1880 signed by Lt. F.J. Conroy R.E. the 54·00 contour
	51·75		1·092	0·258	1·468	being derived from that at 54·08
	52·00		1·229	0·290	1·726	shown on the Survey.
	52·25		1·366	0·324	2·016	
	52·50		1·518	0·360	2·341	
	52·75		1·671	0·399	2·700	
	53·00		1·889	0·439	3·099	
	53·25		2·007	0·481	3·538	
	53·50		2·077	0·510	4·019	
	53·75		2·148	0·528	4·529	
	54·00		2·225	0·547	5·057	
	54·25		2·303	0·566	5·604	
	54·50		2·383	0·586	6·170	
	54·75		2·463	0·606	6·756	
	55·00		2·545	0·626	7·362	
	55·25		2·628	0·647	7·985	
	55·50		2·713	0·668	8·635	
	55·75		2·799	0·689	9·303	
	56·00		2·887	0·711	9·992	
			2·975	0·733	10·703	
					11·436	

Area in Mg. of Sq. Feet	Capacity between contours Mg. Ft.	Capacity at contour Mg. Ft.	Remarks
2·007	0·568	4·019	Based on Survey of 22nd November 1880.
2·056	0·521	4·527	
2·106	0·533	6·047	
2·156	0·545	5·580	
2·207	0·561	6·125	
2·284	0·582	6·686	
2·372	0·604	7·268	
2·462	0·627	7·872	
2·553	0·650	8·499	
2·646	0·673	9·149	
2·740	0·697	9·822	
2·837	0·721	10·519	
2·934		11·240	Watershed, Upper Tank

Table of area, levels, spread and capacity of the Halcan Tank prior to the construction of the Upper Tank in 1877.

Reduced Level M.S.D.	Survey Contour Level	Gauge Readings	Area in Mg. of Sq. Feet	Capacity between contours Mg. Ft.	Capacity at contour Mg. Ft.	Remarks
	41·00	9·00	1·850			
	41·25	8·75	1·988	0·480	1·628	
	41·50	8·50	2·126	0·514	2·108	
	41·75	8·25	2·286	0·551	2·622	
	42·00	8·00	2·446	0·591	3·173	
	42·25	7·75	2·616	0·633	3·764	
	42·50	7·50	2·787	0·675	4·397	
	42·75	7·25	2·968	0·719	5·072	
	43·00	7·00	3·149	0·764	5·791	
	43·25	6·75	3·345	0·811	6·555	
	43·50	6·50	3·533	0·859	7·366	
	43·75	6·25	3·738	0·909	8·225	
	44·00	6·00	3·943	0·960	9·134	
	44·25	5·75	4·001	0·998	10·094	
	44·50	5·50	4·060	1·007	11·087	
	44·75	5·25	4·125	1·022	12·094	
	45·00	5·00	4·191	1·037	13·116	
	45·25	4·75	4·243	1·053	14·153	
	45·50	4·50	4·305	1·068	15·206	
	45·75	4·25	4·368	1·084	16·274	
	46·00	4·00	4·431	1·100	17·358	
	46·25	3·75	4·495	1·116	18·458	
	46·50	3·50	4·560	1·132	19·574	
	46·75	3·25	4·624	1·148	20·706	
	47·00	3·00	4·688	1·164	21·854	
	47·25	2·75	4·754	1·180	23·018	
	47·50	2·50	4·820	1·197	24·198	
	47·75	2·25	4·887	1·213	25·395	
	48·00	2·00	4·954	1·230	26·608	
	48·25	1·75	5·021	1·247	27·838	
	48·50	1·50	5·089	1·264	29·085	
	48·75	1·25	5·157	1·281	30·349	
	49·00	1·00	5·226	1·298	31·630	
	49·25	0·75	5·295	1·315	32·928	
	49·50	0·50	5·365	1·332	34·243	
	49·75	0·25	5·435	1·350	35·575	
	50·00	0·00	5·506	1·368	36·925	
					38·293	

Appendix No. 10

Tabling area of water spread to
Capacity Halsur Lower to
Upper Tanks -

Halsur Tank. Appendix No

Statement showing particulars of water supply for the year 1880.

Dates	Gauge Readings	Contents Millions of C. Feet	Volume expended Total M.C.F.	Used for Troops M.C.F.	Lost M.C.F.	Volume received M.C.F.	Rainfall inches	Remarks.
January 1st	0·52	35·023						The zero of the gauge is level with the crest of the waste weir and its value is M.D.D 2929·97.
" 20	0·92							
" 21	0·92						0·62	
" 22	0·94							
" 31	1·12	32·051	2·972	0·247	2·725			Railway Contour level 50·00.
February 1	1·15							
" 3	1·20	31·658	0·393					
" 4	1·00							
" 5	0·67			0·283	2·689	3·464	—	From upper Tank.
" 6	0·50	35·122						
" 7	0·51							
" 29	1·02	32·543	2·579					
			2·972	0·283	2·689	3·464	0·00	
March 1	1·06							
" 20	1·66						0·17	
" 21	1·67		4·774	0·332	4·442			
" 22	1·70						0·27	
" 31	2·00	27·769						
			4·774	0·332	4·442	0·000	0·44	
April 4	2·10							
" 7	2·17						0·07	
" 11	2·25	26·570	1·199				0·07	
" 12	1·83	28·590		0·337	3·693	2·020	1·20	
" 19							0·16	
" 30	2·42	25·759	2·831					
			4·030	0·337	3·693	2·020	1·50	
May 6	2·59							
" 7	2·59						0·48	
" 8	2·61	24·857	0·902					
" 9	2·42	25·759				0·902	0·59	
" 10	2·42						0·23	
" 11	2·42						0·19	
" 12	2·44							
" 13	2·46	25·569	0·190					
" 14	2·38						0·40	
" 15	2·25			0·279	1·538	2·828	0·60	
" 16	2·17						0·58	
" 17	1·87	28·397					0·79	
" 18	1·00							
" 19	1·92						0·15	
" 21	1·76						0·20	
" 23	2·00	27·769	0·628				0·09	
" 24	1·71						0·65	
" 25	1·67					1·693	0·47	
" 26	1·65	29·462					0·33	
" 27	1·6	29·365	0·097					
" 28	1·67					2·047	0·48	
" 29	1·33						1·27	
	5	5	6		5	5	5	

Appendix No. 10

Catchment area of watershed to Halsur Lower & Upper Tanks =

Halsur Tank. Appendix No

Statement showing particulars of water supply for the year 1880.

Dates	Gauge Readings	Contents Millions of C. Feet	Volume expended Total M. of C. Feet	Used for Troops M. of C. Feet	Lost M. of C. Feet	Volume received M. of C. F.	Rainfall inches	Remarks.
January 1st	0·62	35·023						The zero of the gauge is level with the crest of the waste weir and its value is M. S. L. 2929·97.
" 20	0·92							
" 21	0·92						0·62	
" 22	0·94							
" 31	1·12	32·051	2·972	0·247	2·725			Quay Contour level 50·00
February 1	1·15							
" 3	1·20	31·658	0·393					
" 4	1·00							
" 5	0·67			0·283	2·689	3·464	—	From upper Tank.
" 6	0·50	35·122						
" 7	0·51							
" 29	1·02	32·543	2·579					
			2·972	0·283	2·689	3·464	0·02	
March 1	1·06							
" 20	1·66						0·17	
" 21	1·67		4·774	0·332	4·442			
" 22	1·70						0·27	
" 31	2·00	27·769						
			4·774	0·332	4·442	0·000	0·44	
April 4	2·10							
" 7	2·17						0·07	
" 11	2·25	26·570	1·199				0·07	
" 12	1·83	28·590		0·337	3·693	2·020	1·20	
" 19							0·16	
" 30	2·42	25·759	2·831					
			4·030	0·337	3·693	2·020	1·50	
May 6	2·59							
" 7	2·59						0·48	
" 8	2·61	24·857	0·902					
" 9	2·42	25·759				0·902	0·59	
" 10	2·42						0·23	
" 11	2·42						0·19	
" 12	2·44							
" 13	2·46	25·569	0·190					
" 14	2·38						0·40	
" 15	2·25			0·279	1·538	2·828	0·60	
" 16	2·17						0·58	
" 17	1·87	28·397					0·79	
" 18	1·80							
" 19	1·92						0·15	
" 21	1·96						0·20	
" 23	2·00	27·769	0·628				0·09	
" 24	1·71						0·65	
" 25	1·67					1·693	0·47	
" 26	1·66	29·462					0·33	
" 27	1·67	29·365	0·097					
" 28	1·67					2·047	0·48	
" 29	1·33						1·27	
8	5	5	5	5	5	5	5	

Dates	Gauge Readings	Contents Millions of C.F.	Volume expended: Total Mc ft.	Used for Irrig. Mc ft.	Lost Mc ft.	Volume received Mc ft.	Rainfall Inches	Remarks
May 30	1·33							1473
" 31	1·25	31·418					0·66	
			1·817	0·279	1·538	7·470	8·16	
June 6	1·42	30·581	0·631					
" 7	1·38							
" 8	1·38	30·776				0·195	0·50	
" 10	1·42	30·581	0·195					
" 11	1·30						0·60	
" 12	1·30			0·254	1·756		0·21	
" 13	1·25						0·43	
" 14	1·04						0·66	
" 15	1·03						0·14	
" 16	1·03						0·06	
" 17	1·03	32·494				1·913	0·14	
" 18	1·04						0·05	
" 29	1·23						0·09	
" 30	1·23	31·510	0·984				0·23	
			2·010	0·254	1·756	2·628	3·11	
July 1	1·19	31·707				0·497	0·35	
" 2	1·20						0·14	
" 3	1·21	31·609	0·098					
" 4	1·10						0·75	
" 5	1·00						0·71	
" 6	1·00	32·641				1·032	0·16	
" 7	1·01						0·03	
" 8	1·02	32·543	0·098				0·08	
" 9	0·75	33·877				1·336	0·99	0·94 in one hour
" 10	0·77			0·272	1·211			
" 18	0·87						0·46	
" 21	0·94	32·938	0·940					
" 22	0·92	33·037				0·099	0·50	
" 23	0·93						0·03	
" 25	0·94						0·33	
" 26	0·95	32·888	0·149				0·08	
" 27	0·87						0·41	
" 28	0·87	33·284				0·396	0·25	
" 29	0·88						0·02	
" 30	0·89						0·05	
" 31	0·91	33·086	0·198				0·15	
			1·483	0·272	1·211	3·059	5·49	
August 1	0·92	33·037	0·049				0·35	
" 8							0·12	
" 10	1·03	32·494	0·543					
" 11	0·87						1·00	
" 12	0·87						0·50	
" 13	0·83						0·25	
" 14	1·50	37·633*				5·139	5·10	
" 15	0·75						0·63	
" 16	0·25							
" 17	0·25			0·302	0·290		0·27	
" 18	0·17		63·476		63·476			
" 19	0·12							
" 20	0·10					63·476	0·02	
" 21	0·08						0·12	
" 22	0·08							
" 23	0·07							

* For gauge reading 0·00 Mc ft.

Discharged Guards	22·713
do	24·856
do	7·667
do	2·446
do	1·917
do	1·057
do	0·727
do	0·528
do	0·462
do	0·396

Date		Gauge Readings	Contents Million Cu. Ft.	Volumes expended Total Mc. Ft.	Used for Irrigation Mc. Ft.	Lost Mc. Ft.	Volume received Mc. Ft.	Rainfall Inches.	Remarks.	Mc. Ft.
August	24	0·06							Discharged towards	0·330
"	25	0·04							do	0·198
"	26	0·03							do	0·132
"	27	0·04						0·22	do	0·132
"	28	0·03						0·22	do	0·066
"	30	0·00						0·22	Total	63·476.
"	31	0·00	37·633					0·10		
				64·068	0·302	63·766	68·615	9·12		
September	1	0·00	37·633					0·02		
"	4	0·02						0·40		
"	5	0·03						0·02		
"	8	0·06	37·331	0·302						
"	9	0·04	37·633				0·302	1·00	Discharged towards	0·079
"	10	0·03							do	0·132
"	11	0·02							do	0·066
"	12	0·08						0·60	do	0·264
"	13	0·21			0·274	5·869		0·55	do	1·190
"	14	0·17							do	1·652
"	15	0·13		5·884			5·884		do	1·124
"	16	0·08						0·03	do	0·661
"	17	0·06							do	0·396
"	18	0·04							do	0·198
"	19	0·02							do	0·106
"	20	0·01							do	0·016
"	21	0·01							Total	5·884.
"	30	0·19	36·676	0·957						
				7·143	0·274	5·869	6·186	2·62		
October	1	0·21						0·13		
"	2	0·23						0·18		
"	3	0·25	36·374	0·302						
"	4	0·25	37·633				1·259	2·06	Discharged towards	1·223
"	5	0·21							do	2·181
"	6	0·29							do	2·512
"	7	0·21						0·70	do	2·512
"	8	0·17							do	1·652
"	9	0·08							do	0·925
"	10	0·04							do	0·304
"	11	0·02							do	0·106
"	12	0·04						0·16	do	0·106
"	13	0·17						0·25	do	0·793
"	14	0·17							do	1·388
"	15	0·08			0·245	65·678			do	0·925
"	16	0·06							do	0·370
"	17	0·12					65·621	2·23	do	0·542
"	18	0·05		65·621				0·50	do	0·621
"	19	0·06							do	0·370
"	20	0·21						1·00	do	1·104
"	21	0·17							do	1·652
"	22	0·58						1·75	do	5·090
"	23	0·58						1·58	do	8·725
"	24	0·37							do	6·610
"	25	0·32						0·70	do	4·098
"	26	0·67						0·63	do	7·337
"	27	0·33						0·10	do	7·271
"	28	0·21							do	2·842
"	29	0·19							do	1·785
"	30	0·17						0·24	do	1·520
"	31	0·12	37·633						do	1·057
				65·923	0·245	65·678	66·880	10·21		65·621.

Date	Gauge Readings	Contents Million C.ft	Volume expended Total Mil.C.ft	Used for Troops Mil.C.ft	Lost Mil.C.ft	Volume received Mil.C.ft	Rainfall Inches	Remarks.
								Discharge Guards 0.727
November 1	0.10							do 0.529
" 2	0.08							do 0.397
" 3	0.06							do 0.198
" 4	0.04							do 0.132
" 5	0.03							do 0.079
" 6	0.02							do 0.033
" 7	0.01							do 0.086
" 8	0.04		2.762			2.762	0.26	do 0.132
" 9	0.03							do 0.079
" 10	0.02						0.02	do 0.033
" 11	0.01						0.18	do 0.086
" 12	0.04						0.13	do 0.132
" 13	0.03							do 0.079
" 14	0.02			0.281				do 0.033
" 15	0.01							do 0.007
" 16	0.00	37.633						
" 17	0.01						0.12	
" 18	0.02							
" 20	0.05	37.381	0.252					
" 21	0.00	37.633				0.252	0.60	do 0.145
" 22	0.06						0.37	do 0.198
" 23	0.04							do 0.132
" 24	0.04						0.05	do 0.132
" 25	0.03							do 0.079
" 26	0.02		1.182			1.182		do 0.033
" 27	0.01							do 0.033
" 28	0.02						0.33	do 0.033
" 29	0.01						0.03	do 0.397
" 30	0.12	37.633					0.60	3.944
			4.196	0.281	3.915	4.196	2.69	
								Discharge Guards 0.595
December 1	0.08						0.02	do 0.330
" 2	0.06							do 0.198
" 3	0.04		1.374			1.374		do 0.132
" 4	0.03			0.273	3.462			do 0.079
" 5	0.02							do 0.033
" 6	0.01							do 0.007
" 7	0.00	37.633						1.374
" 31	0.47	35.272	2.361					
			3.735	0.273	3.462	1.374	0.02	

Date	Gauge Readings	Contents Million C. Feet	Volume expended Total Mc.ft.	Used for Troops Mc.ft.	Lost Mc.ft.	Volume received Mc.ft.	Rainfall Inches	Remarks.
			Summary.					
January	0.512	35.023	2.972	0.247	2.725		0.62	
February			2.972	0.28	2.639	3.464	0.00	* From Upper Tank.
March			4.774	0.332	4.442	—	0.44	
April			4.030	0.337	3.693	2.020	1.50	
May			1.817	0.279	1.538	7.470	8.16	
June			2.010	0.254	1.776	2.108	3.11	
July			1.483	0.272	1.211	3.059	5.49	
August			64.068	0.302	63.766	68.615	9.12	
September			7.143	0.274	6.869	6.186	2.62	
October			65.923	0.245	65.678	66.880	10.21	
November			4.196	0.281	3.916	4.196	2.69	
December	0.47	35.272	3.735	0.273	3.462	1.374	0.02	
	Diffce	0.249	165.123	3.379	161.744	165.372	43.98	

Appendix No. 11

Halsur Tank

Particulars of watersupply 1880

Halsur Tank 1881 Appendix No.

Statement Showing particulars of Water Supply for the year 1881.

Date	Gauge Reading	Contents Million C. Feet	Volume expended Total million C. Feet	Used for Supply million C. Feet	Lost million C. Feet	Volume received million C. Feet	Rainfall in inches	Remarks.
January 1	0.49	35.172						1873
" 12	0.68						0.23	
" 18	0.79			0.328			0.02	
" 31	1.06	32.346	2.826					
			2.826	0.328	2.498	0.000	0.25	
February 1	1.08							Syphon over upper tank weir in work.
" 16	1.48			0.305				
" 23	1.48	30.288	2.058					
" 28	1.45	30.434				0.146		* from upper Tank exclusive of that which Compensated from evaporation &c.
			2.058	0.305	1.753	0.146	0.00	
March 1	1.45	30.434						
" 27	1.67							
" 28	1.68	29.364	1.070	0309			0.42	
" 29	1.50	30.190				0.826	0.014	
" 31	1.54	29.996	0.194					
			1.264	0.309	0.955	0.826	0.46	
April 1	1.56							
" 17	2.00			0.252			0.45	
" 30	2.40	26.855	4.141					
			4.141	0.252	3.889	0.000	0.45	
May 1	2.42							
" 10	2.70	24.431	1.424					
" 11	2.60	25.378				0.947		
" 12	2.62			0.292			0.67	
" 14	2.66						0.07	
" 16	2.58						0.20	
" 30	3.00	23.018	2.360					
" 31	2.71	24.383				1.365	0.81	
			3.784	0.292	3.492	2.312	1.75	
June 1	2.73							
" 4	2.77						0.24	
" 6	2.81	23.912	0.471					
" 7	2.35	26.093				2.181	1.28	
" 8	2.35							
" 9	2.36			0.270				
" 20	2.60							
" 26	2.73							
" 28	2.78							
" 29	2.80							
" 30	2.83	23.818	2.275					
			2.746	0.270	2.476	2.181	2.14	
July 1	2.85							
" 3	2.90						0.10	
" 10	3.02	22.925	0.893	0.276				
" 17	2.60	24.904				1.979		From upper tank
" 31	3.00	23.016	1.886					
			2.779	0.276	2.503	1.979	0.10	

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Date	Gauge Readings	Contents Million Cu. Ft.	Volume expended Total Mg. Cu. Ft.	Volume expended Used for Irrigation Mg. Cu. Ft.	Volume expended Lost & Used Mg. Cu. Ft.	Volume received Mg. Cu. Ft.	Rainfall Inches	Remarks.
August 1	3.00						0.23	1473
" 3							0.19	
" 4							0.08	
" 5							0.18	
" 6							0.16	
" 8							0.08	
" 9	3.10	22.552	0.466				0.37	
" 10	2.80	23.959				1.407	1.20	
" 14	2.88						0.09	
" 19				0.264			0.33	
" 21							0.10	
" 22							1.30	
" 23							0.13	
" 25	2.92	23.394	0.565					
" 26	2.79						1.00	
" 27	2.75						0.66	
" 28	2.65						0.70	
" 29	2.59						0.46	
" 30	2.58						0.37	
" 31	2.58	24.997				1.605		
			1.031	0.264	0.767	3.012	7.62	
September 5	2.69						0.12	
" 11	2.81	23.912	1.087				0.06	
" 12	2.78	24.053				0.141	0.21	
" 13	2.80						0.02	
" 14	2.82						0.04	
" 16	2.86	23.676	0.377				0.10	
" 17	2.71						1.25	
" 18	2.60			0.302			0.20	
" 19	2.60	24.904				1.226	0.37	
" 21	2.62						0.12	
" 22	2.64						0.15	
" 26	2.73	24.289	0.615					
" 27	2.71						0.33	
" 28	2.71						0.10	
" 29	2.71						0.20	
" 30	2.29	26.377				2.090	2.10	
			2.079	0.302	1.777	3.459	5.27	
October 1	2.12						0.40	
" 2	1.87	28.397				2.018	0.94	
" 5	1.94			0.252			0.03	
" 6	1.98						0.10	
" 31	2.50	25.378	3.019					
			3.019	0.252	2.767	2.018	1.47	

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	Gauge Readings	Contents Million Cu. Feet	Volume expended Total M.C.F.	Volume expended used for Power M.C.F.	Volume expended Cost M.C.F.	Volume wasted M.C.F.	Rainfall Inches	Remarks.
ember 1	2·52						0·06	
2	2·53						0·23	
3	2·54	25·489	0·189					
4	2·49	25·426				0·237	0·32	
5	2·50						0·03	
6	2·51	25·331	0·095					
7	2·35	26·093		0·222		0·762	1·16	Probably running 96 hours 7 to 11 P.M.
11	2·40	25·855	0·238					
12	2·27						1·64	
13	2·27	26·475				0·620	0·09	
14	2·28						0·06	
17	2·32						0·05	
19	2·34						0·04	
30	2·50	25·378	1·097					
			1·619	0·222	1·397	1·619	3·66	
ember 9	2·66						0·04	
12	2·69						0·05	
21	2·87	23·630	1·748	0·228				Sluice Upper Tank opened on the 22nd.
25	2·48	25·473				1·843		
31	2·64	24·715	0·758					
			2·506	0·228	2·278	1·843	0·09	

Summary

mmary	0·49	35·172	2·826	0·328	2·498	0·000	0·25	
bruary			2·058	0·305	1·753	0·146	0·00	* from upper Tank
rch			1·264	0·309	0·955	0·826	0·46	
ril			4·141	0·262	3·889	0·000	0·45	
y			3·784	0·292	3·492	2·312	1·75	
ne			2·746	0·270	2·476	2·181	2·14	
ly			2·779	0·276	2·503	1·979	0·10	* from upper Tank
gust			1·031	0·264	0·767	3·012	7·62	
ptember			2·079	0·312	1·777	3·459	5·27	
tober			3·019	0·252	2·767	2·018	1·47	
vember			1·619	0·222	1·397	1·619	3·66	
cember	2·64	24·715	2·506	0·228	2·278	1·843	0·09	* from upper Tank
		Diff. 10·457	29·852	3·300	26·552	19·395	23·28	

Appendix No. 12

Halsur Tank

Particulars of water supply

Halsur Tank 1884 85 Appendix No

Statement showing particulars of water Supply for the year 1883.

