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TAMIL NADU ARCHIVES

GOVERNMENT OF TAMIL NADU

Public works DEPARTMENT

G.O. No. / B.P. No.	1051 - 3 1052 - 3	Press. / Mis.
Dated	23-4-1881	

S.G.M.

Not to be folded or roughly handled

1051/1

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

23rd April 1881, No. 1,051 W.

Buildings and Roads.
Military Works.

Read the following paper:—

No. 65. From Major H. M. VIBART, R.E., Superintendent of Works, Presidency, to the Chief Engineer, Public Works Department, dated Chepauk, 11th April 1881, No. 149.

With reference to G.O., No. 2,476-A W., dated 27th October 1880, I have the honor to forward copies of three statements submitted by the Assistant Engineer, Bangalore, furnishing information regarding (1) discharges, &c., in the mains of the Ulsoor water works, (2) percentage of rainfall stored to that received on the catchment basin, and (3) evaporation.

2. No calculations have been made regarding the discharges through the pipes and loss of head due to bends in the Seven Wells water works. From experiments which have been made the actual discharge through these pipes has been ascertained to be exactly half the theoretical or estimated discharge.

A.

Calculations of Discharges in the Ulsoor Water Works System.

Preliminaries, data, and formula used.
R = discharge in cubic feet per second.
d = diameter of pipe in feet.
H = head in feet for a length of 100 feet.
S = hydraulic gradient.
C = Co-efficients.

$$R = C \times 39{\cdot}27 \sqrt{S\, d^5} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{I.}$$

$$H = \frac{1}{C^2} \times {\cdot}0648 \frac{R^2}{d^5} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{II.}$$

Tables VIII, parts 1 and 3, and XII, part 3, from Jackson's Hydraulic Manual—

C =	for	10-inch	pipe	1·04,	C^2 = 1·08
=	,,	9	,,	·99	= ·98
=	,,	8	,,	·95	= ·90
=	,,	7	,,	·91	= ·82
=	,,	6	,,	·85	= ·72
=	,,	4	,,	·61	= ·37
=	,,	smaller	,,	·61	= ·37

The main A B C D consists of—

1,797	feet	of	10-inch	piping.
710	,,	of	9	,, ,,
1,377	,,	of	8	,, ,,
1,184	,,	of	7	,, ,,

and discharges into the Agram reservoir at D by an over-hanging jet at B; a branch of 6,477 feet of 6-inch piping discharges into the Infantry Barrack cistern at H.

At C a branch of 660 feet of 4-inch piping discharges into the Royal Horse Artillery cistern at K by an over-hanging jet. The junction C is in the middle of the 8-inch piping, 850 feet from the end of the 9-inch piping; at D the main is carried over the Agram cistern and into the service pipes carried from the cistern, and by this means water is pumped into the iron services cisterns at the European hospitals, this branch being composed as follows:—

313 feet of 7-inch piping.
1,017 „ of 6 „ „
1,441 „ of 2½ „ „ to L.
380 „ of 2 „ „ M.
545 „ of 2 „ „ N.

At L a branch of 1½-inch piping conveys the water into the female hospital cistern, of which there are two, the inlet pipe being 28·50 feet above the floor of the building. The length of the branch is 70 feet horizontal and 32·00 feet vertical, or altogether 102 feet.

At M a branch of 1½-inch piping 30 feet long discharges into the Artillery hospital cisterns at 32·75 feet above the floor level, making the total length of this branch.

At N a similar branch feet long discharges into the Cavalry hospital cistern.

The bends in the mains and piping are as follow:—

At D two vertical bends of 90°.

In the branch B H no vertical bends worth noticing, but four horizontal bends of 84⅓°, 88⅓°, 90°, and 35½°.

In c k one horizontal bend of 116° or say 90° + 26°. Two vertical bends of 90°.

In D L two vertical bends of 90° and horizontal bends of 61½° and 61° in the 7-inch portion; 87°, 88°, and 77° in the 6-inch portion; and 29° and 39° in the 2½-inch portion.

At M and N one horizontal bend of 90° and two vertical bends of 90° in each branch.

The formula used for loss of head due to bends is

$$H^b = \frac{b^2\,(\text{Sin}^2 \text{ and} + \text{Sin}^2 B +}{134}$$

where H^b = head necessary to overcome friction and b = velocity in feet per second found by dividing the discharge by the area of the pipe or from the formula.

$$b = 50\sqrt{\frac{h}{l} \times d}$$

The levels of the different points are given on the section which accompanies.

I.—Suppose the valves opened so that water is pumped into the cistern at D alone.

Total length of main = 5,078 feet.
Fall = 92·10 — 59 = 33·10 „

To approximate to the loss of head due to bends assume an average diameter of 8 inches for the main, then—

$$b = 50\sqrt{\frac{33{\cdot}1}{5{,}078} \times {\cdot}66} = 50\sqrt{{\cdot}0043}$$

= 3·35 feet per second.

Then loss of head due to two vertical bends of 90° is

$$H^b = \frac{3{\cdot}35^2\,(\text{Sin}^2\,90 + \text{Sin}^2\,90)}{134}$$

$$= \frac{11{\cdot}22 \times 2}{134} = 0{\cdot}16$$

∴ working head = 92·10 — (59 + ·16)
= 32·94

To find the discharge and true head on each part of the main composed as stated above assume a discharge of 1 cubic foot per second, obtain the separate heads due to it from Table VIII modified by the co-efficients and divide the actual head in the same proportion.

