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Proceedings of the Madras Government, Public Works Department,
19th December 1874.

Read the following:—

No. 769 A.

No. 397. *Note by the Chief Engineer for Irrigation.*

General Irrigation arrangements, Western Delta, Kistna.

The Western Delta of the Kistna will be supplied by three canals, viz.:—

(1.) The Bank Canal, having its off-take in the 8th mile of the Main Canal, while the latter is at 13 miles divided into the (2) Nizamapatam canal, occupying a central position in the delta, and (3) the Commamoor canal which skirts the upland on the north-west.

It should be mentioned here that what is really the Main Canal, viz., the 13 miles from the head to the first lock at Dupirala, has been called by several different names, but to avoid confusion it is necessary that henceforth the proper appellation should be used, and instructions have been issued for the sub-division of the expenditure heretofore charged to the Main and Nizamapatam Canals conjointly, between these canals severally.

Areas under the Primary Branch Canals.

2. The ultimate area of irrigation in this delta has been estimated at 230,000 acres, an area which possibly may be reached in time, and it was distributed among the three canals in the following proportions:—

Bank Canal	75,000 acres.
Nizamapatam Canal	55,000 ,,
Commamoor do.	100,000 ,,

Seeing, however, that a good deal of the land included in the area under the last mentioned canal is land which is as yet unreclaimed swamp, it has been deemed desirable, so as to avoid an over-sanguine estimate, to reduce somewhat the area of the probable extension of irrigation. As the discharge, moreover, of the Main Canal, as designed, has been calculated by the officers who have framed the estimates on a formula* which gives a higher velocity than DuBuat's, which has been adopted for the Godavery canals and other works throughout the Presidency, it has been considered advisable to retain the dimensions fixed for the Main Canal, but to assume that it will irrigate the reduced area of 200,000 acres for which by DuBuat's formula it will afford the proper full supply of 2 cubic yards per acre per hour. This total, moreover, of 200,000 acres has been thus distributed:—

* $v = 916\sqrt{2f \times \text{H. M. D.}}$

Bank Canal	70,000 acres.
Nizamapatam Canal	50,000 ,,
Commamoor do.	80,000 ,,

The gross area of this delta is 950 square miles, of which one-third may be considered to be either—

(1.)—Non-arable.

(2.)—Occupied by village sites, etc.

A

(3.)—Occupied by roads, canals, channels, and drains, and of the remainder the project provides for the irrigation of about one-half.

The irrigated area will amount to 210 acres per square mile of gross area.

3. The circumstances of the water-supply have been carefully inquired into, and the results appear to me to be satisfactory. A statement has been prepared showing for the nine years, from 1864 to 1872 inclusive, the levels at which the water in the river stood on the sill of the head-sluice during the irrigation season from July to December inclusive, and modifying this for the altered acreage, discharge of canal, and to a trifling extent for the actual instead of average head assumed as necessary to pass the supply through the head sluice, corresponding to the discharge of the canal at the several depths, the following general results have been obtained :—

Water-supply.

Appendix C. C. C.

Years.	Supplies available per acre per hour in cubic yards.							Total days of Irrigation season.
	1·46.	1·55.	1·64.	1·74.	1·84.	1·99.	2·00 and upwards.	
	DAYS.	DAYS.	DAYS.	DAYS.	DAYS.	DAYS.	DAYS.	
1864... ...	1	7	13	13	21	38	93	
1865... ...	...	...	2	10	13	25	134	
1866... ...	...	...	...	9	10	32	133	
1867... ...	...	3	2	1	2	13	163	
1868... ...	5	4	5	11	5	15	139	184
1869... ...	...	...	...	2	3	12	167	
1870... ...	...	...	...	...	1	13	170	
1871... ...	4	3	1	3	2	16	155	
1872... ...	...	...	...	...	2	15	167	
Total...	10	17	23	49	59	179	1,321	
Average...	1	2	3	5	7	20	146	184

Although in accordance with the practice hitherto observed 2 cubic yards per acre per hour are deemed a full supply, the opinion formed in the Godavery Western Delta from the experience of the last few seasons is that in the low lying lands a less quantity will suffice, and it is believed therefore that whenever the Main Canal is carrying 1·80 cubic yards or more per acre for the full area, there will be no want of water in this delta, of which the soil is remarkably retentive except in the sandy tracts near the coast, and very much of the land on a low level. Moreover, it is considered that if the total quantity of water required in every ten days be delivered within that period the crops will not in any way suffer, and provision will be made for carrying in the Main Canal a quantity larger by 317 cubic feet a second, or somewhat more than 10 per cent. additional, whenever the circumstances may render this practicable and desirable. This will be secured by admitting a depth of water of 8½ feet instead of 8 feet, and the greater depth has in the past been frequently exceeded. Judging from the table above given it will only be in somewhat unfavorable years that the ordinary full

supply depth will need to be exceeded and even then but seldom. It has not been found practicable to estimate accurately the supply in the river towards the close of the irrigation season. The head sluice sill is 6 feet below the crest of the anicut, and as soon as the river falls sufficiently to allow of this being done, the requisite head of water is obtained by placing on the crest of the dam a rough stone wall, the material of which is subsequently used for the ordinary annual repairs of the lower apron. Through the interstices of this wall a large body of water escapes, but how much it would be difficult to say. What is known is that it has been found practicable to maintain the water level at from 8½ to 9½ feet above the head-sluice sills by this means, coupled in December with the partial closing of the interstices of the stone wall by small stone and quarry rubbish. The length of the anicut being 1,400 yards, a large quantity of water does necessarily pass through the loose stone wall, and if requisite more can be done than has hitherto been considered needful to reduce the quantity thus escaping. Much greater then as will be the future demands of the main canals of this delta, and of that on the other side of the river, I am disposed to think that by the simple means already used there will be no difficulty in meeting them.

The question may perhaps be asked: Why has not some better way of raising the water level at the anicut after the cessation of the freshes been introduced or proposed? A good deal of attention has been given to this subject, and several forms of shutters, beginning with the cast iron posts and planking used at the Godavery anicut and elsewhere, have been designed, some arrangements suggested by the late Major Ryves and experimented with, as also by Mr. F. G. Stoney, being ingenious. All these however involved the setting up of posts or standards in the masonry of the crest, and this has been considered dangerous, as the high velocity of the water with the large amount of drift brought down led, in the case of the posts formerly set up, to damage to the crest. Consequently, should it hereafter be deemed desirable to place moveable shutters on the crest at certain seasons of the year, they must be so designed as to present no obstacle whatever to the passage of the water, and supports as well as planking must, when not in use, lie flush with the crest of the dam; that such shutters would be a convenience will be readily understood, as when the river is fluctuating, and before a rough stone dam can be commenced, they would be useful, and the water level would be raised much more quickly than is at present practicable. For some years to come, however, the simple rough stone wall will certainly suffice, and its cost being quite nominal it may very well be continued until its supersession by some more complete arrangement is demanded.

4. The head-sluice is a substantial work, which has answered its purpose, and which, with the improved shutters and means of working them now to be provided, will be quite efficient. It has fifteen vents of 6 feet span each, the height of the openings being 11 feet, which will be reduced to 8 feet to correspond with full supply level in the canal. There will then be 728 square feet of waterway, and the discharge required being 3,000 cubic feet a second, the velocity would be a little over 4 feet a second; it is intended, however, to build a supplemental head-sluice in which to try Mr. Stoney's equilibrium valve or shutter, and designs for

Head Sluice.

this have been called for. Each vent will have 36 square feet of waterway, and estimates for a sluice of one vent and of three vents respectively will be prepared. The head required to pass a full supply will not exceed 8 inches. The estimate for improvements to the existing sluice amounts to ... Rs. 9,840
and for the additional sluice may be allowed ... ... „ 15,160

Total Rs. 25,000

Maximum flood level in the Kistna is, as far as known, 60·5, the roadway of the sluice being 63. Another foot of margin can easily be obtained and should be given, and the stop and flood banks should not be lower than 66; and then, should any emergency arise, the roadways may easily be raised temporarily to the same level.

Main Canal.

5. The Main Canal has at present a bottom width of 96 feet, and it will be enlarged to 230 feet down to the head of the Bank Canal in the 8th mile and thence to its terminus at 13 miles, the width at sole will be 141 feet, with side slopes of 2 to 1 and a fall of 0·27 feet a mile. The discharge with an ordinary full supply depth of 8 feet will be 3,011 cubic feet a second, or sufficient for 200,750 acres, at 2 cubic yards per acre per hour.

Similarly the discharge is calculated to be with the intended maximum depth of 8½ feet, 3,317 cubic feet, or 2·21 cubic yards per acre per hour.
A depth of 7½ feet, 2,756 „ „ „ 1·84 „ „
A „ 6½ „ 2,195·5 „ „ „ 1·46 „ „
Below the head of the Bank Canal the full supply discharge will be, per second, cubic feet 1,884. The acreage assumed by the Delta Officers was 155,000, and as reduced it will be 130,000. For the latter the supply will be at the rate of 1·93 cubic yards per acre per hour, and the acreage, 50,000 under the Nizamapatam Canal side channels, should receive the full supply of 2 cubic yards, leaving 1·89 cubic yards for the Commamoor Canal, which receives a good deal of drainage.

Estimate for main supply.

6. The estimate for the enlargement of the Main Canal is

	Rs.
Earthworks	5,36,085
Land compensation	1,935
	5,38,020
No statement of the land to be taken up for the Main Canal has been received; it is all dry land; probably one-twentieth of the compensation amount will represent the assessment, and this capitalized will amount to Rupees 2,418, say	2,480
Total...	5,40,500

The proposed expenditure on main supply which will be divisible among the three sections of irrigation will therefore be 5,40,500 + 25,000 = 5,65,500 Rupees.

Past expenditure Main and Nizamapatam Canals.

Vide G. O., 21st August 1874, No. 2,365.

7. The past expenditure, which from the absence of a distinction between the Main and Nizamapatam Canals has to be divided between these, was up to the 31st March last Rupees 5,10,365.

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Drainage.

8. The drainage of the delta is a matter of great importance both as regards the well being and prosperity of this tract of very rich country, but also from a financial point of view. It became necessary to introduce some principle on which to base the designs of this class of work, and the arrangements prescribed are as follow. It was manifestly impracticable, in a country situated as is the delta, to dispose of rainfall drainage within the delta and that from the uplands after its entrance within the delta limits as fast as it came down or accumulated, and it was believed also to be unnecessary that this should be done. Generally speaking standing wet crops would not be liable to injury from an excess of water during several days, or from submergence for a short period. It is, therefore, intended to dispose of the maximum estimated drainage of six days within that time. Moreover, as the amount of drainage is not in direct proportion to the area drained, and as it is believed that the real proportion is sufficiently closely determined by the formula $D = C\sqrt{M^2}$, in which M represents the area drained in square miles, that equation has been made use of. For the determination of the actual discharge a standard area of 5 square miles has been taken, and C has been assumed for this particular part of the country to be 450 per cubic feet a second. On these data the maximum drainage from 5 square miles will be 1,314 cubic feet a second, equivalent to a little under 10 inches in the 24 hours. Six days have been taken as the time within which the lands are to be freed from flood waters, and in addition to the maximum rainfall drainage of 10 inches on one day, it has been supposed that 2 inches will be due to the other 5 days, so that altogether 12 inches will have to be disposed of in 6 days, or 2 inches a day from the area of 5 square miles. For other areas the relative drainage has been determined by the formula above given, and the results are as follow:—

10	square miles	discharge due to a	drainage from the whole area of	1·60 inches.
20	Do.	do.	do.	1·27 „
30	Do.	do.	do.	1·10 „
40	Do.	do.	do.	1·00 „
50	Do.	do.	do.	0·90 „
75	Do.	do.	do.	0·81 „
100	Do.	do.	do.	0·74 „
125	Do.	do.	do.	0·69 „
150	Do.	do.	do.	0·65 „

and so on for any other areas.

This arrangement is applicable of course only to drainage within the delta, the area of which will be sub-divided by canals, channels, main and subsidiary drains, into a number of comparatively small spaces, on which drainage will accumulate after very heavy falls of rain, and thereafter be carried away as fast as the drains will allow.

Upland or extra delta drainage will have to be disposed of, so far as passing it across the canals is concerned, as fast, or very nearly as fast, as it can come down. The Commamoor Canal, like the Ellore Canal, runs transversely to a great extent of drainage; the plan to be adopted is, that a certain proportion of the discharge, corresponding to heavy but not extraordinary rainfall, will be passed under the canal, while all above and beyond that will be passed across by means of inlets and

outlets, this arrangement being, as far as I am able to judge, the only way in which security and economy can be combined.

The Western Delta will be cleared of flood-waters by three main drains.

1. The Repalli main drain, occupying a position about midway between the Bank and the Nizampatam Canals, and discharging into a tidal creek which communicates with the Nizampatam backwater.
2. The Toongabudra, a small river which at present overflows its banks on very small provocation, which has been obstructed at different times for purposes of irrigation, and which needs great enlargement and much improvement.
3. The Rampairu, which is now a great swamp, covering a large extent of land, much of which is valuable, in which the drainage of about 400 square miles accumulates and takes months instead of days to run off.

The subsidiary drains will be numerous; the positions of all which have to be separately estimated for have been determined, and the designs are under preparation.

The drainage of the delta lands, so far as this may be connected with the disposal of surplus irrigation water, rendered necessary to admit of the extension of irrigation, or may be required for the benefit of lands already irrigated, is fairly chargeable to the general scheme of the delta irrigation. Beyond this it would seem that the irrigation works are in no way liable to bear the charge, and if any further works be debited to the capital account of the delta scheme, it should only be on the ground that if there be a likelihood of a return from irrigation considerably exceeding the interest on the money invested, some part of the capital represented by the difference may be invested in the genera improvement of the condition and healthfulness of the country from which such revenue is derived. If so, it is of course surplus revenue only that should be applied to such a purpose.

It has been supposed by the Government, in connection with the papers on the village drainage of the Godavery, that artificial irrigation is a principal cause of the need of drainage, but that this is not really the case may easily be shown. Very small drains comparatively will convey away all the surplus irrigation water. The total supply on this account is but a little over one-third of an inch in the 24 hours, and of this only a small fraction is surplused from the lands, because when there is heavy rainfall, and when consequently much water is not required on the fields, the quantity admitted at the head-sluices is diminished, and much of that which enters the canals is sent direct into the drains and natural streams. Probably therefore, at the outside, one-fifth of an inch in the 24 hours would be the largest drainage due to the irrigation works, and as has been above shown this would be but one-tenth of the quantity due to rainfall. Natural causes render great drains necessary, and it would seem to follow that the irrigation project is not bound to pay more than a comparatively small fraction of the cost of providing them. The subject has been touched upon here because it appears to me highly probable that it will have to be considered before long, and that unless this principle be acknowledged to be right, so that it may be acted upon when necessary, it will be requisite to wait until all the estimates are in before any of them can be sanctioned for execution.

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19*th December* 1874.

That the extension of irrigation will of itself yield an ample return there is no room for doubt; that with it may be combined several improvements and advantages, such as navigation and a great deal of the drainage, I have every reason to believe; but there is a limit to the returns which may be anticipated, and it will be quite possible to include so much work in the estimates as to make the interest on the capital outlay approximate much too closely to the net revenue. So to do would be very prejudicial to the real interests of the delta, which may reasonably be allowed to receive as soon as possible those benefits which are readily attainable, even if others, which it may be desired to bestow, cannot concurrently or as rapidly be carried out.

The several drainage estimates will in due course be reviewed.

Nizamapatam Canal.

9. This canal commences at, and includes, the Dugirala Lock, with the head works of the side channels for distribution. It was originally designed and constructed to carry irrigation water, but the slight current admissible for navigation caused the deposit of so much silt that the late Colonel Anderson, when in charge of the division, determined to carry the irrigation water in side channels having a considerably greater fall and velocity, and this modification has been carried out. The withdrawal of this supply deteriorated the navigation greatly, and it was first proposed to insert two additional locks between the first and second pairs, but on examination it was found that the improvement desired, viz., the provision of an adequate depth of water on the lower sills of the Dugirala and Kuchipudi Locks could be secured at a small cost by raising and strengthening the banks in the first and second reaches, and the estimates provide for this improvement. All surface fall will be eliminated, and the depth of water on the lower sills will be 5 feet and on the upper sills 8 feet. It is desirable that this minimum of 5 feet should be confined to the lock lower sills, and the bed should be placed a foot lower immediately below the locks. The work in the estimate is entered for raising and strengthening the banks only, and the soil for this purpose should be taken, where necessary, from the canal, so as to afford a minimum width at sole of 30 feet and of depth of 6 feet, which, with side slopes of 2 to 1, will give a width at water surface of 54 feet and 42 feet fully for navigation. The cross sections show that the depth is generally very nearly 6 feet, and that with but few exceptions but very little widening will be needed. The two reaches of the canal which are to be thus improved extend from the 13th mile, or the commencement, to 31½ miles. The estimate for this work* is Rupees 10,645. From the Jutur lock 31¼ to the Tidal lock at 40 miles no work is considered necessary.

* "Main Canal Earthworks."

Nizamapatam Canal Distribution.

10. As noticed the irrigation water is carried by two side channels which run close to the canal. The *eastern side channel* is to be extended so as to allow of the Nullavada swamp being drained, an improvement which cannot be effected until certain irrigation channels obtaining their supply therefrom shall have been otherwise provided for. A very extensive tract of country, which is to be relieved of flood-waters by the Repalli main drain, is interested in the carrying o u

of this extension, which in addition to some 3,000 acres of existing irrigation will supply 4,000 acres of land. The work provided for is—

		Rs.
Extending the side channel 4¾ miles—Earthworks		6,040
Masonry	Improving head-sluice	3,515
	Minor masonry works	2,000
	Total ..	11,555

The western side channel is likewise to be prolonged to about the same extent, and the estimate includes the following items :—

	Rs.
Extension about 4½ miles—Earthworks	2,055
Improving head-sluice	1,885
Minor masonry works	1,000
Total ..	4,940

11. The present and expected areas of irrigation under the Nizamapatam canal are as follow. It will be seen from Statement C. C. that the lands now irrigated direct from the canal are to be supplied from the two side channels, but it is not shown how this area of 1,800 acres is to be distributed. The present irrigation, or rather that of 1871-72 is—

Present and anticipated area of irrigation.

	Acres.	Assessment.
		Rs.
Under the Canal	1,800	10,166
Do. East side Channel	12,759	71,226
Do. West ,, ,, ...	6,986	42,344
	21,545	1,23,736

and the extensions contemplated are entered as under—

The East side Channel	21,241
,, West ,, ,, ...	14,014
	35,255

making the ultimate total 56,800. From this the 1,800 acres, which are to be transferred, have to be deducted, as also the reduction of 5,000 acres made in paragraph 2 above, and the irrigation to be supplied from this canal will then be 28,455 acres; lastly, 3,000 acres now supplied from the Nullavada swamp are to be brought under the east side channel, so that the paying increase of area will be 25,455 acres, and these at Rupees 4 an acre water-rate will yield a gross revenue of Rupees 1,01,820. All that can be said in this place as regards returnon proposed expenditure is that the outlay required to provide for this extension of irrigation may be taken to be approximately—

Probable returns.

	Rs.
One-fourth* of the outlay on the Main Canal.	1,36,965
The estimate for the Nizamapatam Canal ...	10,645
Do. do. side channels or distributaries	16,495
	1,64,105
Adding also for establishments 25 per cent.	41,026
Tools and Plant 8 per cent. ...	13,129
	54,155
Total outlay...	2,18,260

* Total area of irrigation, Western Delta, 200,000 acres. Nizamapatam Canal 50,000 acres, or one-fourth of the total.

This approximation shows that the improvements estimated for will yield a very ample return, but at present it cannot be shown what the returns, with reference to the total outlay from the commencement, will be, and, moreover, a very large amount will have to be added rateably to the estimates on account of drainage works. These latter are as necessary now of course as they will be in the future, and therefore the question as to what should be done for improving the drainage is virtually independent of the proposals to render the irrigation more complete and efficient. As regards the eastern side channel, it has been already mentioned that its extension will make it possible to carry out much needed drainage works, which cannot be undertaken until the Nullavada swamp has ceased to be utilized for irrigation purposes.

Vide paragraph 1 above.

The gross area of the section under th[illegible]izampatam is 209 square miles, and t[illegible]0,000 acres to be irrigated will be 239 acres to the square mile of gross area.

Proportion between gross and irrigated areas.

12. The enlargement of the Main Canal will take many years. The excavations above full supply level can be gone on with steadily to the extent that the supply of labor available will allow, but below that level work can be done only during the short time annually that this duct can be closed. The enlargement above full supply level will certainly not be gone on with too rapidly, and that below will have to be executed probably in ten successive widths of about 5 yards each. The widening must, to prevent silting, be effected from end to end, regularly commencing from the lower end, and not more than 60,000 to 70,000 Rupees annually, including the work on the higher level, can be expended, while on that below full supply level probably the work represented by 25,000 Rupees will be as much as can be done. There is, therefore, no risk of the increase of the supply out-running the rate at which irrigation may be expected to extend, and I think, therefore, that the estimate may be sanctioned and the work commenced at latest in the season of 1875-76.

Enlargement of Main Canal will occupy a long period.

13. The Main Canal has only one lock, that at its head, and the chamber walls are at 63·00, highest flood in the Kistna being 60·50. The margin is hardly sufficient, and at least the front wings and returns and the side walls to the upper gates should be raised to 64·50, and be connected with the flood banks; it will then be improbable that any damage of consequence will occur. The Dugirala lock, the first on the Nizamapatam canal, has its chamber walls 1·25 feet above full supply level. This margin will not suffice, for occasionally the canal will carry 8½ feet, which could raise the water to 0·75 feet below the top of the walls, and a mistake in regulation might lead to an overflow and considerable damage. It will be better, therefore, to raise the walls of this lock 9 inches, which can be done with a single course of stone, and will not cost much. Then full supply

Margin of lock walls above water level.—See paragraph 5 of Specification Report, Accompaniment No. 2.

level and maximum water level should be marked on the entrance walls and also on all the regulating works just above the lock, so that the water may not be allowed to rise at any time above the maximum level of 42·00. The head sluice at Sitanagaram being 13 miles off, and surplus being disposable only by the line of the Commamoor canal, the upper part of which was formerly the Toongabudra, and thence by the Jagurlamudy surplus sluices, which are at a distance of 6 miles, it is essential that a considerable margin should be allowed to afford time for the correction of any mistakes which may possibly be made at the head-sluice, or to obviate the risk which might result from the shutting off of the supply to the Bank Canal.

Below Dugirala the supply of water to the canal will be only that required to make up for evaporation, lockage, etc., and the margins existing at the Kuchipudy, Nallavada, and tidal locks are ample, while that (1 foot) at the Jutur lock will suffice.