Date	Gauge Readings	Contents millions of Cubic Feet	Volume expended			Volume of rainfall millions of Cubic Ft.	Rainfall Inches	Remarks.
			Total Millions of Cubic Ft.	used for Irrigation Millions of Cubic Ft.	Lost Millions of Cubic Ft.			
December 31	2.64	24.715						1493
January 1	2.59	24.952				0.237	0.46	
" 2	2.59			0.206			0.05	
" 3	2.59							
" 31	3.26	21.808	3.144					
			3.144	0.206	2.938	0.237	0.51	
February 1	3.28							
" 28	4.00	18.458	3.360	0.250				
			3.350	0.250	3.100	0.000	0.00	
March 1	4.02							
" 31	4.92	14.490	3.968	0.268				
			3.968	0.268	3.700	0.000	0.00	
April 1	4.95							
" 13	5.33			0.276			0.42	
" 30	5.83	10.769	3.721					
			3.721	0.276	3.445	0.000	0.42	
May 1	5.86							
" 9	6.10						0.01	
" 10	6.13	9.595	1.174					
" 11	6.11						0.70	Duration 30 minutes till 10th
" 13	6.09	9.748				0.153	0.41	do 15 do
" 14	6.11	9.672	0.076					
" 15	6.00			0.268			0.90	3 to 8 P.M.
" 16	6.00						0.55	8 P.M. to 4 A.M. 17th
" 17	6.00						0.18	
" 18	6.83						0.40	
" 19	5.74						0.67	
" 20	5.72	11.208				1.536	0.21	
" 30	5.94						0.01	
" 31	5.96	10.253	0.955					
			2.205	0.268	1.937	1.689	4.04	

Date	Gauge Reading	Contents Million Cubic feet	Volume expended Total Million C. ft.	Used for purposes Million C. ft.	Lost Million C. ft.	Volume per second Million Cubic ft.	Rainfall Inches	Remarks.
June 1	5.98							1673
" 2	5.99						0.07	
" 3	6.01						0.01	
" 5	6.05						0.01	
" 6	6.07						0.04	
" 7	6.10						0.05	
" 8	6.12						0.25	
" 10	6.18						0.03	
" 11	6.20			0.292			0.02	
" 13	6.25						0.05	
" 15	6.31						0.18	
" 22	6.49	8.261	1.992					
" 23	6.33							Sluice of upper tank opened
" 24	6.18						0.33	
" 25	6.16	9.480				1.219		
" 29	6.27	9.061	0.419					
" 30	6.25	9.134				0.073	0.78	
			2.411	0.292	2.119	1.292	1.82	
July 1	6.27	9.061	0.073					
" 2	6.25	9.134				0.073	0.40	
" 3	6.26						0.03	
" 4	6.27	9.061	0.073				0.03	
" 5	6.25						0.18	
" 6	6.25						0.25	
" 7	6.25	9.134				0.073	0.16	
" 8	6.26						0.04	
" 9	6.27						0.02	
" 10	6.28						0.01	
" 13	6.33						0.02	
" 14	6.34	8.807	0.327	0.245				
" 15	6.33	8.843				0.036	0.26	
" 19	6.44						0.04	
" 20	6.46						0.02	
" 21	6.48						0.02	
" 23	6.60						0.06	
" 24	6.50	8.225	0.618				0.09	
" 25	6.46						0.78	
" 26	6.46						0.21	
" 27	6.46						0.01	

July 28	6·42						0·35	
" 29	6·37						0·52	
" 30	6·25						0·58	
" 31	6·25	9·134				0·909	0·07	
			1·091	0·241	0·850	1·091	4·15	
August 1	6·25						0·07	
" 2	6·23	9·211				0·077	0·24	
" 6	6·26	9·098	0·113					
" 7	6·25						0·15	
" 8	6·16						0·75	
" 9	6·15							
" 10	5·94	10·332				1·234	0·62	
" 11	5·95						0·07	
" 18	6·02						0·15	
" 20	6·05			0·248			0·08	
" 21	6·07						0·02	
" 23	6·09	9·748	0·584				0·70	
" 24	5·94						0·66	
" 25	5·94						0·02	
" 27	5·94						0·28	
" 28	5·94						0·45	
" 29	5·83	10·769				1·021	0·60	
" 30	5·85						0·13	
" 31	5·87	10·610	0·159				0·03	
			0·856	0·248	0·608	2·332	5·02	
September 1	5·89						0·02	
" 3	5·94						0·09	
" 4	5·96						0·05	
" 5	5·96						0·23	Duration 2h 2¼ l.h.
" 7	5·98						0·15	
" 11	6·04						0·06	
" 16	6·15						0·17	Duration 7½ 29 l.h.
" 21	6·23	9·211	1·399	0·255			0·29	
" 22	5·96	10·253				1·042	0·68	
" 25	6·02						0·26	
" 26	6·04	9·940	0·313					
" 27	6·02						0·42	
" 28	6·02						0·12	
" 29	5·98	10·173				0·233	0·21	
" 30	6·00	10·094	0·079					
			1·791	0·255	1·536	1·275	2·75	

October 1	6.00	10.094						
" 2	5.96	10.253					0.01	
" 3	5.98					0.159	0.38	
" 4	5.98						0.02	
" 5	5.98	10.173	0.080				0.19	
" 7	5.94							Syphon working over Syphon tank main
" 8	5.73							
" 10	5.67			0.263			0.85	
" 12	4.58						0.18	
" 13	4.33						0.75	
" 14	4.33						0.61	
" 15	4.21						0.10	
" 18	4.21	17.534					0.25	
" 21	4.22					7.361	0.15	
" 31	4.42	16.621	0.913				0.08	
			0.993	0.263	0.730	7.520	3.57	
November 1	4.44							
" 4	4.50	16.274	0.347				0.02	
" 5	4.44							
" 6	3.83						1.08	
" 9	3.50	20.706					2.35	
" 15	3.59					4.432	0.84	
" 16	3.60	20.253	0.453				0.08	
" 17	3.50	20.706		0.231		0.453	0.03	
" 23	3.59	20.299	0.407				0.25	
" 24	3.08						0.48	
" 25	2.87						1.88	
" 26	2.75						0.51	
" 27	2.71						0.25	
" 28	2.42						0.04	
" 29	2.33						0.70	
" 30	2.23	26.666					0.34	
			1.207	0.231	0.976	6.367		
December 1	2.21	26.762				11.252	8.85	
" 31	2.62	24.810	1.952	0.251		0.096		
			1.952	0.251	1.701	0.096	0.00	

Date	Gauge Reading	Contents Millions Cubic Feet	Volume expended Total Mg. Sq. Ft.	Volume expended used for Supply Mg. Sq. Ft.	Volume expended Leak Mg. Sq. Ft.	Volume received Millions Cubic Ft.	Rainfall Inches	Remark.
January	2·64	24·715	3·144	0·206	2·938	0·237	0·51	* 31 December 1881
February			3.350	0.250	3.100	0.000	0.00	
March			3.968	0.268	3.700	0.000	0.00	
April			3.721	0.276	3.445	0.000	0.42	
May			2.205	0.268	1.937	1.689	4.04	
June			2.411	0.292	2.119	1.292	1.82	Sluice 2 upper tank opened
July			1.091	0.241	0.860	1.091	4.15	
August			0.856	0.248	0.608	2.332	5.02	
September			1.791	0.255	1.536	1.275	2.75	
October			0.993	0.263	0.730	7.620	3.57	Syphon working over upper Tank Weir.
November			1.207	0.231	0.976	11.252	8.85	
December	2·62	24·810	1·952	0·251	1·701	0·096	0·00	
	Diff. +	0·095	26·689	3·049	23·640	26·784	31·13	

Appendix No. 13

Halsur Tank

Particulars of Water Supply 1882

£15
30/5/84.

Halsur Tank 187 Appendix No. 40

Statement Showing particulars of water Supply for the year 1883.

Date	Gauge Reading	Contents Million Cubic Feet	Volume expended Total Million Cubic Feet	Volume expended used for Troops Million Cubic Feet	Volume expended Lost Million Cubic Feet	Volume received Million Cubic Feet	Rainfall Inches	Remarks.
December 31: 82	2·62	24.810						1473
January 1	2·65			0.264				
" 31	3·27	21.762	3.048					
			3048	0·264	2.784	0.000	0.00	
February 1	3.29			0.244				
" 28	3.96	18.637	3.125					
			3.125	0.244	2·881	0.000	0·00	
March 1	3·99							
" 2	4·02			0.289			0.07	
" 31	4·83	14.869	3.768					
			3.768	0.289	3.479	0.000	0·07	
April 1	4·87							
" 24	5.60						0·16	
" 27	5.67			0.341			0·23	
" 29	5.69	11.329	3.540					
" 30	5·67	11.409				0.080	0·37	Duration 4 hr 6 m 29 s
			3.540	0.341	3.199	0.080	0·76	
May 1	5·70							
" 2	5.73						0·17	
" 13	6.03						0·19	
" 15	6.07						0.18	
" 18	6·17	9·441	1.968					
" 19	6·12	9·633		0.323		0·192	0·61	
" 24	6.25							
" 25	6.25						0.35	
" 28	6.31						0·17	
" 29	6·31						0·20	
" 30	6·33						0·005	
" 31	6·36	8·807	0.826					
			2·794	0·323	2·471	0·192	1·675	
June 1	6·39							
" 14	6·76						0·13	
" 21	6·95						0·12	
" 22	6·96			0·303			0·26	
" 25	7·02						0·02	
" 28	7·06						0·09	
" 30	7·09	6·280	2·527					
			2·527	0·303	2·224	0·000	0·62	

100

Date	Gauge Readings	Contents Millions of Cubic Feet	Volume expended Total Mg. Cft.	Volume expended used for Troops Mg. Cft.	Volume expended Lost Mg. Cft.	Volume received Mg. Cft.	Rainfall Inches	
July 1	7.11							
" 2	7.13						0.04	
" 5	7.21	5.913	0.367					
" 6	7.02	6.494				0.581	0.82	
" 7	7.03						0.08	
" 8	7.04						0.14	
" 9	7.04						0.10	
" 10	7.05						0.01	
" 12	7.07						0.02	
" 13	7.08						0.07	
" 14	7.10						0.23	
" 17	7.16	6.066	0.428	0.296			0.24	
" 18	7.12						0.38	
" 19	7.12						0.65	
" 20	7.04	6.433				0.367		
" 21	7.05	6.403	0.030					
" 22	6.84						0.93	Duration 3h 8l.h. 21 ch.
" 23	6.73	7.435				1.032	0.63	do 3.15 & 3.45 h. 22 ch.
" 24	6.74	7.401	0.034					
" 25	6.72	7.469				0.068	0.22	
" 26	6.73						0.10	
" 27	6.73						0.16	
" 28	6.74						0.05	
" 31	6.80	7.204	0.265					
			1.124	0.296	0.828	2.048	4.87	
August 1	6.82							
" 4	6.90						0.39	
" 6	6.94						0.03	
" 7	6.95						0.08	
" 8	6.97						0.04	
" 9	6.99	6.587	0.617					
" 10	6.55						1.62	Duration from 7h. 9m. 8s
" 12	6.48	8.298				1.711	0.22	5h. 10 m.
" 13	6.37						0.20	
" 14	6.33			0.285			0.11	
" 15	6.29						0.01	
" 16	6.25						0.46	
" 17	6.25						0.33	
" 18	6.21						0.16	
" 19	6.17						0.46	
" 20	6.17						0.01	
" 21	6.15	9.518				1.220	0.29	
" 22	6.17						0.04	
" 24	6.19						0.02	
" 26	6.21						0.09	
" 27	6.22						0.03	

Date	Gauge Readings	Contents Million Cubic Feet	Volumes expended			Volume received	Rainfall Inches
			Total Mc.ft.	used for Trotter Mc.ft.	Lodi Mc.ft.	Mc.ft.	
August 29	6·24						0·05
" 31	6·26	9·198	0·420				
			1·037	0·285	0·752	2·931	4·64
September							
" 1	6·27						
" 5	6·34	8·807	0·291				
" 6	6·13						0·54
" 7	6·05	9·902				1·095	
" 10	6·09			0·258			0·02
" 12	6·13						0·02
" 13	6·16						0·13
" 25	6·46						0·13
" 30	6·58	7·960	1·952				
			2·243	0·258	1·985	1·095	0·74
October 1	6·60	7·881	0·069				
" 2	6·56						0·76
" 3	6·56						0·30
" 4	6·31						0·85
" 5	6·12						0·90
" 6	5·92						0·90
" 8	5·83	10·769					
" 9	5·85	10·690	0·079			2·888	
" 10	5·29	12·952		0·280			0·10
" 11	4·54	16·103				2·262	1·70
" 12	4·33					3·151	1·90
" 13	4·23						0·04
" 14	4·12						0·16
" 15	4·04	18·282					0·13
" 16	3·42					2·179	0·07
" 17	3·37	21·303					2·22
" 29	3·60	20·253	1·050			3·021	0·03
" 30	3·58						
" 31	3·25	21·854					0·27
			1·198	0·280	0·918	1·601	1·65
November 1	3·25					15·102	11·88
" 2	3·17						0·05
" 4	3·16	22·273					0·85
" 5	3·16			0·281		0·419	0·19
" 7	3·18						0·07
" 18	3·35						0·03
" 19	3·35						0·05
" 30	3·53	20·570	1·703				0·19
			1·703	0·281	1·422	0·419	1·43

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Date	Gauge Readings	Contents Million Cubic Feet	Volume expended Total Mm³/sec⁻¹	used for Trips Mm³/332	Lost Mm³/sec⁻¹	Volume receiving Million Cubic Feet	Pumped Inches	Remarks.
December 1	3.55							
" 4	3.59	20.298	0.872					1473
" 8	2.91	23.441				3.143		From upper Tank
" 12	2.98	23.112	0.329				0.28	
" 13	2.90			0.273			0.30	
" 14	2.60						1.04	
" 15	2.52						0.21	
" 16	2.52	25.283				2.171	0.04	
" 31	2.76	24.147	1.136					
			1.737	0.273	1.464	5.314	1.87	
			Summary					
January	2.62	24.810	3.048	0.264	2.784	0.000	0.00	
February			3.125	0.244	2.881	0.000	0.00	
March			3.768	0.289	3.479	0.000	0.07	
April			3.540	0.341	3.199	0.080	0.76	
May			2.794	0.323	2.471	0.192	1.875	
June			2.527	0.303	2.224	0.000	0.62	
July			1.124	0.296	0.828	2.048	4.87	
August			1.037	0.285	0.752	2.931	4.64	
September			2.243	0.258	1.985	1.095	0.74	
October			1.198	0.280	0.918	15.102	11.88	
November			1.703	0.281	1.422	0.419	1.43	
December	2.76	24.147	1.737	0.273	1.464	5.314	1.87	
	Diffs	0.663	27.844	3.437	24.407	27.181	28.75	

Appendix No. 1470

Halsar Tank

Particulars of W. Supply 1883

Halsar Tank. 293 Appendix No 15.

Summary of particulars of water Supply from 1880 to 1883 inclusive

Years.	Gauge Reading	Contents Million Cubic ft	Volume expended Total Inches & %	Used for Irrigation Inches & %	Lost Inches & %	Volume received Million Cubic ft	Rainfall Inches	Area of Catchment Basin opp. tank	Proportion of Rainfall received	Percentage of Rainfall received
1880	0·52	35.028	165.123	3.379	161.744	165.372	43.98	4·64	0·349	34·90
	0·47	35·272								
1881	0·49	35.172	29.852	3·300	26.552	19.396	23·28	do	0·077	7·70
	2·64	24·715								
1882	2·64	24·715	26.689	3.049	23.640	26.784	31·13	do	0·080	8·00
	2·62	24·810								
1883	2·62	24·810	27·844	3·437	24·407	27.181	28·75	do	0·087	8·70
	2·76	24·147				238·732	127·14		0·174	17·40
							Rainfall Bowring Civil Hospital Inches			
1880							51·69		0·297	29·70
1881							27·44		0·065	6·50
1882							37·02		0·067	6·70
1883							34·80		0·072	7·20
						238·732	150·95		0·146	14·60
	Years 1881, 1882 & 1883. Halsar Rock Rain Register					73·360	83·16		0·0851	8·51
	do — do - Bowring Civil Hospital Rain Register					do	99·26		0·0713	7·13.

NB
A. Sq. In = 3097600 Sq. yds = 27·8784 Ms ft sq. Feet 4·645 Sq. M = 129·356 Ms ft sq. Feet.

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Appendix No. 16 — 194 — 45

Approximate Abstract estimate for diverting drainage of Western Feeder from Halsur Tank.

Quantity	Description	Unit	Rate			Amount	Work Totals.	
	Bund from Culvert at mouth of Western Feeder & main bund of Halsur Tank 1095.465							1473
	dd. puddle wall 121.770							
	" pavement 120.540							
789.195	" gravel backing 43.960 306.270	1000 C.F.	3	7	6	2738		
121.770	Puddle wall	do	4	11	-	671		
120.540	Revetment (formed of sized stones)	100 C.F.	9	8	-	11.461		
639.60	Gravel backing	do	2	-	-	1279	16039	
	New waste weir - erect 90 feet							
24.42	Concrete	100 C.F.	12	8	-	305		
100.50	Rubble masonry	do	14	1	-	1417		
24.44	Rough stone apron . . .	do	9	8	-	232		
	Excavation and filling					39	1993	
	Lowering old waste weir 4 feet						300	
	Diverting North West drain into Western Feeder.							
42.126	Earthwork forming channel & culvert under cart road	100 C.F.	2	14	3	122		
						300	422	
							18,754	
	Contingencies						96	
							18.850	

NB. The rates were obtained from the office of the Executive Engineer Presidency Division.

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Specification attached.

ESTIMATE FORM — Abstract.

Quantity.	Description of Work.	Rate.	Per	Amount.	Total.
		Rs.		Rs.	Rs. 1473
	Detailed Data for 100 C/ft of Concrete of the following proportions				
50	Broken Stones 3/4" to 1" Cube	6-4	100 C/ft	3-0-2	
8 1/2	Screened and washed gravel	3-0-0	"	0-4-0	
16 2/3	Slaked Lime	0-4-3	C/ft	1-6-10	
16 2/3	Sand ditto	0-1-9	"	1-13-2	
25	Sand	1-13-9	100 C/ft	0-7-5	
4	Men Coolies	0-3-0	Each	0-12-0	
12	Women Do	0-1-8	"	1-4-0	
	Contingencies			0-8-5	
	Total for 100 C/ft			Rs 12-8-0	
	— Do — one			0-2-0	

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Grand Total of Estimate . .

Station

Dated

Executive Engineer.

NOTES.

REFERENCE TO MADRAS P. W. D. CODE.

PARAS. 1074, 1075, 1086, 1087, 1091 TO 1094, 1108, 1111 TO 1114, 1139 AND 1145 TO 1147.

(1.)—ABSTRACTS of Estimates should be prepared under such sub-heads as are to be separately shown in the Accounts (Register of Works, work-vouchers, &c.) of the work. For repairs of buildings and roads, the classification of the Budget Estimate should be strictly followed, one estimate only being framed for each Budget entry, and if a further estimate is required, it should be supplemental to the first; by this means, as the Work Abstracts follow the estimates, the Register of Works, the Schedule of Expenditure, and the Books of the Central Office will show by one entry the entire outlay on repairs to each work for the whole year, which is not the case when several estimates are sanctioned for the repairs of one work in the course of the year.