For 1 cubic foot discharge heads will be—

0·1612 × 17·97 ÷ 1·04² = 2·68 for 10-inch pipe.
0·2731 × 7·10 ÷ ·99² = 1·96 9 „ „
0·4921 × 13·77 ÷ ·95² = 7·52 8 „ „
0·9594 × 11·95 ÷ ·91² = 13·98 7 „ „
26·34

$$\frac{32{\cdot}94}{26{\cdot}34} = 1{\cdot}25$$

Hence true heads on each portion of the main will be—

on 10 inch pipes 2·68 × 1·25 = 3·49
9 „ „ 1·96 × 1·25 = 2·49
8 „ „ 7·52 × 1·25 = 9·44
7 „ „ 13·98 × 1·25 = 17·52
32·94

$$\therefore\ R = \frac{1 \times \sqrt{32{\cdot}94}}{\sqrt{26{\cdot}34}} = \sqrt{1{\cdot}25}$$

= 1·11 cubic feet per second.
= 414·25 gallons per minute.

Also the relative heads along the main above datum will be as follow:—

at stand pipe 92·10
B 3·49 = 88·61
b 2·49 = 86·12
c 9·44 = 76·68
D 17·52 = 59·16

II.—Suppose valves opened so that the cisterns at D and H are being filled simultaneously.

The head available to discharge through the branch B H being 88·61 at B, the fall in the branch is 88·61—78·15=10·48. The total length of the branch being 6,477 feet, the velocity

$$b = 50\sqrt{\frac{10{\cdot}48}{6477} \times {\cdot}5} = 50 \times {\cdot}026$$

= 1·3 feet per ~~1 inch~~ second.

$$\therefore H^b = 1{\cdot}3^2\,\frac{(\text{Sei}^2\,84\tfrac{1}{2} + \text{Sei}^2\,84\tfrac{1}{2} + \text{Sei}^2\,90 + \text{Sei}^2)}{134}$$

$$= 1{\cdot}69\,\frac{({\cdot}98 + {\cdot}98 + 1 + {\cdot}32)}{134}$$

= ·041

∴ Working head = 10·48 — ·04 = 10·44

$$\therefore\ R = 6{\cdot}939\sqrt{\frac{10{\cdot}44}{6477}} \times 0{\cdot}84$$

= 6·939 + ·04 + ·84
= 0·23 C. ft. per second.
= 86·25 galls. per minute.

This leaves 414·25—86·25 = 328 gallons per minute to pass along the main to D, which cannot run full unless 86·25 + 414·25 = 501·5 gallons were delivered at B. The 10 inch piping under the existing conditions cannot do this.

III.—Suppose the outlet to D closed so that pumping is carried on through the branches to the cisterns at H K and L M N.

The discharge through the 6 inch branch is the same as before. The relative head at the commencement and end of the 8 inch pipe being 86·12 and 76·68 respectively, the head in the main at C, 850 feet from the 8 inch pipe commencement will be 80·32 and the loss of head on the branch C K = 80·32 — 53·76 = 26·56.

There are two vertical bends of 90° and one horizontal bend of 116° or 90° + 26° to account for.

$$b = 50\sqrt{\frac{26{\cdot}56}{660} \times {\cdot}33} = 50\sqrt{{\cdot}0132}$$

= 50 × ·114 = 5·7 ft. per ~~1 inch~~

$$\therefore H^b = \frac{(5{\cdot}7^2\,(\text{Sin}^2\,90 + \text{Sin}^2\,26 + 2\,\text{Sin}^2\,{\cdot}90)}{134}$$

$$= \frac{32{\cdot}49\,(3 + {\cdot}19)}{134} = 0{\cdot}77 \text{ foot}$$

∴ Working head = 26·56 — ·77 = 25·79

$$\therefore R = 2{\cdot}59\sqrt{\frac{25{\cdot}79}{660}} \times {\cdot}84$$

$$= 2{\cdot}59 \times \sqrt{{\cdot}039} \times {\cdot}61$$

$$= 2{\cdot}59 \times {\cdot}197 \times {\cdot}61$$

$$= {\cdot}306 \text{ C. ft. per second or } 114{\cdot}37 \text{ galls. per minute.}$$

For discharge in branch C D L M N take loss of head as before at C as 11·37, so that 80·37 is the available head at C, the head of the branch which is made up as follows :—

527	feet of 8 inch	pipe
1,497	„ of 7	„ „
1,017	„ of 6	„ „
1,441	„ of 2½	„ „
4,482	Total length.	

The first cistern to be filled is that at the female hospital at L, where water has to be delivered at a level of 66·28, so that 80·32 — 66·28 = 14·04 is about the loss of head on the branch C L. On this assumption and working out the different heads as before, it is found that the loss of head in the 2½ inches portion will be 13·53. At the end of the 2½ inch pipe however there must be a head on the branch to carry the discharge in the 1½ inch branch from L and a correction is made thus—

Length of 2½ inch pipe = 1,441
„ 1½ „ branch = 102
fall on 2½ inch pipe = 13·53

loss of head on 1½ inch pipe $= \frac{13{\cdot}53 \times 102}{1441} = {\cdot}95$

∴ water would reach extremity of 2½ inch pipe at L at about 66·28 + ·95 = 67·23, and total loss of head from C to L = 80·32 — 67·23 = 13·09.

Assuming a discharge of 1 cubic foot per second the heads on the several portions would be as follows :—

On 8 inch	·4921	× 5·27 ÷ ·9	=	1·77
7 „	·9594	× 14·97 ÷ ·82	=	17·51
6 „	2·0736	× 10·17 ÷ ·72	=	29·23
2½ „	202·5	× 14·41 ÷ ·37	=	7,877·25
				7,925·76

$\frac{13{\cdot}09}{7{,}925{\cdot}76} = {\cdot}0016$, true heads will be—

On 8 inch	1·77	× ·0016 =	·0029
7 „	17·51	× ·0016 =	·0289
6 „	29·23	× ·0016 =	·0483
2½ „	7,877·25	× ·0016 =	12·9974
			13·0775

$$\therefore R = \frac{1 \times \sqrt{13{\cdot}09}}{\sqrt{7925{\cdot}76}} = 1 \times \sqrt{{\cdot}0016}$$

$$= {\cdot}04 \text{ C. ft. per second}$$

$$= 15{\cdot}00 \text{ gallons per minute which is the amount delivered at L,}$$

the extremity of the 2½ inch piping to supply the cisterns in the hospitals.

