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Proceedings of the Madras Government, Public Works Department,
31st March 1877. No. 1,091.

Read the following papers:—

No. 779. From J. D. GRANT, Esq., Officiating District Engineer, Tinnevely, to the Chief Engineer for Irrigation, dated Palamcottah, 25th January 1877, No. 170.

THE complaints of the cultivators under the south main channel of the Sriviguntum anicut project have been so constant, and their statements regarding the insufficiency of water apparently so well founded, that it was determined to investigate the whole question carefully *ab initio*, and I have the honor now to forward, for your instructions, the result of the calculations, &c., drawn up by Mr. Hughes.

2. In order, as far as possible, to get at the root of the matter, a series of gaugings was taken by Sub-Conductor Falvey, in a straight reach of the channel, half a mile from the head sluice, and, though these gaugings are few in number and necessarily somewhat rough, they were, however, taken with great care and as much accuracy as circumstances would permit, and cannot but afford useful data for arriving at the true discharge of the channel.

3. From these gaugings—

The mean velocity was found to be	...	...	...	1.714
Hydraulic mean depth being	...	...	...	4.701
Mean area of section	...	...	...	315.16
Surface fall	...	...	...	$\frac{1}{7200}$

Applying to this the formula given at page 33 of the 3rd Edition of Jackson's Hydraulic Manual, the mean velocity is found to be 1.0675, making the discharge 336.28 cubic feet per second, from which again the co-efficient of the head sluice is found to be .906.

4. Again, using the formula on page 34 of the Manual previously quoted (C having been found = 41.21) the co-efficient of friction is found to be .05, from which, in the accompanying memorandum, a table is given showing C for different hydraulic mean depths.

5. The accuracy of all these calculations of course depend, in great measure, on the accuracy of the formula given in the Hydraulic Manual used, but there would seem no doubt that the formula for channels $\sqrt{v} = 100 \sqrt{RS}$ is very incorrect, and that the formula for sluices $\sqrt{v} = C \sqrt{2gh}$, when C is from .62 to .75 is also wrong.

6. Having obtained what appears correct data, the next thing is to apply them to the channel which cultivates 7,150 acres, against 5,650 under the north channel.

7. The tank capacity under the south channel is to that under the north channel in about the proportion 6 to 5, so that if, as would appear best, the water be divided proportionately to the tank capacity, the south channel should get six-elevenths of the supply in the river.

8. To effect this the supply of the south main channel must be increased, and this may be done in two ways, either—

- (1) by widening the channel leaving the head sluice unaltered, or,
- (2) by increasing the size of the head sluice and widening the channel.

9. By the first plan, in order to give the south main channel its fair share of water, it would be necessary to widen the channel to 57 feet at a cost of about 20,100 rupees. This plan has the objection, however, that it dangerously diminishes the berm, and that there would be a difficulty in getting rid of the excavated material.

10. If it is considered better to add three vents to the head sluice and widen the channel 9 feet (or to 45 feet), the cost would be only 15,100 rupees.

11. The result of these improvements if executed would be (taking the channel as full for sixty days) an increase of discharge of nearly 420 million cubic feet of water, a quantity equal to about half the tank capacity.

12. Next in importance to the main channel is the Ahtur channel, where for a series of years there has been loss of crop and much trouble in the distribution of the water available.

13. The discharge of the main channel being 413 feet per second, the Ahtur channel is entitled to 40 per cent. or 165 cubic feet; to carry which quantity it would be necessary to enlarge the present channel to 27 feet at bottom; this would be expensive and dangerously reduce the berms.

14. It would however be possible to increase the fall to 2 feet per mile by lowering the aqueduct (now converted into a drop) and thus render a bottom width of 18 feet sufficient, and with provision for supplying Sathukavoitan tank, its due share of water could be drawn off by the Ahtur channel.

15. The Ahtur tanks are found to contain sufficient water for only twenty-three days' supply to the cultivation, and, considering the exceedingly variable supply in the river, it would be advisable, as much as possible, to increase their capacity. They cannot be raised to a greater height than sufficient to hold thirty-two days' supply, but with the improvements proposed to the channel, rendering it capable of filling the tanks in nine days, a very material improvement would be effected, and even if nothing is done to the channel, the repair of the tanks must be carried out.

16. The cost of improving the channel, &c., will be Rupees 7,800, against which, however, should be set the annual cost of maintaining the temporary dam in the river at the old head sluice, viz., Rupees 390.

17. A short time ago, with your permission, the aqueduct near the old head sluice was converted into a drop, and in great measure, owing to this improvement, all the land this year cultivated under Ahtur tank (about half the ayacut) will be saved. The figures given in the accompanying memorandum may not be all absolutely correct, as at this time a pressure of other work is occupying every one's attention, thus preventing my going through the figures very carefully; a few inaccuracies I have detected and altered.

18. The calculations are, however, I think sufficient to show that there is something radically wrong with the channel, and point clearly to the remedy, and I have the honor to request that you will consider the subject and favor me with instructions.

From the same Officer, dated Palamcottah, 28th February 1877, No. 192.

I HAVE the honor to inquire whether I may go on with the preparation of estimates for the improvements to Ahtur channel mentioned in my letter, No. 170, of 25th

January 1877. If this is to be done I request permission to alter in one particular the arrangements described, as from recent experience it does not seem advisable to leave the two bridges in Ahtur channel of 10 feet span only.

2. Since knocking down the side wall of the aqueduct, the surface fall has been considerably increased, the result being that the velocity through the present bridges of 8 feet waterway is too great.

3. I propose, therefore, to increase the waterway as much as necessary, and, if in other particulars you approve the proposals, I would go on with the preparation of the estimates.

From the same Officer, dated Palamcottah, 23rd March 1877, No. 202.

In reference to your memorandum No. 17 T N of 13th instant, I have the honor to forward a correct copy of Mr. Hughes' memorandum on the proposed improvements of water-supply to south main channel, Sriviguntum anicut project.

Memorandum on Proposed Improvement of Water-supply to South Section of Sriviguntum Anicut Works.