(2.)—Quantities are to be entered as so many units.

(3.)—All rates are to be quoted in Rupees, Annas and Pies.

(4.)—Annas and Pies are to be excluded from the Abstract Estimates, the cost of each item being brought to the nearest Rupee. Totals of estimate need not be brought to round numbers.

P. W. D. Form No. M 267.

CIRCLE—

DIVISION—

ESTIMATE FORM.—Abstract.

(To accompany the Detailed Estimate No. of 188 -8 for)

* Here enter the name and description of work in full.

Plan No 11

Specification for the diversion of the Western Feeder of the Halsur Lower Tank.

1 a bund 2460 feet in length, as shown on the Survey, from which the Table of water spread and capacity was prepared, Ble run from near the left wing of the 5 vent Culvert at the lower end of the Feeder, in a curve & near the point marked M, and thence nearly parallel Bthe road, at a minimum distance of 90 feet between the near top edge of the bund and the top edge of the road, up B 60 from the site of the new weir where the bund wing will curve Bthe Eastward & connect with the main bund.

2. The ground Ble cleared of all vegetation; and a trench 6 feet wide and 3 feet deep Ble excavated and filled with puddle formed of well tempered clayey soil taken from the bed of the tank, before the formation of the bund is commenced.

3. The top width of the bund Ble 8 feet: the interior slope 1½ B 1 and the exterior slope 2 B 1. The top of the bund will lie 3½ feet above Full Tank Level.

4. A puddle wall Ble carried up simultaneously with the bund, and B terminate at 1½ feet below the top of the latter with a width of 2 feet. The faces Bhave a batter of 1 in 6.

5. The interior slope Ble pitched B and ½ a foot above Full Tank Level, with stones 1½ feet long laid at right angles Bthe slope on 1 foot of gravel backing

This height of revetment has been deemed sufficient because at the time of the year (march) when the Easterly winds are strong, the Water Level will lie from 3 to 3½ feet below the top of the revetment. The rear slope blie similarly revetted to the level 2927.97. The revetments blie carried up simultaneously with the Earthwork.

6. All earthwork blie well watered and rammed.

7. The general arrangement of the channel between the bund and the road is shown on the Section.

8. The present waste weir of the tank blie lowered 4 feet or to 2925.97. This is supposed blie as low a level as can be secured without reconstructing the bridge, but it would be advantageous to lower it still further if found blie feasible.

9. A new waste weir with a crest 90 feet long, and one foot above the present Full Tank Level, ie at 2930.97 instead of 2929.97, blie constructed a few feet from the present main bund on the line of the new bund, as shown on the Survey.

It is calculated that the new weir will with a depth of 1½ feet passing over discharge

Plan No 12

297 479

$D = 90 \times 3.56 d\sqrt{d}$

$D = 76\frac{1}{2} \times 3 d\sqrt{d}$

654 Cubic feet a second, whereas the present weir with a nominal length of 90 feet but actual only 76½ feet, and with a wide irregular crest does not discharge more than 422 Cubic feet. Consequently maximum water level will not lie more than 18 inches above the new crest level, and it probably will very rarely exceed 1 foot.

1423

10. The drainage channel which now enters the Tank at its North West Corner blie diverted along the West of the road forming the Western boundary of the tank, and blie dropped into the channel now called the Western feeder.

The diversion Channel blie 4½ feet wide at bottom, with side slopes of ½ to 1.

Its length will be 2,340 feet.

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Appendix № 17 198 50

Approximate estimate for constructing a channel 5 miles in length to... into the Halsur Lower Lank the drainage of 2·174 sq.r miles to the East

Length	Area of Cross section	Thousands of Cubic feet.
5280	48	253,440
5280	$\frac{48+28}{2}$	200,640
5280	$\frac{28+21}{2}$	129,360
5280	$\frac{21+13}{2}$	89,760
5280	$\frac{13+10}{2}$	60.720
		733.920

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Quantities	Description	Unit	Rate	Amount	Totals of works
733.920	Cutting channel & forming left Bank. - - - -	1000 C.F.	2 4 3	2121	
	Rock cutting	do		500	2621
300	Waste weirs	Sq Foot	5 - -	1500	1500
	Tail weir			330	330
	Culvert for cross road Knoxpett			200	
	do for main road Binnamangalam			300	
	4 other culverts for village tracks		120 - -	480	980
					5431
	Contingencies - - - -				29
					5,460.
20	Compensation for land	Acres	50 - -	-	1,000
					6460
	Compensation for diversion of water				?

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Appendix No. 17 A.

Approximate estimate for constructing a channel 9½ miles in length bring into the Halsur Lower Lank the drainage of 3.10 sq: miles to the Eastward

Length	Area of Cross Section	Thousands Cubic Feet.
5280	48	253.440
5280	$\frac{48+40}{2}$	232.320
5280	$\frac{40+36}{2}$	200.640
5280	$\frac{36+30}{2}$	174.240
5280	$\frac{30+26}{2}$	147.840
5280	$\frac{26+22}{2}$	126.720
5280	$\frac{22+18}{2}$	105.600
5280	$\frac{18+14}{2}$	84.480
5280	$\frac{14+10}{2}$	63.360
2640	$\frac{10+8}{2}$	23.760
		1412.400

Quantities	Description	Unit	Rate	Amount	Total of Works
1412.400	Cutting channel & forming left bank	1000 c.ft	2 14 3	3083	
	Rock cutting 6 & 7 mile			800	
	do elsewhere			700	4,583
500	Waste weirs	R² foot	5 - -	2500	2,500
	Tail weir			330	330
	Culvert for cross road, Knoxpett			225	
	do for main road, Bunamangalam			335	
	do - do near 5 mile stone			220	
	9 other culverts for village tracks		125 - -	1125	1905
					9.318
					52
	Contingencies				9370
			50 - -		1750
35	Compensation for land				11,120
	Compensation for diversion of water.				?

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H. 1

Appendix No. 17.A.

Appendix № 17 B. 202 852

Dimensions &c of Channels for additional Catchment to Eastward of Halcur Lower Tank. 1473

(1) Channel for catchment of 3·10 square miles.

Miles from Lower end	Side Slopes	Depth of water Feet	Bottom width Feet	Area of water-way Sqr. Feet	$\sqrt{r}$	$c\sqrt{s}$	Feet per Second	Discharge cubic feet per second	Area of catchment approximately Sqr. M.	Discharge in inches draining off per day.
1	½ to 1	3	12	40·50	1·47	1·236	1·817	83·59	3·10	one
2	do	3	12	40·50	1·47	1·236	1·817	83·59	3·10	do
3	do	2½	11	30·62	1·36	1·176	1·60	49·00	1·80	do
4	do	2½	8	23·12	1·30	1·139	1·48	34·22	1·44	do
5	do	2¼	8	20·53	1·25	1·106	1·38	28·33	1·00	do
6	do	2	8	18·00	1·20	1·074	1·29	23·22	0·84	do
7	do	2	6	14·00	1·16	1049	1·22	17·08	0·67	do
8	do	2	4½	11·00	1·10	1·005	1·11	12·21	0·45	do
9	do	1¾	4	8·53	1·04	0·960	1·00	8·53	0·30	do
9½	do	1½	3	5·62	0·94	0·887	0·83	4·66	0·15	do

(2) Channel for catchment of 2·174 square miles.

1	½ to 1	2½	12	33·12	1·37	1·180	1·62	53·66	2·17	One
2	do	2½	12	33·12	1·37	1·180	1·62	53·66	2·17	do
3	do	2	8	18·00	1·20	1·074	1·29	23·22	0·85	do
4	do	2	5	12·00	1·13	1·026	1·16	13·92	0·50	do
5	do	1½	4	7·12	0·98	0·916	0·897	6·39	0·23	do

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Appendix No 17 C.

Specification for catchment channels to bring in drainage, from the Eastward, to the Halcurhouse Sank.

The channels, which ever may be adopted, are intended to convey a quantity of water equal to 1 inch draining off the catchment in 24 hours; this is about the equivalent of a rainfall of 3 inches. Any supply in excess will be discharged to waste by means of surplus weirs.

2. The surface fall throughout will be 2 feet a mile. The changes in depth, where such occur, will be secured by raising the bed or in other words increasing the bed fall. Thus in the 3rd mile the bed fall will be 2½ feet, instead of 2 feet as in the 1st and 2nd miles.

3. The height of the banks above normal full supply level to be equal to the depth of water, as a minimum.

4. The depth of water passing over the surplus weirs to be one third of the depth of water (normal) in the channel, as a maximum; the crests of the weirs being of course at normal full supply level.

5. Except in the part of the first mile where

the channel will run alongside a road, the alignment can be made so as to give approximately just about the quantity of cutting to make up the banks to the required section. Only one, the left bank will be required and its top width may conveniently be made double the normal depth of water.

6. The estimated quantities of cutting and bank forming are necessarily approximations as until the channel is marked out and cross sections of the ground taken, the exact quantities cannot be determined. Generally the depth of cutting allowed is about five feet in excess of the depth of water.

7. Lump sums have been entered for rock cutting. There will be but little in the 5 miles channel, and only in the ~~latter half of the~~ 6th mile and ~~such half~~ as much of the latter as much of the 7th mile is much likely to be met with in constructing the 9½ miles channel, should that be selected for execution.

Appendix 17 B
do 17 C

No 21
3035 54

Comparative Statement of Rainfall and Evaporation for Helena Station

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Year.		January	February	March	April	May	June	July	August	September	October	November	December
1880 Helena Station	Rain	0 62	2 62	2 125	9	11	16	8	1 50	0 40	2 69	10 21	1 62
1880 Bunting Station	Rain	0 670	2 480	2 940	11	3	8	9	1 60	0 610	2 840	10 960	4 780
1881 Helena R.	Rain	0 25	5 24	7 62	8	11	16	9	2	0 46	3	1 47	3
1881 B. C. & L.	Rain	0 390	3 790	8 080	5	3	3	3	0	0 360	4	4 320	4
1882 Helena R.	Rain	0 57	2 76	5 02	5	2	1	0	0	0	0	3 54	3
1882 B. C. & L.	Rain	0 680	4 050	5 720	4	1	1	0	0	0	0	4 470	4
1883 Helena R.	Rain	.	0 94	4 64	4	1	1	0	0	0	0	9 670	9
1883 B. C. & L.	Rain	.	1 050	4 660	4	1	1	0	0	0	0	1 43	1
												11 76	1
												12 580	2
													2
													2

Appendix No. 18

Comparative Statement of rainfall as gauged at the Halsuer Rock & Bowring Civil Hospital for the years 1880 & 1883

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3035 1/2

Appendix No 19. 55

Comparison by months of Rainfall as registered at the Halsuer Rock and Bowring Civil Hospital. 203

Months	Years	Rainfall H.R. Inches	Rainfall B.C.H Inches	Difference Inches	Per centage	Remarks.
January	1880	0.62	0.67	+0.05	+8.06	
do	1881	0.25	0.39	+0.14	+56.00	
do	1882	0.51	0.68	+0.17	+33.33	
do	1883	–	–	–	–	
		1.38	1.74	+0.36	+26.09	
March	1880	0.44	0.41	-0.03	-6.82	
do	1881	0.46	0.36	-0.10	-21.74	
do	1882	–	–	–	–	
do	1883	0.07	0.05	-0.02	-28.57	
		0.97	0.82	-0.15	-15.46	
April	1880	1.50	2.16	+0.66	+44.00	
do	1881	0.45	0.63	+0.18	+40.00	
do	1882	0.42	0.53	+0.11	+26.19	
do	1883	0.76	0.72	-0.04	-5.26	
		3.13	4.04	+0.91	+29.07	
May.	1880	8.16	9.35	+1.19	+14.58	
do	1881	1.75	3.20	+1.45	+82.85	
do	1882	4.04	4.41	+0.37	+9.15	
do	1883	1.87	1.81	-0.06	-3.46	
		15.82	18.77	+2.95	+18.65	
June	1880	3.11	3.90	+0.79	+25.56	
do	1881	2.14	2.10	-0.04	-1.87	
do	1882	1.82	1.69	-0.13	-7.14	
do	1883	0.62	0.80	+0.18	+29.03	
		7.69	8.49	+080	+10.40	
July	1880	6.49	6.68	+1.19	+21.67	
do	1881	0.10	0.22	+0.12	+120.00	
do	1882	4.15	5.60	+1.45	+34.94	
do	1883	4.87	5.28	+0.41	+8.42	
		14.61	17.78	+3.17	+21.69	
August	1880	9.12	11.74	+2.62	+27.56	
do	1881	7.62	8.08	+0.46	+6.04	
do	1882	5.02	5.72	+0.70	+13.94	
do	1883	4.64	7.66	+3.02	+65.09	
		26.40	33.20	+6.80	+25.76	
September	1880	2.62	2.78	+0.16	+6.10	
do	1881	5.27	3.79	-1.48	-28.08	
do	1882	2.75	4.05	+1.30	+47.27	
do	1883	0.74	1.05	+0.31	+41.89	
		11.38	11.67	+0.29	+2.55	

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Appendix No. 19.

Comparative Statement of Rainfall as registered at the Halsur Rock and Bowring Civil Hospital for the years 1880 to 1883

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Appendix No. 19. 55

Comparison by months of Rainfall as registered at the Halsur Rock and Bowring Civil Hospital.

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Months	Years	Rainfall H.R. Inches	Rainfall B.C.H Inches	Difference Inches	Per Centage.	Remarks.
January	1880	0.62	0.67	+0.05	+8.06	
do	1881	0.25	0.39	+0.14	+56.00	
do	1882	0.51	0.68	+0.17	+33.33	
do	1883	–	–	–	–	
		1.38	1.74	+0.36	+26.09	
March	1880	0.44	0.41	-0.03	-6.82	
do	1881	0.46	0.36	-0.10	-21.74	
do	1882	–	–	–	–	
do	1883	0.07	0.05	-0.02	-28.57	
		0.97	0.82	-0.15	-15.46	
April	1880	1.50	2.16	+0.66	+44.00	
do	1881	0.45	0.63	+0.18	+40.00	
do	1882	0.42	0.53	+0.11	+26.19	
do	1883	0.76	0.72	-0.04	-5.26	
		3.13	4.04	+0.91	+29.07	
May.	1880	8.16	9.35	+1.19	+14.58	
do	1881	1.75	3.20	+1.45	+82.85	
do	1882	4.04	4.41	+0.37	+9.15	
do	1883	1.87	1.81	-0.06	-3.46	
		15.82	18.77	+2.95	+18.65	
June	1880	3.11	3.90	+0.79	+25.56	
do	1881	2.14	2.10	-0.04	-1.87	
do	1882	1.82	1.69	-0.13	-7.14	
do	1883	0.62	0.80	+0.18	+29.03	
		7.69	8.49	+080	+10.40	
July	1880	5.49	6.68	+1.19	+21.67	
do	1881	0.10	0.22	+0.12	+120.00	
do	1882	4.15	5.60	+1.45	+34.94	
do	1883	4.87	5.28	+0.41	+8.42	
		14.61	17.78	+3.17	+21.69	
August	1880	9.12	11.74	+2.62	+27.56	
do	1881	7.62	8.08	+0.46	+6.04	
do	1882	5.02	5.72	+0.70	+13.94	
do	1883	4.64	7.66	+3.02	+65.09	
		26.40	33.20	+6.80	+25.76	
September	1880	2.62	2.78	+0.16	+6.10	
do	1881	5.27	3.79	-1.48	-28.08	
do	1882	2.75	4.05	+1.30	+47.27	
do	1883	0.74	1.05	+0.31	+41.89	
		11.38	11.67	+0.29	+2.55	

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Months	Years	Rainfall H.R. Inches	Rainfall B.C.H. Inches	Difference Inches	per Centage
October	1880	10.21	10.95	+0.74	+7.24
	1881	1.47	4.43	+2.96	+201.36
	1882	3.57	4.47	+0.90	+25.35
	1883	11.88	12.56	+0.68	+5.72
		27.13	32.41	+5.28	+19.46.
November	1880	2.69	2.84	+0.15	+5.57
do	1881	3.68	4.21	+0.53	+14.40
do	1882	8.85	9.87	+1.02	+11.53
do	1883	1.43	2.86	+1.43	+100.00
		16.65	19.78	3.13	+18.80
December	1880	0.02	0.21	+0.19	+950.00
do	1881	0.09	0.03	−0.06	− 66.66
do	1882	—	—	—	—
do	1883	1.87	2.61	+0.74	+39.57
		1.98	2.85	+0.87	+43.94
		Summary.			
	1880	43.98	51.69	+7.71	+17.53
	1881	23.28	27.44	+4.16	+17.87
	1882	31.13	37.02	+5.89	+18.98
	1883	28.76	34.80	+6.05	+21.04
		127.14	150.95	+23.19	+18.24

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Ulsur Rock Rain Register, Monthly Fall and Number of Rainy Days.

Year.	January		February		March		April		May		June		July		August		September		October		November		December		Annual.	
	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.	Inches.	Days.
1873	..	..	0·45	3	..	..	2·08½	8	0·20	2	1·36½	5	0·66	3	4·12½	11	2·78½	7	9·42	15	0·10	1	..	..	21·09	56
1874	..	..	..	..	..	..	0·60	1	12·60	11	1·22½	7	3·76	9	8·82½	14	12·23	20	5·67½	15	0·90	5	..	..	45·60½	82
1875	..	..	1·36	3	0·55	3	3·01	7	3·25	11	1·86½	7	4·16	13	1·77	7	1·59	6	0·82	3	0·05	2	18·42½	62		
1876	..	..	..	..	0·50	3	0·80	2	4·93½	9	2·03½	5	1·71	11	3·22½	15	1·81½	6	1·70	3	0·45½	3	..	..	17·17½	67
1877	..	..	..	..	0·61½	4	1·70	1	2·63	8	2·60	8	0·97	7	2·49½	12	10·47½	19	6·82	18	2·20	7	0·20	1	30·70½	86
1878	..	..	..	..	..	..	1·14	2	2·56	8	2·13½	6	4·82	10	12·32	16	6·02	15	4·58	11	0·61	3	..	..	34·08½	71
1879	0·21	1	1·53	3	2·77	3	0·15	1	4·90	9	2·41	5	5·95	16	2·76	13	8·79	9	8·35	12	0·66	4	..	..	33·48	76
1880	0·62	1	..	..	0·44	2	1·50	4	8·16	17	3·11	11	5·49	18	9·12½	14	2·62	7	10·21	15	2·69	11	0·02	1	43·98½	101
1881	0·25	2	..	..	0·46	2	0·45	1	1·75	4	2·14	8	0·10	1	7·62	18	5·97	15	1·47	4	3·68	10	0·09	2	28·28	67
1882	0·51	2	..	..	..	..	0·42	1	4·04	10	1·82	12	4·15	23	5·02	17	2·75	13	3·57	12	8·85	14	..	..	31·13	104
1883	..	..	..	..	..	..	0·76	3	1·87½	8	0·62	6	4·87	18	4·64	20	0·74	5	11·78	16	1·43	7	1·87	..	28·65½	88

Isaac's 11 | 15 | 18 | 15 | 0·58 | 16 | 0·91 | 25 | 4·23 | 8 | 2·06 | 7·5 | 2·11 | 14 | 5·83 | 16 | 4·57 | 11 | 5·72 | 11 | 2·3 | 6 | 4·00 | 1 | 29·73 | 77

Isaacs

Register of the Rainfall gauges daily at 7 A.M. at the Ulsur Rock for the Month of [illegible] 188[illegible]

Month and Date | Inches | Cents

Rainfall to the end of [illegible] for the following years:—

Years	Inches	Cents
1873	[illegible]	
1874	[illegible]	
1875	[illegible]	
1876	[illegible]	
1877	[illegible]	
1878	[illegible]	
1879	[illegible]	
1880	[illegible]	
1881	[illegible]	
1882	[illegible]	
1883	[illegible]	

Total [illegible]

Bangalore, [illegible] 188[illegible]

[illegible]
Engineer in Charge,
Ulsur Water Works

* Waste weir

Level of Water below the Koday on the undermentioned dates:—

Year.	31st January.	28th February.	31st March.	30th April.	31st May.	30th June.	31st July.	31st August.	30th September.	31st October.	30th November.	31st December.	Remarks.
	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	
1873	0 11	1 5	2 2½	2 4	3 2¼	3 5½	3 11	2 9	2 5	*	0 5½	1 2	
1874	1 8¼	2 3½	3 1¼	3 9½	*	0 1½	*	*	*	*	*	0 6½	
1875	1 1½	1 7½	2 0	2 7	2 7¾	2 9⅛	2 11½	2 11½	3 2¼	3 4½	3 10½	4 5	
1876	4 11½	5 7	6 2¼	6 10¼	5 8	6 0	6 4⅞	6 6½	6 8¼	6 9½	7 4	8 0	
1877	8 10½	†	†	9 7⅜	9 6¼	9 3⅜	10 1	9 8½	3 5½	1 1½	0 7¼	1 1	
1878	1 9	2 6⅜	3 5	3 0	3 0	3 3	2 4	*	*	0 ¼	0 6½	1 1½	
1879	1 2¼	1 ½	0 8¾	1 7½	1 5	1 5⅜	0 5	0 7½	0 5	*	0 3½	0 6	
1880	1 1½	2 ¼	2 0	2 5	1 3	1 2¾	0 10⅛	*	0 2¼	*	*	0 5⅜	
1881	1 ¾	1 5½	1 6½	2 4⅜	2 8½	2 10	3 0	2 7	2 3½	2 6	2 6	2 7⅜	
1882	3 3½	4 0	4 11	5 10	5 11½	6 3	6 3	5 10½	6 0	4 5	2 2¾	2 7½	
1883	3 3¼	3 11½	4 10	5 8	6 4⅜	7 1⅛	6 9½	6- 3⅜	6-7	3-3	3-6⅜	2-9 1/16	
1884													
1885													

Bangalore, 2 January 188[illegible]

* Overflowing. † Dried up.