With the above discharge the velocities in the different parts of the line will be as follows :—

In 7 inch pipes $= \frac{{\cdot}04}{{\cdot}26} = 0{\cdot}16$ foot per second

6 „ „ $= \frac{{\cdot}04}{{\cdot}19} = 0{\cdot}21$

2½ „ „ $= \frac{{\cdot}04}{{\cdot}03} = 1{\cdot}36$

∴ loss of head due to bends will be

in 7 inch pipes $= {\cdot}16^2 \frac{(4 \sin^2 92 + \sin^2 61\frac{1}{2} + \sin^2 61)}{134}$

$$= {\cdot}025 \frac{(4 + 1{\cdot}52)}{134} = {\cdot}001$$

In 6 inch pipes $= {\cdot}21^2 \frac{(2 \sin^2 92 + \sin^2 77)}{134}$

$$= \frac{{\cdot}04 + 2{\cdot}94}{134} = {\cdot}0009$$

In 2½ „ „ $= 1{\cdot}36^2 \frac{(\sin^2 29 + \sin^2 39)}{134}$

$$= \frac{1{\cdot}84 + {\cdot}61}{134} = {\cdot}009$$

∴ total loss due to bends between C and L is ·0109 foot, a loss so small that it may practically be neglected.

Taking the small branch from L to the female hospital cisterns.

$$R = {\cdot}61 \times 39{\cdot}27\sqrt{\frac{{\cdot}9}{102} \times {\cdot}12^5}$$

$$= {\cdot}61 \times 39{\cdot}27\sqrt{{\cdot}00000021} = {\cdot}0116 \text{ C. ft.}$$

$$= 4{\cdot}35 \text{ galls. per minute.}$$

From L the 2 inch pipe carries the water to M, where a 1½ inch branch conveys it to the Royal Artillery hospital cistern.

Length of branch = 65
„ of L M = 380

Total = 445 on which the loss of head is 67·23 — 64·89 = 2·34

∴ loss on the branch may be taken at $\frac{2{\cdot}34 \times 65}{380} = {\cdot}4$

$$\therefore R = {\cdot}61 \times 39{\cdot}27\sqrt{\frac{{\cdot}4}{65} \times {\cdot}12^5}$$

$$= {\cdot}61 \times 39{\cdot}27 \times {\cdot}00037$$

$$= 009 \text{ C. ft. per second}$$

$$= 3{\cdot}375 \text{ galls. per minute.}$$

From M the branch may be taken as 545 of 2 inch and 64 feet 1½ inch pipes with a total loss of head of 65·29 — 62·88 = 2·41. Assuming a discharge of ·2 cubic foot per ~~1 inch~~ second, the comparative heads are—

5·45	× 20·16	÷ ·37	= 296·4
·64	× 332·5	÷ ·37	= 575·2
			871·6

$$\therefore R = \frac{{\cdot}2 \times \sqrt{2{\cdot}41}}{\sqrt{871{\cdot}6}} = {\cdot}2 \times {\cdot}051$$

$$= 0102 \text{ C. ft. per second}$$

$$= 3{\cdot}825 \text{ galls. per minute}$$

$$\text{or total} = 4{\cdot}35 + 3{\cdot}375 + 3{\cdot}825$$

$$= 11{\cdot}55 \text{ galls.}$$

The amount calculated as being delivered at L was 15 gallons. per minute, while the totals of the discharges into the cisterns at L M N is 11·55, a difference of 3·45 gallons. A closer approximation could be obtained by going over the calculations again and correcting heads, but I do not think this is necessary. It is not possible to gauge accurately by observation the amount conveyed to these cisterns, for the main along which the water is conveyed is also connected with the plunge baths, stand cocks, and service pipes of the barracks into each or all of which the discharge may be flowing as well as into the cisterns.

To recapitulate.

Discharge through	main direct to D	= 414·25	galls. per	~~1 foot~~ minute
Do.	through branch B H	= 86·25	galls. per	1 foot
Do.	do. and to D	= 328·00	„	„
Do.	through B H	= 86·25	„	„
Do.	do. C K	= 114·37	„	„
Do.	do. C D L	= 15·00	„	„

By observation on 7th and 21st instant I find that in the Agram cistern 3,840 gallons was pumped in 12 feet 7 inches, equivalent to a discharge of 312 gallons per minute and in the Royal Horse Artillery cistern 1,266 gallons was pumped in in 13 feet 40 inches, equivalent to a discharge of 92·4 gallons per minute but the pipes did not run full in the latter. I cannot gauge the amount passing into the Infantry Barracks cistern, as there is no valve to close the outlet pipes, and while the cistern is being filled by the main water is also passing out to supply the barracks, and there is no means of ascertaining the exact amount of the draft.

From the statements of pumping during certain days last month, the figures given below represent the quantities discharged into the several reservoirs on the specified dates. The figures are only approximate, as during pumping the reservoirs were also supplying the barracks, and an allowance has been made at the average rate of consumption in 24 hours for the draft on the cisterns.

Cisterns.	Gallons per minute on			
	21 Inch.	24 Inch.	25 Inch.	28 Inch.
Infantry Barracks	81·21	74·36	69·20	69·20
Agram	270·00	297·7	274·20	255·90
Royal Horse Artillery	95·00	108·07	104·50	108 07
Hospitals	18·50	17·55	13·30	17·50

On 15th September 1879 128,565 gallons were pumped into the Agram cistern direct in 5 hours 13 minutes, equivalent to a discharge of 410·75 gallons per minute.