14. Care must be taken that the heads of minor distributaries are placed at such points on the side channels as will afford a sufficient fall thence to the lands to be irrigated. This important matter has not hitherto received sufficient attention, and it is essential to a convenient and efficient system of distribution. Dams for raising the water level at the heads of individual irrigation channels are very objectionable, and the primary object of the construction of the side channels, viz., the conveyance of water at a velocity which would have been inconvenient in a navigation canal, will be defeated if much of the fall originally intended be eliminated by a succession of dams. The general fall of the country is ample, and by proper location of the minor channel heads all that is necessary for the requisite command of the lands can be secured.

Off-takes of minor distributaries.

15. The arrangements proposed for this canal are not in all respects those which would have been recommended had not the canal been in existence. What has been provided for in the estimates submitted is as efficient an arrangement as can be secured under existing circumstances without undue expense. The estimates as first submitted in November 1872 were fully reviewed, and the requisite instructions given;* as revised many important improvements have been introduced and omissions rectified. The first estimates amounted to Rupees 3,53,845, the revised are Rupees 4,48,000. A comparative statement has been furnished by the Superintending Engineer, but it has been made out in a manner difficult of comprehension, the canal works and those of the distributaries being mixed up together. The following abstract may however be useful :—

Bank Canal.

* No. 430-B, 18th July 1873.

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19*th December* 1874.

Particulars.	First Estimate.		Revised Estimate.		Remarks.
	Items.	Total.	Items.	Total.	
1.—*Canal.*	Rs.	Rs.	Rs.	Rs.	
a. Earthworks	1,50,800		1,15,715		
b. Three Rest-houses	1,800		5,000		
c. Head Sluice improvements	1,500		3,390		
d. Head Lock do.	.....		500		
e. Kistna flood bank	.....		38,490		
f. Inlets above Vullabhapuram... ...	695		7,275		
g. Ramps	.....		9,750		
h. Raising banks above locks to hold up water for navigation	.....		8,000		
i. Surplus Weir and Channel, Kollipara.	.....		2,865		
j. Kollur Lock Weir alterations... ...	.....		1,000		
k. Kollur Lock, 2nd class	13,250		23,500		
l. Vellatur Lock Weir alterations ...	.....		800		
m. Do. Lock	18,410		19,400		
n. Penumudi Lock Weir alterations ...	.....		800		
o. Penumudi Lock	12,710		18,070		
p. Mortola Lock	13,180		.....		Not required.
q. Regulating Bridge, Mortola	2,200		.....		Do. do.
r. Bobarlunka do.	.....		19,310		
s. Do. surplus Weir	.....		2,735		
t. Surplus Weir, Sadiapalum	2,200		.....		Do. do.
u. Tail Lock	29,380		26,620		
v. Do. surplus Weir	2,620		3,310		
		2,48,745		3,06,530	
2.—*Kollipara Channel.*					
a. Earthworks	.....		.....		
b. Masonry	.....		705		
		.....		705	
Kollur side Channel.					
a. Earthworks	.....		.....		
b. Masonry	.....		640		
				640	
Distribution.					
3.—*Kollur Channel.*					
a. Earthworks	5,100		6,370		
b. Masonry	475		1,920		
c. Compensation	680		940		
		6,255		9,230	
4.—*Vellatur Channel.*					
a. Earthworks	16,720		16,720		
b. Masonry	3,480		1,600		
c. Compensation	870		870		
		21,070		19,190	
5.—*Vellatur side Channel.*					
a. Earthworks	.....		.....		
b. Masonry	.....		450		
		.....		450	
6.—*Vemavaram Channel.*					
a. Earthworks	.....		.....		
b. Masonry	.....		700		
		.....		700	
7.—*Jagajairu Channel.*					
a. Earthworks	5,050		2,110		
b. Masonry	*71		990		* Instead of 695 as the total of the first estimate was 5,760.
		5,760		3,100	

Particulars.	First Estimate.		Revised Estimate.		Remarks.
	Items.	Total.	Items.	Total.	
	Rs.	Rs.	Rs.	Rs.	
8.—*Repalli Tank Channel.*					
a. Earthworks	.....		.....		
b. Masonry	.....		200		
		.....		200	
9.—*Isakapalli Channel.*					
a. Earthworks	25,590		19,330		
b. Masonry	11,950		15,070		
c. Compensation	390		585		
Arapulli Branch.					
a. Earthworks	3,130		2,465		
b. Masonry	595		1,090		
c. Compensation...	390		505		
Ulipolliem Branch.					
a. Earthworks	6,240		3,430		
b. Masonry	550		3,030		
c. Compensation...	350		715		
Allapuru Branch.					
a. Earthworks	4,120		2,720		
b. Masonry	550		3,815		
c. Compensation	130		715		
Koochinapud Branch.					
a. Earthworks	3,830		2,635		
b. Masonry	550		3,415		
c. Compensation...	90		595		
Prignam Branch.					
a. Earthworks	1,880		2,600		
b. Masonry	405		1,810		
c. Compensation...	100		445		
		60,820		64,970	
10.—*Nallur Tank Channel.*					
a. Earthworks	1,450		1,250		
b. Masonry	.....		200		
		1,450		1,450	
11.—*Visweswaram Channel.*					
a. Earthworks	4,360		3,980		
b. Masonry	395		2,050		
c. Compensation	340		645		
		5,095		6,675	
12.—*Potumeraka Channel.*					
a. Earthworks	3,480		2,300		
b. Masonry	600		1,205		
c. Compensation	570		655		
		4,650		4,160	
13.—*Minor Distributaries.*					
a. Earthworks	.....		15,000		
b. Masonry	.....		15,000		
				30,000	
Total Distribution...	.....	1,05,100	.....	1,41,470	
Grand Total...	...	3,53,845	.....	4,48,000	

The revision of the canal levels resulted in a considerable reduction of earthworks with, at the same time, more convenient arrangements. The fall of 7 inches a mile for the first 26 miles nearly, with the resulting velocity of about 2 feet a second, could not be reduced without a very radical alteration of the canal, but should hereafter the traffic become of such importance as to require it, one or more locks may be interpolated. The distribution arrangements have also been revised and rendered more complete. The total of the estimate is divisible into—

Irrigation	Rupees 3,30,000
Navigation	,, 1,18,000

The irrigation includes the item* for admitting to the canal the drainage of certain lands in the upper part which has been intercepted thereby, and the navigation comprises only the masonry works provided for that purpose, and not the additional cost of the canal arrangements generally due to adapting it for this object.

* Rupees 7,275 (1.*f.*)

16. The estimates as now submitted give a fairly accurate idea of the cost of completing this canal. Some modifications will be desirable in carrying out the work, but it is almost impracticable to determine beforehand all the details, nor would it be advisable to fix these absolutely in the first instance, seeing that a gradual extension of irrigation has to be provided for, and it would not, therefore, be wise to anticipate this altogether and to make the canal as large and complete to begin with as it is hoped it will be some eight or ten years hence. All the principal arrangements may be considered to have been settled, and a few observations will now be made on some of the details which may perhaps with advantage be re-considered in due course.

Estimates should be considered to be a close approximation.

17. It has been assumed that 70,000 rather than 75,000 acres will be the ultimate area of irrigation, and for this a bottom width of canal of 75 feet instead of 81 feet, as provided for in the estimate for the first 13½ miles from the head, will suffice. Similarly, in the 20 miles below the 13½ miles, some diminution of the bottom widths of 75, 60, and 49 feet will probably be practicable. Some saving may also be effected by placing the bed of the canal 3 inches higher than the level shown in the longitudinal section in the first 7 miles. The discharge with a depth of 6¼ feet would be considerably in excess, and it is not desirable that this should be the case ; 6 feet will be a good working depth, and the water surface level will remain unaltered. The area of irrigation in 1871-72 was only 17,868 acres, and it is known that in the upper part of this canal water has not been taken to the extent which the state of the distributaries here would have allowed. On the other hand, lower down the land is better adapted for wet than for dry cultivation, and it may be anticipated that the extension of irrigation will, when the drainage works shall have altered the condition of the country, be both large and rapid.

Capacity of canal.

The requirements of the Kistna flood bank, which is also the left bank of the canal, will have to be considered, and the completion of that which should not be postponed will make it necessary to enlarge the canal more quickly than the

demand for water would render necessary. It will be observed that the special and additional work for this flood bank, which is to be constructed, or rather improved and rendered capable of fulfilling its object, is estimated to cost Rupees 38,490, and it has been deemed a part of the irrigation project, though from the proportion which the irrigated* will bear to the whole area of the delta it is evident that but little, if any, of this charge is, strictly speaking, debitable to irrigation, which by the formation of the canal will provide at least its share of the cost of the bank.

* Rather less than one-third ($\frac{21}{64}$)—*vide* paragraph 2 above.

Below the 33½ miles the dimensions of the canal have been fixed so as to afford sufficient facilities for navigation, the bottom width to the terminus at 45¾ miles being 25 feet, the depth of water 5 feet, and the width at water surface 45 feet. The surface slope has been adjusted to secure the required discharge with these arrangements.

18. The present head-sluice has five vents ; three additional vents have been estimated for but will not be required for some years to come. Indeed, only when the supply in the main canal is short will the capacity of this sluice be at all inadequate even for the ultimate supposed area of 70,000 acres.

Head Sluice.

19. The provision of Rupees 9,750 for ramps for cattle crossings may stand until it is decided what accommodation is to be allowed in connection with recent orders on the subject of bridges and ferries in the deltas. Probably a considerably larger sum will have to be spent on this account, and this may be met wholly or in great part from the savings on the earthworks and other items.

Ramps (1. *g*).

20. The five required will all be in the upper 7 miles, and above the point where the left bank of the canal becomes the flood bank. The design is fairly good except that the pathway across the bridge (4 feet) is too narrow, and a minimum of 6 feet should be given. Care should be taken that for towing this bridgeway is conveniently situated. The tow-paths are to be as close to the water as possible, and about 18 inches above full supply level ; the bridgeways should be as little removed from the line of the tow-paths as possible.

Drainage inlets.

21. Where the full supply level is above ground level the water is to be confined to its proper and regular section by continuing the side slopes up to 1 foot or 18 inches above full supply level, and the tow-paths may be conveniently placed at the top of the side slopes.

Tow-paths.

22. In the Godavery Eastern and Western Delta estimates provision was made for rest-houses and was approved, but since then the Government have had the subject of the construction of such buildings under consideration, and it is doubtful how far they are prepared to allow such charges to be included in the Kistna Delta estimates. In the present case the Superintending Engineer has proposed to construct a second-class rest-house, consisting of a room 15 feet square with a bath-room, near Kollipara in the 14th mile of the canal, a similar house about 9 miles west of the canal, on the road from Repalli to Nizampatam and close to the Iskapalli distribution channels, while a first-class rest-house, with three rooms and two bath-rooms, estimated to cost Rupees 3,000, has been designed for Penumudi in the 34th mile of the canal. The first-class rest-house is somewhat too expensive, and probably actual requirements would be met by the two side rooms and bath-rooms without the central room, by which alteration 2,000 Rupees would suffice. It is recommended that 4,000 Rupees be allowed for the three rest-houses, on the ground that the additional cost to the works will be immaterial ; that the shelter they will afford will be of great value to the officers and upper subordinates of the delta in the hot weather ; and that such shelter will perhaps prove really more remunerative than any other distinct portion of the proposed outlay. Delta officers usually devote their time very ungrudgingly to their duties, and the Government get far more out of them than could be demanded. Even if the interest on the cost of rest-houses should amount to 700 or 800 Rupees yearly there will be no loss to Government, and it is hoped much benefit to those for whose use they will be primarily intended.

Rupees 1,000.

23. The first lock below the head will be at Kollur, 20$\frac{9}{16}$ miles. The design has been prepared so as to hold up the water to 6·15 feet above full supply level, with a view to facilitate navigation when the supply of water is small. The effect would be to reduce by one-half the surface fall in this reach, but as it is impracticable to obtain still water, and as the only effectual way of improving the navigation would be the interpolation of two locks at about the 7th and 14th miles, it is not thought advisable to incur the expense of making this lock so high and raising the banks above it, neither would it be desirable to retain the water at upwards of 7½ feet above ground level.

Kollur Lock, 21st mile.

It may be well to bear in mind that possibly at some future time two intermediate locks may be given, to select sites for these, and then in finding earth for the flood bank to take as much soil as may be convenient from the canal at the parts where cutting below the locks would in that case be required, instead of from outside pits, arranging the berms and spoil banks accordingly, so that there may be nothing to be removed afterwards.

The plan and the specification of this lock do not agree. The design shows a chamber 612 instead of 105 feet long, and the walls are described as 1½ feet above full supply level instead of 7·65 feet as drawn.

It seems probable that a depth of 3 feet of concrete for the foundations will be necessary. It is always advisable to provide fully adequate foundations, any failure of these being certain to lead to great subsequent trouble and expense. The floorings of the side culverts and entrance and tail bays should not be less than 1 foot thick instead of the 6 inches shown, which is too small a depth for works of this class.

The girders of the tail bay bridge should be placed so as to give a clear headway of 11¾ feet. The minimum headway prescribed in Circular No. 14 is not intended to be adopted when circumstances will admit of more room being given. The design should be revised ; the cost will be less than the estimate.

The part of Item 1. *h*., Rupees 8,000, appertaining to this lock, will not be required.

A plan of the arrangements for the location of this lock has not been forwarded. The weirs have been already built on the line of the canal so the locks have to be placed in side channels and the curves of these will have to be laid out to admit of easy navigation. Those shown on Plan $\frac{B.1}{No.16}$ * are too sharp, and the notes thereon made should receive attention.

* Penumudi Lock.

There is no objection to the use of bricks for the chamber invert and the side culvert arches, provided they be really good. Table-made bricks of good soil may be expected to wear well. The faces of the vent arches should be of stone.

24. The modifications required to this weir are not very extensive. It has six arches of 10 feet each. The crest should be raised to 26·75 or 3 feet below full supply level; the end sluice vents should be closed, the other four covered in and furnished with good shutters, and the discharge over the weir should be regulated by shutters with screw gearing. The platform for working the shutters to be 7 feet above crest, and the parapet on this side may be moved in 2 feet if necessary, to afford room for working the shutters. The present width of the roadway is 11 feet, that of the tail bay bridge of the lock 13 feet, and on the sketch map no road at all is shown. Probably, therefore, a width of 9 feet will be quite sufficient, being that prescribed for minor district roads. The provision in the estimates for the alterations to this weir is Rupees 1,000. This will be exceeded, but it will be more than covered by reduction of cost of the lock.

Kollur Lock Weir.

25. The next lock will be at the existing weir in the lower part of the 26th mile. The reach above being short it is quite feasible to secure still water navigation when the irrigation supply runs short.

Vellatur Lock, 26th mile.

In the design it is proposed to hold up the water so as to give 6¼ feet on the Kollur Lock lower sill, but this is manifestly more than is necessary, and if a minimum depth of 4½ feet there be secured the navigation will be sufficiently good:—

Maximum water level will then be 23·08 instead of 24·83.
Top of lock walls 24·58 do. 26·33.

Additional depth* of concrete in foundations may be found necessary, and if so, will be nearly covered by the reduction in height of walls, gates, etc.

* 3 instead of 2 feet.

26. With reduction in the maximum water level above this work, the roadway will be 1·75 feet above water, which will suffice if the arrangements for disposing of surplus water, not required in the lower reach, be good. The Vellatur channel, which has its head here, crosses the Munnunghy drain at 1½ miles below its head sluice, and surplus can be conveyed by this route and there disposed of.

Lock Weir.

The weir has five bays of 10 feet each, and the discharge required being 600 cubic feet a second, the crest should be 2½ feet below full supply level or at 19·08.

27. There will be no change at this point of the canal bed level, but the depth of water will be reduced to 5 feet below, and so a regulating lock is

Penumudi Lock, 34th mile.

required. The modifications of design necessary are of the same kind as those mentioned for the Vellatur lock, and have been noted on the plan. The requirements of the approach and tail channels have likewise been noted on the separate plan of the lock site.

The longitudinal section shows that the Repalli road crosses the Bank Canal at about 31¾ miles, and on the Atlas sheet this road is marked as crossing at Penumudi, so that it is supposed the traffic will use the lock bridge. The Superintending Engineer has not noticed the intended arrangements, which should be so carried out as to be convenient and efficient.

28. This work, which was built some years ago, has four spans of 8 feet each, and will require a raised crest 2 feet above the present floor, or at 12·50. Two sluice vents of 3 feet width each may be allowed in the wall. The estimate allows 800 Rupees for the alterations, and this will hardly be enough, but there will be some saving on the lock which will cover the extra cost of the weir. On the plan the proper arrangements have been noted.

Lock Weir.

29. This lock will have a drop of 4 feet. Still water navigation can be secured in the reach above by a difference of 1·07 feet between ordinary full supply level* and maximum water level.† Two or three matters requiring attention have been noted on the plan.

Bobarlunka Lock, 40th mile.
* 11·43.
† 12·50.

30. The weir as designed with a bay of 8 feet would not, with a depth of 3 feet on the crest, give the required discharge of 189 cubic feet a second. The bay should be made 10 feet and the crest should be placed at 8·26, giving a depth of 3·17 feet of water passing over. Certain other modifications of design have been shown on the plan. The increased cost, if any, will be nominal. Bridges over locks and lock weirs should have the same width of roadway. In this case 13 feet have been allowed for the former and 9 feet for the latter. Probably the latter is the proper width, as there does not appear to be a road of any importance.

Lock Weir.

31. As designed the upper sill is to be at + 1·86 and the lower sill at — 6·38, but on comparing the Kistna and Godavery levels it would appear that to satisfy the rule that the lower sill must be not higher than 5 feet below mean sea, or tide, level, the proper level would be — 7·24. This conclusion is further supported by the intimation on the longitudinal section that "low water or average level of low tide" is — 3·38, and the lower sill is 3 feet below this. The Circular on the subject prescribes 3 feet below *low water springs* as the proper level for this sill, and in all probability dead low water is quite 0·86 below the average.

Tail Lock, 45¾ miles.

No. 30.

For navigation the water will require to be held up less than 1 inch above full supply level at the upper side of this lock, but to exclude Kistna freshes it may be well to fix maximum water level at 8·50 when the water will always be a few inches higher above than below the lock. The lock walls may as designed be built up to 10·87.

The headway under the tail bay bridge appears to be greater than is necessary, as boats would not pass in and out when the river is in high flood; a head way of $11\frac{3}{4}$ feet above a fresh rising to 4 feet above high water mark will suffice, and the roadway will then be at 18·25 instead of 20·12.

The form of lower wing, shown in dotted lines, is in some respects preferable to the straight wings of the design. Major Hasted may with advantage take an opportunity of inspecting some of the new locks in the Western Delta of the Godavery, with a view to see in what respects their details are good and applicable. Possibly as regards gates too, some hints may thus be obtained. The experience gained in the Godavery is valuable, and should be fully availed of in carrying out the similar works in the Kistna.

Some improvement of the manner of joining the canal to the Kistna below the tidal lock may be effected as noted on the Plan, B-1, Nos. 24 and 25.

Tidal Lock Weir.

32. This will be in effect a surplus weir. It will have one bay of 8 feet with its crest 3 feet below full supply level or at 3·87. Some modifications of detail are deemed desirable, and have been noted on the plan. They will not add to the cost, as it is not necessary to place the cushion wall on quite so low a level as was proposed.

Disposal of Surplus 1st and 2nd reaches.

33. As branch channels are given off the capacity of the canal diminishes, and it is requisite that there should be means of disposing of the greater part of the successive differences by surplus works, as during local heavy rain the distributaries will often be incapable of taking much of the irrigation water.

The discharge of the canal in the first reach will be, with the reduced bottom width of 75 feet, 1,050 cubic feet a second, of which 900 cubic feet can be passed at the Kollur Lock weir into the second reach, but when not so required it has been proposed to get rid of surplus to the extent of 745 cubic feet a second at a surplus weir to be placed in the 14th mile near Kollipara, the apparent reason for the selection of this site being that it is convenient for discharging the water into the Repalli main drain. There are, however, several objections to this arrangement: 1*st*, the weir would be at a distance of between 6 and 7 miles from (above) the Kollur lock and weir; 2*ndly*, the proposed level of the floor or apron is at 26·88, while that of the Repalli drain at the junction was as originally designed to have been about 31·83, and though a lower level was suggested in reviewing the estimate for that drain, it is not likely that so great a difference would be made. The Kollur lock is too far from any drain to be a convenient point for discharging surplus, and so the best plan appears to be to cancel the estimate for the Kollipara weir and to place a work of this kind near the Vellatur lock weir and between that and the Vellatur channel, and carrying the surplus by a cut on the south side of the Bandole road into the Munnunghy drain; the length of this cut will be about 1¼ miles.

The first reach of the canal is to carry 1,050 cubic feet a second, the Kollur lock weir will pass 900 cubic feet, and the Vellatur lock weir 600 cubic feet. Consequently it would do were 450 cubic feet a second to be discharged at the proposed Vellatur surplus weir, but in order that the capacity may be ample 600

Proceedings of the Madras Government, Public Works Department,
19*th December* 1874.

cubic feet may be arranged for. The maximum water level here will be 1½ feet above the full supply level, and if the weir crest be placed at 2½ feet below full supply level the maximum depth there upon will be 4 feet, and three bays of 7½ feet each will suffice. One sluice* on canal bed level may be placed in the crest wall of the central bay. The level of the floor, or of the crest of cushion wall, will have to be determined with reference to the bed of the drain. The cost of the weir itself will, if arranged on the general design of the Bobarlunka lock weir, which is suitable, be about 4,000 Rupees against Rupees 2,865, that allowed for Kollipara weir. There will also be the cost of the outfall channel; the similar channel from the Kollipara site does not appear to have been estimated for, though it is referred to in the abstract given in paragraph 14 above, Item 1. i.

* 3×3.

Third reach.

The Penumudi lock weir is to pass 225 cubic feet a second, consequently 600 — 225 = 375 cubic feet a second may have to be disposed of above this point. The only feasible way of doing this is to send surplus down the Iskapalli channel to the point where this crosses the Munnunghy drain. This channel is to carry 337·5 cubic feet a second for irrigation, and it may, it is thought, be made to do all that is required. An escape is marked on the tracing showing the areas of irrigation, but a plan and estimate cannot be traced, and, so far as can be judged from the specification of the channel, no surplus weir has been provided, though this was suggested in paragraph 5 of the Memorandum, No. 430-B., of the 18th July 1873, for the purpose of allowing the dimensions of this distributary to be proportioned to the acreage. At any rate a suitable escape will be required at this point, and a plan and estimate for one capable of discharging 400 cubic feet a second, and with the sill on channel bed level, should be prepared.