The principle having been laid down that the water taken off from the river at Sriviguntum should, in the first place, be supplied to the land irrigated before the construction of the anicut, and the surplus only rendered available for extension of cultivation, certain modifications in the existing works are required in order to distribute the supply more nearly than now in proportion to the acreage of old irrigation on either side of the river. There are no accounts in this office to show what the exact acreage is, but from the returns of actual cultivation it appears to be about—

	ACRES.
For the south section	7,150
Do. north "	5,650

or nearly in the proportion of 5:4. Should the probable extension of cultivation be also taken into account, nearly the same proportion would be arrived at for the distribution. The extent of new cultivation will depend entirely on the quantity of water available in the tanks, as the ryots are most anxious to extend the irrigation as quickly as possible, and have taken up for wet cultivation under all the tanks of the south and some of the north section quite as much land as can ever be irrigated from them. In considering the ultimate extent of cultivation there would be an obvious advantage in dividing the supply in proportion to the tank capacity, and as those of the south section are about one-fifth times the capacity of those of the north, while they receive less drainage, they ought to get more than six-elevenths of the water taken off from the river.

2. The question is thus reduced to a consideration of the best manner of regulating the distribution so as to give five-ninths of the river supply to the south section. This cannot be done by any regulation of the sluices, but must be effected by improving the south channel or channel and head sluice. The channel is much too small, and is found incapable of filling the tanks without a succession of good freshes, and the discharging capacity as explained below is for a given depth only about two-fifths of that calculated on when the work was projected; but by running it somewhat deeper than formerly intended we get a discharge during freshes of

about half that calculated on. A good deal of water goes to waste over the anicut, but the north channel is sufficiently large for present needs, and only the south channel requires improvement.

3. Before proceeding with calculations for this work a few words are necessary regarding the formulæ and coefficients in most general use for estimating the discharge of channels and sluices. That most frequently used for channels is of the form.

$D = AV = A \times 100 \sqrt{RS}$, A being the area of water section, R , the hydraulic mean depth and S the sine of the surface fall, and for sluices $D = AV = A \times C \times \sqrt{2g h}$, C being taken at from .62 to .75. It became evident from watching the discharge of the head sluice into the Sriviguntum main channels that the results given by these formulæ are widely inconsistent, and to ascertain approximately the amount of error, some gaugings of the south main channel have been made by the Sub-division Officer Mr. Falvey. The observations were made with care, and for this particular instance afford a sufficiently near approximation, but do not pretend to great exactitude as the number of observations was small. A straight reach of the channel was selected about half a mile from the head, and 360 feet length and the velocity observed at intervals of 120 feet. When the water subsided sufficiently cross sections were taken at the points of observation. The part of the channel selected is in rather stiff clay cutting and the bed and sides are pretty free from grass and weeds. There is no drainage into the channel between this part and the head. The sectional area varied from 307 to 329 square feet.

The results obtained are as follow:—

Mean area of four sections	315.16 square feet.
Mean hydraulic, mean depth	4.701 feet.
Maximum velocity	1.714 feet per second.
Surface fall *	$\frac{1}{7.200}$

The mean velocity was obtained from Bazin's formula

$$V_m = V_x - 25.3 \sqrt{RS}$$

(When V_m and V_x are the mean and maximum velocities, R the hydraulic mean depth and S the sine of the surface slope)

and was found to be 1.0675 feet per second. The discharge was, therefore, 336.28 cubic feet per second. The area of head sluice vents open was 45 square feet, the measured head 1 foot, and the velocity of approach at gauge 2 feet per second, whence the co-efficient for the sluice is .90. The floor and sides of vents are of dressed granite. The vents are 4 feet width: the cut waters are equilateral triangles in plan and have sharp edges and the rear wings are curved outwards from the vents. The co-efficient deduced for the sluice cannot be put forward as quite exact, as the calculation of the channel discharge assumes the correctness of Bazin's formula for the mean velocity, but there is every reason to believe that it must be nearly correct.

4. It is quite clear that the formula $D = Ax \sqrt{RS}$ is inapplicable for earth channels of moderate depth. Darcy and Bazin's experiments proved conclusively that the co-efficient varies very much according to the nature of the sides and bed of a channel, and from their results and other observations and experiments Kutter and Ganguillet deduced a formula for mean velocity of channels and which appears to give a much more nearly correct estimate generally than any other yet published. The formula is $V = C \times (RS)^{\frac{1}{2}}$ for metrical measures, when R = hydraulic mean depth S = sine of surface slope and $C = \frac{23 + \frac{1}{x} + \frac{.00155}{S}}{1 + (23 + \frac{.00155}{S})^{\frac{2}{3}}}$ where f is a co-efficient of friction varying from .01 for very smooth plastered channels or glazed

pies to 0.35 for rivers and canals with earthen beds in bad order and regimen and having large quantities of stones and weeds. For English measures $C = \frac{23 + \frac{1}{F} + \frac{.00155}{S}}{.553 + (23 + \frac{.00155}{S}) \frac{F}{R}}$. The co-efficient

of friction given by the authors of this formula appears too low for ordinary irrigation channels of moderate size. From the gaugings of the south main channel a value of $C = 40.4$ is arrived at for a hydraulic mean depth 4.7 and surface fall $\frac{1}{3958}$. This gives a co-efficient of friction = .05 and calculating from the formula with this co-efficient; the co-efficient C for the Sriviguntum main channels allowing surface fall $\frac{1}{3958}$ will be—

For hydraulic mean depth	...	...	...	...	... = 1, C = 24
Do. do.	...	...	...	...	... = 1.5, C = 28
Do. do.	...	...	...	...	... = 2, C = 31
Do. do.	...	...	...	...	... = 2.5, C = 33
Do. do.	...	...	...	...	... = 3.0, C = 35
Do. do.	...	...	...	...	... = 3.5, C = 37
Do. do.	...	...	...	...	... = 4.0, C = 38
Do. do.	...	...	...	...	... = 4.5, C = 40