(True Extract.)

[illegible]
Engineer in charge Ulsur W. works

True Copy [illegible]
[illegible]

Appendix No. 20

STATISTICS

OF THE

ULSUR WATER WORKS

Appendix No. 21

Statement Showing the quantity of water pumped into Barracks from 1st January 1880 & 31st December 1883.

Months	1880		1881		1882		1883.	
	Gallons	Cubic Feet	Gallons	Cubic Feet	Gallons	Cubic Feet	Gallons	Cubic Feet
January	1546155	247385	2050768	328123	1287610	206018	1651025	264164
February	1768848	283016	1909111	305454	1560997	249760	1525611	244097
March	2072318	331571	1933897	309424	1672599	267616	1806906	289105
April	2103776	336604	1573369	251739	1728029	276485	2129982	340797
May	1746597	279456	1824984	291997	1677910	268466	2019481	323113
June	1585168	253627	1687072	269932	1825481	292077	1896280	303405
July	1677338	271698	1727428	276388	1503986	240638	1849755	295961
August	1889608	302337	1651321	264211	1548497	247756	1779623	284740
September	1709843	273575	1885543	301687	1591941	254711	1613033	258085
October	1531657	245065	1575696	252111	1641803	262688	1751046	280167
November	1756350	281016	1388406	222145	1442475	230796	1780573	284892
December	1704696	272751	1426100	228176	1567219	250755	1704318	272691
Total	21114354	3378301	20633695	3301391	19048547	3047766	21507633	3441217

Summary

Years	Millions of Cubic Ft.
1880	3.378
1881	3.301
1882	3.048
1883	3.441
	13.168
Average	3.292

Greatest monthly quantity
April 1883 0.341

Greatest hourly quantity gallons 2,960
Average do — do " 2,349

Prepared from a Statement in Gallons obtained from the Engineer in charge of the Halsur Water Works

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Appendix No. 21

[illegible] steam water pumps
into Brick[illegible] in the W[illegible]
1870 to 1883 inclusive

[illegible]

Appendix No. 22.

Register of Pumping operations at No 2 well on right bank of water course 760 yards South of South Station Hospital.

Date	Pumping						Times and water levels			Revolutions of Fly wheel			
	Time of starting		Time of stopping		water levels		Times		water levels	number per minute	Time at which taken		
1884.	H	M.	H	M	Ft	In	H	M	Feet		H	M.	
17 March	14	50			5	5½	14	53	6·50	90	14	55	40 lbs Steam
							14	57	7·50		14	56	
							15	1	8·50	72	15	2	38 do
							15	4	9·50		15	3	
							15	7½	10·50	73	15	8	
							15	11	11·50		15	9	
			15	16½	13	0	15	14½	12·50				
	15	20	15	22	13	6	15	22	13·50				
18 do	11	7			11	4	11	9	12·00				40 do
							11	13	13·00				
							11	16	14·00				
							11	19	15·00	94	11	19	
							11	23	16·00		11	20	
							11	27	17·00		11	27	
			11	30	17	10	11	30	17·83	92	11	28	
							17	30	17·50				
19 do							6	25	15·75				
							16	30	15·08				
20 do							6	0	13·92				
							16	30	13·08				
21 do							6	0	12·17				
22 do							6	0	8·38				

Diameter of well at 10 ft from B.M. at top 8-50 — 11·50 area 59·74 103·87.
" " " 7·50 " " 14·00 — 10·50 do do 86·59
" " " 14·00 " " 8 26 00 — 9·25 do do 67·19

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Summary of Results

Engine 6 Horse power Nominal, Clayton & Shuttleworth, Lincoln. No 21199. Pump 4 inch Centrifugal, Tangye Brothers and Holman — Suction and delivery pipes both 4 inches. Height from B.M. to centre of delivery pipe 3.25 feet.

First pumping — First 7 minutes, 211.89 C. ft raised on the average 6.50 + 3.25 = 9.75 feet

afterwards 21½ do. 519.54 C ft raised 10.50 + 3.25 = 13.75

Second pumping. First 9 minutes 231.19 C. ft raised 13.66 + 3.25 = 16.91

afterwards 14 do 257.34 = do 15.92 + 3.25 = 19.17

$\frac{211.89}{7}$ = 30.27 × 9.75 × 62 = 18298 ft. lbs per minute = 0.55 Horse power nominal

$\frac{519.54}{21\frac{1}{2}}$ = 24.16 × 13.75 × 62 = 20896 — do — = 0.62 — do —

$\frac{231.19}{9}$ = 25.69 × 16.91 × 62 = 26341 — do — = 0.77 — do —

$\frac{257.34}{14} = \frac{18.38}{96.50} \times \frac{19.17}{14.10} \times 62 = \frac{21845}{80,000} = \frac{0.66}{260}$ — do — = 0.66 — do —

0.65

equivalent to 13.68 25.00

do gallons 86.77 do.

Mr. J. H. Gwynne put the duty of their centrifugal pumps of the same size at 250 gallons raised 25 feet with an expenditure of 2.6 × 0.95 horse power. The duty was in this case about one third of their standard, the chief cause being that the pump was too small for the engine a 7 inch pump would have been more suitable.

Inflow between the 2 days pumping at 0.17 feet × 86.67 = 187.90 C. Feet.

Time 19.75 hours = 57 per hour 9.87 "

Inflow after 2nd days' pumping at 3.83 × 67.17 = 257.34 "

= 1.83 × 86.67 = 158.46 "

Time 66.50 hours 415.80 "

Equivalent to 20.8 gallons per hour = 5.25 per horse power = 5.37

Appendix No 23.

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Specification and approximate estimate for the supply of the European Cavalry Regiment, 2 Batteries of Field artillery, and the South station Hospital, with water for drinking and cooking, from wells in the small valley to the South of the Hospital.

1. Wells. The wells to be 7 in number and 20 feet in diameter.

The sump well to be in the centre and to be placed at or close to the present well No 2, with its bottom at 2886.00.

vide Plan 12.

The remaining 6 wells to be arranged as a hexagon, at a distance of 500 feet from the sump well, centre to centre, and consequently 500 feet apart. Their bottoms to be at 2888.00. It is estimated that these wells will collect the water from 72 acres, or from a circle with a radius of 1000 feet.

The 6 wells to be connected with the sump well by 6 inch cast iron pipes laid with their ends at the external wells at 2890.00 and at the sump well at - - 2888.00

All the wells to be steined with stone in mortar from 1 foot above ground level to 5 feet below that level, and below this with dry stone. The space at the back of the masonry steining to be filled in with red

The steining from the level 2902.00, or 10 feet below the top to be stepped in 4 inches for each course (of 8 inches) so as to reduce the top diameter of the well

red soil, like that used for compound walls, well puddled and carefully trodden in, so as to prevent any surface drainage getting into the wells.

The platform of the pumpwell Blue at 2912·00, the beam stones for the pumps at 2909·33 and the sole of the Suction pipe at 2890·00, the lowest level to which the water is the drawn off being 2891·00 or 18·33 feet below the valve of the pumps.

2. The water supply required being taken at 400 gallons per hour or 9600 gallons a day, and the pumping time at 10 hours, the pumps should be capable of raising 960 gallons an hour.

J. Taylor & Sons treble barrel 3½ inch pumps with frame, Fig. 204/21, price £31. are estimated to raise 940 gallons an hour to a height of 100 feet with 4 men.

The greatest lift required is from 2891.00 to about 2988·50 or 97 feet.

Two sets of coolies, or 8 men, taking turn & turn would be needed. The cost of this arrangement including suction pipe and fixing, freight and carriage may be taken Blue Rupees 600 with bullock gear treble 5 inch pumps would be better and the cost would be about

wells 5·10 feet, a suitable convenient for beam stones.

* floor of cistern of Female Hospital 2984·75

about Rupees 1200. This latter will be entered in the estimate as the work would be hard for coolies.

3. For laying the pipes connecting the other wells with the sumpwell a deep trench 3 feet wide will have to be cut, and properly shored. The quantity of soil to be removed will be 6×500×3×2½ = 27,000 C.F. Costing about 1500 Rupees. The cost of the item of 3000 Rupees allowed is for planks and board for shoring.

4. Pumping will be necessary in connection with the well sinking, and the laying of the connecting pipes and as it is difficult to estimate the time required Rupees 3000 will be allowed

approximate

Appendix No 23.

Approximate estimate.

7 wells . . . . . at Rs 650 = 4550.

6 X 510 = 3060 feet of 6 inch C.I. pipes $\frac{3}{8}$ inch metal at 23.4 lbs per foot 71604 lbs or 32 Tons

4500 feet of 3 inch C.I. pipe, $\frac{3}{8}$ inch at 12.4 lbs. per foot, 55800 lbs or = 25 Tons.

1000 feet of 2 inch do. at 8.7 lbs per foot 8700 lbs or = 4 Tons.

60 Tons

60 Tons of C.I. Pipe at Rs 95 5,700

2000 feet of 1½ inch wrought iron pipe at . . 0-8-6 1063

Laying 1020 yds of 6" pipe at 0/10/6 Rs 637-8-0

1500 do of 3" do at 0/7/6 = 703-2-0

1000 do of 2" do at 0/4/6 = 250-0-0 1,591.

Pump with gear 1,200

Trench for connecting pipes 3,000

Unwatering during Construction 3,000

Taps and fittings 2,000

Contingencies 1,896

24,000

Appendix No 24.

1473

Specification and approximate estimates for the supply of the Troops from Agaram Tank.

1. Data for supply. The ordinary supply, on the average of 4 years, has been 5.6376 gallons per day, the greatest 7.1040 gallons. It is probable that 6,000 gallons would be sufficient, which are equivalent to 9600 cubic feet, but to allow of a possible extension of the distribution it is proposed to provide for a maximum quantity of 14,400 cubic feet a day.

It is desirable that this supply should be capable of delivery into the cisterns in 8 hours, and the quantity per minute will then be 30 cubic feet.

The Agaram Tank is about 3 miles from the old Race Course Barracks and nearly 4½ miles from the cistern which supplies the European Infantry Barracks.

This latter cistern is also at the highest level at which water has to be delivered viz 2999.62. The present Full Tank Level of the Agaram Tank is ~~2871.72~~ 2873.35

To obtain the required head for discharge through the pipes, the water must be lifted or forced over a standpipe the head (centre of

1/23

of which is intended to be at 3015.00

2. There are two alternative ways of obtaining water from the Agaram tank.

1. From a supply well sunk in the bed of the tank, in which case clean water would be obtained and artificial filters would not be needed.

2. From the tank direct, and in that case filtration prior to pumping would be requisite. It would for this arrangement be necessary also to increase the capacity of the tank.

It is doubtful whether the quality of the water would not suffer from filtration through the soil into a supply well sunk in the tank bed, seeing that water taken from wells not many yards from and above the tank has been found to be inferior to that of the tank itself, though it remains to be determined whether a well sunk in the tank or perhaps below the tank, would give similar results.

The maximum height to which water would have to be raised under this arrangement would be 161 feet.

With the alternative arrangement the maximum height is estimated at 151 feet

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3. Engines and pumps.

The quantity of water being 30 cubic feet a minute, and the maximum lift 161 feet the nominal engine Horse Power required is $\frac{30 \times 62 \times 161}{33000}$ = just over 9 Horse Power.

It is intended therefore to provide 2 engines each of 12 horse power nominal, and there should be of the compound condensing type. There should be 3 boilers, each capable of supplying, with wood fuel, full steam to one engine. The three boilers to be fixed side by side and to be connected by means of the usual steam domes and pipes with valves, so that any one or two adjacent boilers may be used at a time.

Fuel being dear, the present price being Rs 8-34 per ton equivalent to Rs 33-36 a ton for coal, it is essential that in designing the engines and boilers economy of consumption should be specially studied

Pumps. There should be of the ordinary plunger kind and there should be a set for each engine. Each set to consist of 3 barrels about 8 inches in diameter and from 20 to 24 inches stroke. The delivery with the former stroke would require 17-20 strokes a minute nearly and with the

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the latter 14·33 strokes a minute.
The other requirements will be noticed in connection with the alternative arrangements.
An air vessel of ample capacity is provided to equalize the pressure and flow. The amount entered for engines and pumps is based on the cost of the machinery at the Oholiés wells which is said to have been £1138 in England

4. Standpipes- These are 3 in number and with 16 inches internal diameter- one up pipe and one down pipe connected by a bend at the top, and one waste pipe connected with a vertical pipe from the summit of the bend, such connection being at 4 feet above the centre of the bend, and 4 feet below the open top of the pipe.
The length of the pipes above the masonry platforms will differ by about 7 feet in the two arrangements for the supply, but in either case the pipes are intended to be set up with a batter of 1 in 12, and be strutted and braced at intervals of 2, or at most 3, lengths of pipe i.e. probably at every 18 or 27 feet, so as to make the whole structure quite rigid and able to withstand the pressure of gales

vide plan 14

1473

gales at times experienced.
The pipes should rest on a bare plate of suitable form and they as well as the connecting pipes below should be securely bolted thereto.
The metal is supposed to be 7/16 inch thick and a special rate is allowed to cover the subsidiary parts.

490×79 = 38710 lbs. . . . . = 18 Tons.
6 Sets of Struts and braces.
Bed plates. 18 Tons at Rupees 120 = 2,160
Erecting 340
2500

masonry foundation if water drawn from Tank direct. . . 1430
Do. if drawn from supply well in Tank 1000

5 Delivery mains. The main from the foot of the stand pipe to a short distance from the Race Course Cistern, Cavalry Barracks, a distance of about 18,000 feet will be of 10 inches diameter and 3/8 of an inch thick.
Flanged pipes are provided for. The working head, exclusive of the margin for bends which will however be very slight, is arranged to give a gradient of 0·60 of a foot in a thousand feet.
By Reuilles formula,

$$V = 140\sqrt{R.S} - 11\sqrt[3]{R.S.}$$

the latter 14·33 chokes a minute.
The other requirements will be noticed
in connection with the alt
An air vessel
provid

[illegible] the discharge would be
the proportional discharge into the Race course
cistern will be 18·60 cubic Feet a minute,
and the gradient to this cistern being high
viz 1·94 feet in a thousand, a 7 inch pipe
will be ample. The length of this branch
will be about 500 feet.
The discharge of the other branch will for
1500 feet to the head of the Horse Artillery Station
Branch pipe, be 11·40 Cubic feet a minute,
and for the rest of the distance, about [illegible] feet,
to the E.I.R. Cistern 9·07 a minute
pipe has been allowed for at 8 inch. A 7 inch
The R.H.A pipe 3 inches will be a suitable
diameter. Its length will be about 1200 feet
18,000 ft. 10 inch pipe, 3/4 inch thick,
×79 = 1422,000 lbs = - - - - - 635 Tons.
7000 ft. of 7 inch pipe 5/8 inch thick
×46·7 = 326,900 lbs = - - - - - 146 Tons.
1200 feet of 3 inch pipe, 3/8 inch thick
×12·4 = 14,880 lbs = - - - - - 6½ Tons.

1473

787½ Tons of C.I. Pipe at 120 Rs = - - 94,500
Laying 6000 yds at 1/2/0 6,750
2333 yds at 0/10/0 1,452
Contingencies 5298
1,18,000

6. The cisterns and subsidiary distribution are intended to be left as at present.

7. Arrangements at Agaram Tank and pumping station (1st) with a supply well in or below the tank
In this case the only special works required would be a well in the bed of the Tank at the deepest part of the small bay near the waste weir bridge, and a pipe therefrom to the Engine at the Pumping Station.
The well would be 30 feet in diameter at top with its bottom at 2850·00, and its top at 2880·00, the excavated soil being arranged round that part of the draining which would be above tank bed level, so as to prevent any surface water passing into the well. The draining to be constructed in masonry down to 5 feet below bed of ground level, and below that in dry stone
The draining above bed level may be arched as shown in the section, or it may be stepped in 6 inches for each course, and then covered in at top with slab stones.

× about 2868·63

Plan No 14.

The well will be 30 feet in diameter for 3 feet below bed level, 27 feet for the next 7 feet, and 24 feet for the last 7 feet. The contents of the well, from estimated L.W.L 2855.60 to bed level, are 7485.64 cubic feet, or rather more than half the supply required in the 24 hours.

The calculated required inflow of water is $\frac{14400 - 7485}{8 \text{ hours}} = 864\frac{1}{2}$ cubic feet per hour.

The surface for inflow is

1st the area of the bottom of the well 452.39 sq. ft.

2nd the sides, where lined with dry stone, 1404.29 square feet, which may be taken as $\frac{1}{8}$ th unobstructed. $\frac{175.54}{627.93}$

so that 1.4 c.ft. per square foot per hour will be needed.

The probable cost of the well will be

9 300 Earth work at Rs 15.10.0 per 1000 c.ft.	148
17.82 Dry stone steining at 12-0-0 per 100 c.ft.	223
17.17 steining stone in mortar at 18-12-0 do	322
Slab stones	
Sundries	50
	37
Contingencies	760
	140
Total	900

Suction pipe 12 inches diameter, $\frac{3}{4}$ inch metal about 500 feet

500 / 93.7 = 46,850 lbs = say 21 Tons.

1423

21 Tons of C.I. Pipe at 95 = Rs 1995

Laying 167 yards at Rs 1-6-0 = " 210

Trench to pumping station, for laying pipe, average depth about 12 feet

500 × 12 × 12 = 24,000 c.ft at 10 lbs per thousand 240

Sundries - - 125

Total. 2570

The suction pipe would have a connection, with a suitable valve, with each set of pumps. 2nd if water be drawn off direct from the tank. The special works are:

(1) a suction pipe from the tank to the pumps.

(2) A pair of filters, with a pure water well attached and a suction pipe there from to the pumps;

(3) an increase to the capacity of the tank;

(1) The suction pipe, which would be connected with each set of pumps to be 12 inches in diameter, and to be run out into the deep part of the tank, so as to be able to draw off water to about the 2866.63 level, or 6.72 feet below present Full tank level. The length will be about 960 feet

960 feet × 93.7 = 89,952 lbs - - - = 40 Tons.

40 Tons C.I. pipe at 95 - - = 3800

Laying 320 yds at Rs 1-4-0 - - = 400

Trench for pipe, average depth 6 feet, 960 × 4 × 6 = 23,040 c.ft at 7 per thousand = 161

Sundries. 239/4.600.

another suction pipe will be required from the pure water well. It will be 10 inches in diameter. 150×79 = 11,860 lbs = 5 Tons.
5 Tons of C.I. pipe at 95 = Rs. 475.
Laying 5.0 yards at 1/2/- 56

Sundries 29/560

(2) The quantity of water to be filtered being 30 C. Feet a minute or 1800 Cubic feet an hour, and the usual allowance being 2 Square feet of filter bed for every Cubic foot per hour, 3600 square feet will be the area of each filter, or say 90 by 40 feet. The filters will be placed side by side, with a pure water well in connection with both. Depth of filters 10 feet and of well 13 feet; diameter of well 15 feet. Probable cost of the whole Rupees 15,000.

(3) The present capacity of the tank above the sill of the lowest sluice is 24.068 millions of C. feet. It is proposed to raise the F.T.L 3 feet which will increase the capacity by 20.601 millions, or to 44.669 millions of Cubic feet altogether. The present height of the bund varies considerably. There is only one waste weir 119 feet in length

1473

of which about 115 feet are effective, and this is not sufficient for the area of the catchment basin, 32.105 square miles. There was formerly a bypass at the other (east) end of the tank, but this was closed some time ago. The lowest estimate of the maximum discharge would be 2666 C.F. a second, viz.

$D = 350\sqrt[3]{32^2} = 3,528$ C.F. a second,

with the time extended one third by the action of the upper tanks.

The difference between Full tank Level and M.W.L should be limited to 3 feet and the proper length of weir will then be 157 feet, say 160 feet, or 45 feet additional are required.

The revetment being out of section from settlements will be rebuilt with a good and small stone backing; and the outside of the bund will be made, as is always desirable, on the inside, so far as may be practicable with due regard to securing a good alignment for the road.

The top of the bund will be 6.28 feet above Full Tank Level, and the clear width of roadway 15 feet. A width of 18 feet has been allowed at road level, so as to admit of

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side ridging which adds to the security of the traffic, and tends to maintain the edges of the bank in good order.

There being a great length of bund at the East end with but very little water spread, it will be cheaper and better to make a cross bund to the high ground immediately west of the village of Agara, and the connection of this bund with the main bund will be at about 2920 feet on the longitudinal section, the zero of which is at the 7th mile long of the 6th mile. For this new bund a top width of 6 feet and slopes of 1½ to 1 inside, and 2 to 1 outside, have been allowed, and revetment 1½ feet thick up to 2 feet below the top, which is the height to which the revetment generally will be carried up.