Fourth and fifth reaches.

If all surplus down to the Penumudi lock be disposed of, as suggested, the Bobarlunka and tidal lock weir will get rid of any surplus below this point, as only 225 cubic feet a second will pass the Penumudi weir.

Disposal of fall from head to tail of canal.

34. The difference of level to be overcome is from the head-sluice to the sill of the tail lock (taken as — 7·24), 35·50 + 7·24 = 42·74 feet, and is thus arranged:—

Fall in 1st reach, 20$\frac{7}{8}$ miles, being 7 inches a mile ...	12·00
Kollur Lock	5·00
Fall in 2nd reach, 7 inches a mile	3·17
Vellatur Lock	3·00
Fall in 3rd reach, 7 inches a mile	4·39
Penumudi Lock	0·00
Fall in 4th reach, 5¼, 3½, 2¾ inches a mile successively	1·51
Bobarlunka Lock	4·00
Fall in 5th reach, 1 inch a mile	0·57
Tidal Lock...	9·10
	42·74

35. The principal branch channels and the areas to be irrigated by them are as follow:—

Head on Bank Canal.	Designation.	Acreage.	Amount of Estimate.	Present acreage.	
M. CHS.					
13 40	Kollipara Channel ...	5,000		Not given.*	* In Statement No. 7, part of the 8,877 acres under canal and small channels.
20 45	Kollur do. ...	12,500	705	Do.	
25 65	Vellatur do. ...	20,000	9,230	6,306	
30 6	Jagajairu do. ...	2,500	19,190	Not given.*	
33 34	Isakapalli do. ...	22,500	3,100	2,685	
34 40	Nallur Tank do. ...	2,500	64,970	Not given.*	
37 25	Visweswaram do. ...	6,000	1,450	Do.	
39 5	Potumyraka do. ...	3,500	6,675	Do.	
			4,160		

The proportionate reduction under the branches to correspond with the decrease of 5,000 acres under the canal has not been attempted. It is of course impracticable to say exactly how the irrigation will be extended and developed, though the probability is that in the southern part of this section of the delta the extension will be most rapid. The distribution is at present in a very imperfect state, and the condition of the country to be irrigated is, as regards drainage, so bad that it is not a matter of surprise that the acreage under the bank canal should as yet have extended to only 17,868 acres.

Kollipara Channel.

36. This is an old channel, and the only expenditure upon it provided for is the small amount shown for minor masonry works, to which will be added a share of the sum* allowed for minor distribution.

* 15,000 masonry.
15,000 channels.

Kollur Channel.

37. This channel will be a new one, and is intended, in addition to direct irrigation from its left bank, to take up the supply of the land now under that part of the Peddaravur channel to the east of the Repalli main drain. Care must be taken that drainage from the northwards which may be intercepted by this new channel is conducted into the main drain. There will probably be no difficulty in arranging for this if it be kept in view when carrying out the channel, as much of the latter will be in embankment and the outside cutting will form a drain.

The *head-sluice* will be worked under a head of $4\frac{3}{4}$ feet and, as the velocity of discharge will consequently be high, the arrangements should be such as to reduce this velocity as quickly as possible, to which end certain modifications of design have been noted on the plan.

The *channel* has been planned with a bed fall of 9 inches a mile, and a drop of 1 foot at the $\frac{3}{4}$ mile of 1 foot. The object of this arrangement is not apparent, and as a fall of 1 foot a mile with a depth of $3\frac{1}{2}$ feet will give a velocity of 2 feet a second, which is not too great, the channel may be so laid out; its bottom width will then be 20 feet, and the lower floor of the head sluice will be at 21·87.

The junction of the new and old channels can be effected on a better line than that shown on the Survey Plan $\frac{B}{\frac{4}{2}}$. The discharges of the Peddaravur and Addipalli tank channels are not thereon noted, and it will depend somewhat upon this what the exact direction should be.

Vellatur Channel.

38. This channel formerly had its head at the Kistna, but since the construction of the Bank Canal its supply has been obtained from the latter. It is a very irregular work, and at present its section is altogether out of proportion to the quantity of water to be conveyed. The head-sluice floor is at 15·42, and this approximates closely to the level of the canal bed, which will be 15·33; but as at a distance of rather less than $1\frac{1}{2}$ miles from the head the bed at the Bhattiprole under-tunnel must be at 15·00, it is intended that the nominal bed below the head sluice shall be at 16·25. This will affect only the water surface level for discharge and the height of the banks. With waterway generally in excess of what is wanted, and at no two sections alike, it is impraticable to secure the exact water levels desired, and the work proposed is rather for the purpose of enabling the old channel to carry a depth of $4\frac{1}{2}$ feet of water and a supply for the estimated area of 20,000 acres safely, than for anything else. The falls of 10 inches and 8 inches a mile are as small as can, looking to the quantity of silt carried by Kistna water, be adopted, otherwise a broad channel, having some approach to regularity of section, might have been obtained.

It does not appear, however, to have been ascertained whether a new channel could not be cut for as little or possibly less money than patching up the old one, and at any rate before it is finally decided to spend 16,000 on the earthworks of some $9\frac{3}{4}$ miles it will be well to see what a new channel would cost. The conditions are approximately—

A discharge of 300 cubic feet a second.
A velocity of about 2 feet a second.
Bed of channel to be $2\frac{1}{2}$ feet in soil for a depth of $4\frac{1}{2}$ feet of water.

The bed fall would be about $10\frac{1}{2}$ inches a mile, and it would seem that the old channel would do for a drain for the country to the northwards, and that no drainage would have to be passed across the new channel.

$9\frac{3}{4}$ miles.

If a cutting for the latter of about $2\frac{1}{2}$ feet can be obtained, the cost would be, at 1 Anna a cubic yard, about 1,000 Rupees a mile for the part having a bottom width of 25 feet, and the soil would just suffice for banks 2 feet above water level, 3 feet wide at top with 2 to 1 interior and $1\frac{1}{2}$ to 1 exterior slopes. It will be quite worthwhile therefore to examine whether a better channel cannot be constructed for the same or less money than the estimate for the adaptation of the old one.

Jagajairu channel.

39. This is an old channel four miles in length, of which the upper half is to be retained for irrigation and the lower half is to be used for drainage only. It tails into the Munnunghy drain. As designed with a bottom width of 4 feet, a depth of water of 3 feet, and a fall of 7 inches a mile, it would carry only 34·20 cubic feet a second, whereas for a channel of this acreage (2,500) required the maximum discharge needed may amount at times to about 54 cubic feet a second. The head sluice vent is 3 feet wide, and if, as is probable, it is also 3 feet high, the head required for a discharge of 54 cubic feet a second would be 6 feet, for which 18 inches head will suffice, and a depth of water in the channel of $3\frac{3}{4}$ feet can there-

Circular 27.

fore be allowed; and the discharge then would be very nearly that required. This modification will entail only the raising of the banks 9 inches. On the other hand, the Superintending Engineer can, if thought preferable, make the required alteration of discharging capacity by a smaller increase to the depth and an enlargement of the bottom width. The channel is really only a small one. It is to be noticed that from this office memorandum, No. 430-B, of the 18th July 1873, it would appear that originally the sill of the head sluice was stated to be at 12·75, but in the present section it is shown as at 11·00. No explanation of the circumstances determining the arrangements generally, or of reason for turning the lower part of the channel into a drain, has been given.

Iskapalli Channel.

40. This is the most important branch of the Bank Canal, and is intended to irrigate 22,500 acres, the present area being only 2,685 acres. As will be seen on referring to the statement given in paragraph 14, Distribution Item No. 9, the arrangements first proposed have been materially modified. This was partly necessitated by alterations in the levels of the canal, and partly to avoid making the channel of nearly the same width throughout, although as successive branches are given off the discharge gradually diminishes. The channel itself is, with the exception of the last two miles of its length, already in existence, but requires to be greatly improved; the five proposed branches have yet to be made.

No. 430-B.

In commenting on the original estimate it was pointed out that the alignment of the channel is defective, but that so much of it is already in existence that it would probably be cheaper to improve the old rather than select a new line. I did not then know that the present acreage was so small, and the cross sections on Sheet $\frac{B}{\frac{14}{1}}$ do not indicate what the dimensions of the existing channel are, but the sketch map of the Western Delta and the longitudinal section of the first five miles or so of the channel appear to show that the head is in the wrong place, and that it should be some three miles or thereabouts higher up the canal, at or near the head of the Jagajairu. It is not practicable, with the information given, to decide whether an alteration in this direction should be made, but the subject requires to be looked into, for the estimate for distribution is high, being at the rate of nearly 3¼ Rupees an acre (extension).

A point which was noticed in the memorandum already quoted was the advantage of discharging surplus into the Munnunghy drain in the 5th mile, and it has been above noticed (paragraph 32) that certain surplus of the canal must be so disposed of. There is no surplus work provided in the estimates for this position, and it is essential that the omission should be made good. In the 5th mile the discharge required for irrigation will be reduced more than one-half,

307·50 to 142·50.

and of course the difference of capacity must be supplemented by means of disposing of the water.

The amount of the estimate, Rupees 64,970, will it is thought suffice to afford effective means of distribution, but the details evidently need further study. Wherever the soil will allow of a greater fall than the 7 inches a mile shown in the longitudinal section, with its corresponding velocity varying from 1·75 to

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1·39 feet a second, such increase of slope should be given on the ground of economy of first construction and subsequent maintenance. For Kistna water 2 feet a second is not generally too high a velocity, and it is much better that the silt should be carried into the fields than allowed to remain in the channels. The same consideration applies to the branches of the Iskapalli channel, and it may be added that drops should not be introduced unless the fall of the country be greater than can properly be given to distribution channels, having, when carrying their full supply, the smallest convenient and economical depth of water.

Nallur Tank Channel.

41. This is a comparatively small distributary, which is already in use, and to which the improvements contemplated are of small extent. Plan $\frac{B}{\frac{17}{1}}$ shows the arrangements. It has not been mentioned whether the tank is to be kept up, nor is it shown how the natural drainage into it is to be carried across the channel or otherwise disposed of.

Visweswaram Channel.

42. This channel is at present only a little more than a mile and a half in length. It is to be extended to just beyond five miles from its head, where it will tail into a creek and there have a surplus weir. The acreage to be irrigated is 6,000. The bed fall 9 inches a mile, which can be increased if found desirable, the depth of water 2 feet, and the bottom width at the head 28 feet, diminishing to 8 feet in the last mile. The discharge will be 85 cubic feet a second against an ordinary requirement of 90 and a maximum of 101 cubic feet. The difference may be obtained either by increasing the fall to 10 inches a mile or the depth by between 2 and 3 inches. The head-sluice design should be modified to correspond with the revised maximum water levels on the canal.

Potunuraka Channel.

43. This will be a new channel, with its head just above the Bobarlunka lock. It has been laid out with a bed fall of 9 inches a mile which, with reference to the levels of the canal and of the salt creek into which it tails just below four miles, is suitable. The bottom width of the channel at the head will be 16 feet, and at the lower end 3 feet, depth of water 2 feet. This is the lowest considerable distributary from the Bank Canal. What little drainage there may be from the northward should be conducted along the rear of the right bank into the creek.

Crossings of Distributaries.

44. Advantage should be taken in constructing sluices, regulators, drops, etc., upon distribution channels, to afford as much accommodation as may be required and obtainable for village traffic of all descriptions. By this means future expenditure on bridges will be reduced to a minimum, and it should not be forgotten that it is desirable to reduce as far as possible the number of places where cattle will have to cross the channels by ramps in going to and from the fields, as they do a good deal of damage in such soil as is commonly found in the deltas.

Result of proposed improvements.

45. It is perhaps not possible to estimate accurately the gross revenue which will be derived from the extension of irrigation under the Bank Canal,

because it cannot be determined beforehand what particular lands will be irrigated. The revenue derived from the 17,868 acres supplied in 1871-72 was Rupees 86,843, and this includes the assessment on the land independently of water-supply. From the detailed statements for the years 1871-72 and 1872-73, recently submitted to Government, it appears that in this the Western Delta the average assessment is per acre Rupees 2·65.
water-rate do. do. 2·53.

No. 716, dated 12th September 1874.

but it has been pointed out that it is not quite clear how the water-rate has been arrived at. In the southern part of the tract of country now under consideration much of the land to be irrigated is now waste, and the outlay for its irrigation and drainage will be entitled to be credited with the assessment as well as the water-rate.

For the purpose of this report on the estimate it will probably be safe to assume that 3 Rupees an acre or 1 Rupee less than in the Godavery will be the return, and this on the contemplated increase of area will amount to in round numbers 1½ lakhs of rupees, or more than 33 per cent. On the other hand, the expenditure already incurred on this section of the delta is—

		Rs.
Ultimate		70,000
Present		17,868
	Increase ..	52,132

		Rs.
Proceedings Madras Government, No. 2,365 of the 21st August 1874.	(Up to 1873-74)	2,24,947
	Add present estimates	4,18,000
	Total outlay...	6,72,947
	Total area of irrigation 70,000 acres at 3 Rupees...	2,10,000

The proportion of returns is thus not materially different from that indicated for the extension by itself. Of course the gross returns will be largely reduced when outlay on drainage, charges for establishments, share of main canal, etc., come to be taken into account, but the results will certainly be good, and there appears to be no sufficient reason therefore for delaying the commencement of improvements, which will take many years to execute, until the financial aspect of the whole Western Delta can be considered.

46. It is recommended that the following estimates, to which it will be seen an addition of 8 per cent. for tools and plant has been made, be approved for entry in the Budget of 1875-76, and that the Government of India be requested to sanction them with a view to the commencement of operations next year :—

Amount of estimates recommended for sanction.

		Rs.	Rs.
Paragraph 6 above.	Main Canal	5,40,500	
	Tools and Plant about 8 per cent. ...	43,200	
			5,83,700
Paragraphs 9 and 10 above.	Nizamapatam Canal	10,645	
	Distribution do.	16,495	
		27,140	
	Tools and Plant	2,160	
			29,300
	Bank Canal	4,48,000	
	Tools and Plant	35,800	
			4,83,800

The way in which these estimates have been prepared reflects much credit on Lieutenant McNeil Campbell, R.E.

47. It must be noticed that the task of reviewing these estimates has been made one of considerable difficulty, owing to the absence of a report from the officer who prepared them, and from the Superintending Engineer of the district. These officers assumed that, as former estimates had been examined, and particulars of revision of arrangements decided upon, such reports were unnecessary, but this was far from being the case, and it should be remembered in future that not only as a material assistance to this office, but also as an important aid and instruction to the officers who may carry out the works, reports explaining the connection of, and reasons for, the various arrangements should be prepared and transmitted with all important parts of the general scheme. Some of the notes on the plans will serve to show that the exact arrangements intended required further elucidation. All descriptions of works should be as short as possible. There is only one Bank Canal in the Western Delta, and it should be called by that name and not Western Bank Channel Main Duct.

48. The following estimates for the Western Delta remain to be completed and submitted for sanction :—

1. Commamoor Canal.
2. Drainage between Bank and Nizamapatam Canals.
3. Toongabudra drainage (between Nizamapatam and Commamoor Canals).
4. Rampairu drainage, country below the lower half of the Commamoor Canal.

It is not probable that any of these will be ready in time for entry in next year's Budget.

(Signed) JOHN MULLINS, Lieut.-Colonel, R.E.,
Chief Engineer for Irrigation.

28*th September* 1874.

List of Papers, Plans, etc., submitted with the Revised Estimate of Main Canal, Western Delta, Nizampatam Canal and Principal Branches.

1. Report (letter, No. 1, dated 20th March 1874).
2. Specification Report, No. A-1—No. 1 of the canal.
3. Do. of head-sluice No. A-1—1.
4. Do. of do. East Side Channel, No. C-1—from A-10.
5. Do. of do. prolongation, No. C-1—from A-10.
6. Do. of West Side Channel head-sluice, No. D-1—from No. 7-A.
7. Do. of do. prolongation.
8. Comparative Statement of the original and revised estimate.

9. Statement showing the area commanded, the present and the intended area of irrigation, and the anticipated cost of works, C. C.

10. Statement showing the outlay already incurred and that now proposed on the works of this project.

11. Table showing the velocity, etc., of the Main Canal, Nizampatam Canal, and its principal branches.

12. Statement C.C.C. showing the discharge of the Main Canal with the depth of water on the sluice floor varying from 7 feet to 9.

13. Estimate of the probable cost of widening the Main Canal from Sitanagram to Duggirala lock.

14. Estimate for raising and sectioning the banks of Nizampatam Canal from Duggirala lock to Jutur lock.

15. Estimate for providing new gearings and shutters to the head-sluice of Main Canal at Sitanagram.

16. Estimate for do. do. East Side Channel at Duggirala lock.

17. Estimate for do. do. West Side Channel in Duggirala escape weir.

18. Estimate for prolongation of East Side Channel from Nallavada to Komaravole channel.

19. Statement showing the increase and carriage allowed over the current rates at Bezwada.

Plans.

		No. of Sheets.
1.	General plan showing the area commanded by the Nizampatam Canal and its principal branches	1
2.	Longitudinal section of Main Canal, Nizampatam Canal, and its two principal branches	1
3.	Survey and sections of Main Canal, Nizampatam Canal, from Sitanagram to Jutur	23
4.	Survey and section of the East Side Channel of Nizampatam Canal for the part to be prolonged	1
5.	Plan of head-sluice of Main Canal at Sitanagram	1
6.	Do. of do. shutter with the screw gearing as received from the Chief Engineer for Irrigation	1
7.	Plan of head-sluice, East Side Channel...	1
8.	Do. do. shutter, etc.	1
9.	Do. do. West Side Channel	1
10.	Do. do. shutter of do.	1
	Total ...	32

MASULIPATAM,
21*st March* 1874.

(Signed) D. McNEIL-CAMPBELL, Lieut., R.E.,
7th Range Officer, Kistna.
(,,) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

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Proceedings of the Madras Government, Public Works Department,
19th December 1874.

From Lieutenant D. McNEIL-CAMPBELL, R.E., Assistant Engineer in charge of 7th Range, Kistna, to Major J. O. HASTED, R.E., District Engineer, Kistna, dated Masulipatam, 21st March 1874, No. 1.

I HAVE the honor to forward plans and estimates of the Nizampatam canal revised in accordance with the instructions contained in memorandum, No. 397 A, from the Chief Engineer for Irrigation, and beg to make the following remarks with reference to the different paragraphs of that memorandum.

2. *Paragraph* 2.—The statement called for is herewith forwarded.

3. *Paragraph* 3.—Appendix C has been corrected and Supplemental Appendix C.C. has been added giving the required information for the principal channels.

4. *Paragraph* 4.—An Appendix C.C.C. containing the required information is herewith forwarded.

5. *Paragraph* 5.—A plan of the head-sluice showing the proposed alterations has been prepared and allowance made for screw gearing according to the plan received from the Chief Engineer with his letter to you, No. 903, dated 18th December 1873.

6. The formula used in calculating the discharge of sluices is $D = 7A\sqrt{H.}$ and not $\cdot 7 A\sqrt{H.}$ as suggested by the Chief Engineer; it is nearly the same as the formula used in Beardmore's Treatise on Hydraulics. The head used was half the difference between full supply level in front and rear of the sluices, but this was not applied to the head-sluice.

7. *Paragraph* 6.—The expenditure cannot be divided between Main canal and Nizampatam canal. The fall of the Nizampatam canal bed has been revised according to the instructions received from you; the surface fall is made parallel to that of bed which is 0·308 per mile, and the depth of water is 8·0 throughout; this gives the following widths of bed, from head-sluice to Revendrapad sluice 220 feet, from Revendrapad sluice to Duggirala lock 141 feet. The works at Revendrapad and Duggirala can easily stand this depth of water, and will therefore require no alteration.

8. Allowance has been made for compensation, as it is found that the earth excavated will have to be deposited partly in the fields outside the present banks of the Main canal.

9. By reference to statement C of velocity, etc., it will be seen that the East and West Side channels are quite large enough for the lands now under them, and also for the proposed extensions.

10. A lump sum of Rupees 3,000 has been allowed for minor masonry works and regulating dams for the two side channels.

11. A detailed longitudinal section of the Nizampatam canal between Duggirala and Jutur has been taken, and from it it would appear that the additional locks proposed by Captain Vibart, R.E., are not necessary.

12. The difference in cost between the original estimate submitted by Captain Vibart, R.E., and those now prepared is as follows :—

Original Estimate.	Rs.
Earthwork—Nizampatam canal, 1st reach	5,67,000
Do. East Side channel of do. extension	6,520
Masonry works—Locks in 2nd and 3rd reaches	29,180
Total...	6,02,700

Revised Estimate.

		Rs.
Earthwork—Nizampatam canal, 1st reach		4,80,445
Do. do. 2nd and 3rd reaches		10,645
Extension of East and West Side channels		8,095
Masonry works...		18,240
Compensation for land to be taken up		1,275
Total...		5,18,700
Difference or Saving...		84,000

A-I—No. 1.

Western Delta, Kistna.

Specification Report to accompany Plan and Estimate for the Main Canal from Sitanagram to Duggirala and for the Nizampatam Canal from Duggirala to Nizampatam. Length 13 and 27 miles respectively.

	Rs.	A.	P.
1. Amount of estimate, Main Canal	5,47,860	0	0
Comprising the following items :—			
313,196 cubic yards of earthwork in the first half mile, at 4 Annas per cubic yard	85,799	0	0
3,398,071 cubic yards of do. in the remaining 12½ miles of the first reach to Duggirala lock, at 2 As. per cubic yard.	4,24,758	14	0
Sundries and contingencies, at Rupees 5 per cent.... ...	25,527	2	0
	5,36,085	0	0
64-49 Acres compensation for land to be taken up, at Rs. 30 per acre	1,935	0	0
Improvements to the head-sluice at Sitanagram	9,840	0	0
Total Main Canal Estimate...	5,47,860	0	0
Improvement of Nizampatam Canal 10,645			
Do. of do. Side channels ... 16,495			
	27,140	0	0
	5,75,000	0	0

2. The Main Canal is to irrigate 230,000 acres of land; it leaves the Kistna river at Sitanagram about 200 yards above the anicut, and is supplied by a head-sluice of 15 vents of 6 feet span each, the floor of which is + 37·0 or 6·0 below crest of anicut. Flowing in a south-westerly direction at 7¾ miles it throws off its first branch the Bank canal at Revendrapad; its width from head to this point will be 230 feet, with side slopes of two to one. Below this point to Duggirala escape weir its width will be 141 feet, and with the above slopes it will be capable of carrying water for 155,000 acres. The fall of both portions will be 0·27 feet per mile, and the water in them will run 8 feet deep. The sanctioned width of the canal as far as the Duggirala weir being 96 feet, it will have to be widened by 134 and 45 feet in the two portions respectively.