5. The following table shows the width as far as it can be calculated which ought to be given to the south channel that it may draw off five-ninths of the water reaching the anicut. The calculations are made for each foot of depth from 2 feet up to anicut crest level; 1° on the supposition that the head sluice is unaltered, 2° on the supposition that three vents are added to it. The depth which the south channel will carry is limited to 5½ feet or 5½ feet as we cannot run it deeper without flooding a large extent of nunjah. It would be of course possible to bund this round and drain it by a syphon under the channel, but the cost would be quite disproportionate to any possible advantage:—

disproportionate

Depth in River at Anicut.				Depth in North Main Channel co-efficient of Head Sluice = .8.	Discharge.	Proposed discharge South Main Channel = $4 \frac{1}{2} \times$ Column 3.	Depth in South Main Channel co-efficient of Head Sluice = .9.	Required bottom width.	Depth in South Main Channel with Head Sluice of 6 vents.	Required bottom width.
1	2	3	4	5	6	7	8			
2	2	51	64	1.87	52	2.0	42			
3	2.9	109	136	2.7	53	2.9	45			
4	3.9	185	231	3.5	55	3.87	45			
5	4.8	286	357	4.2	61	4.8	46			
6	5.75	403	504	4.8	65	5.75	47			
(= crest level)										
Mean	...	...	...	...	57	...	4			

NOTE.—The co-efficient for north head sluice is taken at 8 as the masonry is dressed fair on the face for only 2 inches round the joints and the rest left rough.

The following are approximate estimates:—(1) of the cost of widening the channel to 57 feet bottom width and (2) of widening it to 45 feet and adding three vents to the head sluice. The vents of both sluices are now all 4 feet wide and 8 feet high.

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Estimate for widening south main channel to 57 feet bottom width or 21 feet more than present width.

Quantity.	Description of Work.	Rate.	Amount.
C. YDS.		RS. A. P.	RS. A. P.
171,500	Earth	0 1 3	13,398 7 0
1,833½	Removing and rebuilding pitching	0 10 0	1,145 13 4
275	Rough stone pitching to raise to 6½ above bed	2 0 0	550 0 0
611½	Broken stone backing	1 8 0	916 12 0
233½	Widening flooring to 57 feet	2 0 0	466 10 4
	Rock excavation in 3rd mile and pitching near masonry works		2,000 0 0
	Returns to head sluice wings		400 0 0
	Sundries and Contingencies		822 5 4
	Superintendence		400 0 0
	Total ...		20,100 0 0

Estimate for widening south main channel to 45 feet and adding three vents to the head sluice.

Quantity.	Description of Work.	Rate.	Amount.
C. YDS.		RS. A. P.	RS. A. P.
63,000	Earth	0 1 3	4,921 14 0
916½	Removing and rebuilding pitching	0 10 0	572 14 8
275	New pitching	2 0 0	550 0 0
396½	Broken stone backing	1 8 0	595 2 0
100	Widening flooring to 45 feet	2 0 0	200 0 0
	Rock excavation in 3rd mile and pitching near masonry works		700 0 0
	Sundries and Contingencies		560 1 4
	Superintendence		200 0 0
	Sluice.		8,300 0 0
	Adding three vents		6,500 0 0
	Temporary bridge		150 0 0
	Superintendence		150 0 0
			6,800 0 0
	Total ...		15,100 0 0

6. Besides the excess on cost there are other objections to widening the channel to 57 feet. The berms were originally made 12 feet wide, but the bunds and spoil banks have been washed down a good deal, and if the channel were widened 21 feet, there would be practically no berm left, and there would also be much difficulty in many places in finding a place to put the large quantity of spoil. These objections would exist but in a slight degree in cases the channel be widened only 9 feet. It would be better to add three vents to the head sluice and widen the channel 9 feet than to add a less number and have to widen the channel more since the chief cost of the alteration to the sluice would consist in that of building new wings, and the number of new vents added would not greatly affect the estimate: and it would be no advantage worth considering to add more than three vents, as whatever the number the width of channel would have to be about 45 feet to discharge the required amount with moderate depths in the river.

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7. The water-registers prior to June 1873 do not furnish any reliable data for estimating the quantity of water reaching the anicut.

From June 1873 to April 1874 the water was over the crest of
anicut 64 days.
May 1874 to April 1875 56 "
May 1875 to April 1876 probably 24 "

The registers for this last year are incomplete, that for November having been lost; seven days are however corrected for that month. The season was a very bad one, but the others may be taken as average ones. Taking the full depth of the south channel at 5½ feet, the extra quantity of water which can be drawn off from the river during the year, if the proposed improvements be carried out, may be taken as the difference in its discharge with width 36 feet and with width 45 feet for 60 days or $60 \times 24 \times 60 \times 60 \times (413 - 832) = 419.9$ millions cubic feet, or about half the tank capacity on the south bank. It should be mentioned that the south channel has never been excavated to the proper depth in the latter half of the 3rd mile. There is a good deal of rock there varying up to 1½ feet above proper bed-level, and this reduces the surface fall in the first 2½ miles, generally to about a foot a mile. This, however, does not make so great a difference in the quantity of water drawn off from the river as would at first appear an estimate was made last year for excavating the rock, but it has not been yet sanctioned. The calculations made above all pre-supposes that the bed slope is as designed with a fall of 1½ feet per mile.

Ahtur Channel.

The heaviest sufferers from the present inadequate arrangements for the distribution of water are the Ahtur ryots. The Ahtur channel irrigates over a third of the total irrigation on the south bank and making allowance for some drainage received into the south channel, and on the other hand, the considerable waste by percolation from the Ahtur channel and the small capacity of the Ahtur tanks it would appear fair to give to this branch 40 per cent. of the water taken off the river or when the south channel was getting full supply, after improvements proposed above are carried out $\frac{40}{100} \times 413 = 165$ cubic feet per second. The present channel is 12 feet wide with side slopes 2-1, and fall 1 foot per mile. The full depth (which cannot be exceeded without flooding the Tricaloor lands) is 4½ feet, and to make the channel with this depth and fall carry 165 cubic feet per second a bottom width of 27 feet would be required. This would involve much expense, and besides be unsatisfactory for the reason that the berms are only 9 feet wide. The alternative is to increase the fall. If the fall be made 2 feet per mile, it will be sufficient to increase the bottom width of channel to 18 feet. The hydraulic mean depth will be 3.19 feet, and the co-efficient, calculated according to the formula used for the main channels, will be for this hydraulic mean depth = 39. The head sluice which has an area of 23 square feet will probably be found sufficiently large, but the slopes will have to be pitched for about 50 feet in rear of the sluice. There are two bridges each of two vents 4×4 with a pier 2 feet wide. The piers will have to be removed and the arches 10 feet span 2 feet rise built and the slopes pitched for a short distance above and below. The upper part of the aqueduct will have to be removed and the arches rebuilt with springing at lower level, or else stone girders substituted. The new channel should be dropped into the old one through the side of the aqueduct, a sluice being built for supply of Sathukavoithan tank. The channel supplying the latter tank will have to be lowered nearly 2 feet for 1½ miles length, but its width may be reduced to 6 feet. The head sluice of the old channel may be closed as it admits very little water since the anicut was built at Sriviguntam. By closing it Rupees 390 a year allowed for the up-keep of the temporary dam will be saved.