The new weir will be built towards the South end of this cross bund. The estimate for it has been made out on the supposition that the crest will be at 3 feet above ground level, but it is probable that a good site may be found on a higher level in which case the cost will be proportionately reduced.

There is a small irrigation sluice to the Eastward of the position of the cross bund and it is proposed to put a 6 inch pipe in or under the crest wall of the new weir to supply the lands under that sluice. The discharge of water through the pipe can be regulated by a wooden plug.

The surplus from the new weir will have to be passed across the road at the old outfall by lowering the road to 1128. feet above present full tank level with ramps of 1 in 25 at either end.

If the low level road be 200 feet in length the maximum depth of water passing over will not exceed one foot, and if the lower side be well revetted, with 3 or 4 feet of rough stone apron at the toe of the revetment, no other protection will be required. Moreover if a cut 9 feet wide be made on the South side of the road to the present culvert, which is on a lower level, no water will pass over the road in ordinary seasons. Rupees 500 have been allowed for these alterations. Sufficient stone will be obtainable from the present bund to the East of the cross bund.

8. The levels of the Agaram Tank, as plotted, require an addition of 1.63 feet as noted on Plans 13. 15 and 16. The levels were ordered to be

to be taken from the floor at the South end of the Cavalry part of the South Station hospital and they were actually started from an off set 0.96 feet above the floor. It has also been found that the levels on Lt Romilly's section are not quite correct His levels make the floor of the Hospital 30.38 above datum which is 11.50 feet below Halsur Tank waste weir so the floor is 18-88 above the weir.

The Zero of the Tank gauge is 11.95 feet below the Bench mark on the offset on South faced the Rock Engine House, and the difference between that B.M. and the floor of the Cavalry Hospital is 7.60 feet, so the latter is 19.55 feet above Halsur Full Tank Level or a difference of 0.67 feet.

The reduced level (Kamwar mean sea level) of the Zero of the Halsur Lower Tank gauge is 2929.97, so the floor of the Cavalry Hospital is 2949.52, and the bench mark on the offset 2950.48

In levelling to the Agaram Tank the value 18.88 + 2929.97 = 2948.85 was used for this B.M., hence the connection of 1.63 feet requiring to be added to the plotted levels above referred to.

The levels entered on plan 14 have been corrected as regards the Agaram Tank, but the levels of the several parts of the Garrison

Vide Section at end of Paper on Ootacamund water works by C.C.C.L.H. in No 4 July 1881 of Roorkee Prof. Papers.

1423

distribution have been left as given in Lt Romilly's section, as no connected series of check levels of the cisterns has been taken, and the stand pipe has been designed so as to secure ample head

9. The following is an abstract approximate estimate of the cost of enlarging the Agaram tank

Quantities	Description	Unit	Rate	Amount	Work Totals
476,857	Earthwork & lump and forming Croft bund	1000 C.ft	3 7 6	1654	1,654
50602	Rebuilding old revetment	100 C.ft	1 8 -	760	
337,35	Gravel backing & do.	do	2 - -	675	1,435
363,44	New revetment	do	9 8 -	3453	
242,29	Gravel backing & do.	do	2 - -	485	3,938
	alterations & waste weir and 11 ments culvert			840	
	alterations & sluice new waste weir, 45 feet crest			350	1,190
	sluice pipe				
4625	Rubble masonry	100 C.ft	14 1 0	650	
1224	Rough stone apron	do	9 8 -	116	
5	Feet Sluice pipe 6 inches in diameter and ½ inch thick with elbow at Tank end			10	
	Sundries			37	813
	Covering road & passing from new weir, without on South side of road & culvert			500	500
53.3	Land compensation for additional water spread	acres	60 - -	3198	3198
	Contingencies				272
				Total	13,000

The additional capacity being impounded amounts 20½ millions of Cubic feet, the cost of storage would be per million Cubic feet Rupees.

Rupees 634 – which seems reasonable as the reinstating of the old revetment and the new waste weir are works appertaining to the security of the present tank, and under that item the cost per million moved he under Rs 525.

10. The ground selected for the pumping station measures 4·5 acres and provision has been made for enclosing the whole with a wall of stone in mud, pointed with mortar, and coped with stone in mortar. The wall is to be 6 feet in height. The item, Rs 4000, is a considerable one, but it is the important as it excludes all but employees from otherwise perfect cleanliness cannot be ensured.

11. Subjoined is a general abstract of the alternative arrangements for the supply of the Tropo from this source. As the present Establishment at the Haleur Rock water works would suffice for the Agaram works, and as the working expenses generally would be much the same, no provision has been made on this account.

(3)

Particulars	Water drawn direct from Tank Amount	Water drawn from supply well in addition Tank Amount
	Rupees.	Rupees
Engines and Pumps	36,500	36,500
Standpipes	2,500	2,500
Masonary foundation –do–	1430	1,000
Delivery mains	118,000	118,000
Suction pipe from Supply well	———	2370
Supply well	———	900
Suction pipe from tank	4,000	———
do from pure water well	560	———
2 Filters	15,000	———
Enlarging tank	13,000	———
Ground for pumping station	250	250
Engine house and Chimney	12,500	12,500
2 Quarters for Engineer &c	3,000	3,000
Enclosure walls	4000	4,000
	211,340	181,220
Contingencies	8,660	6,780
Total	220,000	188,000

Appendix No 24

Specification and approximate estimate for the supply of the Troops from the Agaroor Tank.

No 24
Ft Tank

Condenser List No. 1.

Pure Cold Fresh Water from Sea Water with great economy of Coal.

For YACHTS, SHIPS, or on LAND.

4,500 Gallons, or 20 Tons for 1 Ton of Coal. (Results guaranteed abroad if required.)

NORMANDY'S IMPROVED PATENT

FRESH WATER DISTILLING MACHINERY.

This Machinery converts Sea, or other Impure Water, into *Pure Cold Fresh Water*, equal in appearance and taste to the best River or Spring Water, and at the immediate use as it leaves the Machinery, which will also force it to any distance, and to a height of 30 yards or metres, or more if desired.

It is well known that an *insufficient or impure* water supply, is *a constant source of danger, from a sanitary point of view*. There are many places where such a state of things exists, and where the introduction of this Machinery would at once provide a *pure and abundant water supply*. Over 1,010 Machines have been supplied, and some of the Land Stations and Ships supplied are given on the last page.

THE PROCESS MAY BE BRIEFLY STATED AS FOLLOWS:—

Water distilled by the ordinary process, viz., by a boiler for generating steam, and a worm for condensing steam into water, is open to these objections:

1. *The entire heat of the condensed steam is lost.*
2. The water formed by the condensed steam contains organic impurities, which give it a disagreeable flavour.
3. This water is destitute of air, which it has lost in the process of boiling, and it is hence flat and vapid to the taste, besides being somewhat heavy if drunk in quantity.

These objections may be, to a certain extent, removed by exposing the water to air for a long time. *But on board ship, and in doubtful places, the boiler may absorb air which is not pure.*

Normandy's Improved Apparatus removes all these objections by using over again the heat liberated by one or more successive condensations of steam, thus increasing the amount of distilled water to from 15 to 21 times the water evaporated by the Boiler. The distilled water is stated in the process of condensation, and is cooled down to the temperature of ordinary [illegible] in the outer air. Volatile taint of organic matter is completely removed from the distilled water by passing it through a filter of prepared animal charcoal, from which it flows out cold, pure, well aerated, and equal in taste and appearance to the best River water as usually supplied to towns.

Result of the Trial of Normandy's Improved Patent Distilling Machinery, for the DUTCH GOVERNMENT, January and February, 1877.

THIS MACHINERY was supplied as suitable for producing 6,000 gallons of Pure Fresh Water, per 24 hours, from Sea Water.

By the direction of Mr. Van Dorp, Chief Engineer of the Waterstaat, in the Province of Zealand, Holland, this Machinery was carefully tested by being worked under the inspection of officials appointed for the purpose, the result being, that in 10 *hours work*, this Machinery produced 22,700 litres of Fresh Water, and consumed 1,545 kilos. of coal. This is equal to 5,479 gallons for 24 hours of Fresh Water, produced with 1¼ tons of coal in 10 *hours' work*.

The [illegible] was supplied from the Machinery, was *tasteless, clear, cold, and agreeable, without any peculiar taste, and, in fact, equal in appearance and taste to the best river or spring water.*

It will be seen, therefore, that this Machinery, when worked *for* 10 *hours*, produced 33 *per cent. more water than it was said to produce* in that time, and yielded 4,100 *gallons for* 15 *tons*) *for* 1 *ton of coal*, it would have produced more had the Machinery been less [illegible] worked, as smaller Machines at Aden and elsewhere have yielded over 20 tons or 4,500 gallons of water per ton of coal.

In the above trial, the productive power and consumption of coal were ascertained as follows:—The Machinery having been fairly started, the coals were [illegible] from the furnaces, and the working was continued, under inspection, with weighed coals. After 10 *hours' working, the ascertained coals were removed from the furnaces and weighed*, and their weight was deducted from the quantity of weighed coals put into the furnaces, the difference being taken as the weight consumed. The Fresh Water produced from the Sea-Water was collected in an iron tank and carefully measured.

REPORTS on the QUALITY of the Fresh Water produced by Normandy's Improved Patent Machinery *for producing from Sea Water, pure, cold, and agreeable Fresh Water for Drinking purposes.*

Analysis in Pharmacy, Doctor of Science, late Professor of Chemistry to the Faculty of Sciences of Concepcion, and Professor of Chemistry and Physics to the Normal of Alicante, etc., etc.

Opinion of DON JOSE SOLER Y SANCHEZ.

ALICANTE, 15th September, 1879.

I hereby certify, that [illegible] on my laboratory a sample of pure fresh water [illegible] known as distilled water from Sea Water, by the Normandy Process, and that I have found as follows:—

This sample of fresh water was received in the presence of the Notary, Mr. Nicasio Arbiol, in two glass bottles duly sealed and stamped with the letters J.C.B., the vessels being as follows:—

1st. Its hydrometrical degree is 0.

2nd. A litre of water contains [illegible] of organic substances.

3rd. Does not contain any organic matter.

Therefore, by the above [illegible] it is to be considered a most necessary drinkable water.

Dr. J. SOLER Y SANCHEZ.

Report of Dr. NOAD, F.R.S.

Professor of Chemistry at St. George's Hospital, London.

I find the water to be absolutely free from organic matter, which all pure and well water contain, more or less, and which is acknowledged to be a [illegible] of pure drinking water. It is also bright, colourless, well aerated and agreeable, and it contains an exceedingly small percentage of saline matter, which in this case was all [illegible] from the best natural sources.

From a sanitary point of view, I consider this water to be quite equal, and in the absence [illegible] to be preferred to spring water for domestic purposes.

HENRY M. NOAD, Ph.D., F.R.S.

Report of Dr. LETHEBY, M.B., M.A.

Professor of Chemistry at the Medical College of the London Hospital and Medical Officer of Health for the City of London.

The sample was colourless and well aerated, and it was agreeable to the palate. It contained a very small proportion of saline matter, which I regard as an advantage, as it [illegible] the quality of the water to that derived from the best natural sources. For domestic purposes, the proper character of the water is essential. The water was absolutely free from organic matter, and it is very soft.

I am of opinion, from these results, that the water is very [illegible] and will [illegible] in all domestic purposes.

H. LETHEBY, M.B., M.A., &c.

For further Testimonials, see [illegible]

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LIST of PARTICULARS of NORMANDY'S IMPROVED PATENT DISTILLING MACHINERY for producing and taste to the best Water from Sea Water into Pure Cold Fresh Water, equal in appearance the Machinery which will also force it to a distance and to a height of 40 yards (or more if desired).

See Reports and Result of Government Trial at Flushing, on other side.