3. At Duggirala the end of the first reach of 13 miles from head there are four masonry works, two to supply the Commamore Canal carrying water for 100,000 acres, and two to supply the East and West Side channels of the Nizampatam Canal carrying water for 55,000 acres.

4. All the water required for irrigation being taken off above Duggirala lock, the canal below will be made a still water one, the water being held up below at the locks for navigation, for which purpose an estimate has been framed for raising and sectioning banks below Duggirala, retaining the bed as at present.

5. There is a head lock on the Main canal and five locks on the Nizampatam Canal; their floor and water levels, etc., will be as follows :—

Number.	Names.	Length, Miles.	Upper Sill.			Drop.	Lower Sill.			Fall per mile.
			Sill.	Water, full supply level.	Chamber walls.		Sill.	Water, full supply level.	Chamber walls.	
			Level of ordinary high flood in rivers.							
1	Sitanagram ...	...	+37·5	+60·5	+63·0	...	+37·5	+45·5	+63·0	...
2	Duggirala ...	13	+33·5	+41·5	+42·75	8·0	+25·5	+30·5	+42·75	0·308
3	Kuchipudy ...	8¼	+22·5	+30·5	+33·5	8·0	+14·5	+19·5	+33·5	0·343
4	Jutur ...	9	+11·5	+19·5	+20·5	6·5	+ 5·0	+10·0	+20·5	0·333
5	Nallavada ...	5¼	+ 5·0	+10·5	+12·0	5·0	0·0	+ 5·0	+12·0	0·0
6	Nizampatam tidal lock ...	4	0·0	+ 5·0	+ 7·0	8·0	— 8·0	— 4·62 or low tide level.	+ 7·0	0·0
	Total length of miles ...	40	....	.....	.....	...	.....	.. ...	.....	...

6. Thus it will be seen that with the exception of the locks at Duggirala and Jutur all the rest have a broad margin above full supply level; that, unless it is proposed to hold up water here also for navigation after the cultivation season is over, there will be no necessity for raising the chamber walls, and therefore this item has been omitted in the present estimate.

7. The general direction of the channel below is south-west, and, as above stated, it runs through alluvial black cotton and sandy soils; the banks throughout are 3 feet and upwards above full supply level.

8. At the end, the channel tails into the salt creek of Nizampatam, which communicates with the sea, and there it is provided with an escape weir of ample capacity.

9. The following additions are now provided in the revised estimate for the two principal branches of the canal :—

East Side Channel.	Rs.
Prolongation from Nallavada to Komaravole channel, 92,057 cubic yards, at 1 Anna per cubic yard	6,040
Providing new gearings and shutters to the head-sluice at Duggirala.	3,515
Regulating dams and sluices	2,000
Total...	11,555
West Side Channel.	
Prolongation from Nallavada to Allur creek	2,055
Providing new gearings and shutters to the head-sluice in Duggirala escape weir	1,885
Regulating dams and sluices	1,000
Total...	4,940
	16,495

10. The total cost of this canal and its principal branches as given in this report is—

	Rs.
Main Canal from head to Jutur lock	5,58,505
Principal branches	16,495
Total Main Canal and Branches...	5,75,000

(Signed) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

A.-1.—No. 1.

WESTERN DELTA.

Specification Report to accompany Plan and Estimate (amounting to Rupees 9,840) *for providing screw gearings and new shutters to the head-sluice of the Main Canal at Sitanagram.*

THIS sluice consists of 15 vents of 6 feet span each, and with a head of 0·5 feet will be capable of discharging 3,528 cubic feet a second against the required discharge of 3,450 cubic feet for the 230,000 acres under it, at 2 cubic yards per hour per acre The present vents are 6 feet × 11 feet; it is now proposed to block up the upper 3 feet leaving 8 feet below, which would be ample for the said acreage.

2. Each of the vents will be provided with shutters worked by screw gearings as shown in the plan accompanying the estimate, which has been drawn up after the plans received from the Chief Engineer for Irrigation with his No. 903, dated 18th December 1873. They will be prepared in Government Workshop at Madras. The shutters and cross beams will be of teak-wood; the former will be provided with four rollers on each side; the grooves will be lined with angle iron to diminish friction.

3. The level of the floor of this work is 37·5 above high water mark, and that of anicut crest is 43 feet. In order to gain the head of 0·5 feet (the minimum required) a rough stone dam is raised annually over the anicut.

4. Statement C.C.C., prepared in compliance with the requisition of the Chief Engineer, shows clearly the quantity of water discharged through the sluice for the last nine years from 1864 to 1872 both years inclusive.

MASULIPATAM,
21*st March* 1874. (Signed) D. McNEIL-CAMPBELL, Lieutenant, R.E.,
7th Range Officer, Kistna.

C. I.—from A.-10.

WESTERN DELTA.

Specification Report to accompany Plan and Estimate (amounting to Rupees 3,515) *for providing screw gearings and shutters to the head-sluice of East Side Channel of Nizampatam canal adjoining Duggirala Lock.*

THIS sluice has 6 vents, each 4×4·5, and with a minimum head of 3·25 feet is capable of discharging 972 cubic feet a second against the required discharge of 510 cubic feet a second for the 34,000 acreage proposed to be taken up under it.

2. The parts painted with gamboge represent the improvements now proposed; the arches will be prolonged 2 feet, the spandrills filled up and raised 1½ feet high, the piers also to be raised to that height for a length of 1 foot, and the rest of the piers raised 2 feet to support a wooden platform 3 feet wide with railings on the Main canal side for the use of lascars to work the screws.

3. The screw gearings consist of an iron bar 1½ inches thick with screw cut for a length of 4½ feet. The female screw to which the handle is attached on top is to be fitted between the two beams on the raised parts of the piers and arches.

4. The female screw turns between the collar plate fixed around it and so effects the opening and closing of the shutter.

The dimensions of the different parts are given in the plan.

The floor of this sluice is 35·5 above high water mark. Water in Main canal will be 8 feet ·0 or 6 feet ·0 on the front floor, and that on the rear will be 4·5.

MASULIPATAM,
21*st March* 1874. (Signed) D. McNEIL-CAMPBELL, Lieutenant, R.E.,
7th Range Officer, Kistna.

C. I.—from A.-10.

WESTERN DELTA.

Specification Report to accompany Plan and Estimate for prolonging Nizampatam canal, East Side Channel, from the calingulah at Nallavada to Komaravole head-sluice near the village of Poodivada, Repally Taluq, Western Delta, Kistna, Amount of estimate, Rupees 6,040.

THIS channel is to irrigate 7,000 acres of land; it will leave the Eastern side channel at the calingulah (level of floor 7·25), and will be carried across Nallavada along the foot of the east bank of the Nizampatam canal for a distance of one-eighth mile, and then takes its course in an easterly direction along the south bank of Nallavada down to its end, and from thence along the south bank of the Repally main drain for a distance of three-eighths of a mile. From here the channel will be carried along the Pudivadavada down to Komaravole channel head-sluice 3 vents of 4 feet span, where it will terminate at a level of 3 feet 14 inches above high water mark. The Toollavagu channel will take off at 2½ miles; it is already provided for with a head-sluice of 2 vents of 4 feet span. The total length of the channel will be 4⅜ miles, width of channel 14 feet at head reduced to 10 at of bed ·94 per mile throughout, depth of water 3 feet, and height of bunds 2 feet above water with side slopes of 1½ to 1.

MASULIPATAM,
21*st March* 1874. (Signed) D. McNEIL-CAMPBELL, Lieut., R.E.,
7th Range Officer, Kistna.

D. I.—from A-7.

WESTERN DELTA.

Specification Report to accompany Plan and Estimate (No. D. 1. *amounting to Rs.* 1,885) *for providing new screw gearings and shutters to the head-sluice of West Side channel in Duggirala weir.*

THIS sluice has two vents, each 5 × 5, and with the minimum head of 1·25 is capable of discharging 388·5 cubic feet a second against the required discharge of 315·0 cubic feet a second for the 21,000 acreage proposed under it.

The parts colored with gamboge exhibit the improvements now proposed to fit up the screw gearings and shutters with a roadway width 9 feet for which certain alterations have been found necessary in the masonry at the rear, and the removal of the old parapets. The spandrill spaces will be filled in with masonry which will be raised to a height of 1½ feet above the arches throughout the whole length of the work; the piers for a length of 1 foot will also be raised the same height. Outside this a platform 3 feet wide with railings is allowed for the establishment to work the gearings.

The screw gearings consist of an iron bar 2 inches thick with screw cut for a length of 5·0 feet; the female screw to which the handle is attached on top is to be fitted in between the two beams allowed for the purpose. The female screw will turn in the brass collar plate fixed around it and so effect the opening and closing of the shutter.

The dimensions of the different parts are given in the plan.

The floor level of the sluice is + 34·5 above high water mark. Water in Main canal will be 8 feet or 7 feet on floor in front; that on the rear will be 4·5. The head used in the calculation is thus 1·25, or half the full head.

MASULIPATAM,
21*st March* 1874.

(Signed) D. McNEIL-CAMPBELL, Lieut, R.E.,
7th Range Officer, Kistna.

D. 1.—from A. 7.

WESTERN DELTA.

Specification Report to accompany the longitudinal section of West Side channel prolongation from Nallavada to Allur creek, for which, in the absence of a detailed estimate, a lump sum of Rupees 2,055 *has been allowed in the estimate.*

THIS channel is to irrigate 2,000 acres of land; it will follow the south bank of Nizampatam canal from Nallavada, where it ends at present, to the blocked up old course of the creek near the village of Allur. It will have a bottom width of 3 feet, side slopes 2 to 1, and running 4 feet deep, with a fall of 0·87 feet, will discharge 83·6 cubic feet a second against the required discharge of 30 cubic feet for the acreage proposed to be taken up under it. The banks on top will be 2 feet wide, side slopes 1½ to 1, they will be raised 2½ feet above water full supply level. The bed at the starting point will be 4·26 above high water mark.

MASULIPATAM,
21*st March* 1874.

(Signed) D. McNEIL-CAMPBELL, Lieut., R.E.,
7th Range Officer, Kistna.

(,,) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

No. 8.

Comparative Statement of the Original and Revised Estimate of Nizampatam Canal Main Duct and its Principal Branches.

Description of Works.	As per original Estimate.				As per revised Estimate.				Increase.		Decrease.		Remarks.
	Quantity.	Rate.		Amount.	Quantity.	Rate.		Amount.					
		Rs. A. P.		Rs. A. P.		Rs. A. P.		Rs. A. P.	Rs. A. P.		Rs. A. P.		
1. Main Canal (Sitanagram) Head sluice.	.....	.....		.....	.....	.....		.....	9,840 0 0		.....		Nothing allowed in original estimate.
2. Main Canal from Sitanagram to Duggirala lock.	387,875 3,537,023	0 4 0 0 2 0		5,66,400 0 0	Cubic yards. 343,196 3,398,071	0 4 0 0 2 0		5,36,085 0 0	.....		30,315 0 0		Owing to fall being increased less width is required.
3. Compensation for land ...	.....	.....		.....	Acres. 64·49	30 0 0		1,935 0 0	1,935 0 0		.....		Nothing allowed in original estimate.
4. Rest-house	.....	.....		600 0 0	.....	.....		.....	.....		600 0 0		Not included in this estimate.
5. Nizampatam Canal ...	.....	.....		.....	Cubic yards. 121,657	0 4 0 0 2 0		10,645 0 0	10,645 0 0		.....		For raising banks.
6. 1 Lock (2nd class) with a drop of 4 feet between Duggirala and Kutchipudy.	.....	.....		14,420 0 0	.....	.....		.....	.....		29,180 0 0		Not necessary, as raising the banks will answer the purpose better.
7. 1 Lock (2nd class) with a drop of 4 feet between Duggirala and Jutur.	.....	.....		14,760 0 0	.....	.....		6,040 0 0	.....		450 0 0		Decreased, reducing embanking.
8. East Side channel prolongation ...	119,219	0 0 10		6,520 0 0	92,057	0 0 10		3,515 0 0	3,515 0 0		.....		
9. Do. head-sluice improvement...	.....	.....		.....	.....	.....		2,000 0 0	2,000 0 0		.....		Not allowed in original estimate.
10. Do. minor masonry works ...	.....	.....		.....	.....	.....		2,055 0 0	2,055 0 0		.....		
11. West Side channel prolongation ...	.....	.....		.....	.....	.....		1,885 0 0	1,885 0 0		.....		
12. Do. head-sluice ...	.....	.....		.....	.....	.....		1,000 0 0	1,000 0 0		.....		
13. Do. minor masonry works ...	.....	.....		.....	.....	.....		.....	.....		.....		
Total Estimate...	.....	.....		6,02,700 0 0	.....	.....		5,75,000 0 0	32,875 0 0		60,575 0 0		
Net Saving...	.....	.....		.....	.....	.....		.....	.....		32,875 0 0		
									.....		27,700 0 0		

(Signed) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

C. C.
No. 9.

Statement showing the Area commanded, the present and the intended area of irrigation and anticipated cost of works as shown below.

Names of Works.	Area commanded by each channel and by each of its principal branches.	Proposed Acreage.	Present area of Irrigation.		Intended increase of Irrigation with proposed works.	Cost of proposed works.			Expected profit.
			Acreage.	Assessment.	Assessment.	Irrigation.	Drainage.	Total.	
1	2	3	4	5	6	8	9	10	11
	Sq. miles.			Rs.	Rs.	Rs.	Rs.	Rs.	
Main Canal	950*	230,000	...	...	...	5,47,860	.....	.....	The expected profit cannot be entered here as expenditure will be incurred on other channels to irrigate this acreage.
1. Nizampatam Canal ...	...	...	1,800	10,166	...	10,645	.....	.....	
2. Do. East Side channel	145—28	34,000	12,759	71,226	11,241	11,555	.....	.....	
3. Do. West Side channel	64—31	21,000	6,986	42,344	14,014	4,940	.....	.....	
Total...	209—59	...	21,545	1,23,736	35,255	5,75,000	.....	.....	

* *Vide* paragraph 76 of Captain Vibart's report, dated 5th April 1872.
The assessment shown for present wet includes Rupees 287, 6,127, and 4,765 for dry crops watered under the above three channels, respectively. In future No. (1) or lands under main channel will be supplied by Nos. 2 and 3.
Present acreage above given is for fasli 1281 or A.D. 1871-72.

(Signed) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

18/39

No. 10.

Kistna District.

Statement showing the Outlay already incurred and that now proposed on the under-mentioned works in Western Delta :—

Name of Works.	Outlay.* Expenditure to 1872-73. Original.	Amount of Estimate now framed.	Total proposed outlay.
1	2	3	4
	Rs.	Rs.	Rs.
Anicuts proportionate cost	3,41,646	...	3,41,646
Main Canal from Sitanagram to Duggirala lock	5,33,359	5,47,860	...
Do. from do. to tidal lock, Nizampatam		10,645	...
East Side channel of Nizampatam Canal	34,643	11,555	46,198
West Side do. do. do.	33,783	4,940	38,723
Total...	9,43,431	5,75,000	...

N.B.—The expenditure on the Main Canal and Nizampatam Canal will be separated as soon as possible.

(Signed) J. MULLINS, Lieut.-Col., R.E.

* This is taken from statements sent by the District Engineer to Controller and Chief Engineer to 1872-73.

(Signed) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

No. 11.

KISTNA DISTRICT, WESTERN DELTA.

Table showing the Velocity, Discharge and Acreage, etc., of Nizampatam Canal and its Subsidiary works.

No. of Division.	No. of Main Duct.	No. of Branch Ducts.	Name of Channel.	Distance from head.	Side slopes.	Bottom width.	Fall of Channel.	Depth of water.	Area of cross section.	Hydraulic mean depth.	Mean Velocity.	Discharge required in cubic feet per second.	Actual discharge in cubic feet per second.	Discharge in cubic yards per hour.	Area in square miles under command of anicut water.	Proposed Acreage.	Proposed acreage per square mile.
				MILES.		FEET.	FEET.	FEET.	SQR. FT.	FEET.							
A	1	1	Main Canal from Sitanagram to Revendrapad.	7¾	2 to 1	230	0·27	8·0	1,968	7·38	1·82	3,450	3,581·76	477,448	.....	230,000	.....
A	C	10	Do. to Duggirala Lock	13	Do.	141	0·308	8·0	1,256	7·1	1·9	2·325	2,386·4	314,853·3	.....	155,000	.....
...	...	...	East Side channel, Nizampatam Canal, below Duggirala Lock.	Starts from do.	Do.	42	0·83	4·5	229·5	3·67	2·26	510	518·67	69,156	145·28	34,000	234·03
...	...	...	Below Kuchenapaudy Lock ...	8¼	Do.	30	0·87	4·5	175·5	3·5	2·26	157·5	396·63	52,884	41·58	10,500	254·94
...	...	...	Below Jutur Lock	18	Do.	18	0·554	4·5	125·1	3·19	1·72	69·0	208·98	27,864	19·38	4,600	237·35
...	...	...	Do. Nallavada prolongation ...	23¼	Do.	14	0·94	3·0	60	2·18	2·0	105	108·	14,400	35·01	7,000	200
A	D	7	West Side channel below Duggirala Lock.	Starts from the 13th mile.	Do.	24	0·83 0·87 below Tanally.	4·5	148·5	3·3	2·14	315	317·79	42,372	64·31	21,000	326·52
...	...	...	Below Kuchinapaudy Lock ...	8¼	Do.	18	0·87	4·5	121·5	3·19	1·79	90·0	217·48	28,997·3	23·76	6,400	269·36
...	...	...	Below Jutur Lock	18	Do.	12	0·516	4·5	94·5	2·94	1·59	36·0	150·25	20,033·3	5·34	2,000	374·53
...	...	...	Do. Nallavada do. prolongation ...	23¼	Do.	3	0·87	4·0	44·0	2·1	1·9	30·0	83·6	11·150	5·78	2,000	346·02

(Signed) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

C. C. C.

Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season. Loss of head through Sluice assumed to be 0·75 feet.

Irrigation Months.	DAYS MORE THAN 7′ 0″ AND LESS THAN 7′ 3″ ON FLOOR.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	DAYS MORE THAN 7′ 3″ AND LESS THAN 7′ 6″ ON FLOOR.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	DAYS MORE THAN 7′ 6″ AND LESS THAN 7′ 9″ ON FLOOR.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	DAYS MORE THAN 7′ 9″ AND LESS THAN 8′ 0″ ON FLOOR.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
	No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
For the year 1864.																
July	...	...	Velocity 1·65, D 2,606·175 cubic feet a second.	347,403·1 C. yds. or 1·49 C. yds. per hour per acre.	...	...	Velocity 1·68, D 2,761·29 cubic feet per second.	368,074 C. yds. or 1·6 C. yds. per hour per acre.	...	...	Velocity 1·71, D 2,920·68 cubic feet per second.	389,326 C. yds. or 1·692 C. yds. per hour per acre.	2	12, 13	Velocity 1·75, D 3,102·1 cubic feet per second.	413,509 C. yds. or 1·796 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	...		
September	...	...			...	...			...	...			...	...		
October	...	...			4	17, 18, 19 and 20.			3	15, 16 and 21			3	14, 22 and 24		
November	...	...			...	...			8	9, 10, 17, 18, 19, 20, 21 and 22.			3	15, 16 and 25		
December	1	31			3	28, 29, 30			2	26, 27			5	21, 22, 23, 24 and 25.		

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 230,000.

Proceedings of the Madras Government, Public Works Department, 19th December 1874.

19/39

***Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season: Loss of head through Sluice assumed to be 0·75 feet.*—(Continued.)**

Irrigation Months.	Days more than 8′ 0″ and less than 8′ 3″ on floor.				Days more than 8′ 3″ and less than 8′ 6″ on floor.				Days more than 8′ 6″ and less than 8′ 9″ on floor.				Days more than 8′ 9″ and less than 9′ 0″ on floor.			
	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
—	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
For the year 1864.																
July	1	11	Velocity 1·77, D 3,252·37 cubic feet per second.	C. yds. 433,540 or 1·605 C. yds. per hour per acre.	2	10, 14	Velocity 1·80, D 3,428 cubic feet per second.	456,262 C. yds. or 1·966 C. yds. per hour per acre.	4	2, 8, 9, 15	Velocity 1·83, D 3,601·44 cubic feet per second.	480,070 C. yds. or 2·08 C. yds. per hour per acre.	1	7	Velocity 1·85, D 3,862·19 cubic feet per second.	514,829 C. yds. or 2·23 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	...		
September	...	...			...	...			4	21, 22, 23 and 24.			3	26, 25 and 30.		
October	6	12, 13, 23, 25, 26, 28.			3	11, 27, 29			7	1, 3, 4, 5, 10 30 and 31.			1	2		
November	4	8, 14, 24 and 26.			6	13, 23, 27, 28, 29, 30.			2	11 and 12			2	1, 7		
December	10	1 to 8 and 19 and 20.			9	9 to 15 and 17, 18.			1	16			...	...		

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 230,000.

***Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season: Loss of head through Sluice assumed to be 0·75 feet.*—(Continued.)**

Irrigation Months.	Days more than 7′ 0″ and less than 7′ 3″ on floor.				Days more than 7′ 3″ and less than 7′ 6″ on floor.				Days more than 7′ 6″ and less than 7′ 9″ on floor.				Days more than 7′ 9″ and less than 8′ 0″ on floor.			
	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
For the year 1865.																
July	...	...	Velocity 1·65, D 2,606·175 cubic feet per second.	347,403·1 C. yds. or 1·49 C. yds. per hour per acre.	...	...	Velocity 1·63, D 2,761·29 cubic feet per second.	368,074 C. yds. or 1·6 C. yds. per hour per acre.	...	...	Velocity 1·71, D 2,920·68 cubic feet per second.	389,326 C. yds. or 1·692 C. yds. per hour per acre.	...	...	Velocity 1·75, D 3,102·1 cubic feet per second.	413,509 C. yds. or 1·796 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	...		
September	...	...			...	...			...	...			...	...		
October	...	...			...	...			...	...			6	5, 6, 7, 8, 9 and 10.		
November	...	...			...	...			...	...			...	...		
December	...	...			...	...			2	30 and 31			4	16, 17, 28 and 29.		

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 239,000.

***Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season. Loss of head through Sluice assumed to be 0·75 feet.*—(Continued.)**

Irrigation Months.	Days more than 8′ 0″ and less than 8′ 3″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 3″ and less than 8′ 6″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 6″ and less than 8′ 9″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 9″ and less than 9′ 0″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
	No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.		
—	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
For the year 1865.																
July	...	...	Velocity 1·77, D 3,252·37 cubic feet a second.	C. yds. 433,540 or 1·605 C. yds. per hour per acre.	...	...	Velocity 1·80, D 3,428 cubic feet per second.	456,952 C. yds. or 1·936 C. yds. per hour per acre.	...	...	Velocity 1·83, D 3,601·44 cubic feet per second.	480,070 C. yds. or 2·03 C. yds. per hour per acre.	...	...	Velocity 1·85, D 3,852·19 cubic feet per second.	514,639 C. yds or 2·23 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	...		
September	...	...			...	...			2	29 and 30			...	...		
October	5	2, 3, 4, 11 and 12.			3	1, 13 and 14			2	15 and 16			1	17		
November	...	...			...	...			1	30			2	28 and 29		
December	8	11, 12, 13, 14, 15, 25, 26, 27.			13	5, 6, 7, 8, 9, 10, 18, 19, 20, 21, 22, 23, 24.			4	1, 2, 3, 4			...	...		

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 230,000.

***Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season. Loss of head through Sluice assumed to be 0·75 feet.*—(Continued.)**

Irrigation Months.	Days more than 7′ 0″ and less than 7′ 3″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 3″ and less than 7′ 6″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 6″ and less than 7′ 9″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 9″ and less than 8′ 0″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
	No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
For the year 1866.																
July	...	...	Velocity 1·65, D 2,606·175 cubic feet per second.	347,403·1 C. yds. or 1·49 C. yds. per hour per acre.	...	...	Velocity 1·68, D 2,761·29 cubic feet per second.	368,074 C. yds. or 1·6 C. yds. per hour per acre.	...	...	Velocity 1·71, D 2,920·68 cubic feet per second.	389,326 C. yds. or 1·692 C. yds. per hour per acre.	...	...	Velocity 1·75, D 3,102·1 cubic feet per second.	413,509 C. yds. or 1·796 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	...		
September	...	...			...	...			...	...			...	...		
October	...	...			...	...			...	...			...	...		
November	...	...			...	...			...	...			8	5, 6, 7, 8, 9, 10, 11 and 12.		
December	...	...			...	...			...	...			1	31		

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 230,000.

Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season. Loss of head through Sluice assumed to be 0·75 feet.—(Continued.)

Irrigation Months.	Days more than 8′ 0″ and less than 8′ 3″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 3″ and less than 8′ 6″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 6″ and less than 8′ 9″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 9″ and less than 9′ 0″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
	No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.		
—	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
For the year 1866.																
July	3	10, 11, 13	Velocity 1·77, D 3,252·37 cubic feet per second.	C. yds. 433,540 or 1·885 C. yds. per hour per acre.	1	9	Velocity 1·80, D 3,428 cubic feet per second.	456,952 C. yds. or 1·986 C. yds. per hour per acre.	2	8, 14	Velocity 1·83, D 3,601·44 cubic feet per second.	480,070 C. yds. or 2·08 C. yds. per hour per acre.	2	7, 17	Velocity 1·85, D 3,862·19 cubic feet per second.	514,839 C. yds. or 2·23 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	...		
September	2	22, 23			5	18, 19, 20, 21 and 24.			2	17 and 25			...	...		
October	...	...			2	19, 20			...	...			3	3, 18, 21		
November	3	4, 13, 14			2	3 and 15			3	2, 16, 17			3	1, 18, 19		
December	2	29, 30			7	15, 16, 17, 18, 19, 27, 28.			8	9, 10, 11, 12, 13, 14, 20, 26.			7	4, 5, 6, 7, 8, 24, 25.		

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 230,000.

Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season. Loss of head through Sluice assumed to be 0·75 feet.—(Continued.)

Irrigation Months.	Days more than 7′ 0″ and less than 7′ 3″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 3″ and less than 7′ 6″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 6″ and less than 7′ 9″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 9″ and less than 8′ 0″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
	No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
For the year 1867.																
July	...	...	Velocity 1·65, D 2,606·175 cubic feet per second.	347,403·1 C. yds. or 1·49 C. yds. per hour per acre.	3	1, 2, 21	Velocity 1·68, D 2,761·29 cubic feet per second.	368,074 C. yds. or 1·6 C. yds. per hour per acre.	2	3, 20	Velocity 1·71, D 2,920·68 cubic feet per second.	389,336 C. yds. or 1·692 C. yds. per hour per acre.	1	17	Velocity 1·75 D 3,102·1 cubic feet per second.	413,509 C. yds. or 1·796 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	...		
September	...	...			...	...			...	...			...	...		
October	...	...			...	...			...	...			...	...		
November	...	...			...	...			...	...			...	...		
December	...	...			...	...			...	...			...	...		

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 230,000.

Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season. Loss of head through Sluice assumed to be 0·75 feet.—(Continued.)

Irrigation Months.	Days more than 8′ 0″ and less than 8′ 3″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 3″ and less than 8′ 6″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 6″ and less than 8′ 9″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 9″ and less than 9′ 0″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
	No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.		
—	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
For the year 1867.																
July	...	...	Velocity 1·77, D 3,252·37 cubic feet per second.	C. yds. 438,540 or 1·985 C. yds. per hour per acre.	3	4, 17, 18	Velocity 1·80, D 3,428 cubic feet per second.	456,952 C. yds. or 1·986 C. yds. per hour per acre.	...	...	Velocity 1·83, D 3,501·44 cubic feet per second.	480,670 C. yds. or 208 C. yds. per hour per acre.	...	...	Velocity 1·85, D 3,562·19 cubic feet per second.	514,329 C. yds. or 2·23 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	...		
September	...	...			...	...			...	...			6	23, 24, 25, 26, 27, 28.		
October	2	9, 10			1	8			1	7			1	1		
November	...	...			3	11, 13, 14			5	9, 10, 12, 15 and 16.			7	2, 3, 7, 8, 17, 18, 19.		
December	...	...			...	...			...	...			2	30 and 31		

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 230,000.

Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season. Loss of head through Sluice assumed to be 0·75 feet.—(Continued.)

Irrigation Months.	Days more than 7′ 0″ and less than 7′ 3″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 3″ and less than 7′ 6″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 6″ and less than 7′ 9″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 9″ and less than 8′ 0″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
	No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
For the year 1868.																
July	...	...	Velocity 1·65, D 2,606·175 cubic feet per second.	347,403·1 C. yds. or 1·49 C. yds. per hour per acre.	...	...	Velocity 1·68, D 2,763·29 cubic feet per second.	365,074 C. yds. or 1·6 C. yds. per hour per acre.	1	21	Velocity 1·71, D 2,920·68 cubic feet per second.	389,326 C. yds. or 1·692 C. yds. per hour per acre.	2	19, 20	Velocity 1·75, D 3,102·1 cubic feet per second.	413,609 C. yds. or 1·796 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	...		
September	...	...			...	...			...	...			4	24, 25, 26 and 27.		
October	...	...			...	...			...	...			...	...		
November	...	...			...	...			...	...			4	27, 28, 29, 30		
December	5	10, 11, 12, 13, 14.			4	6, 7, 8, 9			4	2, 3, 4, 5			1	1		

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 230,000.

Proceedings of the Madras Government, Public Works Department, 19th December 1874.

Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season. Loss of head through Sluice assumed to be 0·75 feet.—(Continued.)

Irrigation Months.	Days more than 8′ 0″ and less than 8′ 3″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 3″ and less than 8′ 6″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 6″ and less than 8′ 9″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 9″ and less than 9′ 0″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
	No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.		
—	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
For the year 1868.																
July	...	...	Velocity 1·77, D 3,252·37 cubic feet per second.	433,540 C. yds. or 1·885 C. yds. per hour per acre.	1	18	Velocity 1·80, D 3,423 cubic feet per second.	456,562 C. yds. or 1·986 C. yds. per hour per acre.	...	...	Velocity 1·83, D 3,591·44 cubic feet per second.	480,070 C. yds. or 2·08 C. yds. per hour per acre.	1	17	Velocity 1·85, D 3,862·19 cubic feet per second.	514,829 C. yds. or 2·23 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	...		
September	3	22, 23 and 28			2	21, 29			1	30			1	20		
October	...	...			7	19 to 25			2	17, 18			...	...		
November	2	25, 26			2	23, 24			2	21, 22			5	15, 16, 18, 19, 20.		
December	...	...			...	...			...	...			...	...		

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 230,000.

Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season. Loss of head through Sluice assumed to be 0·75 feet.—(Continued.)

Irrigation Months.	Days more than 7′ 0″ and less than 7′ 3″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 3″ and less than 7′ 6″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 6″ and less than 7′ 9″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 9″ and less than 8′ 0″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
	No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
For the year 1869.																
July	...	...	Velocity 1·65, D 2606·175 cubic feet per second.	347,403·1 C. yds. or 1·49 C. yds. per hour per acre.	...	...	Velocity 1·68, D 2,761·29 cubic feet per second.	368,074 C. yds. or 1·6 C. yds. per hour per acre.	...	...	Velocity 1·71, D 2,920·68 cubic feet per second.	389,338 C. yds. or 1·692 C. yds. per hour per acre.	2	11, 12	Velocity 1·75, D 3,102·1 cubic feet per second.	413,599 C. yds. or 1·796 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	...		
September	...	...			...	...			...	...			...	...		
October	...	...			...	...			...	...			...	...		
November	...	...			...	...			...	...			...	...		
December	...	...			...	...			...	...			...	...		

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 230,000.

28/37

Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season. Loss of head through Sluice assumed to be 0·75 feet.—(Continued.)

Irrigation Months.	Days more than 8′ 0″ and less than 8′ 3″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 3″ and less than 8′ 6″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 6″ and less than 8′ 9″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 9″ and less than 9′ 0″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
	No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.		
—	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
For the year 1869.																
July	3	3, 19, 20	Velocity 1·77, D 3,352·37 cubic feet per second.	438,540 C. yds. or 1·885 C. yds. per hour per acre.	3	10, 13, 15	Velocity 1·80, D 3,423 cubic feet per second.	456,952 C. yds. or 1·963 C. yds. per hour per acre.	3	14, 16, 18	Velocity 1·83, D 3,601·44 cubic feet per second.	480,070 C. yds. or 2·03 C. yds. per hour per acre.	3	2, 9, 17	Velocity 1·85, D 3,362·19 cubic feet per second.	514,829 C. yds. or 2·21 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	...		
September	...	...			...	...			...	...			...	...		
October	...	...			3	24, 25, 26			3	22, 23, 27			4	19, 20, 21 and 28.		
November	...	...			...	...			...	...			...	...		
December	...	...			...	...			...	...			...	...		

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 230,000.

Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season. Loss of head through sluice assumed to be 0·75 feet.—(Continued.)

Irrigation Months.	Days more than 7′ 0″ and less than 7′ 3″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 3″ and less than 7′ 6″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 6″ and less than 7′ 9″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 9″ and less than 8′ 0″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
	No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
For the year 1870.																
July	...	...	Velocity 1·65, D 2,606·175 cubic feet per second.	347,408·1 C. yds. or 1·49 C. yds. per hour per acre.	...	...	Velocity 1·68, D 2,761·29 cubic feet per second.	368,0·74 C. yds. or 1·6 C. yds. per hour per acre.	...	...	Velocity 1·71, D 2,920·68 cubic feet per second.	389,326 C. yds. or 1,692 C. yds. per hour per acre.	...	...	Velocity 1·75, D 3,102·1 cubic feet per second.	413,509 C. yds. or 1·796 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	...		
September	...	...			...	...			...	...			...	...		
October	...	...			...	...			...	...			...	...		
November	...	...			...	...			...	...			...	...		
December	...	...			...	...			...	...			...	...		

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 230,000.

25/39

Statement showing the depth of water of Sitanagram Head Sluice front floor during the Irrigation season. Loss of head through sluice assumed to be 0·75 feet.—(Continued.)

Irrigation Months.	Days more than 8′ 0″ and less than 8′ 3″ on floor.				Days more than 8′ 3″ and less than 8′ 6″ on floor.				Days more than 8′ 6″ and less than 8′ 9″ on floor.				Days more than 8′ 9″ and less than 9′ 0″ on floor.			
	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
—	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
For the year 1870.																
July	...	...	Velocity 1·77, D 3,252·37 cubic feet per second.	C. yds. 433,540 or 1·385 C. yds. per hour per acre.	1	9	Velocity 1·80, D 3,428 cubic feet per second.	456,952 C. yds. or 1·936 C. yds. per hour per acre.	2	7, 8	Velocity 1·83, D 3,601·44 cubic feet per second.	480,070 C. yds. or 2·08 C. yds. per hour per acre.	1	6	Velocity 1·85, D 3,662·19 cubic feet per second.	514,829 C. yds. or 2·23 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	?		
September	1	15			1	14			2	7, 13			2	6, 10		
October	...	...			...	...			...	...			...	...		
November	...	...			3	15, 16, 17			4	13, 14, 18 and 19.			4	11, 12, 20 and 21.		
December	...	...			...	...			...	...			...	...		

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 230,000.

Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season. Loss of head through sluice assumed to be 0·75 feet.—(Continued.)

Irrigation Months.	Days more than 7′ 0″ and less than 7′ 3″ on floor.				Days more than 7′ 3″ and less than 7′ 6″ on floor.				Days more than 7′ 6″ and less than 7′ 9″ on floor.				Days more than 7′ 9″ and less than 8′ 0″ on floor.			
	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	No.	From what date to what date.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
For the year 1871.																
July	...	...	Velocity 1·65, D 2,606·175 cubic feet per second.	347,903·1 C. yds. or 1·49 C. yds. per hour per acre.	...	...	Velocity 1·68, D 2,761·29 cubic feet per second.	368,874 C. yds. or 1·6 C. yds. per hour per acre.	...	...	Velocity 1·71, D 2,920·68 cubic feet per second.	393,325 C. yds. or 1·692 C. yds. per hour per acre.	...	...	Velocity 1·75, D 3,102·1 cubic feet per second.	413,599 C. yds. or 1·796 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	...		
September	...	...			...	...			...	...			...	...		
October	...	...			...	...			...	...			...	...		
November	...	...			...	...			...	...			...	...		
December	4	24, 25, 26, 27.			3	21, 22, 23			1	20			3	17, 18, 19		

Bottom width 230 feet. Fall 0·27 feet pea mile. Acreage 230,000.

2b/29

Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season. Loss of head through sluice assumed to be 0·75 feet.—(Continued.)

Irrigation Months.	Days more than 8′ 0″ and less than 8′ 3″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 3″ and less than 8′ 6″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 6″ and less than 8′ 9″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 8′ 9″ and less than 9′ 0″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
	No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.		
—	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
For the year 1871.																
July	...	...	Velocity 1·77 D, 3,252·37 cubic feet per second.	433,540 C. yds. or 1·885 C. yds. per hour per acre.	1	12	Velocity 1·80, D 3,423 cubic feet per second.	456,952 C. yds. or 1·987 C. yds. per hour per acre.	1	11	Velocity 1·83, D 3,601·44 cubic feet per second.	480,070 C. yds. or 2·03 C. yds. per hour per acre.	4	10, 14, 15 and 16.	Velocity 1·85, D 3,862·19 cubic feet per second.	514,929 C. yds. or 2·23 C. yds. per hour per acre.
August	...	...			...	...			...	...			2	30, 31.		
September	...	...			2	17, 18			1	26			6	1, 16, 19, 25, 27, 28.		
October	...	...			5	21, 22, 23, 24, 25.			2	20, 26			5	27, 28, 29, 30, 31.		
November	...	...			...	...			...	...			3	1, 2, 3		
December	3	15, 16.			2	6, 14			2	57,13			5	3, 4, 7, 11and 12		

Bottom width 230 feet. Fall 0·27 feet per mile, Acreage 230,000.

Statement showing the depth of water on Sitanagram Head Sluice front floor during the Irrigation season. Loss of head through sluice assumed to be 0·75 feet.—(Continued.)

Irrigation Months.	Days more than 7′ 0″ and less than 7′ 3″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 3″ and less than 7′ 6″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 6″ and less than 7′ 9″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	Days more than 7′ 9″ and less than 8′ 0″ on floor.		Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
	No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.			No.	From what date to what date.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
For the year 1872.																
July	...	...	Velocity 1·65, D 2,606·175 cubic feet per second.	347,403·1 C. yds. or 1·49 C. yds. per hour per acre.	...	...	Velocity 1·68, D 2,761·29 cubic feet per second.	368,079 C. yds. or 1·6 C. yds. per hour per acre.	...	...	Velocity 1·71, D 2,920·68 cubic feet per second.	389,326 C. yds. or 1·692 C. yds. per hour per acre.	...	...	Velocity 1·75, D 3,102·1 cubic feet per second.	413,599 C. yds. or 1·796 C. yds. per hour per acre.
August	...	...			...	...			...	...			...	...		
September	...	...			...	...			...	...			...	...		
October	...	...			...	...			...	...			...	...		
November	...	...			...	...			...	...			...	...		
December	...	...			...	...			...	...			...	...		

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 230,000.

Statement showing the depth of water on Sitanagram Head Sluice front flo
assumed to be 0·75 feet.—

Irrigation Months.	No.	From what date to what date.	Days more than 8′ 0″ and less than 8′ 3″ on floor.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	No.	From what date to what date.	Days more than 8′ 3″ and less than 8′ 6″ on floor.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	No.	From what date to what date.	Days more than 8′ 6″ and less than 8′ 9″ on floor.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.	No.	From what date to what date.	Days more than 8′ 9″ and less than 9′ 0″ on floor.	Velocity and discharge in Main Canal with this depth in cubic feet per second.	Available discharge in cubic yards per hour per acre.
	16		17	18	19	20		21	22	23	24		25	26	27	28	29		30	31	32	33
	—			Velocity 1·77, D 3,252·87 cubic feet per second.	438,540 C. yds. or 1·855 C. yds. per hour per acre.	Velocity 1·83, D 3,362·19 cubic feet per second.			Velocity 1·86, D 3,423 cubic feet per second.	456,925 C. yds. or 1·986 C. yds. per hour per acre.	Velocity 1·87, D 3,601·44 cubic feet per second.			480,070 C. yds. or 2·08 C. yds. per hour per acre.	Velocity 1·85, D 3,362·19 cubic feet per second.	514,829 C. yds. or 2·23 C. yds. per hour per acre.					
For the year 1872.																						
July	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
August	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
September	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
October	...	2	24, 25	...	...	...	6	20, 21, 22, 27, 30, 31.	...	...	...	4	23, 26, 28, 29	...	...	...	...	...	1	19	...	...
November	...	...	...	...	...	...	4	1, 2, 3, 4	...	...	...	...	...	...	...	...	...	...	1	5	...	...
December	...	...	...	...	...	...	...	...	...	...	...	1	22	...	...	...	...	...	...	...	...	...

Bottom width 230 feet. Fall 0·27 feet per mile. Acreage 230,000.

28/39

DETAILED ESTIMATE No. 1 A. OF 1873-74.

KISTNA DISTRICT—WESTERN DELTA.

WORK—*Widening Main Canal from the Head-Sluice to Duggeralla Lock. Length* 13 *Miles. Bottom width from head to Ilenendrapaud* 230 *feet, from thence to Duggeralla* 141 *feet. Side slopes* 2 *to* 1. *Fall* 0·27 *per mile. Water depth* 8·0. *Velocity* 1·51. *Discharge* 2,981 *cubic feet per second. Acreage* 200,000 *and* 130,000.

Number of Stations.	Length.	Depth of cutting.	Height of embanking	Area of cutting.	Area of embanking.	Square contents.	Cubical contents.	—
1	2	3	4	5	6	7	8	9
				Bottom width of Channel 230 *feet.*				
1	100	5·97	...	230 × 5·97	...	1,373·10	...	Widening bed.
				50 × 12·66	...	633·00	...	Sloping east side.
				50 × 4·88	...	244·00	...	Do. west ,,
2	...	5·13	...	230 × 5·13	...	1,179·90	...	Widening bed.
				70 × 8·32	...	582·40	...	Sloping east side.
				50 × 11·9	...	595·00	...	Do. west ,,
3	...	5·64	...	230 × 5·64	...	1,297·20	...	Widening bed.
				100 × 12·57	...	1,257·00	...	Sloping east side.
				60 × 10·45	...	627·0	...	Do. west ,,
4	...	13·08	...	230 × 13·08	...	3,008·40	...	Widening bed.
				100 × 21·97	...	2,179·0	...	Sloping east side.
				10 × 4·54	...	45·40	...	Do. west ,,
5	...	10·75	...	230 × 10·75	...	2,472·55	...	Widening bed.
				100 × 17·74	...	1,774·00	...	Sloping east side.
				20 × 9·52	...	190·40	...	Do. west ,,
6	...	17·6	...	230 × 17·6	...	4,048·00	...	Widening bed.
				70 × 20·45	...	1,431·50	...	Sloping east side.
				5 × 1·34	...	7·15	...	Do. west ,,
7	...	10·8	...	230 × 10·8	...	2,484·00	...	Widening bed.
				110 × 18·53	...	2,038·30	...	Sloping east side.
				10 × 1·79	...	17·90	...	Do. west ,,
8	...	11·26	...	230 × 11·26	...	2,589·80	...	Widening bed.
				70 × 19·71	...	1,301·70	...	Sloping east side.
				50 × 4·62	...	231·00	...	Do. west ,,
9	...	11·03	...	230 × 11·03	...	2,536·90	...	Widening bed.
				90 × 15·6	...	1,404·00	...	Sloping east side.
				40 × 14·94	...	597·60	...	Do. west ,,
10	...	10·36	...	230 × 10·36	...	2,382·80	...	Widening bed.
				90 × 11·4	...	1,026·00	...	Sloping east side.
				50 × 8·11	...	405·5	...	Do. west ,,
11	...	11·72	...	230 × 11·72	...	2,695·60	...	Widening bed.
				80 × 17·64	...	1,411·20	...	Sloping east side.
				40 × 9·96	...	398·40	...	Do. west ,,
12	...	12·43	...	230 × 12·43	...	2,960·74	...	Widening bed.
				80 × 17·16	...	1,372·80	...	Sloping east side.
				40 × 10·38	...	415·20	...	Do. west ,,
13	...	13·17	...	230 × 13·17	...	3,029·10	...	Widening bed.
				70 × 14·98	...	1,048·60	...	Sloping east side.
				50 × 7·99	...	399·75	...	Do. west ,,
14	...	12·1	...	230 × 12·1	...	2,783·00	...	Widening bed.
				80 × 14·55	...	1,164·00	...	Sloping east side.
				40 × 6·94	...	277·60	...	Do. west ,,
15	...	12·65	...	230 × 12·65	...	2,889·50	...	Widening bed.
				80 × 14·32	...	1,145·30	...	Sloping east side.
				40 × 9·09	...	363·60	...	Do. west ,,

WORK—*Widening Main Canal from the Head-Sluice to Duggeralla Lock, etc.*—(Continued.)