The ayacut area under Ahtur channel is acres 325
and under tanks 2,111

The tanks have been neglected in a great measure for several years, and the state of the bunds does not allow of them holding more than 64.8 millions cubic feet, but by repairing the bunds,

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so that water can be retained to the top of dam stones of calingulabs, the capacity will become 89 millions cubic feet or 42,200 cubic feet per acre of cultivation. This is equivalent to 32 days' supply at 1,300 cubic feet per acre per day. If the improvements proposed to channel and tanks be carried out, it will take (allowing 20 cubic feet per second for loss and supply of Sathukavoithan tank and 35 cubic feet drawn off for cultivation under channel and tanks) 9½ days for the channel running full to fill the tanks.

The cost of improvements to channel will be approximately as follows:—

Quantity.	Description of Works.	Rate.	Amount.
C. YDS. 43,300	Earth... ..	RS. A. P. 0 1 0	RS. A. P. 2,707 12 0
	Altering two bridges	300 0 0	600 0 0
	Altering aqueduct, providing flooring, &c.	...	1,200 0 0
	Sundries, pitching, &c.	...	492 4 0
	Superintendence	...	200 0 0
			5,200 0 0
	Deduct saving of up-keep of temporary dam, Rupees 390 capitalized.		7,800 0 0
	Saving		2,600 0 0

The small quantity of water which will be lost by closing the old head sluice is to be considered, but on the whole it is believed that the improvements proposed would result in positive gain.

PALAMCOTTAH,
26th December 1877.

(Signed) W. HUGHES,
Asst. Engr., Tinnevely Dn. Officer.

No. 141 W.

No. 779-A. *Note by the Chief Engineer for Irrigation.*

THE insufficiency of the water-supply for the irrigation under the Sriviguntum anicut south main channel has been the ground of frequent complaints on the part of the ryots, and these complaints have taken the form either of remonstrances by the former holders of wet lands against allowing any water being passed down to the channels and tanks below the Kadamba tank, or of petitions by the ryots who have taken up fresh land in the belief that water would be available in proportion to the acreage to be irrigated.

2. It appeared to the undersigned that the ryots who held irrigated lands before the construction of the anicut, and whose supply had been more or less interfered with by the new arrangements, had a fair claim to be first adequately supplied, and instructions to this end have from time to time been issued. The practical difficulty in effecting an equitable distribution however has arisen from the fact that the quantity of water available in any month is extremely uncertain, and without some reasonable basis for calculation it has been impossible to decide when, for instance, the supply in the Kadamba tank, an important reservoir at the lower end of the south main channel could be deemed sufficient for the cultivation under it, and what level of the water therein might be assumed to afford a sufficient reserve to avoid risk of the exhaustion of the supply before fresh-water from the river or from rain-

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fall might be received to supplement the storage. The Sriviguntum anicut is the lowest of a series of weirs across the Tamrapurni, and only in considerable freshes does much water reach it.

3. A partial remedy for the evils entailed by an inadequate supply of water can alone be adopted. The broad facts are that the present supply is much less than what is wanted; that the revenue has fallen far short of what was anticipated; that complaints from holders of both old and new wet lands are numerous and consistent; and, lastly, that there is even in bad seasons some water in the river, which, under present circumstances, runs to waste instead of being utilized. Such being the case it is clearly advisable, with as little delay as possible, to introduce improvements, the need of which has been so forcibly demonstrated.

4. The Officiating District Engineer has transmitted a valuable memorandum by Mr. Hughes containing the result of his investigations. It has unfortunately been so badly transcribed that the examination in detail of the formulæ and calculations is a matter of great difficulty. The want of correspondence between the actual and calculated levels of the water above and below the head sluices of the

Proceedings of the Madras Government, No. 848,
31st March 1875, notes paragraphs 16 and 17.

main channels and elsewhere attracted observation when the works were last inspected, and it was clear that the south channel from some cause or other was not discharging the supply due to the depth indicated. It is now shown that this was due in part to the excavation in the third mile not having been properly completed, but Mr. Hughes considers that only a part of the difference is due to this cause, and that the calculated discharge originally was in excess of that which the channel with the fall and dimensions adopted could convey. The formula* in use in the

* Dubuat's.

Irrigation Department does with the low surface falls prevalent in the northern deltas give results not widely divergent from the observed velocities, and for the much greater surface falls of the Sriviguntum channels there is no extended experience to appeal to. It cannot however be taken as probable without further investigation that Dubuat's formula would give results so widely differing from the fact as is indicated by the discharges given in Mr. Hughes' memorandum. He shows, paragraph 5, that the south main channel with a bottom width of 45 feet and a depth of 5¾ feet would discharge 504 cubic feet a second. He has not stated all the data, but it has been assumed that

the side slopes of the channel are 1½ to 1,
,, surface fall 1 in 3,960 or 16 inches a mile,
,, hydraulic mean depth 4.7 feet;

and in that case Dubuat's formula would give a discharge of 915 cubic feet a second and a mean velocity of 3 feet a second. It is to be noticed that the smaller discharge would make the velocity only 1.65 feet a second or 1,985 yards an hour equal to 1½ miles, and the latter does not agree with the experience of the undersigned on a channel of this size with so considerable a fall. Taking again the calculations based upon observations given in paragraph 3 of the memorandum: the actual depth of water is not given, but as the sectional area of the channel where the observations were made is greater than that of the intended enlarged section with 5¾ feet depth, the water is presumed to have been of greater depth; but then it is not clear how a

hydraulic mean depth closely corresponding to that of the enlarged channel was obtained, though this is quite possible. The observed maximum velocity was 1.714 feet only, and the mean velocity deduced was 1.0675 feet. By Dubuat's formula, with the surface slope of $\frac{1}{1100}$ stated, the mean velocity would be 2.18 nearly, or more than double that shown from observation. The surface fall in this case is more nearly that of the canals in the northern deltas, though still considerably greater, and the results of the observations therefore must be considered open to serious doubt.