BANGALORE,
21st March 1881.

(Signed) F. J. ROMILLY, Lieut., R.E.,
Assistant Engineer.

B.

STATEMENT of Rainfall and corresponding rises in the Ulsoor Tank from April to October 1880 with deductions of percentage of rainfall stored from catchment basin.

Let A = area of catchment in square feet.
„ a = do. do. tank do.
„ R = total rise of tank in inches.
„ f = rainfall in inches.
Rf = r = rise of tank due to discharge from catchment.

$\therefore \frac{100 \times a \times r}{A \times f}$ = percentage of rainfall stored.

In the present instance—

A = 5 square miles = 139,392,000 square feet.
a = 124 acres = 5,401,440 „ „

$\therefore \frac{100 \times a}{A} = 3{\cdot}87$ and

percentage $= 3{\cdot}87 \times \frac{r}{f} = P.$

Date.	R.	f.	P.	Remarks.
		April 1880.		
4	...	·07	...	
7	...	·07	...	
12	5	1·2	12·2	
19	...	·19	..	
		May.		
7	...	·48	...	
9	2⅜	·59	13·7	
10	...	·23	...	
11	...	·19	...	
14	1	·40	5·8	

Date.	R.	f.	P.	Remarks.
		May—cont.		
15	1½	·60	5·8	
16	1	·58	2·8	
17	3½	·79	13·2	After a week of continued rain, so the catchment was probably saturated.
19	...	·15	...	
21	...	·20	...	
23	...	·09	...	
24	3⅕	·65	17·1	
25	½	·47	...	
26	½	·33	...	
28	...	·48	...	
29	4	1·27	8·32	
31	1	·66	2·0	
		June.		
7	½	·5	...	
11	1⅕	·6	5·8	
12	...	·21	...	
13	⅓	·43	...	
14	2⅕	·66	10·7	
15	⅛	·14	...	
16	...	·06	...	
17	...	·14	...	
18	...	·05	...	
29	...	·09	...	
30	...	·23	...	
		July.		
1	½	·35	16·1	
2	...	·14	...	
4	1¼	·75	2·5	
5	1¼	·71	...	
6	...	·10	...	
7	...	·03	...	
8	.	·08	...	
9	3¼	·99	8·83	
18	¼	·46	...	
22	¼	·50	...	
23	...	·03	...	
25	...	·33	...	
26	...	·08	...	
27	⅞	·41	4·33	
28	...	·25	...	
29	...	·02	...	
30	...	·05	...	
31	...	·15	...	
		August.		
1	...	·35	...	
8	...	·12	...	
11	1⅞	1·0	3·3	
13	⅕	·22	4·9	
14	28	5·10	17·37	A very rapid fall.
		September.		
9	¾	1·0	...	
12	...	·60	...	Weir discharging, so rise due.
13	...	·50	...	To inflow cannot be deduced.
		October.		
4	3	2·06	1·7	

From the above it will be seen that the percentages vary considerably, and an accurate deduction cannot be made except on data of rainfall collected from various points of the catchment basin together with a correct survey of the basin itself. The average percentage is 8·67. No rise of less than ·25 inch in the tank is recorded.

BANGALORE,
21st March 1881.

(Signed) F. J. ROMILLY, Lieut., R.E.,
Assistant Engineer.

C.

STATEMENT of Monthly Evaporation from Observations at the Ulsoor Rocks.

Month.	Evaporation.	Rainfall.	Remarks.
	INCHES.	INCHES.	
1873.	6·00	...	
January	4·50	...	Average daily.
February	7·80	...	Evaporation for 225 days = 0·22.
March	6·58	2·85	
April	7·76	·20	Taking the hot months.
May	5·95	1·365	January, March daily.
June	...	·56	Evaporation = $\frac{18·4}{91}$ = ·202.
July			
August	4·50	4·12	
September	7·00	2·27	Evaporation observed for thirteen days only.
1875.			
April	4·81	·55	Evaporation for 24 days.
May	5·31	3·10	Do. for 22 do.
June	?	3·23	Do. windy and rainy.
July	2·51	1·86	Do. for 14 days.
December	5·31	·05	Average for 91 days = 0·197.
1876.			
January	6·61	...	
February	5·75	·5	Average daily evaporation for 91 days = 0·205.
March	6·34	·8	
1877.			
May	6·10	2·63	
June	4·80	2·60	Average daily evaporation for 123 days = 0·176.
July	5·90	·97	
August	4·90	2·49	

(Signed) F. J. ROMILLY, Lieut., R.E.,
Assistant Engineer.

No. 66. ORDER THEREON, 23rd April 1881, No. 1,051 W.

ORDERED to be forwarded to the Government of India.

(Here enter No. 1,052 W., dated 23rd April 1881.)

(True Extract.)

(Signed) R. H. SANKEY, Colonel, R.E.,
Secretary to Govt., P.W.D.

Exd. E. C. Shunker.
Spare Copies

P.W. Dep. 2044/81

BUILDINGS AND ROADS.
MILITARY WORKS.

Govt. of [1881] Madras.

PUBLIC WORKS.

Dated April 23rd

Issued

Recd.

G. O., 23rd April 1881, No. 1,051 W.

APRIL.

Nos. 65-66.

Ulsoor Water Works at Bangalore.—Report on the — forwarded to the Government of India.

5078

P1

No. 1129

Madras,

Chepauk, 11th April 1880.

1051/b.

From

The SUPERINTENDENT of WORKS,
PRESIDENCY,

To

The Chief Engineer,
P.W. Dept.

Sir,

Enclosures.