Number of Stations.	Length.	Depth of cutting.	Height of embanking.	Area of cutting.	Area of embanking.	Square contents.	Cubical contents.	—
1	2	3	4	5	6	7	8	9
				Bottom width of Channel 230 feet. —(Continued.)				
16	100	11·68	...	230 × 11·68	...	2,686·40	...	Widening bed.
				70 × 14·49	...	1,014·30	...	Sloping east side.
				50 × 12·29	...	614·75	...	Do. west ,,
17	...	12·51	...	230 × 12·51	...	2,877·30	...	Widening bed.
				60 × 14·8	...	888·00	...	Sloping east side.
				50 × 9·52	...	476·00	...	Do. west ,,
18	...	11·97	...	230 × 11·97	...	2,754·48	...	Widening bed.
				60 × 16·04	...	962·40	...	Sloping east side.
				40 × 6·95	...	278·00	...	Do. west ,,
19	...	12·95	...	230 × 12·95	...	2,978·50	...	Widening bed.
				70 × 18·59	...	1,301·30	...	Sloping east side.
				40 × 7·78	...	311·28	...	Do. west ,,
20	...	11·87	...	230 × 11·87	...	2,730·10	...	Widening bed.
				70 × 11·79	...	825·30	...	Sloping east side.
21	...	12·03	...	40 × 73·5	...	294·00	...	Do. west ,,
				230 × 12·03	...	2,766·90	...	Widening bed.
				70 × 12·92	...	904·40	...	Sloping east side.
22	...	11·57	...	40 × 7·46	...	298·40	...	Do. west ,,
				230 × 11·57	...	2,661·10	...	Widening bed.
				60 × 14·04	...	842·82	...	Sloping east side.
23	...	10·6	...	40 × 9·85	...	394·20	...	Do. west ,,
				230 × 10·6	...	2,438·00	...	Widening bed.
				60 × 12·44	...	746·4	...	Sloping east side.
24	...	11·8	...	40 × 10·02	...	400·8	...	Do. west ,,
				230 × 11·8	...	2,714·00	...	Widening bed.
				30 × 9·2	...	276·00	...	Sloping east side.
25	...	10·47	...	40 × 10·22	...	408·88	...	Do. west ,,
				230 × 10·47	...	2,408·10	...	Widening bed.
				50 × 9·56	...	578·0	...	Sloping east side.
26	...	10·71	...	40 × 9·68	...	387·48	...	Do. west ,,
				230 × 10·71	...	2,463·30	...	Widening bed.
				50 × 93·86	...	469·30	...	Sloping east side.
				40 × 10·14	...	405·60	...	Do. west ,,
						104,870·98		
27	40	10·37	...	230 × 10·37	...	2,380·48	...	Widening bed.
				60 × 9·22	...	553·50	...	Sloping east side.
				40 × 12·24	...	489·60	...	Do. west ,,
						3,423·58		
				$\frac{104,870·98 \times 100}{27}$	=	388,411		
				$\frac{3,423·58 \times 40}{27}$	=	5,072		
						393,483		
						50,287		Deduct for work already sanctioned.
						343,196		Cubic yards.

WORK—*Widening Main Canal from the Head-Sluice to Duggeralla Lock, etc.*—(Continued.)

Number of Stations.	Length.	Depth of cutting.	Height of embanking.	Area of cutting.	Area of embanking.	Square contents.	Cubical contents.	—
1	2	3	4	5	6	7	8	9
				Bottom width of Channel 230 feet. —(Continued.)				
2	2,640	...	...	56 × 12·23	...	684·88	...	Sloping west side.
				46 × 10·15	...	466·90	...	Do. east ,,
				87 × 12·11	...	1,053·57	...	Widening west ,,
				47 × 11·12	...	522·46	...	Do. east ,,
3	...	...	...	51 × 10·32	...	526·32	...	Sloping west ,,
				41 × 10·51	...	430·91	...	Do. east ,,
				80 × 14·09	...	1,127·29	...	Widening west ,,
				54 × 12·95	...	699·30	...	Do. east ,,
4	...	...	...	58 × 11·73	...	680·36	...	Sloping west ,,
				57 × 8·33	...	474·81	...	Do. east ,,
				74 × 15·89	...	1,175·96	...	Widening west ,,
				60 × 10·58	...	834·80	...	Do. east ,,
5	...	...	...	45 × 9·88	...	444·60	...	Sloping west ,,
				40 × 8·83	...	354·00	...	Do. east ,,
				94 × 16·34	...	1,535·96	...	Widening west ,,
				40 × 10·29	...	411·60	...	Do. east ,,
6	...	...	...	46 × 11·84	...	544·64	...	Sloping west ,,
				34 × 9·28	...	315·52	...	Do. east ,,
				86 × 14·46	...	1,242·56	...	Widening west ,,
				48 × 10·75	...	516·00	...	Do. east ,,
7	...	...	...	32 × 8·00	...	256·00	...	Sloping west ,,
				36 × 9·87	...	355·33	...	Do. east ,,
				72 × 11·96	...	861·18	...	Widening west ,,
				61 × 11·70	...	713·70	...	Do. east ,,
8	...	...	...	35 × 6·88	...	240·80	...	Sloping west ,,
				27 × 8·00	...	216·00	...	Do. east ,,
				101 × 11·93	...	1,204·93	...	Widening west ,,
				33 × 8·73	...	288·09	...	Do. east ,,
9	...	...	...	40 × 6·51	...	260·40	...	Sloping west ,,
				28 × 7·70	...	215·60	...	Do. east ,,
				61 × 11·14	...	712·96	...	Widening west ,,
				69 × 11·67	...	805·23	...	Do. east ,,
10	...	...	...	32 × 3·62	...	115·84	...	Sloping west ,,
				24 × 5·98	...	143·52	...	Do. east ,,
				86 × 8·22	...	706·92	...	Widening west ,,
				48 × 11·61	...	557·28	...	Do. east ,,
				NIZAMPATAM CANAL WIDENING—(*Continued.*)				
				Brought forward ...		21,696·22		
11	...	...	...	24 × 4·16	...	99·84	...	Sloping west ,,
				21 × 5·16	...	108·36	...	Do. east ,,
				77 × 8·24	...	634·48	...	Widening west ,,
				59 × 7·67	...	452·53	...	Do. east ,,
12	...	...	...	27 × 4·58	...	123·65	...	Sloping west ,,
				22 × 6·12	...	134·64	...	Do. east ,,
				50 × 8·05	...	402·50	...	Widening west ,,
				76 × 11·18	...	848·64	...	Do. east ,,
13	...	...	...	32 × 5·83	...	186·56	...	Sloping west ,,
				18 × 5·18	...	93·24	...	Do. east ,,
				34 × 13·29	...	451·86	...	Widening west ,,
				83 × 8·94	...	742·02	...	Do. east ,,

WORK—*Widening Main Canal from the Head-Sluice to Duggeralla Lock, etc.*—(Continued.)

Number of Stations.	Length.	Depth of cutting.	Height of embanking.	Area of cutting.	Area of embanking.	Square contents.	Cubical contents.	—
1	2	3	4	5	6	7	8	9
				Bottom width of Channel 230 *feet.* —(Continued.)				
14	2,640	...	...	13 × 6·00	...	78·00	...	Sloping west side.
				13·62 × 2·47	...	47·26	...	Do. east ,,
				123 × 9·69	...	1,191·87	...	Widening west ,,
				Nil.	...	Nil.	...	Do. east ,,
15	...	...	...	20 × 5·53	...	110·40	...	Sloping west ,,
				18 × 4·93	...	88·74	...	Do. east ,,
				44 × 7·13	...	313·72	...	Widening west ,,
				90 × 8·83	...	794·70	...	Do. east ,,
16	...	...	...	16 × 4·78	...	76·56	...	Sloping west ,,
				14 × 4·36	...	61·04	...	Do. east ,,
				112 × 9·58	...	1,073·52	...	Widening west ,,
				17 × 5·38	...	79·46	...	Do. east ,,
							29,889·81	
17	1,320	...	...	30 × 5·18	...	155·40	...	Sloping west ,,
				25 × 8·73	...	200·73	...	Do. east ,,
				25 × 5·55	...	138 75	...	Widening west ,,
				110 × 10·45	...	1,160·16	...	Do. east ,,
				Bottom width 141·				
	1,320	...	...	30 × 5·18	...	155·40	...	Sloping west ,,
				17 × 4·67	...	79·39	...	Do. east ,,
				25 × 5·55	...	138·75	...	Widening west ,,
				21 × 4·79	...	100·59	...	Do. east ,,
							2,129·17	
18	2,640	...	...	21 × 4·42	...	92·82	...	Sloping west ,,
				17 × 1·37	...	23·29	...	Do. east ,,
				36 × 7·19	...	258·12	...	Widening west ,,
				2 × 0·50	...	1·00	...	Do. east ,,
19	...	...	...	30 × 5·28	...	164·40	...	Sloping west ,,
				16 × 4·22	...	67·52	...	Do. east ,,
				15 × 5·44	...	81·60	...	Widening west ,,
				30 × 5·78	...	173·40	...	Do. east ,,
20	...	...	...	19 × 2·87	...	54·53	...	Sloping west ,,
				16 × 4·12	...	65·92	...	Do. east ,,
				8 × 2·07	...	16·56	...	Widening west ,,
				39 × 7·08	...	276·12	...	Do. east ,,
21	..	...	...	16 × 3·88	...	62·08	...	Sloping west ,,
				14 × 3·92	...	54·84	...	Do. east ,,
				15 × 4·18	...	62·70	...	Widening west ,,
				30 × 7·0	...	210·00	...	Do. east ,,
22	...	...	...	21 × 3·48	...	73·08	...	Sloping west ,,
				18 × 5·3	...	95·40	...	Do. east ,,
				16 × 3·96	...	63·36	...	Widening west ,,
				29 × 6·87	...	199·23	...	Do. east ,,
23	...	...	...	23 × 3·27	...	75·21	...	Sloping west ,,
				22 × 3·34	...	73·48	...	Do. east ,,
				14 × 3·53	...	49·42	...	Widening west ,,
24	...	...	...	31 × 6·21	...	192·52	...	Do. east ,,
				20 × 5·42	...	108·40	...	Sloping west ,,
				17 × 1·77	...	30·11	...	Do. east ,,
				43 × 7·55	...	324·65	...	Widening west ,,
				3 × 0·7	...	2·25	...	Do. east ,,

WORK—*Widening Main Canal from the Head-Sluice to Duggeralla Lock, etc.*—(Concluded.)

Number of Stations.	Length.	Depth of cutting.	Height of embanking.	Area of cutting.	Area of embanking.	Square contents.	Cubical contents.	—
1	2	3	4	5	6	7	8	9
				Bottom width of Channel 230 *feet.* —(Concluded.)				
25	2,640	...	...	13 × 6·81	...	88·53	...	Sloping west side.
				Nil.	...	Nil.	...	Do. east ,,
				46·914	...	420·44	...	Widening west ,,
				Nil	...	Nil.	...	Do. east ,,
26	...	...	...	17 × 3·54	...	60·18	...	Sloping west ,,
				20 × 3·5	...	71·00	...	Do. east ,,
				22 × 3·76	...	82·72	...	Widening west ,,
				25 × 4·95	...	123·73	...	Do. east ,,
						3,798·61		
				$\frac{33,688·42 \times 2,640}{27} = 3,293,978$				
				$\frac{2,129·17 \times 1,320}{27} = 104,093$				

	Rs.	A.	P.
Latter 12½ miles deducting work already sanctioned, 3,398,071 cubic yards, at As. 2 per cubic yard	4,24,758	14	0
Of the 1st half mile 343,196 cubic yards, at As. 4 per cubic yard	85,799	0	0
Sundries and Contingencies, at Rupees 5 per cent.... ...	25,527	2	0
Total Earthwork Estimate for the first thirteen miles of Nizampatam canal	5,36,085	0	0
64·49 Acres of compensation, at Rupees 30 per acre ...	1,935	0	0
Grand Total...	5,38,020	0	0
Improvements to Head-Sluice at Setanagaram and providing screw gearing and new shutters	9,840	0	0
Do. to east side channel branch duct	3,515	0	0
Do. to west do. do. do.	1,885	0	0
Raising and sectioning banks of the main Nizampatam canal below Duggeralla to hold up water for still water navigation as per estimate attached	10,645	0	0
Prolongation of east side channel branch duct from Nallavada to Komaravole channel	6,040	0	0
Do. of west do. do from	2,055	0	0
Regulating dams and sluices to the side channels	3,000	0	0
Total Main Canal and its subsidiary works...	5,75,000	0	0

(Signed) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

DETAILED ESTIMATE No. 1 A. OF 1873-74.

KISTNA DISTRICT—WESTERN DELTA.

Main Canal.

WORK.—Improvements to the Head-Sluice.

Particulars.	Number.	Measurement. Length.	Breadth.	Depth.	Square Contents.	Cubical Contents.
Rough Stone-in-chunam.						
Over cut-stone in vent	15	6·0	2·5	1·5	...	337·50
Do. in archway	15	Area. (29·27)		1·25	...	548·81
Piers and corresponding half of abutments ...	15	3·25	3·0	6·5	...	950·62
Cutwaters of do. do.	15	3·0	1·25	6·5	...	365·62
Total Cubic feet of Rough Stone-in-chunam...	...	...	...	...	...	2,202 55 or 81·57
Cut-stone Work.					C. yds.	
Cut-stone in vent	15	8·0	2·5	1·0	...	300·00
Do. under joists	16	1·5	1·25	0·17	...	5·1
Do. above do.	16	2·0	1·0	0·208	...	6·65
Total Cubic feet of Cut-stone work...	...	...	...	...	...	311·75 or 11·54
Cut-stone Facing.					C. yds.	
Wall above cut-stone in vent	15	6·0	...	3·0		270·0
Do. in arch wall	15	Area. (29·27)		...		439·05
Piers and corresponding half of abutments ...	15	6·5				709·05
Cutwaters of do. do. ...	15	6·0	...	6·5		633·75
Total Cubic feet of Cut-stone facing...	...	...	...	7·5		675·00
				...		2,017·80 or 224·20
Pointing as per the above facing	...	...	...	...	S. yds. Sqrs.	20·17
Wood Work.						
Beams	2	135·0	0·75	0·75	...	151·87
Shutters	15	6·92	0·25	8·5	...	220·57
Joists over cutwaters	16	6·0	0·5	0·75	...	36·00
Planks over joists	1	135·0	3·0	0·25	...	101·25
Upright posts	16	0·33	0·25	3·0	...	3·96
Do. middle	15	0·12	0·12	2·75	...	0·59
Bottom rail	1	138·0	0·5	0·42	...	28·98
Top do.	1	138·0	0·12	0·25	...	14·49
Intermediate do.	1	138·0	0·33	0·33	...	15·02
Struts	16	2·5	0·25	0·25	...	3·50
Total Cubic feet of Wood work...	...	...	...	...	...	576·23

Proceedings of the Madras Government, Public Works Department,
19th December 1874.

WORK.—Improvements to the Head-Sluice.—(*Concluded.*)

Particulars.	Number.	Measurement. Length.	Breadth.	Depth.	Square Contents.	Cubical Contents.
Iron Work.		Inches.				
Bolts for fixing the shutters, 1 inch diameter.	30	8·5	Area. 0·7,854		...	200·27
Heads for do. do. ...	30	3·0	3·0	1·5	...	40·50
Nuts do. octagon, 3 inches diameter	30	Area. (7·068)		1·5	...	318·06
Plates under nuts	30	3·0	3·0	0·5	...	135·00
Rollers, 3 inches exterior diameter	120	4·0	4·71	1·0	...	2,260·80
Axletrees, 1 inch diameter in centre ...	120	Area. (·7854)		4·00	...	376·99
Do. do. ends	120	3·5	1·0	1·0	...	420·0
Plates far axletrees	240	9·0	2·0	0·5	...	2,160·00
Thick parts attached to end plate	120	3·0	3·0	1·5	...	1,620·00
Plate at end of shutters	30	114·0	6·0	0·5	...	10,260·00
Do. for shutter planks where the wheels are used.	120	9·0	2·5	0·5	...	1,350·00
Do. sides of the shutters	30	102·0	6·0	0·5	...	9,180·00
Bolts for do., 1 inch diameter	780	4·0	Area. 0.7,854.		...	2,450·44
Round heads of do., 2 inches diameter 1 inch height.	780		Area. 2·09	...	...	1,630·20
Total Cubic inches of Iron work...	...	...	...	...	...	32,402·26 or lbs. 9,076·26
Angle iron	1	600	×7·5	...	...	lbs. 4,500·00
Total lbs. of Iron work...	...	...	...	...	...	13,576·26

(Signed) D. CAMPBELL, Lieutenant, R.E.,
7th Range Officer, Kistna.

ABSTRACT ESTIMATE No. 1 A of 1873-74.

KISTNA DISTRICT—WESTERN DELTA.

Main Canal.

WORK.—Improvements to the Head-Sluice.

Quantity or No.	Description of Work.	Rate.	Per.	Amount.	Total.
		RS. A. P.		RS. A. P.	RS. A. P.
81·57	Cubic yards of rough stone-in-chunam.	1 2	C. yd.	250 10 6	
11·54	Do. of cut-stone work ...	11 0 0	Do.	126 15 0	
224·20	Sq yards of cut-stone facing ...	1 3 10	Sq. yd.	277 14 7	
20·17	Squares of pointing	2 4 2	Square.	46 3 6	
	Removing piers and cutwaters.	.....	.....	50 0 0	
				751 11 7	
	Sundries and Contingencies ...	5 0 0	Cent.	38 4 5	
	Total...	.....	.....	.....	790 0 0

WORK.—Improvements to the Head-Sluice.—(*Concluded.*)

Quantity or No.	Description of Work.	Rate.	Per.	Amount.	Total.
		RS. A. P.		RS. A. P.	RS. A. P.
576·23	C. feet of teakwood work ...	2 8 0	C. foot.	1,440 9 2	
13,576·26	lbs. of wrought-iron ...	0 2 6	lb.	2,121 4 7	
15	Shutters gearing estimated as per plan furnished by the Chief Engineer for Irrigation —*Vide* his Memo., No. 903, dated 18th December 1873.	207 3 0	Each.	3,107 13 0	
	Freight for do. do. ...	.....	.....	525 0 0	
	Fitting of do. do. ...	.....	.....	250 0 0	
	Land carriage of do: ...	.....	.....	49 0 0	
				7,493 10 9	
	Sundries and Contingencies...	10 0 0	Cent.	741 5 3	
				8,235 0 0	
	Future allowance increased...	10 0 0	Cent.	815 0 0	
					9,050 0 0
	Total Estimate...	.....	.....	.....	9,840 0 0

(Signed) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

MASULIPATAM.
21*st March* 1874.

(Signed) D. CAMPBELL, Lieutenant, R.E.,
7th Range Officer, Kistna.

DETAILED ESTIMATE No. 10 A OF 1873-74.

KISTNA DISTRICT—WESTERN DELTA.

Nizampatam Canal, East Side Channel.

WORK.—Providing new Shutters and Screw gearings to the six Vents (of 4 × 4-5) of the existing Head-Sluice.

Particulars.	Number.	Measurement. Length.	Breadth.	Depth.	Square Contents.	Cubical Contents.
Rough Stone-in-chunam.						
Piers	5	2·0	2·0	2·5	...	50·00
Cutwaters of do.	5	2·0	1·33	2·5	...	33·25
Spandrils	6	2·0	2·0	2·0	...	48·00
Pial over arches and piers	1	40·0	2·0	1·5	...	120·00
Do. remainder over piers	5	2·0	1·33	1·5	...	19·95
Do. do. over abutments	2	3·0	1·33	1·5	...	11·97
Parapet wall	1	40·0	1·25	1·0	...	50·00
Blocking up the arch in front...	6	Area. (2·28)		1·0	...	13·68
Total Cubic feet of Masonry work...	...	...	...	...	...	346·85
					C. yards.	or 12·84

WORK.—Providing new Shutters and Screw gearings to the six Vents, etc.—(*Continued.*)

Particulars.	Number.	Measurement. Length.	Breadth.	Depth.	Square Contents.	Cubical Contents.
Arch Work.						
Arches, semicircular	6	8·64	2·0	1·5	...	155·52
					C. yards.	or 5·76
Cut-stone Work.						
Cut granite stones in archway...	6	6·0	1·0	1·0	...	36·00
Total Cubic feet of Granite stones...	...	...	...	...	...	36·00
						or
Total Cubic yards of Cut-stone work...	...	...	...	...	...	1·33
Cut-stone Facing.						
Piers and abutments	12	2·0	...	2·5	60·00	
Cutwaters	5	5·0	...	2·5	62·50	
Pials sides and top	1	43·0	5·0	...	215·00	
Parapet wall	1	41·0	3·0	...	123·00	
Blocked up part of the arch	6	Area. (4·56)			...	27·36
Total Square feet of Facing...	...	...	...	...	487·86	
					S. yds.	or 54·20
Pointing as for the above facing	...	...	...	...	487·86	
					Sqrs.	or 4·87
Plastering Work.						
Soffit of arches	6	6·28	1·0	...	37·68	
					Sqrs.	or 0·37
Wood Work.						
Beams	2	38 0	0·42	0·67	...	21·38
Shutters	6	4·33	0·21	5·0	...	27·27
Joists over piers	5	6·25	0·33	0·5	...	5·15
Upright posts	7	3·0	0·25	0·33	...	1·73
Struts, upper	5	3·0	0·25	0·25	...	0·93
Do. lower	5	2·5	0·25	0·25	...	0·78
Platform planks...	1	40·0	4·0	0·17	...	27·20
Rails	2	40·0	0·12	0·25	...	2·40
Total Cubic feet of Wood work...	...	...	...	...	...	86·84
Wrought Iron Work.						
Bars, 1½ diameter	6	Area. 1·78		60·0	...	640·00
Female screws, 5 inches diameter	6	Area. 19·63		5·0	...	588·90
Square part of do.	6	3·0	3·0	1·0	...	54·00
Handles, centre, 5 inches do.	6	Area. 19·63		1·0	...	117·78
Do. remainder	6	3·5	1·5	1·0	...	31·50
Bosses at end of shafts	6	2·5	2·5	2·0	...	75·00
Socket pieces, thick part	6	8·0	2·5	3·0	...	360·00
Do. remainder	6	13·0	2·5	0·5	...	97·50
Shoe plates for boss to press on when forcing down.	6	25·0	2·5	0·25	...	93·75

WORK.—Providing new shutters and screw gearings to the 6 Vents, etc.—(*Concluded.*)

Particulars.	Number.	Measurement. Length.	Breadth.	Depth.	Square Contents.	Cubical Contents.
Bolts for fixing the socket pieces ¾ inch diameter	12	60·0	Area. 0·4418		...	318·09
Heads and nuts of do.	24	2·0	1·5	0·5	...	36·00
Plates at the bottom of shutters	6	17·0	2·5	0·5	...	127·50
Plates over holding down bolts	7	11·5	3·0	0·25	...	60·37
Holding down bolts ¾ inch diameter	14	30·0	Area. 0·4418		...	185·55
Do. do. heads and nuts ...	28	2·0	2·0	0·25	...	28·00
Do. do. plates	7	12·0	12·0	0·25	...	252·00
Bolts for fixing brass collar ½ inch diameter ...	24	9·75	Area. 0·196		...	45·86
Heads and nuts of do. do. ...	48	1·0	1·0	0·25	...	12·00
Sundry iron for joint nails, etc.	...	...	...	...	...	60·00
Total cubic inches of wrought iron... ...		...	...	...	...	3,183·80
					lbs.	or 891·82
Brass Work.						
Collar plates	6	11·5	11·5	0·5	...	396·75
Deduct for screw box, 3 inch diameter ...	6	Area. 7·06		0·5	...	21·18
Total cubic inches of deduction... ...		...	...	...	...	375·57
					lbs.	or 112·78
Turning male and female screw	6	5·5=33·0 R. feet			...	...
Grooving work	48·0	R. feet			...	...
Angle iron	56	× 7½ = 420 lbs.			...	...