Roorkee Professional Papers, No. 18-A. A perusal of Captain Alan Cunningham's experimental researches at the Solani

aqueduct on the Ganges canal shows how very carefully observations must be made, and how variable are the velocities even in a channel of perfectly regular section and with masonry floor and sides. Consequently too much reliance must not be placed on the few and comparatively rough observations on the south main channel. The

The present normal bottom width is 36 feet. Sectional area with 6 feet of water is therefore 270 feet against 315.16, and that depth even is somewhat excessive. sectional area of waterway and the small surface slope would appear to indicate that the conditions of the channel at the place chosen for experiment were abnormal, and if so, the results may have been seriously affected.

5. Fortunately it is not necessary to base proposed action on either observations or formula in this case. The channel carries much too little water, and it does not utilize what water there is in the river. The extent to which it can be conveniently widened is limited by the spoil banks. Two proposals have been made: one to add three vents of 4 feet to the head sluice and widen the channel to 45 feet bottom width, and the approximate estimate for this is Rupees 15,100; the other to leave the head sluice as it is, and to widen the channel to a bottom width of 57 feet to compensate for the loss of head at the sluice, the rough estimate for this being Rupees 20,100. Independently of the difference of cost the former arrangement will be in every way preferable; the sluice is known to be too small, and had it not been built before the project was sanctioned it would have been made larger. Loss of head here means loss of water, for the proper head could not be obtained without water going over the anicut. It may be however better in every way to add two vents of 6 feet instead of three of 4 feet to the head sluice, making the height of the vents 6 feet instead of 8 feet, which will be sufficient; the sluice will then fit the channel better, have a slightly greater discharge, and cost less for the alteration.

6. It is necessary to notice that the practical value of Mr. Hughes' memorandum is much lessened by the absence of exact information as to all the data from which his conclusions have been drawn. Every fact bearing on the subject should have been clearly set forth, and though the undersigned has made some use of the information given, no one unacquainted with the locality and not having access to old records could deal with it at all.

7. By the alterations proposed about 420 millions of cubic feet of water additional are expected to be utilized, and this quantity would represent the entire supply required for from 2,000 to 2,500 acres. It will, however, be really much more valuable inasmuch as it will secure a sufficient instead of an inadequate supply to a much larger area, and do much to remove the disappointment which has been felt at the

want of success hitherto of the project as a means of irrigation. It will probably be safe to assume that the outlay will be covered by increase of revenue in two or in three years at the outside.

8. The District Engineer also remarks upon the Ahtur channel, one of the principal distributaries from the main channel. The original arrangements were certainly very faulty, especially as regards the totally inadequate waterway of the bridges. This was noticed in 1869.

Notes of Inspection, 27th November 1869, paragraph 14, with G.O., No. 198, 18th January 1870. These bridges (two) have a waterway of 10 feet only against a present mean waterway of channel of $19\frac{1}{2}$ feet, while it is

shown to be necessary to make the mean width of the latter $25\frac{1}{2}$ feet, at the same time increasing the surface fall. The new Ahtur channel crosses the old source of supply from a head on the river some miles below the anicut by an aqueduct, and in consequence of representations made the

No. 53 T.N., 23rd November 1876.

undersigned authorised the dropping of the water over the side of the aqueduct into the old channel, and this alteration increased the supply materially, and is reported to have saved the land under cultivation last season. The cost of the improvements recommended by the District Engineer is approximately estimated at Rupees 7,800, and it is stated that thereby an annual outlay of Rupees 390 on the maintenance of the old head will be saved. This had better not be taken into account at present, for it may be found desirable to use the double source of supply whenever the state of the river is favorable to the offtake of water at the old head.

9. The approximate estimate for enlarging the head sluice of and widening the south main channel may be approved pending the submission of a regular estimate, and it is recommended that authority be given for preparing materials for the sluice, while the enlargement of the channel to 45 feet bottom width may, it is considered, at once be undertaken as the most valuable work on which a portion of the famine relief labor understood to be available can be employed.

10. A regular estimate for the improvement of the Ahtur channel should be prepared for entry in the Budget of 1878-79. It would perhaps be premature to carry out the enlargement until the main channel has been improved and the water-supply increased and until the general effect of these alterations has been ascertained, but if famine relief labor should need employment the widening of the Ahtur channel may be undertaken earlier, and in that case the regular estimate should not be delayed.

11. There are very special grounds for urging that more than ordinary care should be taken in the case of this project to secure to the people as much water as the Tamrapurni will supply. They have paid considerable sums of money for the right of occupation of lands formerly nearly valueless, in the belief that water was about to be made available, and they have suffered loss owing to that water not being forthcoming. The ideas formerly entertained about the value of the Tamrapurni as a source of irrigation were undoubtedly very sanguine, the difference between the circumstances of this lower anicut and of those situated higher up the river having been too little considered. The seasons have been exceptionally bad for the last two

or three years, and altogether the ryots have had their expectations falsified to a very prejudicial extent from causes which were beyond their own control.

12. The District Engineer should transmit as soon as possible a complete statement of the intended water distribution, showing the areas old and new under each distributary; the supply from the river required; the proportions in which with a given supply water is to be distributed to old and new irrigation, respectively; the storage capacity of tanks connected with each sub-section of the irrigation; the total quantity of water required for the security of the crops; the portion of this total to be obtained from river channels and rain-fall drainage, respectively; and the area of the catchment basins from which the latter supply is to be derived. On such information alone can the dimensions and arrangements of the distributaries be securely based, and though approximations may in many cases have to be acted upon in the absence of accurate information, these will be much better than the very rough and imperfect data on which the details of the scheme appear to have been originally arranged.

FORT ST. GEORGE,
13th March 1877.

(Signed) JOHN MULLINS, Lt.-Col., R.E.,
Chief Engineer for Irrigation.

To the Secretary to Government, Public Works Department.

No. 780.

ORDER THEREON, 31st March 1877, No. 1,094.