Quantity of Cold Pure Water produced from Sea Water in 24 hours. Under favourable circumstances, but producing only 10 lbs. of coal per ton.	Gallons.	Time in Coke Used.	Gallons.	Time in Coke Used.	Gallons.	Time in Coke Used.	Gallons.	Time in Coke Used.
	1000	4.5	1500	7.0	2000	9.5	2500	12.0
	1125	5.0	1560	7.5	2050	10.0	2550	12.5
	1250	5.5	1625	8.0	2100	10.5	2600	13.0
	1300	6.0	1680	8.5	2150	11.0	2650	13.5
	1350	6.5	1700	9.0	2200	11.5	2700	14.0
	1400	7.0	1740	9.5	2250	12.0	2750	14.5
	1450	7.5	1760	10.0	2300	12.5	2800	15.0
	1500	8.0	1800	10.5	2350	13.0	2850	15.5
	1550	8.5	1850	11.0	2400	13.5	2900	16.0
	1600	9.0	1900	11.5	2450	14.0	2950	16.5
	1650	9.5	1950	12.0	2500	14.5	3000	17.0
	1700	10.0	2000	12.5	2550	15.0	3050	17.5
	1750	10.5	2050	13.0	2600	15.5	3100	18.0
	1800	11.0	2100	13.5	2650	16.0	3150	18.5
	1850	11.5	2150	14.0	2700	16.5	3200	19.0
	1900	12.0	2200	14.5	2750	17.0	3250	19.5
	1950	12.5	2250	15.0	2800	17.5	3300	20.0
	2000	13.0	2300	15.5	2850	18.0	3350	20.5
	2050	13.5	2350	16.0	2900	18.5	3400	21.0
	2100	14.0	2400	16.5	2950	19.0	3450	21.5
	2150	14.5	2450	17.0	3000	19.5	3500	22.0
	2200	15.0	2500	17.5	3050	20.0	3550	22.5
	2250	15.5	2550	18.0	3100	20.5	3600	23.0
	2300	16.0	2600	18.5	3150	21.0	3650	23.5
	2350	16.5	2650	19.0	3200	21.5	3700	24.0
	2400	17.0	2700	19.5	3250	22.0	3750	24.5
	2450	17.5	2750	20.0	3300	22.5	3800	25.0
	2500	18.0	2800	20.5	3350	23.0	3850	25.5
	2550	18.5	2850	21.0	3400	23.5	3900	26.0
	2600	19.0	2900	21.5	3450	24.0	3950	26.5
	2650	19.5	2950	22.0	3500	24.5	4000	27.0
	2700	20.0	3000	22.5	3550	25.0	4050	27.5
	2750	20.5	3050	23.0	3600	25.5	4100	28.0
	2800	21.0	3100	23.5	3650	26.0	4150	28.5
	2850	21.5	3150	24.0	3700	26.5	4200	29.0
	2900	22.0	3200	24.5	3750	27.0	4250	29.5
	2950	22.5	3250	25.0	3800	27.5	4300	30.0
	3000	23.0	3300	25.5	3850	28.0	4350	30.5
	3050	23.5	3350	26.0	3900	28.5	4400	31.0
	3100	24.0	3400	26.5	3950	29.0	4450	31.5
	3150	24.5	3450	27.0	4000	29.5	4500	32.0
	3200	25.0	3500	27.5	4050	30.0	4550	32.5
	3250	25.5	3550	28.0	4100	30.5	4600	33.0
	3300	26.0	3600	28.5	4150	31.0	4650	33.5
	3350	26.5	3650	29.0	4200	31.5	4700	34.0
	3400	27.0	3700	29.5	4250	32.0	4750	34.5
	3450	27.5	3750	30.0	4300	32.5	4800	35.0
	3500	28.0	3800	30.5	4350	33.0	4850	35.5
	3550	28.5	3850	31.0	4400	33.5	4900	36.0
	3600	29.0	3900	31.5	4450	34.0	4950	36.5
	3650	29.5	3950	32.0	4500	34.5	5000	37.0
	3700	30.0	4000	32.5	4550	35.0	5050	37.5
	3750	30.5	4050	33.0	4600	35.5	5100	38.0
	3800	31.0	4100	33.5	4650	36.0	5150	38.5
	3850	31.5	4150	34.0	4700	36.5	5200	39.0
	3900	32.0	4200	34.5	4750	37.0	5250	39.5
	3950	32.5	4250	35.0	4800	37.5	5300	40.0
	4000	33.0	4300	35.5	4850	38.0	5350	40.5
	4050	33.5	4350	36.0	4900	38.5	5400	41.0
	4100	34.0	4400	36.5	4950	39.0	5450	41.5
	4150	34.5	4450	37.0	5000	39.5	5500	42.0
	4200	35.0	4500	37.5	5050	40.0	5550	42.5
	4250	35.5	4550	38.0	5100	40.5	5600	43.0
	4300	36.0	4600	38.5	5150	41.0	5650	43.5
	4350	36.5	4650	39.0	5200	41.5	5700	44.0
	4400	37.0	4700	39.5	5250	42.0	5750	44.5
	4450	37.5	4750	40.0	5300	42.5	5800	45.0
	4500	38.0	4800	40.5	5350	43.0	5850	45.5
	4550	38.5	4850	41.0	5400	43.5	5900	46.0
	4600	39.0	4900	41.5	5450	44.0	5950	46.5
	4650	39.5	4950	42.0	5500	44.5	6000	47.0
	4700	40.0	5000	42.5	5550	45.0	6050	47.5
	4750	40.5	5050	43.0	5600	45.5	6100	48.0
	4800	41.0	5100	43.5	5650	46.0	6150	48.5
	4850	41.5	5150	44.0	5700	46.5	6200	49.0
	4900	42.0	5200	44.5	5750	47.0	6250	49.5
	4950	42.5	5250	45.0	5800	47.5	6300	50.0
	5000	43.0	5300	45.5	5850	48.0	6350	50.5
	5050	43.5	5350	46.0	5900	48.5	6400	51.0
	5100	44.0	5400	46.5	5950	49.0	6450	51.5
	5150	44.5	5450	47.0	6000	49.5	6500	52.0
	5200	45.0	5500	47.5	6050	50.0	6550	52.5
	5250	45.5	5550	48.0	6100	50.5	6600	53.0
	5300	46.0	5600	48.5	6150	51.0	6650	53.5
	5350	46.5	5650	49.0	6200	51.5	6700	54.0
	5400	47.0	5700	49.5	6250	52.0	6750	54.5
	5450	47.5	5750	50.0	6300	52.5	6800	55.0
	5500	48.0	5800	50.5	6350	53.0	6850	55.5
	5550	48.5	5850	51.0	6400	53.5	6900	56.0
	5600	49.0	5900	51.5	6450	54.0	6950	56.5
	5650	49.5	5950	52.0	6500	54.5	7000	57.0
	5700	50.0	6000	52.5	6550	55.0	7050	57.5
	5750	50.5	6050	53.0	6600	55.5	7100	58.0
	5800	51.0	6100	53.5	6650	56.0	7150	58.5
	5850	51.5	6150	54.0	6700	56.5	7200	59.0
	5900	52.0	6200	54.5	6750	57.0	7250	59.5
	5950	52.5	6250	55.0	6800	57.5	7300	60.0
	6000	53.0	6300	55.5	6850	58.0	7350	60.5
	6050	53.5	6350	56.0	6900	58.5	7400	61.0
	6100	54.0	6400	56.5	6950	59.0	7450	61.5
	6150	54.5	6450	57.0	7000	59.5	7500	62.0
	6200	55.0	6500	57.5	7050	60.0	7550	62.5
	6250	55.5	6550	58.0	7100	60.5	7600	63.0
	6300	56.0	6600	58.5	7150	61.0	7650	63.5
	6350	56.5	6650	59.0	7200	61.5	7700	64.0
	6400	57.0	6700	59.5	7250	62.0	7750	64.5
	6450	57.5	6750	60.0	7300	62.5	7800	65.0
	6500	58.0	6800	60.5	7350	63.0	7850	65.5
	6550	58.5	6850	61.0	7400	63.5	7900	66.0
	6600	59.0	6900	61.5	7450	64.0	7950	66.5
	6650	59.5	6950	62.0	7500	64.5	8000	67.0
	6700	60.0	7000	62.5	7550	65.0	8050	67.5
	6750	60.5	7050	63.0	7600	65.5	8100	68.0
	6800	61.0	7100	63.5	7650	66.0	8150	68.5
	6850	61.5	7150	64.0	7700	66.5	8200	69.0
	6900	62.0	7200	64.5	7750	67.0	8250	69.5
	6950	62.5	7250	65.0	7800	67.5	8300	70.0
	7000	63.0	7300	65.5	7850	68.0	8350	70.5
	7050	63.5	7350	66.0	7900	68.5	8400	71.0
	7100	64.0	7400	66.5	7950	69.0	8450	71.5
	7150	64.5	7450	67.0	8000	69.5	8500	72.0
	7200	65.0	7500	67.5	8050	70.0	8550	72.5
	7250	65.5	7550	68.0	8100	70.5	8600	73.0
	7300	66.0	7600	68.5	8150	71.0	8650	73.5
	7350	66.5	7650	69.0	8200	71.5	8700	74.0
	7400	67.0	7700	69.5	8250	72.0	8750	74.5
	7450	67.5	7750	70.0	8300	72.5	8800	75.0
	7500	68.0	7800	70.5	8350	73.0	8850	75.5
	7550	68.5	7850	71.0	8400	73.5	8900	76.0
	7600	69.0	7900	71.5	8450	74.0	8950	76.5
	7650	69.5	7950	72.0	8500	74.5	9000	77.0
	7700	70.0	8000	72.5	8550	75.0	9050	77.5
	7750	70.5	8050	73.0	8600	75.5	9100	78.0
	7800	71.0	8100	73.5	8650	76.0	9150	78.5
	7850	71.5	8150	74.0	8700	76.5	9200	79.0
	7900	72.0	8200	74.5	8750	77.0	9250	79.5
	7950	72.5	8250	75.0	8800	77.5	9300	80.0
	8000	73.0	8300	75.5	8850	78.0	9350	80.5
	8050	73.5	8350	76.0	8900	78.5	9400	81.0
	8100	74.0	8400	76.5	8950	79.0	9450	81.5
	8150	74.5	8450	77.0	9000	79.5	9500	82.0
	8200	75.0	8500	77.5	9050	80.0	9550	82.5
	8250	75.5	8550	78.0	9100	80.5	9600	83.0
	8300	76.0	8600	78.5	9150	81.0	9650	83.5
	8350	76.5	8650	79.0	9200	81.5	9700	84.0
	8400	77.0	8700	79.5	9250	82.0	9750	84.5
	8450	77.5	8750	80.0	9300	82.5	9800	85.0
	8500	78.0	8800	80.5	9350	83.0	9850	85.5
	8550	78.5	8850	81.0	9400	83.5	9900	86.0
	8600	79.0	8900	81.5	9450	84.0	9950	86.5
	8650	79.5	8950	82.0	9500	84.5	10000	87.0
	8700	80.0	9000	82.5	9550	85.0	10050	87.5
	8750	80.5	9050	83.0	9600	85.5	10100	88.0
	8800	81.0	9100	83.5	9650	86.0	10150	88.5
	8850	81.5	9150	84.0	9700	86.5	10200	89.0
	8900	82.0	9200	84.5	9750	87.0	10250	89.5
	8950	82.5	9250	85.0	9800	87.5	10300	90.0
	9000	83.0	9300	85.5	9850	88.0	10350	90.5
	9050	83.5	9350	86.0	9900	88.5	10400	91.0
	9100	84.0	9400	86.5	9950	89.0	10450	91.5
	9150	84.5	9450	87.0	10000	89.5	10500	92.0
	9200	85.0	9500	87.5	10050	90.0	10550	92.5
	9250	85.5	9550	88.0	10100	90.5	10600	93.0
	9300	86.0	9600	88.5	10150	91.0	10650	93.5
	9350	86.5	9650	89.0	10200	91.5	10700	94.0
	9400	87.0	9700	89.5	10250	92.0	10750	94.5
	9450	87.5	9750	90.0	10300	92.5	10800	95.0
	9500	88.0	9800	90.5	10350	93.0	10850	95.5
	9550	88.5	9850	91.0	10400	93.5	10900	96.0
	9600	89.0	9900	91.5	10450	94.0	10950	96.5
	9650	89.5	9950	92.0	10500	94.5	11000	97.0
	9700	90.0	10000	92.5	10550	95.0	11050	97.5
	9750	90.5	10050	93.0	10600	95.5	11100	98.0
	9800	91.0	10100	93.5	10650	96.0	11150	98.5
	9850	91.5	10150	94.0	10700	96.5	11200	99.0
	9900	92.0	10200	94.5	10750	97.0	11250	99.5
	9950	92.5	10250	95.0	10800	97.5	11300	100.0
	10000	93.0	10300	95.5	10850	98.0	11350	100.5
	10050	93.5	10350	96.0	10900	98.5	11400	101.0
	10100	94.0	10400	96.5	10950	99.0	11450	101.5
	10150	94.5	10450	97.0	11000	99.5	11500	102.0
	10200	95.0	10500	97.5	11050	100.0	11550	102.5
	10250	95.5	10550	98.0	11100	100.5	11600	103.0
	10300	96.0	10600	98.5	11150	101.0	11650	103.5
	10350	96.5	10650	99.0	11200	101.5	11700	104.0
	10400	97.0	10700	99.5	11250	102.0	11750	104.5
	10450	97.5	10750	100.0	11300	102.5	11800	105.0
	10500	98.0	10800	100.5	11350	103.0	11850	105.5
	10550	98.5	10850	101.0	11400	103.5	11900	106.0
	10600	99.0	10900	101.5	11450	104.0	11950	106.5
	10650	99.5	10950	102.0	11500	104.5	12000	107.0
	10700	100.0	11000	102.5	11550	105.0	12050	107.5
	10750	100.5	11050	103.0	11600	105.5	12100	108.0
	10800	101.0	11100	103.5	11650	106.0	12150	108.5
	10850	101.5	11150	104.0	11700	106.5	12200	109.0
	10900	102.0	11200	104.5	11750	107.0	12250	109.5
	10950	102.5	11250	105.0	11800	107.5	12300	110.0
	11000	103.0	11300	105.5	11850	108.0	12350	110.5
	11050	103.5	11350	106.0	11900	108.5	12400	111.0
	11100	104.0	11400	106.5	11950	109.0	12450	111.5
	11150	104.5	11450	107.0	12000	109.5	12500	112.0
	11200	105.0	11500	107.5	12050	110.0	12550	112.5
	11250	105.5	11550	108.0	12100	110.5	12600	113.0
	11300	106.0	11600	108.5	12150	111.0	12650	113.5
	11350	106.5	11650	109.0	12200	111.5	12700	114.0
	11400	107.0	11700	109.5	12250	112.0	12750	114.5
	11450	107.5	11750	110.0	12300	112.5	12800	115.0
	11500	108.0	11800	110.5	12350	113.0	12850	115.5
	11550	108.5	11850	111.0	12400	113.5	12900	116.0
	11600	109.0	11900	111.5	12450	114.0	12950	116.5
	11650	109.5	11950	112.0	12500	114.5	13000	117.0
	11700	110.0	12000	112.5	12550	115.0	13050	117.5
	11750	110.5	12050	113.0	12600	115.5	13100	118.0
	11800	111.0	12100	113.5	12650	116.0	13150	118.5
	11850	111.5	12150	114.0	12700	116.5	13200	119.0
	11900	112.0	12200	114.5	12750	117.0	13250	119.5
	11950	112.5	12250	115.0	12800	117.5	13300	120.0
	12000	113.0	12300	115.5	12850	118.0	13350	120.5
	12050	113.5	12350	116.0	12900	118.5	13400	121.0
	12100	114.0	12400	116.5	12950	119.0	13450	121.5
	12150	114.5	12450	117.0	13000	119.5	13500	122.0
	12200	115.0	12500	117.5	13050	120.0	13550	122.5
	12250	115.5	12550	118.0	13100	120.5	13600	123.0
	12300	116.0	12600	118.5	13150	121.0	13650	123.5
	12350	116.5	12650	119.0	13200	121.5	13700	124.0
	12400	117.0	12700	119.5	13250	122.0	13750	124.5
	12450	117.5	12750	120.0	13300	122.5	13800	125.0
	12500	118.0	12800	120.5	13350	123.0	13850	125.5
	12550	118.5	12850	121.0	13400	123.5	13900	126.0
	12600	119.0	12900	121.5	13450	124.0	13950	126.5
	12650	119.5	12950	122.0	13500	124.5	14000	127.0
	12700	120.0	13000	122.5	13550	125.0	14050	127.5
	12750	120.5	13050	123.0	13600	125.5	14100	128.0
	12800	121.0	13100	123.5	13650	126.0	14150	128.5
	12850	121.5	13150	124.0	13700	126.5	14200	129.0
	12900	122.0	13200	124.5	13750	127.0	14250	129.5
	12950	122.5	13250	125.0	13800	127.5	14300	130.0
	13000	123.0	13300	125.5	13850	128.0	14350	130.5
	13050	123.5	13350	126.0	13900	128.5	14400	131.0
	13100	124.0	13400	126.5	13950	129.0	14450	131.5
	13150	124.5	13450	127.0	14000	129.5	14500	132.0
	13200	125.0	13500	127.5	14050	130.0	14550	132.5
	13250	125.5	13550	128.0	14100	130.5	14600	133.0
	13300	126.0	13600	128.5	14150	131.0	14650	133.5
	13350	126.5	13650	129.0	14200	131.5	14700	134.0
	13400	127.0	13700	129.5	14250	132.0	14750	134.5
	13450	127.5	13750	130.0	14300	132.5	14800	135.0
	13500	128.0	13800	130.5	14350	133.0	14850	135.5
	13550	128.5	13850	131.0	14400	133.5	14900	136.0
	13600	129.0	13900	131.5	14450	134.0	14950	136.5
	13650	129.5	13950	132.0	14500	134.5	15000	137.0
	13700	130.0	14000	132.5	14550	135.0	15050	137.5
	13750	130.5	14050	133.0	14600	135.5	15100	138.0
	13800	131.0	14100	133.5	14650	136.0	15150	138.5
	13850	131.5	14150	134.0	14700	136.5	15200	139.0
	13900	132.0	14200	134.5	14750	137.0	15250	139.5
	13950	132.5	14250	135.0	14800	137.5	15300	140.0
	14000	133.0	14300	135.5	14850	138.0	15350	140.5
	14050	133.5	14350	136.0	14900	138.5	15400	141.0
	14100	134.0	14400	136.5	14950	139.0	15450	141.5
	14150	134.5	14450	137.0	15000	139.5	15500	142.0
	14200	135.0	14500	137.5	15050	140.0	15550	142.5
	14250	135.5	14550	138.0	15100	140.5	15600	143.0
	14300	136.0	14600	138.5	15150	141.0	15650	143.5
	14350	136.5	14650	139.0	15200	141.5	15700	144.0
	14400	137.0	14700	139.5	15250	142.0	15750	144.5
	14450	137.5	14750	140.0	15300	142.5	15800	145.0
	14500	138.0	14800	140.5	15350	143.0	15850	145.5
	14550	138.5	14850	141.0	15400	143.5	15900	146.0
	14600	139.0	14900	141.5	15450	144.0	15950	146.5
	14650	139.5	14950	142.0	15500	144.5	16000	147.0
	14700	140.0	15000	142.5	15550	145.0	16050	147.5
	14750	140.5	15050	143.0	15600	145.5	16100	148.0
	14800	141.0	15100	143.5	15650	146.0	16150	148.5
	14850	141.5	15150	144.0	15700	146.5	16200	149.0
	14900	142.0	15200	144.5	15750	147.0	16250	149.5
	14950	142.5	15250	145.0	15800	147.5	16300	150.0
	15000	143.0	15300	145.5	15850	148.0	16350	150.5
	15050	143.5	15350	146.0	15900	148.5	16400	151.0
	15100	144.0	15400	146.5	15950	149.0	16450	151.5
	15150	144.5	15450	147.0	16000	149.5	16500	152.0
	15200	145.0	15500	147.5	16050	150.0	16550	152.5
	15250	145.5	15550	148.0	16100	150.5	16600	153.0
	15300	146.0	15600	148.5	16150	151.0	16650	153.5
	15350	146.5	15650	149.0	16200	151.5	16700	154.0
	15400	147.0	15700	149.5	16250	152.0	16750	154.5
	15450	147.5	15750	150.0	16300	152.5	16800	155.0
	15500	148.0	15800	150.5	16350	153.0	16850	155.5
	15550	148.5	15850	151.0	16400	153.5	16900	156.0
	15600	149.0	15900	151.5	16450	154.0	16950	156.5
	15650	149.5	15950	152.0	16500	154.5	17000	157.0
	15700	150.0	16000	152.5	16550	155.0	17050	157.5
	15750	150.5	16050	153.0	16600	155.5	17100	158.0
	15800	151.0	16100	153.5	16650	156.0	17150	158.5
	15850	151.5	16150	154.0	16700	156.5	17200	159.0
	15900	152.0	16200	154.5	16750	157.0	17250	159.5
	15950	152.5	16250	155.0	16800	157.5	17300	160.0
	16000	153.0	16300	155.5	16850	158.0	17350	160.5
	16050	153.5	16350	156.0	16900	158.5	17400	161.0
	16100	154.0	16400	156.5	16950	159.0	17450	161.5
	16150	154.5	16450	157.0	17000	159.5	17500	162.0
	16200	155.0	16500	157.5	17050	160.0	17550	162.5
	16250	155.5	16550	158.0	17100	160.5	17600	163.0
	16300	156.0	16600	158.5	17150	161.0	17650	163.5
	16350	156.5	16650	159.0	17200	161.5	17700	164.0
	16400	157.0	16700	159.5	17250	162.0	17750	164.5
	16450	157.5	16750	160.0	17300	162.5	17800	165.0
	16500	158.0	16800	160.5	17350	163.0	17850	165.5
	16550	158.5	16850	161.0	17400	163.5	17900	166.0
	16600	159.0	16900	161.5	17450	164.0	17950	166.5
	16650	159.5	16950	162.0	17500	164.5	18000	167.0
	16700	160.0	17000	162.5	17550	165.0	18050	167.5
	16750	160.5	17050	163.0	17600	165.5	18100	168.0
	16800	161.0	17100	163.5	17650	166.0	18150	168.5
	16850	161.5	17150	164.0	17700	166.5	18200	169.0
	16900	162.0	17200	164.5	17750	167.0	18250	169.5
	16950	162.5	17250	165.0	17800	167.5	18300	170.0
	17000	163.0	17300	165.5	17850	168.0	18350	170.5
	17050	163.5	17350	166.0	17900	168.5	18400	171.0
	17100	164.0	17400	166.5	17950	169.0	18450	171.5
	17150	164.5	17450	167.0	18000	169.5	18500	172.0
	17200	165.0	17500	167.5	18050	170.0	18550	172.5
	17250	165.5	17550	168.0	18100	170.5	18600	173.0
	17300	166.0	17600	168.5	18150	171.0	18650	173.5
	17350	166.5	17650	169.0	18200	171.5	18700	174.0
	17400	167.0	17700	169.5	18250	172.0	18750	174.5
	17450	167.5	17750	170.0	18300	172.5	18800	175.0
	17500	168.0	17800	170.5	18350	173.0	18850	175.5
	17550	168.5	17850	171.0	18400	173.5	18900	176.0
	17600	169.0	17900	171.5	18450	174.0	18950	176.5
	17650	169.5	17950	172.0	18500	174.5	19000	177.0
	17700	170.0	18000	172.5	18550	175.0	19050	177.5
	17750	170.5	18050	173.0	18600	175.5	19100	178.0
	17800	171.0	18100	173.5	18650	176.0	19150	178.5
	17850	171.5	18150	174.0

REPORTS on NORMANDY'S IMPROVED PATENT MACHINERY for producing from SEA WATER, pure, cold, and agreeable Fresh Water for drinking purposes.

Result of the Trial of Normandy's Improved Patent Distilling Machinery, erected at FLUSHING for the DUTCH GOVERNMENT, January and February, 1853.

This Machinery was supplied as suitable for producing 6,000 gallons, or 27 cubic metres of Good Cold Drinking Water, per 24 hours, from Sea Water.

By the direction of M. Van Diesen, Chief Engineer of the Waterstaat, in the Province of Zealand, Holland, this Machinery was carefully tested by being worked under the inspection of officials appointed for the purpose, the result being, that in 19 hours' work, this Machinery produced 25,500 litres of Fresh Water, and consumed 1,545 kilogrammes of coal. This is equal to 6,270 gallons (or 28 tons) of Fresh Water produced with 1½ tons of coal in 19 hours' work.

The Fresh Water produced, as it flowed from the Machinery, was bright-looking, clear, cool, and agreeable, without any peculiar taste, and, in fact, equal in appearance and taste to the best river or spring water.

It will be seen therefore, that this Machinery, when worked for 19 hours, produced 33 per cent more water than it was said to produce in that time, and yielded 4,700 gallons (or 21½ tons) of fresh water per 1 ton of coal (equal to 18·3 cubic metres per 1,000 kilogrammes of coal); the economy of coal would have been still greater had the Machinery been less overworked, as similar Machinery at Aden and Alexandria has yielded over 20 tons of water per 1 ton of coal for 20 cubic metres per 1,000 kilogrammes of coal).

In the above trial, the productive power and consumption of coal were ascertained as follows:—The Machinery having been fairly started, the coals were renewed from the furnaces, and the cleaning was continued under inspection, with weighed coals. After 19 hours' working, the unconsumed coals were removed from the furnaces and weighed, and their weight was deducted from the quantity of weighed coals put into the furnaces, the difference being taken as the weight consumed. The Fresh Water produced from the Sea Water was collected in an iron tank, and carefully measured. The results were as above stated.

Opinion of DON JOSE ROLER Y SANCHEZ

I hereby certify that having analysed this day (January 4, 1853) a sample of water which sample was delivered to me by the Engineer Attaché to the Royal Commission of Machinery at Amsterdam, the said sample being drawn according to his declaration from Mr. NORMANDY'S Distilling Machine

This sample of fresh water was found to be as follows:—

marked with the letters J.C.R., the result being as follows:—

1st. Its specific gravity at 60° Fah. is 1·000.

2nd. A litre of water contains 0·0 grammes of mineral matter.

3rd. Does not contain any foreign organic matter.

4th. Contains 17·64 c.c. of air per litre of water.

5th. Does not possess any taste whatever.

6th. Is clear, without colour, limpid, and transparent.

Therefore, by its chemical and physical qualities, it is to be considered as perfectly pure and wholesome.

And in order that the interested party may have the certificate of the present analysis, I have thought proper to sign the present, attaching my signature thereto.

Report of Dr. NOAD, F.R.S.

I find the water to be *decidedly free from organic matter*, which will favour and assist digestion, acknowledged to be a preliminary cause of disease, it is quite bright, colourless, and tasteless, and with a small percentage of saline matter, chiefly in the form of chlorides, will render it an agreeable and wholesome drinking water.

From a sanitary point of view, I consider the water to be quite equal, and, in fact, superior to that obtained from the purest natural sources, it is therefore well suited for all domestic purposes.

HENRY M. NOAD, PH.D., F.R.S.

Professor of Chemistry in the Medical School of St. George's Hospital, London.

Report of Dr. LETHEBY, M.B., M.A.

The sample was colourless and well aerated, and it was agreeable to the palate. It contained a very small proportion of saline matter, which is viewed as an advantage as to drinking water. The quality of the water in that respect is about the best I have met with. For domestic purposes, the proper aeration of the water is of importance. I am of opinion, from the results of my examination, that the water is very well adapted for all domestic purposes.

Dr. LETHEBY, M.B., M.A., &c.

Professor of Chemistry to the Medical School of the London Hospital and Medical Officer of Health for the City of London.

KEW-YORK, 10 OAVS, 1853.

I, the undersigned, Master of Mariner, Decorated with the Order of the Franciscan Knighthood, and renowned possessor of COMPANY'S MEDAL, do hereby certify that after an examination of the water of the Distilling Machinery of Mr. NORMANDY, I find that after all examination of the water is perfectly pure, and free from all foreign substance to me to be of any other unpleasant flavour. I therefore consider it a most valuable invention for the use of Machinery, of domestic purposes.

In confirmation of which I have delivered the present certificate.

Doctor OSCAR HEYFELDER
Councillor of State.

All sizes supplied, producing from 100 to 15,000 gallons of water per 24 hours, and yielding up to 20 tons, or 3,480 gallons of water per 1 ton of Coal consumed.

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NOTES AND REMARKS.

The price of the Treble Distilling Arrangement exceeds that of the Double, and that of the Double exceeds that of the Single Distilling Arrangement, but this *extra first cost is soon repaid by the great saving of Coal.*

Applications for Prices and further particulars should state size, kind of arrangement preferred, and whether required to convert sea water into cold fresh water for drinking, for a Land station, or on board Ship, or whether to produce hot or cold fresh water for feeding Locomotive boilers, or other manufacturing purposes, such as for Saltpetre Refining, Dyeing Works, brightening colours for Calico Printing, &c.

This Machinery will force the Fresh Water produced to *any distance* and to a height of 20 yards (or metres) or more if desired, and it may be placed at any convenient distance from the sea, but the surface on which it stands should not be more than 8 yards (or 7.2 metres) above the sea level, which would necessitate special arrangements according to circumstances.

The attendance of *one man* will suffice to work one or more sets of this Machinery, provided that the total quantity of Fresh Water produced per 24 hours does not exceed 8000 gallons if Single Distilling, 16000 gallons if Double Distilling, or 20000 gallons if Treble Distilling.

Full instructions for putting together and working will be supplied with the Machinery, and, if desired, special arrangements may be made for the Machinery to be supplied and erected abroad, *and also worked for an agreed time, the consumption of coal, and the quantity and quality of the Fresh Water produced being guaranteed.*

Note A.

Each of these *Complete sets of Machinery* includes one of Normandy's Improved Patent Condensers with Filter, suitable Cornish or Lancashire (double flue Cornish) Steam Boiler, and Steam Pumps for supplying sea water to the Condenser, and Boiler, and for *forcing the Fresh Water produced to any distance, and to a height of 40 yards (or metres) or more if desired.* Also *all connecting parts and pipe in between above, the whole being arranged in a suitable place, ready for joining together on a level surface abroad.* It also includes Iron Chimneys for the Boilers, complete with guy chains, 40 yards of Suction Pipe from sea to machinery, 20 yards of Waste Sea Water Pipe, and 40 yards of Fresh Water Delivery Pipe. Also a quantity of useful Stores and Tools, such as grate bars, stoking and cleaning tools, spanners for tightening up bolt cans, gauge glasses and sundry useful stores, so that the whole may be ready to set to work, and kept in order without delay or difficulty. The surface on which the Machinery stands should not be more than 8 yards (or 7.2 metres) above the sea level.