(Signed) D. CAMPBELL, Lieutenant, R.E.,
7th Range Officer, Kistna.

ABSTRACT ESTIMATE No. 10 A of 1873-74.
KISTNA DISTRICT, WESTERN DELTA.
Nizampatam Canal, East Side Channel.

WORK.—Providing new shutters and screw gearings to the 6 vents (4 × 4·5) of the existing head-sluice.

Quantity or No.	Description of Work.	Rate.	Per.	Amount.	Total.
		RS. A. P.		RS. A. P.	RS. A. P.
12·84	Cubic yards of rough stone-in-chunam.	3 10 0	C. yd.	46 8 8	
5·76	Do. of arch work ...	5 8 0	Do.	31 10 10	
1·33	Do. of cutstone work ...	10 0 0	Do.	13 4 9	
54·20	Sq. yards of cutstone facing ...	1 2 0	Sq. yd.	60 15 7	
4·87	Squares of pointing work ...	2 2 0	Square.	10 5 6	
0·37	Do. of plastering work ...	2 10 0	Do.	0 15 6	
48·0	Running feet of grooving work...	0 8 0	R. ft.	24 0 0	
	Sundries, 5 per cent...	.....	...	.....	187 12 10 / 7 3 2
	Total...	.....	...	.....	195 0 0

WORK.—Providing new shutters and screw gearings to the 6 vents (4 × 4·5) of the existing head-sluice.—(*Concluded.*)

Quantity. or No.	Description of Work.	Rate.	Per.	Amount.	Total.
		RS. A. P.		RS. A. P.	RS. A. P.
86·84	Cubic feet of teakwood work ...	2 8 0	C. foot	217 1 7	
1,311·82	lbs. of iron wrought and put up.	0 2 6	lb.	204 15 6	
112·78	lbs. of brass work	20 0 0	lb.	2,255 9 7	
33·0	Running feet of turning male and female screw.	2 0 0	R. foot	66 0 0	
					2,743 10 8
	Sundries, 10 per cent...	.....	.....	.....	274 0 0
	Total...	.....	.....	.....	3,017 10 8
	Allowance for future increased rate, 10 per cent.	.....	.....	.....	302 5 4
	Total...	.....	.....	.....	3,320 0 0
	Grand Total, Estimate...	.....	.....	.....	3,515 0 0

MASULIPATAM,
21*st March* 1874.

(Signed) D. CAMPBELL, Lieutenant, R.E.,
7th Range Officer, Kistna.
(Signed) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

DETAILED ESTIMATE, No. 7-A OF 1873-74.
KISTNA DISTRICT, WESTERN DELTA.
Nizampatam Canal, West Side Channel.

WORK.—Providing new shutters and screw gearings to the 2 vents of (5 × 5) of the head-sluice.

Detail of Work.	Numbers.	Measurements. Length.	Breadth.	Depth or Height.	Square Contents.	Cubical Contents.
MASONRY.						
Rough stone-in-chunam.						
Straightening centre pier	1	1·0	0·25	10·0	.....	2·50
Do. side piers above dividing wall ...	2	1·0	0·25	4·0	.....	2·00
Spandrills	2	1·17	2·0	2·5	.....	11·70
Platform in front above the arch	1	19·0	0·88	1·5	.....	23·65
Do. do do. piers	3	3·0	1·25	1·5	.....	16·87
Parapet walls including coping	2	19·0	1·17	3·0	.....	133·38
Removing masonry and fitting holding down bolts and plates.	3	3·0	1·0	1·0	.....	9·00
Total cubic feet of rough stone-in-chunam ...	...	...	...	...	.....	199·10
Or cubic yards...	...	...	...	...	.....	7·37
Coroon work ... ... Running feet.	...	...	...	...	.....	10·0
Arch work, semicircular	2	10·20	1·25	1·5	.....	38·25
Total cubic feet of arch work...	...	...	...	...	.....	38·25
Cubic yards...	...	...	...	...	.....	or 1·41
Plastering soffit of arches	2	7·8	1·25	...	19·50	.....
Total squares of plastering...	...	...	...	...	19·50	.....
Square yards...	...	...	...	...	or 0·19	.....

WORK.—Providing new shutters and screw gearings to the 2 vents, etc.—(*Contd.*)

Detail of Work.	Numbers.	Measurements. Length.	Breadth.	Depth or Height.	Square Contents.	Cubical Contents.
Cut-stone facing.						
Parapet walls	2	19·0	5·25	...	199·50	.....
Platform wall	1	19·0	1·83	...	34·77	.....
Total square feet of cut-stone facing ...	...	...	...	...	234·27	.....
					or	
Square yards...	...	...	...	...	26·03	.....
Pointing as per the above facing	...	...	...	...	234·27	.....
					or	
Squares...	...	...	...	...	2·34	.....
Wood work.						
Beams	4	8·0	0·5	0·67	.....	10·72
Shutters	2	5·33	0·25	5·75	.....	15·32
Girders	2	8·0	0·33	0·55	.....	2·90
Joists over piers	3	5·5	0·33	0·5	.....	2·72
Hand rails	5	3·25	0·25	0·33	.....	1·34
Struts (upper)	2	19·0	0·12	0·17	.....	0·77
Do. lower	3	3·25	0·25	0·33	.....	0·80
Platform planks	3	2·5	0·25	0·33	.....	0·61
	1	19·0	3·00	0·17	.....	9·69
Total cubic feet of wood work...	...	...	...	...	.....	44·87
Iron work.						
		Inches. Area.				
Bars, 2 inches diameter	2	66·0	(3·1416)		.....	414·69
		Area.				
Female screws, 5½ inches diameter	2	(23·75)		5·25	.....	249·37
Square of do.	2	3·5	3·5	1·0	.....	24·50
Boss at end of shafts	2	4·0	3·0	2·25	.....	54·00
		Area.				
Handle (centre) 5½ inches diameter	2	(23·75)		1·0	.....	47·50
Do. remainder	2	43·0	2·0	0·5	.....	86·00
Socket piece (thick part)	2	6·0	3·0	3·5	.....	126·00
Do. (thin part)	2	34·0	3·0	0·75	.....	153·00
Shoe plate	2	48·5	3·0	0·5	.....	145·50
		Area.				
Bolts, 1 inch diameter for fixing socket piece...	8	71·0	(·7854)		.....	446·10
Nuts and heads for do.	16	2·25	2·25	0·5	.....	40·50
Plate to let in the bottom of shutter	7	42·0	3·0	0·5	.....	441·00
Do. over holding down bolts	4	11·5	3·0	0·5	.....	69·00
		Area.				
Holding down bolts, 1 inch diameter	8	30·0	(·7854)		.....	18·49
Nuts and heads of do.	16	2·25	2·25	0·5	.....	40·50
Holding down plates	4	12·0	12·0	0·25	.....	144·00
		Area.				
Bolts for fixing brass plate, ½ inch diameter ...	8	10·0	(·193)		.....	15·44
Nuts and heads of do. ...	16	1·0	1·0	0·25	.....	4·00
Sundry iron for joints, nails, etc.	...	...	...	...	.....	15·0
Total lbs. of iron ... ... lbs.	...	...	...	...	.....	2534·59 or 709·69

WORK.—Providing new shutters and screw gearings to the 2 vents, etc.—(*Concld.*)

Detail of Work.	Numbers.	Measurements. Length.	Breadth.	Depth or Height.	Square Contents.	Cubical Contents.
Brass work.						
Collar plates	2	11·5	11·5	0·75	.....	198·37
Total cubic inches...	...	...	...	...	.....	198·37
Deduct from brass plate for the round cut in centre	1	Area. (3·14)		0·75	.....	2·35
Total inches of brass...	...	...	...	...	.....	196·02 or 58·86
Total lbs. of brass ... ... lbs.	...	...	...	...	.....	.....
Turning male and female screw, Running feet.	...	6·5		...	.....	.....
Angle iron ... ... Running feet	...	60 × 7½ = lbs. 450			.....	.....

ABSTRACT ESTIMATE No. 7 OF 1873-74.

KISTNA DISTRICT, WESTERN DELTA.

Nizampatam Canal, West Side Channel.

WORK.—Providing new shutters and screw gearings to the 2 vents (of 5 × 5) of the head-sluice.

Quantity.	Description of Work.	Rate.	Per.	Amount.	Total.
				RS. A. P.	
7·37	Cubic yards of rough stone-in-chunam	3 10 0	C. yd.	26 11 5	
		5 8 0	Do.	7 12 0	
1·41	Do. of archwork	2 10 0	Square.	0 7 11	
0·19	Squares of plastering	1 2 0	S. yd.	29 4 6	
26·03	Square yards of cut-stone facing	2 2 0	Square.	4 15 6	
2·34	Squares of pointing				
				69 3 4	
	Sundries and contingencies ...	5 0 0	Cent.	5 12 8	
				75 0 0	
	Removing old masonry ...	.. ...	.....	10 0 0	85
44·87	Cubic feet of teak-wood wrought and put up	2 8 0	C. foot.	112 2 9	
		0 2 6	lb.	110 14 10	
709·96	lbs. of iron wrought and put up.	20 0 0	lb.	1,177 3 2	
58·86	lbs. of brass cost and fitting ...	2 0 0	R. foot.	13 0 0	
6·5	Turning male and female screws	0 2 6	lb.	70 5 0	
450	lbs., angle iron				
				1,483 9 9	
	Sundries and superintendence ...	10 0 0	Cent.	146 6 3	
				1,630 0 0	
	Allowance for future increased rates	10 0 0	Do.	165 0 0	1,795
10	Running feet of coroon work ...	0 8 0	R. foot.	.....	5
	Grand Total...	.....	.....	.....	1,885

MASULIPATAM,
1st March 1874.

(Signed) D. CAMPBELL, Lieutenant, R.E.,
7th Range Officer, Kistna.

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DETAILED ESTIMATE No. 1 A. OF 1873-74.

KISTNA DISTRICT, WESTERN DELTA.

WORK.—*Raising and sectioning banks of Nizampatam Canal below Duggerala, so as to allow of the water being held up at Kuchipudi and Jutoor Locks for still water navigation. Top width of the banks to be 6 feet; side slopes 2 to 1; crest of bank above water, full supply level to be 3 feet.*

Number of Stations.	Distance in feet.	Depth of cutting.	Height of bank above ground.	Area of cutting (w + 2 d) d.	Area of embankment (2 w + 4 h) h.	Square feet of equal distances.	Sq. feet of unequal distances.
1	2	3	4	5	6	7	8
97	100	...	...	....	South Side Bank... ...	101·70	
127	660						
129	...	...	...	.....	Do.	13·39	
131	...	...	...	.....	Do.	9·00	
132	...	...	...	.....	Do.	21·99	
133	...	...	...	.....	North do.	8·17	
				.....	Do.	30·96	
134	...	...	...		South do.	14·06	
				.....	North do.	24·84	
135	...	...	...		South do.	25·74	
				.....	North do.	73·98	
136	...	...	...		South do.	78·75	
				.....	North do.	21·95	
137	...	...	...		South do.	34·64	
				.....	North do.	3·54	
138	...	...	...		South do.	6·96	
				.....	North do.	28·08	
139	...	...	...		South do.	29·70	
				.....	North do.	28·12	
140	...	...	...		South do.	38·69	
				.....	North do.	22·90	
141	...	...	...		South do.	31·12	
				.....	North do.	3·15	
142	...	...	...		South do.	6·21	
				.....	North do.	6·61	
143	...	...	...		South do.	28·22	
				.....	North do.	2·98	
144	...	...	...		South do.	17·29	
				.....	North do.	2·43	
145	...	...	...		South do.	9·40	
146	...	...	...	....	North and South do. ...	2·27	
147	...	...	...	.....	North do.	11·51	
				.....	Do.	11·18	
149	...	...	...		South do.	23·57	
				.....	North do.	32·55	
150	...	...	...		South do.	43·48	
				.....	North do.	36·59	
151	...	...	...		South do.	37·80	
				.....	North do.	26·83	
152	...	...	...		South do.	18·93	
				.....	North do.	22·35	
153	...	...	...		South do.	15·29	
				.....	North do.	124·81	
154	...	...	...		South do.	97·27	
				.....	North do.	32·15	
155	...	...	...		South do.	56·52	
				.....	North do.	56·40	
					South do.	73·80	

WORK.—*Raising and sectioning banks of Nizampatam Canal, etc.*—(Contd.)

Number of Stations.	Distance in feet.	Depth of cutting.	Height of bank above ground.	Area of cutting (w + 2 d) d.	Area of Embankment (2 w + 4 h) h.	Square feet of equal distances.	Sq. feet of unequal distances.
1	2	3	4	5	6	7	8
156	660	...	...	.....	North Side Bank... ...	88·62	
					South do.	49·84	
157	...	...	...	.....	North do.	28·24	
					South do.	21·47	
158	...	...	...	.....	North do.	78·60	
					South do.	117·21	
159	..	...	...	.....	North do.	33·19	
					South do.	125·74	
160	...	...	...	.....	North do.	24·17	
					South do.	97·04	
161	...	...	...	.....	North do.	58·70	
					South do.	42·25	
162	...	...	...	.....	North do.	88·83	
					South do.	126·50	
163	...	...	...	.....	North do.	63·64	
					South do.	86·14	
164	...	...	...	.....	North do.	54·02	
					South do.	70·46	
165	...	...	...	.....	North do.	32·06	
					South do.	88·25	
166	...	...	...	.....	North do.	9·06	
					South do.	27·00	
167	...	...	...	.....	North do.	30·43	
					South do.	42 54	
168	...	...	...	.....	North do.	44·78	
					South do.	34·48	
169	...	...	...	.....	North do.	32·82	
					South do.	60·42	
170	...	...	...	.....	North do.	21·57	
					South do.	79·66	
171	...	...	...	.....	North do.	47·26	
					South do.	46·48	
172	...	...	...	.....	North do.	103·71	
					South do.	119·09	
173	...	...	...	.....	North do.	57·40	
					South do.	38·94	
174	...	...	...	.....	North do.	84·79	
					South do.	92·90	
175	...	...	...	.....	North do.	46·26	
					South do.	46·52	
						3,787·25	
177	200	...	...	.....	North do.	40·78	
					South do.	84·71	
179	...	...	...	.....	North do.	51·78	
					South do.	84·21	
181	...	...	...	.....	North do.	51·24	
					South do.	75·44	
183	...	...	...	.....	North do.	82·84	
					South do.	79·75	
185	...	...	...	.....	North do.	42·41	
					South do.	101·55	
187	...	...	...	.....	North do.	52·62	
					South do.	90·97	

WORK.—*Raising and sectioning banks of Nizampatam Canal, etc.*—(Concld.)

Number of Stations.	Distance in feet.	Depth of cutting	Height of bank above ground.	Area of cutting (w + 2 d) d.	Area of embankment (2 w + 4 h) h.	Square feet of equal distances.	Sq. feet of unequal distances.
1	2	3	4	5	6	7	8
189	200	...	...	.....	North Side Bank... ...	55·26	
191	...	...	...	.....	South do.	83·78	
193	...	...	...	.....	North do.	99·90	
195	...	...	...	.....	South do.	78·93	
197	...	...	...	.....	North do.	72·61	
199	...	...	...	.....	South do.	87·23	
201	...	...	...	.....	North do.	69·79	
203	...	...	...	.....	South do.	75·86	
205	...	...	...	.....	North do.	40·36	
207	...	...	...	.....	South do.	74·18	
209	...	...	...	.....	North do.	63·74	
211	...	...	...	.....	South do.	75·79	
213	...	...	...	.....	North do.	76·98	
215	...	...	...	.....	South do.	79·53	
217	...	...	...	.....	North do.	43·99	
219	...	...	...	.....	South do.	80·65	
221	...	...	...	.....	North do.	84·37	
223	...	...	...	.....	South do.	57·12	
					North do.	84·07	
					South do.	108·77	
					North do.	100·34	
					South do.	89·16	
					North do.	61·34	
					South do.	43·45	
					North do.	60·30	
					South do.	46·15	
					North do.	75·53	
					South do.	85·94	
					North do.	133·72	
					South do.	92·04	
					North do.	144·74	
					South do.	92·93	
					North do.	88·73	
					South do.	87·73	
					North do.	110·21	
					South do.	107·77	
						3751·33	
224	100	...	...	.....	North do.	103·18	
					South do.	144·20	
						247·38	

$\frac{3,787{\cdot}25 \times 660}{27} = 92,577$

$\frac{3,751{\cdot}33 \times 200}{27} = 27,787$

$\frac{349{\cdot}08 \times 100}{27} = 1,293$

121,657 cubic yards at 0-1-4 per cubic yard.

	Rupees...	10,138	1 4
Superintendence and sundries	,, ...	506	14 8
	Total...	10,645	0 0

MASULIPATAM,
21*st March* 1874.

(Signed) D. CAMPBELL, Lieutenant, R.E.,
7th Range Officer, Kistna.

Proceedings of the Madras Government, Public Works Department,
19*th* December 1874.

KISTNA DISTRICT, WESTERN DELTA.

NIZAMPATAM CANAL, EAST SIDE CHANNEL.

Prolongation from Nallavada to Komaravole Channel, length 4⅝ miles, fall 0·94 per mile. Bottom width 14′ at head reduced to 4′ at the junction; side slopes 2 to 1. Top width of banks 3′; side slopes 1½ to 1. Acreage 7,000. Discharge 108·0 cubic feet a second.

Number of Stations.	Distance in feet.	Depth of cutting.	Height of bank above ground.	Area of cutting (w + 2 d) d.	Area of embankment (w 1½ d) b (6 + 3 h) h.	Square feet of equal distances.	Sq. feet of unequal distances.
1	2	3	4	5	6	7	8
1	660	...	5·15	South Side Bank.	(3 + 7·72) 5·15 ...	55·20	
			7·20	North do. ...	(3 + 10·80) 7·20 ...	99·36	
						154·56	
4	1,980	...	7·24	South do. ...	(3 + 10·82) 7·24 ...	100·05	
			8·42	North do. ...	(3 + 12·62) 8·42 ...	131·60	
						231·65	
6	1,320	...	6·11	South do. ...	(3 + 9·16) 6·11 ...	74·29	
			7·62	North do. ...	(3 + 11·43) 7·62 ...	109·95	
8	...	...	2·23	South do. ...	(3 + 3·34) 2·23 ...	14·13	
			5·05	North do. ...	(3 + 7·57) 5·05 ...	53·37	
10	...	...	2·01	South do. ...	(3 + 3·01) 2·01 ...	12·08	
			4·16	North do. ...	(3 + 6·24) 4·16 ...	38·43	
12	...	...	4·63	South do. ...	(3 + 6·94) 4·63 ...	46·02	
			6·33	North do. ...	(3 + 9·49) 6·33 ...	79·06	
14	...	...	5·71	South do. ...	(3 + 8·56) 5·71 ...	66·00	
			6·7	North do. ...	(3 + 10·05) 6·7 ...	87·43	
16	...	..	4·46	South do. ...	(3 + 6·69) 4·46 ...	49·21	
			5·09	North do. ...	(3 + 7·63) 5·09 ...	54·10	
18	1,320	...	5·72	South do. ...	(3 + 8·58) 5·72 ...	66·23	
			6·74	North do. ...	(3 + 10·11) 6·74 ...	88·36	
20	...	...	4·86	South do. ...	(3 + 7·29) 4·86 ...	50·00	
			5·26	North do. ...	(3 + 7·89) 5·26 ...	57·28	
22	...	...	4·32	South do. ...	(3 + 6·48) 4·32 ...	40·95	
			5·41	North do. ...	(3 + 8·10) 5·41 ...	60·05	
24	...	...	3·92	South do. ...	(3 + 5·88) 3·92 ...	34·80	
			6·12	North do. ...	(3 + 8·18) 6·12 ...	68·42	
26	...	...	1·75	South do. ...	(3 + 2·62) 1·75 ...	9·83	
			4·2	North do. ...	(3 + 6·30) 4·2 ...	39·06	
						1193·05	
29	1,980	...	2·72	South do. ...	(3 + 4·08) 2·72 ...	19·25	
			3·68	North do. ...	(3 + 5·02) 3·68 ...	29·51	
						48·76	
30	660	...	2·54	South do. ...	(3 + 8·31) 2·54 ...	17·29	
			5·61	North do. ...	(3 + 8·41) 5·61 ...	64·01	
						81·30	
32	1,320	...	3·63	South do. ...	(3 + 5·44) 3·63 ...	30·63	
			4·88	North do. ...	(3 + 7·32) 4·88 ...	50·41	

Prolongation from Nallavada to Konavaoli Channel, etc.—(Concluded.)

Number of Stations.	Distance in feet.	Depth of cutting.	Height of bank above ground.	Area of cutting (w + 2 d) d.	Area of Embankment (w 1½ b) b (6 + 3 h) h.	Square feet of equal disances.	Sq. feet of unequal distances.
1	2	3	4	5	6	7	8
34	...	...	3·12 4·19	South Side Bank. North do. ...	(3 + 4·68) 3·12 (3 + 6·28) 4·19	... ...	23·96 38·88
							143·88
35	660	...	2·34	North do. ...	(3 + 3·51) 2·34	...	15·03

$\frac{250{\cdot}89 \times 660}{27}$ = 6,133

$\frac{280{\cdot}41 \times 1{,}980}{27}$ = 20,563

$\frac{1336{\cdot}93 \times 1{,}320}{27}$ = 65,361

92,057 cubic yards at Anna 1 per cubic yard, Rs... 5,753 9 0

Sundries and contingencies ... ,, ... 286 7 0

6,040 0 0

Land compensation, none.