IRRIGATION, No. 51-A.

IN the papers submitted by the Chief Engineer for Irrigation certain prominent defects in the arrangements for the supply

of the irrigation under the Sriviguntum anicut south main channel have been noticed, and the enlargement of the channel and of its head sluice has been recommended with a view to secure a better supply of water, and prevent the loss over the anicut of water which would be of very great value to the inadequately supplied lands under this channel.

2. Imperfections in the design and arrangement of the works and an over-sanguine estimate of the value of the Tamrapurni as a source of supply have led to disappointment, and the result of the works so far has been widely different from that which was anticipated when the scheme was submitted for sanction.

3. There has existed considerable difference of opinion among Revenue Officers as to the probable future revenue which may be expected from this system of irrigation, and the latest Proceedings in the Revenue Department on the subject are those of the 21st February last, No. 754. Public Works Department No. 52, 6th March 1877. Inadequate water-supply is clearly the great difficulty. With that increased, and distributed under better arrangements, irrigation will certainly be extended and the revenue will be increased. Without more water it may be anticipated that disappointment will continue and possibly even such results as have been attained may show a falling off.

4. The improvements to the south main channel and its regulator are estimated approximately at Rupees 15,100, and His Grace the Governor in Council is of opinion

that the evidence renders it probable that the expenditure of this comparatively small amount will effect a material improvement. The enlargement and improvement of the Ahtur channel, a principal distributary of the south main channel, has also been shown to be very necessary. The approximate estimate of the cost of the alteration is Rupees 7,100.

5. Regular estimates should accordingly be prepared and submitted as soon as possible, and the sanction of the Government of India to them and for the early commencement of the work will then be applied for.

6. The District Engineer should take care in forwarding the estimates to show—

1st.—Whether there will be any saving from the estimate already sanctioned for the Sriviguntum Anicut Project, and, if so, to what extent and on what items.

2nd.—Whether any part of the Budget provision for 1877-78 can be transferred to these improvements, and what sum in addition will be required.

(True Extract.)

(Signed) JOHN MULLINS, Lieut.-Colonel, R.E.,
Secretary to Government, P.W.D.

To the District Engineer, Tinnevely.
" Chief Engineer for Irrigation.
" Examiner of Public Works Accounts.
" Revenue Department.
" Superintending Engineer, Godavari.
" " " Kistna.

Exd. E. C. Shanker.
Spare Copies

N^o 4

Office of the Chief Engineer for
Irrigation Fort St. George 13 March 1877

N^o 141 W.

Note by the Chief Engineer for Irrigation

Ends. 3.

The insufficiency of the water supply for the irrigation under the Striviguntum Aicut South main channel has been the ground of frequent complaints on the part of the ryots, and these complaints have taken the form either of remonstrances by the former holders of wet lands against allowing any water being passed down to the channels and tanks below the Kadamba Tank, or of petitions by the ryots who have taken up fresh land in the belief that water would be available in proportion to the acreage to be irrigated.

2 It appeared to the undersigned that the ryots who held irrigated lands

lands before the construction of the
Anicut, and whose supply had been
more or less interfered with by the
new arrangements, had a fair claim
to be first adequately supplied, and
instructions to this end have from
time to time been issued. The practi-
cal difficulty in effecting an equi-
table distribution however has arisen
from the fact that the quantity of
water available in any month is
extremely uncertain, and without
some reasonable basis for calcula-
tion it has been impossible to decide
when, for instance, the supply in the
Kadamba tank, an important re-
servoir at the lower end of the South
main channel could be deemed suf-
ficient for the cultivation under it,
and what level of the water therein
might be assumed to afford a
sufficient reserve to avoid risk of
the exhaustion of the supply before
fresh water from the river or from

rain-fall might be received to sup-
plement the storage. The Strivi-
guntum Anicut is the lowest of a
series of weirs across the Tambr-
poorny, and only in considerable
floods does much water reach it.
3. A partial remedy for the evils
entailed by an inadequate supply
of water can alone be adopted:—
The broad facts are that the present
supply is much less than what is
wanted, that the revenue has fallen
far short of what was anticipated,
that complaints from holders of
both old and new wet lands are
numerous and consistent, and last-
ly that there is even in bad sea-
sons some water in the river which
under present circumstances runs
to waste instead of being utilized.
Such being the case it is clearly
advisable with as little delay as
possible to introduce improvements
the

the need of which has been so forcibly demonstrated.

4 The Officiating District Engineer has transmitted a valuable memorandum by Mr. Hughes containing the result of his investigations. It has unfortunately been so badly transcribed that the examination in detail of the formulae and calculations is a matter of great difficulty. The want of correspondence between the actual and calculated levels of the water above and below the head sluices of the main channels and elsewhere attracted observation when the works were last inspected, and it was clear that the South channel from some cause or other was not discharging the supply due to the depth indicated. It is now shown that this was due in part to the excavation in the 3 mile not having been properly completed, but

Pross. Madras
G.O. No. 848,
3rd March 1875
Notes paras
16 and 17.

* Dubuat's

but Mr. Hughes considers that only a part of the difference is due to this cause, and that the calculated discharge originally was in excess of that which the channel with the fall and dimensions adopted could convey. The formula in use in the Irrigation Department does with the low surface falls prevalent in the Northern Deltas give results not widely divergent from the observed velocities, and for the much greater surface falls of the Striviguntum channels there is no extended experience to appeal to. It cannot however be taken as probable without further investigation that Dubuat's formula would give results so widely differing from the fact as is indicated by the discharges given in Mr. Hughes' Memorandum. He shows para 5 that the South main channel with a bottom width of 45 feet and a depth of $5\frac{3}{4}$ feet would discharge 504 Cubic feet a second. He has not stated all the data, but it has been assumed

assumed that,
the side slopes of the channel are $1\frac{1}{2}$ to 1,
-- surface fall 1 in 3960 or 16 inches a mile,
-- hydraulic mean depth 4.7 feet,
and in that case DuBuats' formula
would give a discharge of 915 Cubic feet
a second and a mean velocity of 3 feet
a second. It is to be noticed that the
smaller discharge would make the
velocity only 1.65 feet a second or 1985
yards an hour equal to $1\frac{1}{8}$ miles and the
latter does not agree with the experience
of the undersigned on a channel of this
size with so considerable a fall. Taking
again the calculations based upon ob-
servations given in para 3 of the memo:-
The actual depth of water is not given,
but as the sectional area of the channel
where the observations were made is greater
than that of the intended enlarged sec-
tion with 5.4 feet depth the water is
presumed to have been of greater depth,
but then it is not clear how a hy-
draulic mean depth closely correspond-
ing to that of the enlarged channel