The Condensing Tubes are of Solid Brass, tinned inside and outside. The Pumps are of strong and simple construction, and easily adjustable to compensate for wear. The Water is drawn and forced by Plungers moving through Stuffing Boxes, easily packed and kept tight by an *ordinary* gland, thus avoiding the troublesome and difficultly repaired leathers, which so frequently stop other kinds of Pumps. They *work at a moderate speed*, so as to avoid the excessive wear and knocking about of the valves and other parts, always resulting from quick speeds. They have Fly Wheels, and have all valves, bearings, plungers and working parts in contact with water, made of *Brass or Copper. Wrought iron crank shafts, cast Steel piston rods.* The *Boilers* have furnace plates of *Low Moulton Iron bars*, and have dampers, Bourdon's pressure gauge, safety valves, fusible safety plugs in crowns of furnaces, *and all necessary fittings.* They are proved to double the working pressure, and the working pressure is from ½ to ¼ of the bursting pressure.

Note B.

Each of these complete sets of Machinery includes the same as described under Note A, but the Boilers included take up less room, and do not require setting in brick work, being of the Vertical, or Return Flue type, and of simple construction so as to prevent difficulty in Cleaning and working; they are however not so economical of coal, and Pumps as described in Note A are generally preferable, especially for the larger sizes, as they are the most economical of coal, and easiest to clean, and keep in good working order, and are easily fixed in brick work, concrete, cement, stone, &c.

Note C.

Tanks for containing the Fresh Water produced are supplied at extra. They are best made of Galvanized Iron, fitted with drawing off cocks complete. It is convenient to have tanks large enough to contain at least the produce per 24 hours, as per list on opposite page. For convenience of shipping, large sizes are made of flat or curved plates, easily bolted together abroad.

Extra length of Sea Water Suction Pipe, Waste Sea Water Pipe, and Fresh Water Delivery Pipe, including bends and joints to suit vessels or premises, are supplied at per yard as required.

Iron Tanks, Galvanized and Iron columns for containing the Machinery for Land Settings are also supplied at extra prices if required.

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Some of the LAND STATIONS supplied with various kinds of NORMANDY'S PATENT DISTILLING MACHINERY—

Aden, Red Sea	Gibraltar	Ismalia (Egyptian War)
Flushing, Holland	Alicante	Island of Ascension
Abyssinian Expedition	Peru	Krasnovodsk, Caspian Sea
Malta	Chili	Galapagos Islands
Cape Coast Castle	Australia	China Hospital Ships
West Coast of South America	Brighton	Heligoland
Iquique	Packam & Co., Croydon	Fort Moultrie
St. Vincent, Cape Verds	Red Sea Lighthouses	Pure Water Co., London

Some of the above produce 20 tons, or 4,500 gallons, of good cold drinking water from Sea Water per ton of coal.

Some of the SHIPS supplied with NORMANDY'S PATENT DISTILLING MACHINERY

BRITISH GOVERNMENT.

H.M.S. Nelson
" Victor Emanuel
" Flying Fish
" Iron Duke
" Lord Warden
" Lord Clyde
" Charlewitch
" Crocodile
" Euphrates
" Audacious
" Vanguard
" Swiftsure
" Encounter
" Invincible
" Magicienne
" Assistance
" Curacoa
" Cleopatra
" Concorde
" Inflexible
" Diamond
" Agincourt
" Shrapnel
" Sphinx
" Cyclops
" Bellx Isle
" Tryon
" Himalaya
" Sapphire
" Pioneer
" Rover
" Fury
" Lily
" Arab
" Investigator
" Hydra
" Hymalaya

H.M.S. Fairfield
" Costelle
" Cygnet
" Darien
" Sapho
" Pegasus
" Dragon
" Albatross
" Mosquito
" Amethyst
" Shah
" Favorite
" Eclipse
" Dromedary
" Boadicea
" Bacchante
" Raleigh
" Cormorant
" Calypso
" Leander
" Aretheusa
" Phaeton
" Ariel
" Zephyr
" Kestrel
" Ruthenan
" Druid
" Seraphis
" Jumna
" Dasher
" Anchusa
" Caroline
" Inflexible

H.M.S. Malabar
" Hydra
" Iphigenia
" Hotspur
" Seiren
" Volage
" Active
" Hecate
" Mosquito
" Dee
" Champion
" Hebrus
" Hyacinth
" Lark
" Thalia
" Hannibal
" Orlando
" Druid
" Mantis
" Triumph
" Wolverine
" Comus
" Glatton
" Triumph
" Magnificent
" Monarch
" Neptune
" Devastation
" Temeraire
" Sultan
" Alexandra
" Northumberland
" Superb
" Agamemnon
" Warrior
" Black Prince
" Valiant
" Minotaur
" Achilles
" Bellerophon

H.M.S. Perseus
" Iris
" Griffin
" Falcon
" Firebrand
" Pigmy
" Cadmus
" Mutine
" Sylvia
" Stork
" Raven
" Hebrus
" Pike
" Forester
" Wasp
" Fantome
" Forward
" Encounter
" Melita
" Medway
" Spey
" Gay
" Tyne
" Orontes
" Magicienne
" Salamis
" Sphinx
" Coquette
" Penelope
" Volage
" Rover
" Galatea
" Amethyst
" Euryalus
" Shannon
" Nile
" Trafalgar
" Northampton
" Sultan
" Monarch
" Hercules
" Conqueror
" Alexandra
" Temeraire
" Inflexible
" Agincourt
" Minotaur
" Achilles
" Bellerophon

H.M.S. Hotspur
" Mallard
" Gannet
" Onyx
" Cockchafer
" Sea Horse
" Cormorant
" Canada
" Bacchante
" Nimrod
" Alderney
" Kingfisher
" Constance
" Guadiana
" Blanche
" Wanderer
" Wasp
" Egeria
" Lapwing
" Arrow
" Mosquito
" Bittern
" Cygnet
" Wolverine
" Cockchafer
" Snipe
" Lapwing
" Flamingo
" Flying Fish
" Gannet
" Pylades
" Mariner
" Rocket
" Wanderer
" Constance

GERMAN GOVERNMENT.

H.M.S. Konig Wilhelm
" Erin Prinz
" Kaiser

R.M.S. Augusta
" Medusa
" Victoria

H.M.S. Albatross
" Nymphe
" Cumberland

H.M.S. Loreley
" Thetis

CHILIAN, DANISH, BRAZILIAN, PORTUGUESE, ARGENTINE, TURKISH, SPANISH AND JAPAN GOVERNMENTS.

H.M.S. Foo-so
" Kosso
" Hiyei
" Foyen

H.M.S. Independencia
" Ramon de Florenzal
" Almirante Cochrane
" Almirante Brown

H.M.S. Flamenco
" Sandoval
" Monte Zaurel
" Neversund

H.M.S. Florencia
" Tucopel
" Mendaro
" Lucie

H.M.S. Gratera
" Velasco

ROYAL MAIL STEAM PACKET COMPANY.

S.S. Montevideo
" Arrato
" Neva
" Tagus

S.S. Nile
" Boyne
" Shannon
" Fox

S.S. Pilcomayo
" Servia
" Dasher
" Eden

S.S. La Plata
" Tasmanian
" Oronsay

S.S. Elbe

ALLAN LINE of ROYAL MAIL STEAMERS.

S.S. St. Andrew
" St. George
" St. David
" Germany

S.S. Parisian
" Hibernian
" Polynesian

S.S. Norway
" Newfoundland
" Circassian
" Peruvian

S.S. Scandinavian
" Sweden
" Sardinian
" Nova Scotian

S.S. Assyrian
" Austrian

MESSRS. R. & H. GREEN.

S.S. Sirius
" Victoria
" Shannon

S.S. Melbourne
Malabar
Roxburgh Castle

Carlisle Castle
Newcastle
Clarence

Alnwick Castle
Abbotsford
Windsor Castle

Rio de Janeiro
Kilda

BELONGING TO VARIOUS GOVERNMENTS AND SHIP OWNERS.

S.S. Tourmaline
" Hampton
" Harrington
" Wyvelton
" Durham
" Macgregor
" Bothnia
" Benella
" Kingston
" Seaman
" Malabar
" Mahsud
" Sphinx
" Dacca
" Eureka

S.S. Pavonia
" Panama
" Royal Dane
" Caledonia
" Nepaul
" Rath Fawcett
" Servia
" Lena
" Rhine
" Friesland
" Deptford
" Royal Welsh
" Black Watch
" Chesapeake
" Oregon

S.S. Sarmatian
" Zulu Kaffir
" Arabia

Indus
Benjamin Guest
Light Brigade
Eastern Empire
Southern Ocean
City of Melbourne
Minerva
Southern Cross
Rising Light
Rosamond

Young Australia
Lightning
Prince of Wales
Blue Jacket
Sir Robert Sale
Lansborough
Montmorency
Himalaya
Burlington
Caroline Cowley
Jane
Marlborough
Matilda Attwood
Australien
Wambaroo

Whiteley
Kent
Wilmington
Hortensius
Atlanta
Abigail
Conway
Sarah Sands
Sunrise Morning
Orissa
Hesperus
Mermaid
Wizard
Tyrone
Lancaster

Kendal
Canterbury
Gosforth
Avon
Clive
Siam
Belvedere
Wrenfell
Christopher
Thomas
Powell
China
Xenia
Dunbar Castle
Thames

All sizes supplied, and guaranteed to produce from sea water from 100 to 15,000 gallons of best cold drinking water per 24 hours, and yielding up to 30 tons, or 4,500 gallons of water per 1 ton of Coal consumed, with the larger sizes.

See Condenser List No. 3 for particulars of Condensers for Steamships, Yachts, and Torpedo Boats, for working with Cooling Water from Main Injection, Jacket Water, or Hot Well, and also for fresh water for keeping up the full supply of fresh water in Boiler Boilers, most perfect and economizing Boilers.

See Condenser List No. 4 for particulars of Single Injection Condensers for producing good cold drinking water from Sea Water, when worked with Steam from Boilers fed only with Sea Water, these Condensers are less economical of coal,

1473 284 Fl 77

Normandy's Patent Marine Aerated
Fresh Water Co. Ltd
Custom House Station, Victoria Docks,
London, 21st February 1884.
E

Sir,

With reference to Col. J. Mullens' letter to you dated Bangalore 17th Jan 1884, which you were good enough to show me, respecting the water supply at Bangalore, I beg to observe as follows:-

Filtration will not make very foul water reasonably wholesome, and though filters may at first somewhat improve the quality of such impure water, they very soon lose this power, and get out of order.

Such impure water as Col. Mullins describes may, however, be converted into good and agreeable drinking water by distillation with apparatus such as we have supplied for Aden and other places, and which are very economical of fuel.

Ordinary distillation converts salt water into fresh water, but such fresh water is heavy and unwholesome, as well as unpleasant to drink, owing to want of proper aeration, and to its being tainted by an extremely small quantity of a very offensive oil.

If

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1473

287 8/282

Normandy's Patent Marine Aerated Fresh Water Co. Ltd
Custom House Station, Victoria Docks,
London, March 1st 1884.
E.

Genl Hyde,
India Office,
Westminster. SW.

Sir

In reply to your letter of the 29th ults, - as the prepared animal charcoal is not acted upon itself, but acts as explained in paragraph 7 of our letter of the 21st ulto; it does not require renewing for very many years.

What does occur is as follows:- when the machinery is first started, more or less rusty water is produced (for a few minutes) this should be run off so as not to pass into the filter. A little rust, however, always finds its way in, and in the course of about a year may accumulate in the upper 2" thick layer of charcoal, this should then be scraped off, and thrown away, and the rest of the charcoal should be removed from the filter to lighten it (it is apt to become dense by the constant flow of water through it) it is then simply

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simply replaced in the filter.

Your obedient Servant,

For Normandy's Patent Marine
aerated Fresh Water Co. Ld.

(Sd) A. Normandy

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1473

No. 625
5554.

From The Commissary General.

To The Inspector General of Railway Stores
India Office,
Westminster. S.W.

Commissary General's Office,
Bombay 28th August 1883.

Sir,

With reference to your letter of 3rd inst, I have the honour to inform you that the 2 new Condensers were tried at Aden in June last with the following results

The 6000 gallons condenser was worked for 24 hours and the water produced during that period was 7,082 gallons with the expenditure of 1½ ton of coal which gives an outturn of 21 lbs of water to every pound of coal consumed.

The 9000 gallons condenser was worked for 24 hours and the water produced during that period was 12,110 gallons with the expenditure of 2 tons 11 Cwts of coal which also gives 21 lbs 3 ozs of water to every pound of coal consumed.

2 I

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2. I beg to append a copy of the statement showing the results of the working of these new condensers used with these filters from which it will be observed that the result is very satisfactory.

I am Sir
Your obedient Servant
(sd)
Asst Col
Acting Commissary General

Appendix 26A

Standards of Impurity of Waters

	Pure and wholesome waters yields on analysis figures which do not exceed the following limits	Usable waters gives figures which do not exceed the foll^{g} limits	Suspicious waters gives figures which do not exceed the foll^{g} limits.	Bad waters gives figures which exceed the foll^{g} limits.
Total solids .. Grms. per litre	0.114	0.428	0.714	0.714
Volatile solids do do	0.014	0.043	0.071	0.071
Chlorine do do	0.014	0.143	0.086	0.086
Total hardness .. Clark's scale	—	—	—	—
Permanent hardness do do	2°	4°	6°	6°
Free ammonia .. Mlgrms. per litre	0.02	0.05	0.1	0.1
Albumenoid ammonia do do	0.08	0.1	0.15	0.15
Nitric acid do do	—	—	—	—

Enclosure of D.O. from Chemist Examiner to Col R.H. Lanken R.E.
dated 26 May 1883

1883

Appendix 26 B

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Analysis of Samples of Water received from the Engr in charge of Idaroo Water Works with his letter 8/9th May 1888

	1 Sample of water taken direct from the Idaroo Tank	2 Sample of water taken direct after passing through the filter bed.	3 Sample of water taken direct from the Khaja Mullo.
Total Solids: Grms. per litre	0·27	0·26	0·23
Volatile solids - do — do	0·12	0·06	0·09
chlorine - - - do - do	0·081	0·078	0·053
Total hardness - Clark's scale	3°·5	2°·8	3°·86
Permanent hardness	2°·45	1°·78	3°·15
Free ammonia - Milgms per litre	0·4	0·48	0·08
Albumenoid ammonia do — do	0·66	0·48	0·8
Nitric acid - - - - do — do	3·0	3·0	~~3·3~~
Apparent quality of the water as inferred from the results obtained on examination.	Bad	Bad	Bad.

Remark- No 1. Deposit abundant and composed of vegetable debris

" 2 Deposit scanty and composed of vegetable debris and argillaceous matter

" 3 Deposit scanty and composed of vegetable debris

All three samples contain a very large amount of Organic impurity.

(True copy)
(Sgd) T. K. Rogers. M.B. F.R.C.S
Chemical Examiner

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Mercara
24th May 1888

Appendix 26.C.

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KB.

No. 1 to 4 from below bund of new (Opparkalli) Reservoir

	No. 1 Spring Water below Sappers well	No. 2 Bholies well	No. 3 Sappers well	No. 4 Spring direct below Bund in Centre of Valley	No. 5 Millers No. 4 Reservoir
Total Solids .. Grms. per litre	0·3	0·15	0·19	0·32	0·25
Volatile Solids " do - do	0·11	0·08	0·08	0·10	0·08
Chlorine do - do	0·028	0·22	0·21	0·019	0·039
Total hardness " " Clark's scale	5°·95	2°·45	1°·75	4°·7	3°·15
Permanent hardness " " do do	3°·5	1°·75	1°·05	1°·4	1°·75
Free ammonia " Milgrms. per litre.	0·16	0·08	0·06	0·88	0·2
Albumenoid ammonia . do do	0·120	0·592	0·16	0·24	0·4
Nitric Acid . . . . do do as ammonia	1·950	1·950	1·8	2·4	2·1
Apparent quality of the samples as inferred from the results obtained on examination	Usable	Bad	Usable	Bad	Usable.

These waters have been previously analysed and the results reported in the office docket No. 1630 of 13th June 83, addressed to the Dy. Asst. Dr. Master General Bangalore, from whom the samples appeared to have been received.

To

The Chemical Examiner to Government Bangalore Division, Mysore 5th W

with Docket from Chemical Examiner to Government No. 1109 dated 20 July 1883

1973

N.B. Nos 1 to 4 from below bund of new (opposite) Reservoir

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	No 1 Spring Water below Sappers well	No 2 Kholies Well	No 3 Sappers Well	No 4 Spring direct below Bund in Centre of Valley	No 5 Miles No 4 Reservoir
Total Solids .. Grms. per litre	0·3	0·15	0·19	0·32	0·26
Volatile solids " do - do	0·11	0·08	0·08	0·10	0·08
Chlorine . do - do	0·028	0·22	0·21	0·019	0·039
Total hardness " " Clark's scale	5°.95	2°.45	1°.75	7°.7	3°.15
Permanent hardness " ... do do	3°.5	1°.75	1°.05	1°.4	1°.75
Free ammonia " In grms. per litre.	0·16	0·08	0·06	0·88	0·2
Albumenoid ammonia . do do	0·120	0·592	0·16	0·24	0·4
Nitric Acid . . . . do do as ammonia	1·950	1·950	1·8	2·4	2·1
Apparent quality of the samples as inferred from the results obtained on examination	Usable	Bad	Usable	Bad	Usable.

These waters have been previously analysed and the results reported in the office docket No 1030 of 13th June 83, addressed to the Dy. Asst. Dr Master General Bangalore, from whom the samples appeared to have been received.

1973

With Docket from Chemical Examiner to Executive Engineer Bangalore Division, Mysore D.P.W.
No. 1109 dated 20 July 83

N.B. Nos 1 to 4 from below bund of new (Opparkatti) Reservoir

Appendix 26.C.

87

	No 1 Spring Water below Sappers well	No 2 Mobile Lines	No 3 Sappers Wells	No 4 Spring direct below Bund in Centre of Valley	No 5 Miles No 4 Reservoir.
Total Solids .. Grms. per litre	0·3	0·15	0·19	0·32	0·25
Volatile Solids " do - do	0·11	0·18	0·08	0·10	0·08
Chlorine " do - do	0·028	0·22	0·21	0·019	0·039
Total hardness " " " Clark's scale	5°.95	2°.45	1°.75	7°.7	3°.15
Permanent hardness " ... do " do	3°.5	1°.75	1°.05	1°.4	1°.75
Free ammonia " Milligrms. per litre.	0·16	0·08	0·06	0·88	0·2
Albumenoid ammonia " do " do	0·120	0·592	0·16	0·24	0·4
Nitric Acid do do as ammonia	1·950	1·950	1·8	2·4	2·1
Apparent quality of the samples as inferred from the results obtained on examination	Potable	Bad	Potable	Bad	Potable

These waters have been previously analysed and the results reported in the office docket No 1050 of 13th June 03, addressed Sthe Sy. Asst. Dr Master General Bangalore, from whom the samples appeared to have been received.

E3

E 975

with Docket from Chemical Examiner to Executive Engineer Bangalore Division, Mysore D.P.W
No. 1109 dated 20 July 1903

Appendix 28.D. 88

	Ogram Tank water	
Total solids .. Grms. per litre	0.58	
Volatile solids .. do. do.	0.10	
Chlorine .. do. do.	0.043	
Total hardness .. .. .. Clark's scale	10.2	
Permanent hardness .. .. do. do.	10.78	
Free ammonia .. Mlgrms. per litre	0.12	
Albuminoid ammonia do. do.	0.16	
Nitric acid do. do. .. .. (as Ammonia)	3.0	
Apparent quality of the water as inferred from the results obtained on examination.	Usable	

Remarks

An abundant deposit; composed chiefly of vegetable debris.

1884

From

THE CHEMICAL EXAMINER,

Madras,

No. 1674

Dated 5th March 1884

Received

ENCLOSURES.

To

THE Col. J. Bruttin R.E.
Chief Engineer on Special duty
Bangalore

REFERENCE.

Your Letter No. 86 dated
27th January 1884

SUBJECT.

Has the honour to
supply Analysis of a sample
of water as requested.

J K Rogers M.B., F.R.C.S., F.I.C.
Chemical Examiner.

Ref 7/3/84

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| | | |

Appendix 26.F.