With reference to G.O. No. 2496 A.W. dt. 29th October 1880, I have the honor to forward copies of three Statements submitted by the Assistant Engineer, Bangalore, furnishing information regarding (1) discharges &c: in the Mains of the Ulsoor Water Works, (2) Percentage of rain fall stored to that received on the Catchment Basin and (3) Evaporation.

2. No calculations have been made regarding the discharges through the pipes and loss of head due to bends in the Seven Wells Water Works. From experiments which have been made the actual discharge through these pipes has been ascertained to be exactly half the theoretical

o

or estimated discharge.

I have the honor to be
Sir,
Your most obedient servant
Alexr Nelson Capt. R.E.
Superintendent of Works
Pro Tem

105!
1

P.W.C. No 2324

P.C. No. 24762 dr. 29.10.80.

From,

The Supdt of Works,
Presidency.

No. 149

Dated 11th
Recd 12th April 1881.

K-4 (1 plan)

Ukkoor Water Works
Project.-

Forward copies of three
Statements furnishing informa-
tion regarding —

O.14.4.R2½.

A

Calculations of discharges in the
Ukkoor Water Works System.

Preliminaries, data, & formulæ used.

Q. = discharge in cft. per 1"
d = diameter of pipe in feet
H = head in ft. for a length of 100 feet
S = Hydraulic gradient
C = Coefficients

$$Q = C \times 39.27 \sqrt{S d^5} \quad \text{---------- I}$$

$$H = \frac{1}{C^2} \times 0.648 \frac{Q^2}{d^5} \quad \text{---------- II}$$

Tables VIII parts 1 & 2, & XII part 3 of
Jackson's Hydraulic Manual.

C = for 10" pipe 1.02, C^2 = 1.05
= " 9" " .99 = .98
= " 8" " .95 = .90
= " 7" " .91 = .82
= " 6" " .85 = .72
= " 4" " .61 = .37
= " Smaller " .61 = .37

The main A B C D consists of

1797 ft	of	10"	piping
710	"	9"	"
1377	"	8"	"
1184	"	7"	"

and discharges into the Agram preservoir at D by an Over hanging jet

at B a branch of 6477 ft of 6" piping discharges into the Infantry Barrack Cistern at H.

at C a branch of 660 ft. of 4" piping discharges into the R. H. A. Cistern at K by an Over hanging jet. The junction C is in the middle of the 8" piping. 850 feet from the end of the 9" piping. at D the main is carried Over the Agram Cistern & into the Service pipes carried from the Cistern & by this means water is pumped into the iron Service Cisterns at the European Hospitals this branch being composed as follows.

313 ft.	of	7"	piping
1017		6"	"
1441		2½"	" to I.
380		2"	" M
545		2"	" N.

At I a branch of 1½" piping conveys the water into the Female Hospital Cistern of which there are two, the inlet pipe being 28·50 ft. above the floor of the building. The length of the branch is 70 ft. horizontal & 32·00 ft. Vertical or altogether 102 ft.

At M a branch of 1½" piping 30 ft. long discharges into the Artillery Hospital Cisterns at 32·75 ft. above the floor level making the total length of this branch.

At N a Similar branch ft. long discharges into the Cavalry Hospital Cisterns.

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At D — two vertical bends of 90°.

In the branch B H. No vertical bends worth noticing, but four horizontal bends of 84½°, 88½°, 90°, & 35½°.

In C.K. One horizontal bend of 116° or say 90° + 26° — Two vertical bends of 90°.

In D L. Two vertical bends of 90° and horizontal bends of 61½° & 61° in the 7" portion; 87°, 88°, & 77° in the 6" portion; & 29° & 39° in the 2½" portion.

M × N, one horizontal bend of 90° & two vertical bends of 90° in each branch.

The formula used for loss of head due to bends is

$$H^3 = \frac{b^2 (\sin^2 \alpha + \sin^2 \beta + \ldots\ldots)}{134}$$

where H^3 = head necessary to overcome friction & b = velocity in feet per 1" found by dividing the discharge by the area of the pipe or from the formula.

$$b = 50 \sqrt{\frac{b}{l} \times d}.$$

The levels of the different points are given on the Section which accompanies.

Suppose the Values obtained to that main is pumped into the cistern at I alone.

Total length of main = 5078 ft.

Fall = 92·10 − 59 = 33·10 ft.

To approximate to the loss of head due to bends assume an average diam^{r} of 8" for the main, then.

$$b = 50 \sqrt{\frac{33 \cdot 1}{5078} \times \cdot 66} = 50 \sqrt{\cdot 0043}$$

$$= 3 \cdot 35 \text{ ft. per 1".}$$

The loss of head due to two Vertical bends of 90° is

$$H^3 = \frac{3 \cdot 35^2 (\sin^2 90 + \sin^2 90)}{134}$$

$$= \frac{11 \cdot 22 \times 2}{134} = 0 \cdot 16 \quad \frac{1051}{10}$$

$\therefore$ working head = 92·10 − (59 + ·16)

= 32·94.

To find the discharge & true head on each part of the main composed as stated above, assume a discharge of 1 cft. per 1", obtain the Separate heads due to it from table VIII modified by the coefficients & divide the actual head in the same proportion.