was

2/22
was obtained, though this is quite
possible. The observed maximum
velocity was 1.714 feet only, and the
mean velocity deduced was 1.5675 feet.
By DuBuats' formula, with the sur-
face slope of $\frac{1}{7200}$ stated, the mean
velocity would be 2.18 nearly or more
than double that shown from ob-
servation. The surface fall in this
case is more nearly that of the canals
in the Northern Deltas, though still
considerably greater, and the results
of the observations therefore must be
considered open to serious doubt.
A perusal of Captain Alan Cunningham's
experimental researches at
the Solani Aqueduct on the Ganges
canal shows how very carefully ob-
servations must be made and how
variable are the velocities even in a
channel of perfectly regular section and
with masonry floor and sides. Con-
sequently too much reliance must
not be placed on the few and com-
paratively

comparatively rough observations on the South main channel. The sectional area of waterway and the small surface slope would appear to indicate that the conditions of the channel at the place chosen for experiment were abnormal, and if so the results may have been seriously affected.

The present normal bottom width is 36 feet. Sectional area with 6 feet of water is there fore 270 feet against 315.16 and that depth even is somewhat excessive.

5 Fortunately, it is not necessary to base proposed action on either observations or formula in this case. The channel carries much too little water, and it does not utilize what water there is in the river. The extent to which it can be conveniently widened is limited by the spoil banks. Two proposals have been made: one to add 3 vents of 4 feet to the head sluice and widen the channel to 45 feet bottom width, and the approximate estimate for this is Rupees 15,700; the other to leave the head sluice as it is, and to widen the channel to a bottom

256
bottom width of 57 feet to compensate for the loss of head at the sluice, the rough estimate for this being Rupees 20,100. Independently of the difference of cost, the former arrangement will be in every way preferable; the sluice is known to be too small and had it not been built before the project was sanctioned it would have been made larger. Loss of head here means loss of water for the proper head could not be obtained without water going over the Anicut. It may be however better in every way to add 2 vents of 6 feet instead of 3 of 4 feet to the head sluice making the height of the vents 6 feet instead of 8 feet, which will be sufficient; the sluice will then fit the channel better, have a slightly greater discharge and cost less for the alteration.

6 It is necessary to notice that the practical value of Mr. Hughes' memorandum is much lessened by the

the absence of exact information as to all the data from which his conclusions have been drawn. Every fact bearing on the subject should have been clearly set forth, and though the undersigned has made some use of the information given no one unacquainted with the locality and not having access to old records could deal with it at all.

7 By the alterations proposed about 420 millions of cubic feet of water additional are expected to be utilized, and this quantity would represent the entire supply required for from 2000 to 2500 acres. It will however be really much more valuable inasmuch as it will secure a sufficient instead of an inadequate supply to a much larger area, and do much to remove the disappointment which has been felt at the want of success hitherto of the project

project as a means of irrigation. It will probably be safe to assume that the outlay will be covered by increase of revenue in 2 or 3 years at the outside.

8 The District Engineer also remarks upon the Ahtur channel one of the principal distributaries from the main channel. The original arrangements were certainly very faulty especially as regards the totally inadequate waterway of the bridges. This was noticed in notes of Ins. of the bridges. This was noticed in inspection 27 Nov. 1869. These bridges (2) have a waterway of 10 feet only against a present mean waterway of channel of $19\frac{1}{2}$ feet, while it is shown to be necessary to make the mean width of the latter $25\frac{1}{2}$ feet, at the same time increasing the surface fall. The new Ahtur channel crosses the old source of supply from a head on

Notes of Ins.
inspection 27 Nov. 1869
paras 14, with
G.O. N. 198 - 18 Jan. 1870

on the river some miles below the Anis-
cut, by an Aqueduct, and in conse-
quence of representations made the
undersigned authorized the drop-
ping of the water over the side of
the aqueduct into the old channel,
and this alteration increased the
supply materially, and is reported
to have saved the land under culti-
vation last season. The cost of the
improvements recommended by the
District Engineer is approximately
estimated at Rupees 7,800 and it is
stated that thereby an annual out-
lay of Rupees 390 on the mainte-
nance of the old head will be saved.

This had better not be taken into
account at present, for it may be
found desirable to use the double
source of supply whenever the state
of the river is favourable to the off-
take of water at the old head.

9 The approximate estimate for
enlarging the head sluice of and widen-

N^o 53 T. N.
23rd November
1876.

widening the South main channel may be
be approved pending the submission
of a regular estimate, and it is recom-
mended that authority be given for
preparing materials for the sluice
while the enlargement of the chan-
nel to 45 feet bottom width may, it
is considered, at once be undertaken
as the most valuable work on which
a portion of the Famine relief labour
understood to be available, can be
employed.

10 A regular estimate for the im-
provement of the Ahtur channel
should be prepared for entry in the
Budget of 1878-79. It would perhaps
be premature to carry out the enlarge-
ment until the main channel has
been improved and the water sup-
ply increased, and until the general
effect of these alterations has been
ascertained, but if Famine relief
labour

labour should need employment the widening of the Ahtur Channel may be undertaken earlier, & in that case the regular estimate should not be delayed.

11 There are very special grounds for urging that more than ordinary care should be taken in the case of this project to secure to the people as much water as the Tambrapoorney will supply. They have paid considerable sums of money for the right of occupation of lands formerly nearly valueless, in the belief that water was about to be made available, and they have suffered loss owing to ^{that} water not being forthcoming. The ideas formerly entertained about the value of the Tambrapoorney as a source of irrigation were undoubtedly very sanguine, the difference between the circumstances of this lower Ancient and

29/12/6
and of those situated higher up the river having been too little considered. The seasons have been exceptionally bad for the last 2 or 3 years, and altogether the ryots have held their expectations falsified to a very prejudicial extent from causes which were beyond their own control.