Analysis of waters in accordance with D.M.S. Surgeon General's Memo No. 230/E of 14th March 1884

Source and Date of Supply	Physical Characters	Qualitative Tests			Quantitative Chemical Tests		Total residue in water	Chlorine per gallon.	Remarks.
		Nitrous acid	Sulphuretted hydrogen	Ammonia and its salts	Total Organic	Fixed			
No 2 well water to South of Cavalry Hospital 12-3-84	A transparent water without sediment acid or basic.	nil	nil	nil	2·80	·94	·8	1·24	Potable water
West Side of Agaram Tank — No 1 well water 12-3-84	do do	nil	nil	Appreciable	19·54·8		2·80	29·26	According to the extent of present analysis these waters come under the Hygienic subdivision of "Impure"
No 2 well water 12-3-84	Slight sediment	nil	nil	Appreciable	11·20·2		1·6	6·94	
No 3 well water 12-3-84	No sediment	nil	nil	Traces	10·86·9		1·4	4·96	
No 4 well water 12-3-84	No sediment	Nil	Nil	Traces	9·90	6·2	1·	4·21	

Bangalore
17th March 1884

[illegible]
Brigade Surgeon
Supt. North Kanara Hosp.

A. Jno. Laughlin M.B.
Surgeon A.M.D.
Asst. Surgeon A.M.D.

Appendix No. 26

Water Analyses.

Appendix 27. 233 Explanatory memorandum regarding the levels connected with Bangalore water supply investigations. 1473

There are at Bangalore 3 sets of levels referred to mean sea level the one based upon the [illegible] levels and their connection

[illegible] the G.T.S. near on the are determined The first Return of De Havilland's

[illegible] ary levels connection with the Observed 5·40 for pending [illegible] cal Survey upon the [illegible] and [illegible] to above [illegible] the remarks

5·74 by the correction of De Havilland's Bench mark.

1473

1473

Qualitative Analysis of Water. Appendix No. 26 G

| Remarks | | |

Appendix No. 26

Water Analyses.

Appendix 27.

Explanatory memorandum regarding the levels connected with Bangalore water supply investigations.

There are at Bangalore 3 sets of levels referred to mean sea level the one based upon the Madras Railway levels and their connection with the De Hamilton's bench mark at Fort St. George, the second on the G.T.S. levels brought up from Karwar on the West coast, while the third were determined Trigonometrically from Madras. The first and third each need an addition of 1 foot for the corrected level of De Hamilton's Bench mark.

Apart from this the Madras Railway levels were called Blue 0·00 and the Trigonometrically determined levels 4·40 higher than the Spirit levelling from Karwar. The revised differences would be 0·00 and 5·40 respectively. On sheet No 42 of the Topographical Survey issued in 1881 the difference between the G. T. S. Spirit levelling from Karwar and the Trigonometrical determination is shown Blue 4·74 which would apparently remain 5·74 by the correction of De Hamilton's Bench mark.

Memo of G. T. S. Bench marks Copy appended.

2. The value of the crest of the waste weir of the Halevr Lower Tank has been taken blue 2929.97 above mean sea level at Karwar, as noted on a Survey of the upper tank dated 22 November 1889, and signed F. J. Romilly Lt R.E. Asst Engineer. That this value is referred to Karwar is indicated by a list of levels dated 27-6-77, by Mercer Patten, the reduction of which to that datum is given and afterwards the above value for the waste weir. That it is about right has been proved by the connections made with the G.T.S. B.M. on the step of the Gunta at Subedar's chattrum, the value of which is 2996.29. As the Halevr waste weir crest is irregular, it has been thought best to take the Zero of the gauge opposite the Engine house as F.T.L. corresponding to the reduced level 2929.97 above mentioned, and at 3 M. 1495 feet above that Zero has been cut on the offset at base of the South west of the engine house. The value of this B.M. is therefore 2946.92.

3. The waste weirs of the Bangalore water supply reservoir (Coparkatti) are respectively 104.00 feet above the Halevr Tank sills.

* Office record Executive Engineer Residency Division

The least weir is slightly (0.10) the higher of the two.

4. Their values as deduced from connection with the Subedar's Chattram G.T.S. Bench Mark, and by adding 104 to the Halevr waste weir value are

2996.29+37.55 = 3033.84 Most weir } 2929.97+104.00=3033.97
2996.29+37.45 = 3033.74 least weir }

4. The following levels have been taken by Mr Simmons, Surveyor, and will be found in the same order in his Level book, which is indexed.

1. Levels round a contour of a small hill S by W of Subedar's chattram: Intelocks
2. Levels from the least waste weir of the Bangalore Water Supply (Coparkatti) reservoir B.M. 7 miles on the Yelabanka road.
3. Levels from the above point round the hill to the West.
4. Levels from same point to Yelabanka Tank.
5. Levels from a point 0.123 of the contour in No 3, round Bettahalli hill.
6. Levels from a point 0.47 on this contour in No 5, to Subedar's chattram.

With regard to the series of levels —

Jobs

Nos 2 & 6, the first point made was the man tapam on the hill b the north of the weir. There is a recorded G.T.S. value 3116.90 for the floor, but no B.M. being distinguishable, it is uncertain whether Mr Simmons levels are b the same point.
Its value is 311[illegible]6 or just 0.76 difference.
At the Yelahanka Tank the Topographical Survey shows a value 2940 but no B.M. could be traced. These values are shown, by a foot note on the Survey, to require a reduction of 4.74 feet & refer them to M. S. L. Karwar. Consequently the reduced value would be 2935.26. Mr Simmons level of the waste weir at the South end of the Tank is 2939.75.
On closing at Subedars Choultrie the apparent error was 4.37 feet, which is reduced by the connected level of the Reservoir East weir, his starting point, B 4.166.
For the purpose for which the levels were taken, viz b see what ground, on a sufficiently high level b drain into the Reservoir, could be found, they

they are sufficiently accurate.
There are three Field books connected with Mr Simmons' levels—
The rest of the levelling work has been done by Mr Andrews, Surveyor. The levels are in 2 books and the Survey thereunto connected in 3 Field books.
The following is the order in which the levels are recorded in the books.
Book A.
1. Levels from Millers Tank No 1 & Halsur (Lower) Tank weir.
2. Levels between Halsur (Lower) Tank weir and the B.M. on Rock b engine House; between this last and the zero of Tank gauge, and between the latter and crest of upper tank weir.
3. Levels from Halsur lower tank for a supply channel b the Eastward with check levels between 3rd and 5th mile stones of road.
4. Levels from the end of Contour for channel up watershed Northwards, and then along watershed westwards & junction with Eastern watershed of Halsur Tanks.
5 Levels along Northern watershed of Halsur Tanks
6 Levels of Millers Tanks Nos 1 & 4.

Levels

Levels from South Station Hospital along
watercourse to Southward or watershed of
valley, and to Afaraan Tank waste weir.
Levels across the greater breadth of the Factory
or Eastern Supply channel — Malay Tank
Contour levels of the Afaraan Tank & the
levels of wells &c near there to.
10 Levels from Subedars chattrum Northward
along the watershed between the Pinatini
and Arkanattie rivers.
Book B.
11. Continuation of do.
12 Levels from Melakote tank to B. M.
on the above No 11.
13 Check levels from Afaraan Tank to the
B.M. on South Station Hospital.
14 Cross sections of Afaraan Tank bund
15 Check levels from South Station
Hospital to Halaur Tank and back
to Hospital.
16. Check levels from B.M. at Subedars
chattrum to West and East waste weirs
of the Ooparhalli Reservoir, and thence
to P.W.D. B.M. to opposite Railway station
6. The levels of the 1st set are wrong. They make
the weir of Miller's No 1 Tank Rise 69.58 feet

by set 6 the bund of the former weir is
27.31 feet below the P.W.D. bench mark to
opposite the Cantonment Railway Station
the resulting reduced value would be
96.89+(2929.97−3.09) = 96.89+2926.88=3023.77
the G.T.S. value of the B.M. is 3021.30
Difference 2.47
In the hypothetical the value of Miller's
No 1 Tank weir is 65.21+2929.97 = 2995.18
adding 27.31 the P.W.D. B.M. is 3023.09
or 0.81 larger than the G.T.S. value
It may therefore be concluded that Miller's
No 1 Tank weir is 3021.30−27.31=2993.99
and that No 1 set of levels is valueless
In the levels, set 16, which connect the
G.T.S. Bench mark at Subedars chattrum
with the weirs of the new (Ooparhalli) tanks
and the P.W.D. B.M. No 10, the value of the latter
is shown as 3020.68
or 0.62 lower than the G.T.S. value of the
B.M. This confirms the general correctness
of the levels. The levels of the weirs have
already been reduced 8 in para 3 above.
7 Nos 7 & 8 need no explanation
The value of the Zero of the Halaur Lower Tank
gauge is 2929.97
and that of the B.M. on the Rock opposite house 2941.92

8. The levels of No 3 set have been checked in two ways 1st by a line between the 3rd & 4th mile stones of the road and 2nd by a junction line along the East water shed of the Halasur Tanks to the upper tank weir.

The channel contour levels R.B.M. on the 5th mile stone made the value of the latter —

2948.18

Her check levels — do —

2948.73.

a difference of 0.55 feet which in nearly 9 miles is unimportant.

The continuation to Halasur upper tank weir showed a difference if any — 0.8 feet, the start being from the higher value of the 5th mile stone above given. The 11 sets are included in the above.

9. In the 5th set the levels ended at the Mantapam near the G.T.S. Base line station (Book page 33) with a value of —

238.74

or R.L.

3118.71

The G.T.S. value of the floor of the Mantapam is

3116.90

Difference 1.81

There is no G.T. Bench mark discernable on the floor so it is doubtful whether the

65.21
50.00
18.21
2929.97
2948.18.

238.74
50.00
188.74
2929.97
3118.71.

1473

levels are to the same point the error if it be an error is not of importance as all the material levels have been determined.

10. The 6th set of levels are not needed in connection with any of the proposals for the supply of Bangalore

The main pipe line to Tank is as

(1) Engine centre to Tank — 2994.00

(2) do — to 2nd Tank — 2991.35

(3) do — to 3 Tank — to main

(4) do — to 4 — do (closed) 2975.59.

do — to 5 — do

11. The 7th set of levels make the difference between the B.M. on the South Corner of Cavalry part of South Station Hospital and the mean weir of Agrahara Tank 77.13 feet.

2948.85 — 2871.72.

The check levels, set 13, make this difference 77.30 feet.

2949.02 — 2871.72.

& Set 15

The check levels from South Station Hospital to Halasur Tank weir B.M. show the difference of level to be 20.52 feet or to Zero of gauge 20.43 feet.

2948.85 — 2928.33.

The return levels, from the B.M. on Rock engine house make the difference 20.51 feet

2950.48 — 2929.97.

The B.M. in South Station Hospital was originally taken, by mistake, to be at Lt Romilly's value for the floor of the

Also sets 13+15.

15

Hospital on which however it is not situated, but is 296 feet above the floor. The reduced value of the B.M. on the Hospital is now taken 296.48 and this raises the value of the Aprarn Tank weir B. 2873.35. Lt Romilly's levels for this Hospital floor appear to be wrongly (296.48 − 0.96) − (30.38 − 11.50 + 292.97) = 294.52 − 294.85 = 0.67 but the particular part of the floor referred to in his section is not known.

12. The levels set 8, deal only with detail, and in laying out the channel, the alignment would be made as desired.

13. The levels of set 9 have not been connected or checked. The orders were to contour the tank and connect the two ends by levels along the bund. The water in the tank was but little above Full Tank Level, as the levels were taken on the 30 February, and on the 29 January the water was 0.20 below Full Tank Level, which is taken at 0.10 feet above the lowest part of the crest of the weir, which latter is higher at the ends than in the middle.

14. Levels sets 10 & 11 — The levels along the watershed to Kundidroog, Southern Apron, have not been checked. There are many levels along this line shown on the Topographical Survey, and as Mr Andrews took levels to many stones bearing numbers it was hoped that these were the stones to which the levels shown on the Survey referred.

As far as can be ascertained Mr Andrews' levels have no connection with any of the Topographical levels shown against a Δ, and in only 2 cases does it seem probable that with the latter levels placed against a dot has a connection been made.

These latter are B. M. on stones marked

	Feet	Mr Andrews values	Topographical Survey.
37/85	at 68451	3071.71	3068
43/64	at 89262	3079.16	3083.

and it will be seen that the difference is plus in the one case and minus in the other. The two sets of levels should probably differ by 4.74 feet, vide note at foot of sheet 42 of the Survey.

If the idea of bringing water from Kundidroog should be entertained, check levels will be essential, and there are numerous

memorials B. Ms which will admit of check being effected mile by mile.

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Items of G. T. Survey bench marks at or near Ba
as determined by spirit levelling brought from
approximate sea level at Karwar (N. Canara) in 187
and previously. 1473

		Height in feet above Sea level.
1	Lyall-dinne observatory, 25 yards to the West of the old Mandapam about 2½ miles out, on the Hundidung and Bellary roads; brass (O) mark 5 inches below the stone floor (See G. T. S. of India, Spirit levelled heights at 12 S. 9°).	3113.26
	Note. The linear (O) mark defining the S. W end of the Bangalore base line (measured in 1868) lies 3 feet plumb below this. . . .	
2	Plinth outside door way of alone, north side, about ground level. - - - - - - - - -	3113.63.
3	Floor of the Mandapam on top of the mound	3116.9
4	Lowest step at base of the Chief Commissioners Flag staff (350 yards S. of N. W. of Public Offices) about ground level (A new flag staff has been set up since) - - - - - - - - - -	3042
5	St Andrew's Church, top step of Central entrance under the tower (which is 80 feet high) - - -	3006.42
6	Cistern of barometer 2·8 feet above floor of meteorological room at the (Bowring) Civil Hospital - - - - - - - - - - -	2980·9.
7	Flooring of the covered well under the new market clock tower of 1863 in the Cantonment bazaar (just outside the parapet wall) - - -	2953·5"
8	D. P. W. Bench mark Ste 10 (B.M. / 10) at the (Cantonment) Railway Station, across the road and opposite the central or booking office - -	3021·3.
9	Madras Railway B.M. on Coping Stone at East end of South or arrival platform (Cantonment Station) - - - - - - -	3025·91.

* Karwar sea level at Karwar was determined by a series of observations but is still called "approximate" until the results obtained from the record of a self registering tide gauge have been reduced. This

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Note. The Madras Railway levelled values to last point, as derived by Spirit levels from the B.P.W.B.M. in ditch at S.W. gate of Fort Saint George Madras (giving Col. De Havilands value of mean Sea Level = 3033.97 feet or 8.06 feet higher than above given.

1473

The G.T. Survey preliminary Trignometrical values are 4.4 feet greater than the Spirit levelled heights given above.

(Sgd). B.R. Branfill Lt Col.
Dy. Supt. Survey of India
In charge Madras Party.

Copied from the Papers in the Office of the Executive Engineer, Presidency Division

Bangalore
March 1884

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Appendix No. 27

Explanatory Memorandum on Levels -

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P. W. Department.

Read the following :—

Report on the Bangalore Water Supply by
Col. J. Mallins R.E. Chief Engr on Special duty
dy 31st March 1884.
Note by the Chief Engr Pr. Dept dy 23d May 1884.

FOR ORDERS.

I think that this should be done.
J/6.
I think so too.
J/6.
6/6/84 and Sec

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If the Govt approve my proposal that the Agaram tank scheme should be worked out in preference, I would recommend for that duty Captain Nowell, R.E., an officer in every way qualified. He is at present employed on the B Project Division, but his services could be spared for a few months for this special duty.

V. Manockmont

23-5-84

N.B. The maps accompanying the report are lacking, and have not been sent in circulation

FOR ORDERS.

Please file Letter
with the Completion Report
of Gutti Water Supply Scheme

9 JUN 84

1473
1474

Please draft order
according(ly)

9-6-84

2561 L.W. Supt.

Note by Chief Engineer.

1473

In the complete report
Col. Mullins dispose com-
-chensively of the various matters
referred to him for investigation
in connection with the water
supply of Bangalore.

The results are summed up
para 51 of the report, and may
be briefly stated as follows.

(1) The Coparhalli project
is incapable of supplying the
station or the troops.

(2) The Madras tanks are
not capable of being made a
satisfactory source of supply
for the troops.

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(3) Wells may be sunk which
would yield a small quantity

supply for the troops for drinking and cooking purposes, but the quality of the water must remain doubtful.

(4) The Agaram tank offers a new source of supply of suitable water, having an ample and sufficiently clean catchment basin.

(5) Water of unexceptionable quality is probably obtainable at Bangalore only by distillation.

Allusion is also made in the report to the possibility of supplying Bangalore by gravitation from a reservoir to be constructed near Nundidroog; but the Expense would probably be prohibitive being [illegible]

262 extended at some future day

to the supply.

The conclusions arrived at on these points may without be accepted.

1573

With respect to the Cooper hills project, Col Mathias has apparently not noticed Genl Sankey's proposal to supplement the supply by sinking a line of wells below the bund of the reservoir, by means of which the leakage from the reservoir and the sub soil drainage would be caught and pumped, ~~then~~ to be distributed by gravitation. The suggestion may prove to be of importance with respect to the sub station bund [illegible]

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to the troops, for Colonel Mullins' investigations have placed beyond doubt that the troops could not be properly supplied from the tank and of the Coparkalli source, however enlarged and improved.

The proposed supply of the troops from the Agaram tank, the water from which is reported by the Chemical Examiner to be "usable", is estimated to cost Rs 2,70,000/- if the water is drawn direct from the tank, and Rs 1,50,000/- if water is taken from a well within the influence of the tank. But Rs 13,000/- should be added to the

Last-named sum, Rs 6
~~Last-named sum~~ ^A as enlargement
of the tank is apparently
advocated now if the supply
is pumped from the well.

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These amounts do not
include compensation. It
is not clear whether any
would be necessary.

In the concluding sentence
of para 18, Col Mullins
recommends that the tank
be enlarged even if the water
be taken from a well, "as by
"so doing all question of
"injury to land holders under
the tank would be avoided"
It is likely, however, there are
lands round the border,
which might, in such a case,
be injured, and, raising the

must in printing

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weir 3 feet will affect
the supply of tanks lower
down the valley. So there
is sure to be a cry of injury
in some shape or form,
and demands for compensation.

This source of supply seems
to offer the most promising,
if not the only practicable
solution of the difficult
question of water supply to
the Bangalore garrison,
and I am of opinion that
it would be well to
appoint a qualified officer
for the special duty of
elaborating the scheme in
the necessary detail and of
preparing plans and estimate.
This would of course [illegible]

to be done in communication
with the Mysore Govt.

In paragraph 46 of his
report, Col: Mullins remarks
that, to avoid the expense
and complication of
artificial filtration, "in
"any case it would be
"desirable to have an
"experimental well sunk in
"the bed of the tank to test,
"through the water therefrom
"drains, the character of the
"soil through which the
"water has filtered, and
"its effect upon the potable
"qualities of the supply."
This should be done,
although I greatly doubt
the possibility of [illegible]

all artificial filtration
in the case of the Agaram
tank water.

Chief Engineer, S.W. Dept

Chief Engineer's Note thereon dd May 23rd 1874.

Approved
May 23rd 1874

23-5-74 Colonel R.E.

S.W. Department, Mar Records

No 1473 W

Proceedings of the Madras Government,

Under date the 13th June 1874

1473

Read the following:-

Report on the Bangalore Water Supply by Col. J. Mullins, R.E., Chief Engineer on special duty dd March 31, 1874

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His Excellency the Governor in Council concurs in the opinion that the Agaram tank scheme offers the most promising solution of the question of water supply to the Bangalore garrison, which has been so exhaustively treated in the report by Col. Mullins recorded above.

A qualified officer will therefore be appointed to elaborate the scheme

prepare the required plans and estimate.

3. Capt. Romilly RE., at present employed in the B[illegible] Project Survey, has been recommended by the Chief Engineer for the duty, and he will accordingly be directed by the Secty Govt to proceed to Bangalore as early as practicable, and to take the requisite preliminary arrangements in communication with the officers of the Mysore Government.

The suggestion in para 2 of Col: Mullins' report, for having an experimental well in the tank bed in order to ascertain the character of the soil & its effect upon the potable water of the supply, should receive proper attention

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4. H.E. the Governor in Council desires to place upon record his appreciation of the thorough manner in which Col: Mullins has so ably discharged the duty intrusted to him, forming a fitting termination to his long and arduous labours in the service of the State in this Presidency.

5. The Mysore Government will be furnished with a copy of these Proceedings, and they will be requested to facilitate the proposed inquiry.

By
order of H.E. the Governor in Council
(Sd) [illegible]
Secy to Govt

To
The Secretary to the Chief Engineer for Roads & Buildings

Sir,

I am directed to forward for the information of the Chief Engineer for Roads & Buildings, a copy of a letter from the Resident at Mysore, No. 231 dated 15th October 1853, with its enclosures, on the subject of the proposed inquiry into the causes of the unhealthiness of Bangalore.

I have the honor to be
Sir
Your most obedient Servant
(Sd) [illegible]
Secy to Govt

To
The S.E. V Circle.
" IV " with a copy of Col: Mullins' Report to be forwarded to Capt. Romilly RE. now employed on the B[illegible] Project Survey.
" Military D.[illegible] duplicate for information.
Col: Mullins RE
Engr. P.W. Circle

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CONCERNS BOTH BRITISH INDIA
AND INDIAN STATES.

Govt. of 1884 Madras

PUBLIC WORKS.

(256)

G.O. 13 June 1884. No. 1

Bangalore Water Supply

Orders on Col. J. Mullins' Report on the

Bangalore Water Supply

1. Copy of orders on Lt.-Col. J. Mullins' Report (with its