Flow 1 cft. discharge heads will be

0·1612 × 17·97 ÷ 1·04^2 = 2·68 for 10" pipe

0·2731 × 7·10 ÷ ·99^2 = 1·96 − 9" —

0·4921 × 13·77 ÷ ·95^2 = 7·52 − 8" —

0·9594 × 11·95 ÷ ·91^2 = 13·98 − 7" —

26·34

$$\frac{32 \cdot 94}{26 \cdot 34} = 1 \cdot 25.$$

Hence true heads on each portion of the main will be

on 10" pipes 2·68 × 1·25 = 3·49

9" — 1·96 × 1·25 = 2·49

8" — 7·52 × 1·25 = 9·44

15·42

7" pipes $13 \cdot 98 \times 1 \cdot 25 = \begin{matrix} 15 \cdot 42 \\ 17 \cdot 52 \end{matrix}$

$32 \cdot 94$

$\therefore Q = \frac{1 \times \sqrt{32 \cdot 94}}{\sqrt{26 \cdot 34}} = \sqrt{1 \cdot 25}$

$= 1 \cdot 11$ cft. per 1"

$= \underline{414 \cdot 25}$ galls per 1'

also the relative heads along the main above datum will be as follows

at Stand pipe $92 \cdot 10$

B " $- 3 \cdot 49 = 88 \cdot 61$

b " $- 2 \cdot 49 = 86 \cdot 12$

c " $- 9 \cdot 44 = 76 \cdot 68$

D " $- 17 \cdot 52 = 59 \cdot 16$

II Suppose values opened so that the cisterns at D & H are being filled simultaneously.

The head available to discharge through the branch B H, being $88 \cdot 61$ at B the fall in the branch is $88 \cdot 61 - 78 \cdot 15 = 10 \cdot 48$. The total length of the branch being 6477 feet the velocity

$$b = 50 \sqrt{\frac{10 \cdot 48}{6477}} \times \cdot 5 = 50 \times \cdot 026$$

$= 1 \cdot 3$ ft per 1".

$$\therefore H^{\frac{3}{2}} = 1 \cdot 3^2 \frac{(\text{Sec}^2 84\frac{1}{2} + \text{Sec}^2 84\frac{1}{2} + \text{Sec}^2 90 + \text{Sec}^2}{134}$$

$$= 1 \cdot 69 \frac{(\cdot 98 + \cdot 98 + 1 + \cdot 32)}{134}$$

$= \cdot 041$

$\therefore$ Working head $= 10 \cdot 48 - \cdot 04 = 10 \cdot 44$

$$\therefore Q = 6 \cdot 939 \sqrt{\frac{10 \cdot 44}{6477}} \times 0 \cdot 84$$

$= 6 \cdot 939 \times \cdot 04 \times \cdot 84$

$= 0 \cdot 23$ cft. per 1"

$= 86 \cdot 25$ galls per 1'

Thus leaves $414 \cdot 25 - 86 \cdot 25 = 328$ galls per 1' to pass along the main to D, which cannot run full unless $86 \cdot 25 + 414 \cdot 25 = 501 \cdot 5$ galls were delivered at B. The 10" piping under the existing conditions cannot do this.

III Suppose the outlet to D closed so that pumping is carried on through the branches to the cisterns at H, K, & L, M N.

The discharge through the 6" branch is the same as before. The relative head

at the commencement and end of the 8" pipe being 86·12 & 76·68 respectively, the head in the main at C, 850 ft. from the 8" pipe commencement will be 80·32 & the loss of head on the branch CK = 80·32 − 53·76 = 26·56.

There are two vertical bends of 90° and one horizontal bend of 116° or 90° + 26° to account for.

$$b = 50\sqrt{\frac{26\cdot56}{660}} \times \cdot33 = 50\sqrt{\cdot0132}$$

$$= 50 \times \cdot114 = 5\cdot7 \text{ ft. per 1"}$$

$$\therefore H^{\frac{1}{2}} = 5\cdot7^2\left(\frac{\sin^2 90 + \sin^2 26° + 2\sin^2 90}{134}\right)$$

$$= \frac{32\cdot49(3+\cdot19)}{134} = 0\cdot77'$$

$$\therefore \text{working head} = 26\cdot56 - \cdot77 = 25\cdot79$$

$$\therefore Q = 2\cdot59\sqrt{\frac{25\cdot79}{660}} \times \cdot84$$

$$= 2\cdot59 \times \sqrt{\cdot039} \times \cdot61$$

$$= 2\cdot59 \times \cdot197 \times \cdot61$$

$$= \cdot306 \text{ cf. per 1" or } 114\cdot37 \text{ gallons per 1'}$$

For discharge in branch C D. L M N. Take loss of head as before at C as 11·37 So that 80·37 is the available head at C the head of the branch which is made up as follows;

527 ft. of	8"	pipe
1497 −	7"	"
1017 −	6"	"
1441 −	2½"	"
4,482 −	total length.	

The first cistern to be filled is that at the female hospital at L where water has to be delivered at a head of 66·28, so that 80·32 − 66·28 = 14·04 is about the loss of head on the branch C.....L. on this assumption & working out the different heads as before it is found that the loss of head in the 2½" portion will be 13·53. At the end

of the 2½" pipe however there must be a head on the branch to carry the discharge in the 1½" branch from L, & a correction is made thus.

Length of 2½" pipe = 1441

" 1½" branch = 102

fall on 2½" pipe = 13·53

loss of head on 1½" pipe = $\frac{13\cdot53\times102}{1441} = \cdot95$.

∴ Water would reach extremity of 2½" pipe at L at about 66·28 + ·95 = 67·23 & total loss of head from C to L = 80·32 − 67·23 = 13·09.

Assuming a discharge of 1 c.f.s. per 1" the heads on the several portions would be as follows;

On 8" ... ·4921 × 5·27 ÷ ·9 = 1·77

7" ·9594 × 14·97 ÷ ·82 = 17·51

6" 2·0736 × 10·17 ÷ ·72 = 29·23

2½" 202·5 × 14·41 ÷ ·37 = 7877·25

7925·76

$\frac{13\cdot09}{7925\cdot76} = \cdot0016$, true heads will be

on 8" 1·77 × ·0016 = ·0029

7" 17·51 × ·0016 = ·0289

6" 29·23 × ·0016 = ·0483

2½" 7877·25 × ·0016 = 12·9774

13·0775

∴ $Q = \frac{1\times\sqrt{13\cdot09}}{\sqrt{7925\cdot76}} = 1\times\sqrt{\cdot0016}$

= ·04 c.f.s. per 1"

= 15·00 galls per 1' which is the amount delivered at L the extremity of the 2½" piping to supply the cisterns in the hospitals.