12 The District Engineer should transmit as soon as possible a complete statement of the intended water distribution, showing the areas old and new under each distributary, the supply from the river required, the proportions in which with a given supply water is to be distributed to old and new irrigation respectively, the storage capacity of tanks connected with each subsection of the irrigation, the total quantity of water required for the security of

of the crops, the portion of this total to be obtained from river channels and rain-fall drainage respectively, and the area of the catchment basins from which the latter supply is to be derived. On such information alone can the dimensions and arrangements of the distributaries be securely based, and though approximations may in many cases have to be acted upon in the absence of accurate information, these will be better much than the very rough and imperfect data on which the details of the scheme appear to have been originally arranged.

W. H. Williams Lieut. Col. R. E.

Chief Engineer for Irrigation

To The Secretary to Government
P. W. D.

988

6 - March 1877 No 52 Trin
 14 - Decr 1876 - 3210
 5 - " - 3287
 27 - Sep - 2876
 31 - Aug - 2314
 2 - Aug - 1971
 19 July 1875 - 1085 Rev. Dept.
 31 March - 848.
 18 Jan 1870 - 198.

Irrigation
 1877

From

The Chief Engineer for Irrigation
 P.W.D.

15 MAR 77

No. 2804

Dated 13 } March 1877
 Recd. 15 }

Encls. 3

No 141-W.

Strivignatum Ancient - Trinivelly District. - Note regarding the inadequate water supply under the South main Channel and recommending certain improvements to the South main Channel with regulator and to the Ahotur distributary.

N: 979

L. Q 31st March/77 I.B. No 1094

E. I. Form No. 22.

Irish 28
 331

No 1094

Public Works Department.

PROCEEDINGS of the MADRAS GOVERNMENT.

Under date the 31st March 1877

Read the following:—

Note by the Chief Engineer for Irrigation (H.E. No 141-W. 9/13 March 1877)

[Signature]
 as attached.

In the papers submitted by the Chief Engineer for Irrigation certain prominent defects in the arrangements for the supply of the irrigation under the Strivignatum Ancient South main channel have been noticed, and the enlargement of the channel and of its head sluice has been recommended.

recommended with a view
to secure a better supply
of water and prevent
the loss over the Anicut
of water which would
be of very great value
to the inadequately sup-
plied lands under
this channel.

2 Imperfections in the design and arrangement of the works and an over sanguine estimate of the value of the Tambrapourny as a source of supply have led to disappointment, and the result of the works so far has been widely different from that which was anticipated when the scheme was submitted for sanction.

3 There has existed
considerable

[illegible]

considerable difference of opinion among Revenue Officers as to the probable future revenue which may be expected from this system of irrigation, and the latest Proceedings in the Revenue Department on the subject are those of the 21st February last No 754. Inadequate water supply is clearly the great difficulty. With that increased, and distributed under better arrangements irrigation will certainly be extended and the Revenue will be increased. Without more water it may be anticipated that disappointment will continue and possibly even such results as have been

been attained may show a falling off.

4 The improvements to the South main channel and its regulator are estimated approximately at Rupees 15,700, and His Grace the Gover-

nor in Council is of opinion that the evidence renders it probable that the expenditure of this comparatively small amount will effect a material improvement.

~~The materials for the head sluice in anticipation of the sanction of a regular estimate is authorized and if, as supposed, by the Chief Engineer for Irrigation, the enlargement of the channel~~

* The enlargement and improvement of the Ahtur channel, a principal distributary of the South main channel, has also been shown to be very necessary. The approximate estimate of the cost of the alterations is Rupees 7,500

5. Rupees estimates should accordingly be prepared and submitted as soon as possible & the sanction of the Government of India to them & for the early commencement of the work will then be applied for.

6. The District Engineer

Should take care in forwarding the estimates to show

1st. Whether there will be any saving from the estimate already sanctioned for the Strivinguram Ahtur project, and if so to what extent and on what items,

2nd. Whether any part of the Budget provision for 1877-78 can be transferred to these improvements & what sum in addition will be required.

May 24/3

37/ 30
channel can be made to afford useful employment to Famine relief labour, this work may be undertaken at once. Similarly, the improvement of the Ahtur distributary may be proceeded with at an approximate cost of Rupees 7,800 if needed for the employment of Famine labour, otherwise the submission of a regular estimate must precede the commencement of this work.

5. His Excellency in Council hopes that as soon as possible the arrangements for a systematic distribution of the water supply will be matured and thereafter

the current year. In the mean time Rupees 1000 will be placed at his disposal from the Reserve. Any expenditure which may be incurred on the main channel and Ahtur channel improvements (earth-works) will be met from Famine relief funds in the first instance, and will afterwards be adjusted in the Examiners' books as laid down in G. O. No. 3410 dated 14 December 1876. Expenditure on C Works - Ahtur channel, required in connection with Famine relief work undertaken, will be met by appropriation from the Reserve on

19-12-71 - R.A.

thereafter it may be possible to estimate more accurately the increase of irrigated area which may be expected.

6 The approximate estimates now approved are,

(2) Main Canals and branches.

South main channel.

D. Regulators

Head sluice - Rs. 6800

L. Earth works - 8300

(3) Distributaries.

Ahtur channel.

C. Works

L. Earth works } Rupees 7800.

For the expenditure upon the head sluice the District Engineer will report what appropriations will be necessary from the Ordinary grant - Irrigation, Original works, for the

7 A copy of these Pros.
will be forwarded to the
Government of India
for information.

14.14/3

To District Inspr. Tinnevely.
 " - Chief Inspr. for Irrigation
 with 3 ^{other} Inspr.
 " Examiner of P.W. Accounts
 " Rev. Depts. ✓
 " Suptg Inspr Godavery ✓
 " - do - Ristna. ✓

Arad-17-4-77

64

15.3.77

W. J. P.

Gobt. of 1876 Ind. as.

PUBLIC WORKS.

To

The N. L. Limerelly

Dated

Issued

Recd.

Encl.

G. O., 31st March 1877, No. 1094.

Nos. 779-780

Strivingantum Aserob
Ancient Lint Main
Channel, Limerelly Dr

Passing orders on note by
the Chief Engineer for Limerelly
regarding the inadequate
water supply under the

W. J. P.