With the above discharge the velocities in the different parts of the line will be as follows;

In 7" pipes = $\frac{\cdot04}{\cdot26} = 0\cdot16$ ft. per 1"

6" = $\frac{\cdot04}{\cdot19} = 0\cdot21$

2½" = $\frac{\cdot04}{\cdot03} = 1\cdot36$

∴ loss of head due to bends will be

In 7" pipes = $\cdot16^2\frac{(4\sin^2 92 + \sin^2 61\frac{1}{2} + \sin^2 61)}{134}$

$= \cdot 025\left(\frac{4 + 1 \cdot 52}{134}\right) = \cdot 001$

In 6" pipes $= \cdot 21^2\left(\frac{2\sin^2 92 + \sin^2 77}{134}\right)$

$= \frac{\cdot 04 + 2 \cdot 94}{134} = \cdot 0009$

In 2½" $= 1 \cdot 36^2\left(\frac{\sin^2 29 + \sin^2 39}{134}\right)$

$= \frac{1 \cdot 84 \times \cdot 61}{134} = \cdot 009.$

∴ Total loss due to bends between C & L is ·0109 ft. a loss so small that it may practically be neglected.

Taking the small branch from L to the female Hospital Cisterns.

$Q = \cdot 61 \times 39 \cdot 27 \sqrt{\frac{\cdot 2}{102} \times \cdot 12^5}$

$= \cdot 61 \times 39 \cdot 27 \sqrt{\cdot 0000021} = \cdot 0116$ cft.

$= \underline{4 \cdot 35}$ galls. per 1'

From L the 2" pipe carries the water to M where a 1½" branch conveys it to the R. A. Hospital Cistern.

Length of branch = 65

" LM = 380

Total = 445 on which the loss of head is 67·23 − 64·89 = 2·34

∴ loss on the branch may be taken at

$\frac{2 \cdot 34 \times 65}{380} = \cdot 4$ (05/14)

$\therefore Q = \cdot 61 \times 39 \cdot 27 \sqrt{\frac{\cdot 4}{65} \times \cdot 12^5}$

$= \cdot 61 \times 39 \cdot 27 \times \cdot 0037$

$= 009$ cft. per 1"

$= \underline{3 \cdot 375}$ galls. per 1'

From M the branch may be taken as 545 of 2" & 64 ft. 1½" pipes with a total loss of head of 60·29 − 62·88 = 2·41.

Assuming a discharge of ·2 cft. per 1" the comparative heads are.

$5 \cdot 45 \times 20 \cdot 16 \div \cdot 37 = 296 \cdot 4$

$\cdot 64 \times 332 \cdot 5 \div \cdot 37 = \underline{575 \cdot 2}$

$871 \cdot 6$

$\therefore Q = \frac{\cdot 2 \times \sqrt{2 \cdot 41}}{\sqrt{871 \cdot 6}} = \cdot 2 \times \cdot 051$

$= 0102$ cft. per 1"

$= 3 \cdot 825$ galls. per 1'

∴ Total $= 4 \cdot 35 + 3 \cdot 375 + 3 \cdot 825$

$= \underline{11 \cdot 55}$ galls

The amount calculated as being delivered at L was 15 galls. per 1', while the total of the discharges into the cisterns at LMN is 11·55 a difference of 3·45 galls.

a closer approximation could be obtained by going over the calculations again & correcting heads but I do not think this is necessary. It is not possible to gauge accurately by observation the amount conveyed to these cisterns for the main along which the water is conveyed is also connected with the plunge baths, Stand cocks & Service pipes of the Barracks into each of which the discharge may be flowing as well as into the cisterns.

To recapitulate

Discharge through Main

direct to D = 414·25 gall. per ℎ.

—— do —— do through branch BH = 86·25 " "

—— do —— do —— do —— H to D = 328·00 " "

—— do —— do through BH = 86·25 " "

—— do —— do —— do —— C k. = 114·37 " "

—— do —— do —— do —— C D L = 15·00 " "

By observation on 7th & 21st Instant I find that in the Agram cistern 3840 gallons was pumped in 12h 7m —

equivalent to a discharge of 312 gallons per ℎ. 1051/5

17 ℎ. & in the R. H. A. cistern 1266 gallons was pumped in, in 13h 40m equivalent to a discharge of 92·4 gallons per ℎ. but the pipes did not run full in the latter. I cannot gauge the amount passing into the Infantry Barracks cistern as there is no valve to close the outlet pipes, and while the cisterns is being filled by the main water is also passing out to supply the barracks and therefore no means of ascertaining the exact amount of the draft.

From the Statements of pumping during certain days last month, the figures given below represent the quantities discharged into the Several reservoirs on the Specified dates. The figures are only approximate as during pumping the reservoirs were also supplying the barracks & an allowance has been made at the average rate of consumption in 24 hours for the draft

If 20

on the Cisterns.

Cisterns	Gallons per 1'on			
	21"	24"	25"	28"
Infty. Bks—	84·21	74·36	69·20	69·20
Agram—	270·00	297·7	274·20	255·90
R. H. A—	95·00	108·07	104·50	108·07
Hospitals—	18·50	17·55	13·50	17·50

On 15th September 1879. 128,565 gallons were pumped into the Agram Cistern during 5 hours 10 minutes, equivalent to a discharge of 410·75 gallons per 1'.

Bangalore
March 21/81

(Signed) H. J. Romilly, Lieut. R.E.
Resident Engineer.

(True Copy)

Major. R.E.
Superintendent of Works, Presy.

11/4/81.

B

(105) 16

Statement of rain fall and corresponding rises in the Ulsoor Tank from April to October 1880 with deduction of percentage of rain fall stored from Catchment basin.

Let A = area of Catchment in Sq. ft
" a = do do Tank do do
" R = total rise of Tank in inches
" f = rain fall in inches.
R-f = r = rise of tank due to discharge from Catchment.

$\therefore \frac{100 \times a \times r}{A \times f}$ = percentage of rain fall stored

In the present instance

A = 5 Sq. miles = 139,392,000 Sq. ft.

a = 124 acres = 5,401,440 Sq. ft.

$\therefore \frac{100 \times a}{A} = 3{\cdot}87$ and

percentage = $3{\cdot}87 \times \frac{r}{f} = P.$

Date	π	f	P	Remarks
		April 1880.		
4		·07		
7		·07		
12	5	1·2	12·2	
19		·19		
		May.		
7		·48		
9	2 3/8	·59	13·7	
10		·23		
11		·19		
14	1	·10	5·8	
15	1 1/2	·60	5·8	
16	1	·58	2·8	
17	3 1/2	·79	13·2	After a week of continued rain,
19		·15		~~So~~ the Catchment was probably
21		·20		Saturated.
23		·09		
24	3 1/2	·65	17·1	
25	1/2	·47		

Date	π	f	P	Remarks
		May 1880		105/17
26	1/4	·33		
28		·48		
29	4	1·27	8·32	
31	1	·66	2·0	
		June		
7	1/2	·5		
11	1 1/2	·6	5·8	
12		·21		
13	1/2	·43		
14	2 1/2	·66	10·7	
15	1/5	·14		
16		·06		
17		·14		
18		·05		
29		·09		
30		·23		

Date	R	f	P	Remarks.
		July		
1	½	·35	16·1	
2		·14		
4	1¼	·75	2·5	
5	1¼	·71		
6		·10		
7		·03		
8		·08		
9	3¼	·99	8·83	
18	¼	·46		
22	¼	·50		
23		·03		
25		·33		
26		·08		
27	⅞	·41	4·33	
28		·25		
29		·02		
30		·05		
31		·15		

Date	R	f	P	Remarks.
		August		105/16
1		·35		
8		·12		
11	1⅞	1·0	3·3	
13	½	·22	4·9	
14	28	5·10	17·37	A very rapid fall.
		September		
9	¾	1·0		
12		·60		Weir discharging so that the
13		·50		inflow cannot be deduced.
		October		
4	3	2·06	1·7	

From the above it will be seen that the percentages vary considerably, and an accurate deduction cannot be made except on data of rain fall collected from various points of the catchment basin together with a correct Survey of the basin itself

The average percentage is 8.67. As rise of less than .25" in the tank is recorded.

Bangalore.
March 21st/1881.

[Signed] F. J. Romilly, Lieut. R.E.
Asst. Engineer.

[True Copy]

Mar 22/81

Major R.E.,
Superintendent of Works, Pensy.

11/4/81

C

205/07

Statement of monthly evaporation from Observations at the Ulcoor Tanks.

Month	Evapo-ration	Rain fall.	Remarks.
	Inches	Inches	
1873			
January	6·00	—	
February	4·50	—	Average daily
March	7·80	—	Evaporation for 225 days
April	6·58	2·85	= 0·22
May	7·76	·20	Taking the last months
June	5·95	1·365	January-March daily.
July	—	·56	$\text{Evap}^{\text{n}} = \frac{18·4}{71} = ·202$
August	4·50	4·12	
September	7·00	2·27	Evap$^{\text{n}}$ Observed
			for 13 days only.
1875			
April	4·81	·55	Evap$^{\text{n}}$ for 24 days
May	5·31	3·10	" — 22 "
June	?	3·23	— Windy & rainy.

Month	Evaporation	Rainfall	Remarks
	Inches	Inches	
1875			
July	2·57	1·86	Evapn for 14 days
December	5·31	·65	Average for 91 days = 0·197
1876			
January	6·61	—	
February	5·75	·5	Average daily Evapn.
March	6·34	·8	for 91 days = 0·205
1877			
May	6·10	2·63	
June	4·80	2·60	Average daily Evapn
July	5·90	·97	for 123 days = 0·176
August	4·90	2·49	

(Signed) H. J. Romilly, Lieut. R.E.
Assistant Engineer.

(True Copy)

H. Burkinshaw Major R.E.
Superintendent of Works & Engr.

A/Circ 3

In 1057 W 1051/21 PUBLIC WORKS DEPARTMENT.

PROCEEDINGS OF THE MADRAS GOVERNMENT.

UNDER date the 23 apl/81

Read the following :—

From the Supt of Works
Presidency
Circle
Incomplete
only

} No. 149 of 11 April 1881.

Ordered to be forwarded to the Government of India.

To In 1052 W dt 23 apl/81
The Secy to the Govt of India
P.W.D.

Sir

With reference to your Circular No. XXX P.W. dated 24 September 1880, I am directed to forward copy of a letter from the Supt of Works Presidency submitting a report on

on the Alsoor Water
works at Bangalore.

Abstt
13/4/87

Dead to Simla
with tracing
7-6-87.
Revised estimate of
4-6 as no 1057 W
Dead
20-6-87

C.C.R.
Dy W
Asst

C. 14. 4. R 23/4.

1051/
22

2324

Govt. of (1881) Madras.

PUBLIC WORKS.

To

Dated 25/4

Issued

Read.

Encl.

G. O., 23 April 1881, No. 1051
1052 W.

Nos. 65-66

Bloor Water Works at Bangalore Repeating the Financial Effect of Proposals

Bloor Water Works at Bangalore