Total Estimate, Rs... 6,040 0 0

MASULIPATAM,
21st March 1874.

(Signed) D. CAMPBELL, Lieut., R.E.,
7th Range Officer, Kistna.

Proceedings of the Madras Government, Public Works Department,
19th December 1874.

No. 19.

KISTNA DISTRICT, WESTERN DELTA.

Statement shewing the increase and carriage by water allowed over the current rates as now prevalent at Bezwada for the masonry works now estimated for on Nizampatam Canal.

——	Masonry rough stone or brick-in-chunam.	Archwork.	Plastering work.	Pointing work.	Walls dressed.	Grooving work.	Running feet of cordon work.	Cut-stone work.
	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.
Bezwada rates	2 12 9	.....	.....	2 0 11	1 2 0	.....	.....	10 0 0
Increase, 10 per cent...	0 4 5	.....	.....	0 3 3	0 1 10	.....	.....	1 0 0
Total...	3 1 2	.....	.....	2 4 2	1 3 10	.....	.....	11 0 0
Head-sluice, East Side channel	2 12 9	5 8 0	2 3 9	1 13 0	1 2 0	0 8 0	0 8 0	.....
12 Miles punt hire of rough-stone at 0-0-5 per cubic yard per mile	0 5 0	.....	.....	.....	.....	.....	.....	.....
Do. do. of lime at 0-0-2 per parra per 5 miles	0 0 5	.....	0 0 5	0 0 5	.....	.....	.....	.....
Total...	3 2 2	.....	2 4 2	1 13 5	.....	.....	.....	.....
Sundries, 5 per cent...	0 2 6	.....	0 1 11	0 1 6	.....	.....	.....	.....
Total...	3 4 8	.....	2 6 1	1 14 11	.....	.....	.....	.....
Increase, 10 per cent...	0 5 4	.....	0 3 11	0 3 1	.....	.....	.....	.....
Total...	3 10 0	5 8 0	2 10 0	2 2 0	1 2 0	0 8 0	0 8 0	.....
Head-sluice, West Side channel	2 12 9	5 8 0	2 3 9	1 13 0	1 2 0	0 8 0	.....	.....
12 Miles punt hire of rough-stone at 0-0-5 per cubic yard per mile	0 5 0	.....	.....	.....	.....	.....	.....	.....
Do. do. of lime at 0-0-2 per parra per 5 miles	0 0 5	.....	0 0 5	0 0 5	.....	.....	.....	.....
Total...	3 2 2	.....	2 4 2	1 13 5	.....	.....	.....	.....
Sundries, 5 per cent...	0 2 6	.....	0 1 11	0 1 6	.....	.....	.....	.....
Total...	3 4 8	.....	2 6 1	1 14 11	.....	.....	.....	.....
Increase, 10 per cent...	0 5 4	.....	0 3 11	0 3 1	.....	.....	.....	.....
Total...	3 10 0	5 8 0	2 10 0	2 2 0	1 2 0	0 8 0	.....	.....

MASULIPATAM,
21st March 1874.

(Signed) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

(Signed) D. McNEIL-CAMPBELL, Lieutenant, R.E.,
7th Range Officer, Kistna.

From Major J. O. HASTED, R.E., District Engineer, Kistna, to Lieutenant-Colonel J. MULLINS, R.E., Chief Engineer for Irrigation, dated Masulipatam, 30th May 1874, No. 14.

I HAVE the honor to forward, herewith, letter from Lieutenant D. McNeil-Campbell, R.E, with plans and estimates of proposed improvements to the West Bank channel, Western Delta, revised in accordance with remarks made in your memorandum, No 430-B, dated 18th July 1873, and with instructions given by you personally.

1 Letter, No. 2, of 7th April 1874, from Lieut. Campbell.
1 List of papers.

All plans and estimates by steamer *Baydad* expected here on 1st proximo en route to Madras.

From Lieutenant D. McNEIL-CAMPBELL, R.E., Assistant Engineer in charge of 7th Range, Kistna, to Major J. O. HASTED, R.E, District Engineer, Kistna, dated Masulipatam, 7th April 1874, No. 2.

I HAVE the honor to forward plans and estimates (as per the accompanying list) of West Bank channel revised in accordance with the instructions contained in memorandum No. 430-B from the Chief Engineer for Irrigation, and beg to make the following remarks with reference to the different paragraphs of that memorandum.

2. *Paragraph* 2.—The area to be irrigated has now been altered from 80,000 to 75,000 acres. Information regarding area commanded and that now irrigated (17,868 acres*) is herewith forwarded.

* For fasli 1281, A. D. 1871-72.

3. *Paragraphs* 3 *and* 4.—The several discrepancies therein pointed out have been rectified, and for most of the channels fresh plans have been prepared.

4. *Paragraph* 5.—The bed levels of the main duct have been revised, as suggested, by the Chief Engineer. The mean velocity of water which is above the desired maximum of 2,000 yards per hour is unavoidable in this canal. Moreover, the present traffic is quite inadequate to warrant the additional expenditure for an intermediate lock in the first long reach of 20½ miles. The acreage under it being 75,000, the sections now given are ample for the required discharge. In lowering the bed as suggested, the following points have been kept in view, *first* the requisite level of the water surface to supply existing channels, *second* the requirements of the left bank of the canal which is also the river embankment, *third* the requirement of the irrigation in the lower reaches. The general plan of the area commanded, and the general sections of all the channels now estimated, Nos. 11 and 12, will show clearly the alterations and arrangements now made.

5. *Paragraph* 6.—Where the water surface is above the level of ground the side slopes have been carried to 1 foot above full supply level, and provision made for this in the estimate.

6. *Paragraph* 7.—Information regarding the Kistna freshes has now been put in on the general section (No. 12) and the detailed plans of the canal. By careful examination it has now been found that the average surface fall per mile is 0·868 feet. The bank has been made 5 feet higher than the maximum freshes level, with a top width of 6 feet and side slopes of two to one.

7. *Paragraph* 8.—Channel from the tail lock to river is of a length of 330 feet ; its sections have now been added to the last detailed survey sheet. The navigation of this part of the river is good, except during high freshes. It was not at first intended to make the East Bank channel navigable as far south as this, but the Chief Engineer having wished that this should be done, it is settled that the exit or terminal lock will be nearly opposite the similar exit on this channel ; the distance across the river from lock to lock will be 4½ miles.

8. *Paragraph* 9.—Allowance had been made for compensation where it was found to be necessary. The additional earth required will be taken from the space* between the river and the bank, which by G. O., No 941, dated 30th March 1871, will be taken up by Government.

* Area required according to calculation gives 90·33 acres.

9. *Paragraph* 10.—This canal had been recognized as a second class line of navigation, and all the locks now estimated for have been provided with 105′×15′ chambers in accordance with

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19th December 1874.

circular No. 30 of the Chief Engineer. Iron girder bridges have been allowed over all of them to save labor, as they can be made in Bezwada Workshops while the masonry work of the lock is going on.

10. *Paragraphs* 11, 12, 13, 14 *and* 15.—The remarks on the masonry works have been carefully attended to, and all the designs have been entirely recast; information regarding the levels, floors, depth of water, etc., etc., given. Information is also given regarding the masonry works and the old channels that now exist. Lump sums have been allowed for the improvements found necessary.

11. *Paragraph* 16.—Rest-houses have been allowed for in the revised estimate at the following places :—

	Name of Village.	Amount.
1.	Kollipara, second class	Rs. 1,000
2.	Penumudi, first class	,, 3,000
3.	Pallapatta, second class	,, 1,000

12. *Paragraph* 17.—The surplus will be disposed off as mentioned below ; besides this each of the branch ducts and branches will have an escape weir at their end into drains :—

I.—By an escape at Kollipara adjoining the head-sluice of Kollipara channel into the old course of Munnangy drain which flows into Repalli main drain, 99·0 feet waterway.

II.—Into the Velletur channel branch duct (through the head-sluice of 7 vents), and from thence it will be discharged into the Bhattiprole drain over the wall of the under tunnel which passes the former channel over the latter.

III.—Into the Isakapalli channel at 34 miles by the head-sluice of 3 vents of 8 feet span, and from thence it will be discharged into the Bhattiprole drain over the lower wall of the tunnel which passes the former channel over the latter drain.

IV.—By a tail escape weir adjoining the lock at terminus 24 feet waterway.

13. The difference in cost between the original estimate submitted by Captain Vibart, R.E., and that now prepared is as follows :—

Original Estimate.

	Rs.
Main, West Bank channel	2,76,055
Branch ducts—	
Isakapalli channel	56,705
Velletur channel and Nallavada	21,070
Total ...	3,53,830

Revised Estimate.

Main, West Bank channel	3,64,940
Isakapalli channel	64,470
Velletur channel and Nallavada	18,590
Total...	4,48,000
Difference or increase...	94,170
Irrigation	3,23,145
Navigation	1,17,580
Drainage	7,275
Total...	4,48,000

No. 5.

GENERAL REMARKS ON THE EXISTING WORKS OF WEST BANK CHANNEL, MAIN DUCT (*Masonry*).

No. in General Plan and Section.

1. *Head Lock at Revendrapad.*—This lock was built about the year 1862. It consists of two sets of gates fixed in pucka masonry in front and rear to work it. The chamber consists of rough-stone revetments to sides; it is 150 feet long and 20 feet wide, and is filled and emptied with valves in the upper and lower gates. The work, as it stands, answers the purposes well, and a sum of Rupees 500 is allowed for gearings.

3. *Head Sluice, Kollipara Channel.*—This work was built about 1863, and answers the intended purposes well. It consists of three vents of 4 feet span, the actual discharge through which will be 235·0 cubic feet a second at the head now proposed against the required discharge of 75 cubic feet a second for the acreage supposed to be taken up under it. The wings are high enough to stand the designed depth of water in West Bank channel and the roadway tatties pretty nearly with the normal width of the west bank of the main duct there.

The shutters are worked by manual labor now, and in course of time, as the acreage increases, they will be fitted with screw gearings. Rupees 200 allowed.

... drop at Kollur.—This work was built about the year 1867, and answers the intended purposes well. It consists of six vents of 10 feet span each, which equals the full width of the channel there, with 3 feet width of tambogies at bed level in the centre, 3 feet high, through which to avoid silting water is discharged. The work, as it stands, will require no alteration for irrigation, except in the rear floor which is to be lowered by 1 foot as suggested by the Chief Engineer. Seeing that this cannot be done without interfering with the stability of the structure, it is proposed to lower the lower aprons by 1 foot and so to gain the object sought. Rupees 1,000 allowed for gearings and other improvements that may be found necessary hereafter for navigation.

7. *Head Sluice of Side Channel at Kollur.*—The remarks of Kollipara channel (No. 3 above) equally apply to this work. Rupees 200 allowed for gearings.

8. *Head Sluice of Velletur channel, branch duct.*—This sluice consists of 7 vents of 4 feet span; it was built about the year 1866. The discharge through the vents will be 382·2 cubic feet a second with the head now proposed against the required discharge of 300 cubic feet for the acreage to be taken up under it. Seeing that the branch duct and the vents are of ample capacity, it is proposed to make use of them as an escape to West Bank channel in Velletur reach, the surplus thus received being discharged into Bhattiprole drain over the wall of the under tunnel which passes the former over the latter. The wings are high enough to stand the increased height of water in the West Bank channel as now proposed, and the roadway is wide enough to allow of bandies passing freely over it. Rupees 600 allowed for gearings.

9. *Vemavaram Channel, head sluice.*—The remarks of the Kollipara channel (No. 3) apply equally to this work. Rupees 200 allowed for gearings.

11. *Weir with 3 feet drop at Velletur.*—This work was also built about the year 1866, and answers admirably the purposes intended by it. It consists of 5 vents of 10 feet span each, which equals the full width of the West Bank channel there. Each of the vents has a tambogy 3 feet × 3 feet, at level of the upper bed, in centre. Agreeably to the suggestions of the Chief Engineer the upper bed is to be lowered by 1 foot; the plan of the work shows the arrangement proposed, *i. e.*, by lowering the tambogies by 1 foot, and making a corresponding reduction in the lower aprons to agree with the lower bed. The other parts of the work suit the changes now proposed and renders no other alteration or improvements necessary for irrigation, additional 1 foot of planking will be added to the tambogy vents, and the aprons will be repacked. There is to be a lock in connection with this work now on the east or village side. Rupees 800 allowed for gearings and other improvements to be made hereafter for navigation.

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19th December 1874.

No. in General Plan and Section.

13. *Head Sluice, Repally tank, supply channel.*—The remarks of Kollipara channel (No. 3 above) equally applies to this work. Rupees 200 allowed for gearings.

14. *Head Sluice, Isakapalli channel, branch duct.*—This work has 3 vents of 8 feet span each, and is worked by manual labor with planks of 1 foot breadth. Its discharge with the proposed depth of water will be 450·0 cubic feet a second, against the required discharge of 337·5 cubic feet for the acreage proposed under it. The wings are high and the roadway broad enough to admit the increased depth of water and the passage of traffic respectively. Rupees 500 allowed for screw gearings of the head-sluice.

15. *Regulator at Penumudi.*—This work was built about the year 1867. It consists of 4 vents of 8 feet span which will be more than the width of bed below as now designed. Its floor level is + 10·5 and the bed will now be + 8 feet only. As any alterations will interfere with the stability of the structure, it is proposed to retain the former floor, which is 2·5 above the true bed, corresponding to something like the weirs proposed below at Bobarlunka and Adivipalem. There will be no drop here to the channel or to the regulator. The discharge through the 4 vents will be more than necessary.

In this reach of the canal it is proposed to get rid of the surplus by a similar arrangement as that on Velletur channel, viz., by the lower wall of the under-tunnel proposed across the Bhattiprole drain for the passage of Isakapalli channel over the drain in question. There will be a lock in connection with the work here. Rupees 800 allowed for gearings, etc.

17. *Head Sluice, Nallur tank channel.*—This sluice consists of 2 vents of 4 feet span. The remarks of Kollipara channel (No. 3 above) equally applies to this work. Rupees 200 allowed for gearings.

26. *Regulating bridge on Kollipara channel at Tumalur on the road from Guntoor to Masulipatam via Ilur.*—This work was constructed in 1869; the span equals the full width of the channel there, and for purposes of regulation grooves have been provided in the abutments to receive the planking. It answers the requirements well and requires no alterations.

30. *Regulating bridge on Velletur channel in the 3 1/8 mile at Bhattiprole.*—This work was constructed in 1868. It consists of 3 vents of 8 feet span each, which is more than the required width of the channel there. This discharge is ample; the wings are high enough to stand the changed height of water as now proposed, and the roadway broad enough for the second-class road (coast road) which passes over it. Rupees 500 allowed for gearings.

31. *Regulator at Razole at the end of Velletur Channel.*—The plan of this work is similar to the Bhattiprole one (No. 30); it, therefore, fulfils the conditions required, and thus renders no alterations or improvements necessary. It was also constructed in 1868. Rupees 500 allowed for gearings.

MASULIPATAM,
7th April 1874.

(Signed) D. McNEIL-CAMPBELL, Lieut., R.E.,
Asst. Engineer in charge, 7th Range, Kistna.

(,,) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

No. B. 1—from A. 3.

WESTERN DELTA.

Specification Report to accompany Plan and Estimate for improvements to Bank Canal which starts from the 7 and ¾ mile of Main Canal (No. B. 3 in A. 1) at Ravendrapad to its proposed terminus below the village of Adivipalem.

		Rs.
1.	Amount of estimate	4,48,000

	Rs.
Comprising the following items :—	
1,386,224 Cubic yards of earth-work	1,15,715
Navigation banks	8,000
Masonry works	1,31,675
Acres compensation for land	.....
Ramps at village sites	9,750
439,869 Cubic yards of earthwork for river bank	38,490
Rest-houses	5,000
Total Main Channel...	3,08,630

2. This main duct is intended to irrigate 75,000 acres of land in an area of 227·24 square miles of Government land in Repalli Taluq. It leaves the Main canal at Revendrapad, and after running in a southerly direction for a length of 6¼ miles it joins the Kistna west bank cutting pits at Vallabhapuram ; from this point it follows the general direction of the river embankment till it tails into the river below the village of Adivipalem. In the first 6 miles from head it receives the drainage of the country lying between it, the river and the Nizampatam Main canal by five masonry inlets. This channel has the most favorable alignment running as it does along the river bank, and not therefore crossing any stream or drain.

3. The following is the list of masonry works on the main duct :—

Names.	Estimate.	No. on Plans.	Vents. No.	Vents. Span.	Vents. Height.	Level of floor + High Water Mark.
	Rs.			Feet.		
Lock at head	500	1-B	...	...	...	35·5
Head Sluice at Ravendrapad	3,390	2-B	8	6	6	35·5
Outlet weir at Kollipara	2,865	.....	...	...	...	.....
Head Sluice of Kollipara channel ...	200	3-B	2	4	...	.....
Do. of Kollur do.	.....	4-B	2	3	3·5	21·5
Weir at Kollur	1,000	5-B	6	10	...	18·5
Second-class Lock at Kollur	23,500	6-B	...	15	...	18·5
Head-sluice to side channel at Kollur.	200	7-B	2	4	...	.....
Do. to Velletur channel ...	600	8-B	7	4	...	16·25
Do. to Vemavaram do. ...	200	9-B	2	4	...	.....
Weir at Velletur	800	11-B	5	10	...	12·38
Second-class Lock at do.	19,400	10-B	...	15	...	15·33
Head-sluice of Jagageru channel ...	.....	12-B	1	3	2·5	11·0
Do. Repalli tank supply channel ...	200	13-B	2	4	...	.....
Do. Isakapalli channel at Perumudi.	500	14-B	3	8	...	9·5
Weir at Perumudi	800	15-B	4	8	...	8·0
Second-class Lock at Perumudi ...	18,070	16-B	...	15	...	8·0
Head-sluice, Nallur channel	200	17-B	2	4	...	8·3
Do. Visvesweram channel ...	.....	19-B	2	3	2·5	6·75
Do. to Potmeraka do. ...	.....	21-B	2	2·5	2·5	6·43
Weir at Bobarlanka	2,735	23-B	1	8	...	2·43
Second-class Lock at do.	19,310	22-B	...	15	...	2·43
Weir at end	3,310	24-B	1	8·0	...	—6·38
Second-class Tidal Lock at end ...	26,620	25-B	...	15	...	—6·38
5. Drainage inlets above Vallabhapuram	7,275					
Total Masonry Works...	1,31,675					

	Rs.
Irrigation	14,200
Navigation	1,10,200
Drainage	7,275
Total...	1,31,675

4. The following will be the widths of the main duct :—

Ground Marks.	Length.	Fall per Mile.	Bottom width.
	.....	.....	.....
From head to head of Kollipara	13½	0·58	81·0
Kollipara channel	7	0·58	75·0
From do. to Kollur branch duct	6	0·58	60·0
From do. to Velletur channel do.	7	0·58	49·0
From do. to Isakapalli do. do.	1	0·44	25·0
From do. to Nallur branch channel...	2¾	0·28	25·0
From do. to Visvesweram do.	1¾	0·19	25·0
From do. to Potumeraka do.	6¼	0·08	25·0
From do. to Terminus	.....	.....	.....
Total Length ..	45¼	.....	.....

The side slopes of the channel will be two to one. Berms vary as already laid out ; but provision has been made to continue the side slopes up to one above the full supply level to prevent the spread of water over the berms and thereby diminish the surface fall. The east or river bank of the channel will be 5 feet above the highest known fresh of the river with a fall of 0·868 feet per mile 6 feet wide at top, and the channel bank will be 3 feet above full supply level 4 feet wide at top, the fall of the crest being the same as that of the canal water. The soil through which the channel runs is alluvial, and the bottom velocity will nowhere exceed 1·71 cubic feet a second.

In its course the main duct will throw out the following principal branch ducts and branches :—

Names.	Acreage.	Particulars.	Amount.	Total.
	Rs.		Rs.	Rs.
1. Kollipara branch	5,000	Cubic yards of earthwork.	.....	
		Masonry works	505	
		Compensation, acres ...	.....	505
2. Kollur branch duct ...	12,500	97,073 cubic yards of earthwork.	6,370	
		2 Masonry works	1,920	
		Compensation, 47·13 acres.	940	9,230
3. Velletur do.	20,000	254,744 Cubic yards of earthwork.	16,720	
		2 Masonry works	1,000	
Improvements to the regulators at Bhattiprole and Razole and gearings.	.....	Branches	.....	
		Compensation, acres ...	870	18,590
4. Jagajeru branch	2,500	32,061 Cubic yards of earthwork.	2,110	
		2 Masonry works	990	
		Compensation, acres ...	.....	3,100
5. Isakapalli channel, branch duct.	22,500	294,463 Cubic yards of earthwork.	19,330	
		7 Masonry works	14,570	
		Branches...	29,985	
		Compensation, 29·29 acres.	585	64,470
6. Nallur tank supply channel.	2,500	19,068 Cubic yards of earthwork.	1,250	
		Masonry work	.....	
		Compensation, acres ...	.....	1,250

Names.	Acreage.	Particulars.	Amount.	Total.
	Rs.		Rs.	Rs.
7. Visvesvaram channel ...	6,000	60,613 Cubic yards of earthwork.	3,980	
		2 Masonry works	2,050	
		Compensation, 32·34 acres.	645	
				6,675
8. Potumeraka branch ...	3,500	35,132 Cubic yards of earthwork.	2,300	
		2 Masonry works	1,205	
Direct irrigation at head and end.	500	Compensation for land, 32·76 acres.	655	
				4,160
Tail escapes to existing channels.	.....	.....	1,390	1,390
Total branch ducts and branches.	75,000	.....	.....	1,09,370
Minor new branches				15,000
Masonry works of do.				15,000
			Total minor new branches...	30,000

As designed before this channel was navigable for a distance of 20¼ miles only from head to Kollur. The present scheme provides for the navigation throughout its whole length, 45¾ miles, with a tidal lock at the end to connect it with the river.

The following are the sites for ramps provided for in the estimate :—

	Rs.
1. Srungarapuram	615
2. Peddapalem	515
3. Vallabhapuram	550
4. Pedaparru	690
5. Annavaram	570
6. Chelumuru	815
7. Donepudi	510
8. Pidu Pulwaru	655
9. Kollapalem	665
10. Ravi Anantavaram	675
11. Kamarazugadda	645
12. Mortota	515
13. Bobarlanka	515
14. Bobarlanka Sodaipalum	730
15. Gangadipalem	525
16. Adivipalem	520
Total...	9,750

Rest-houses will be built at the sites mentioned below :—

—	Estimate.	Class.
	Rs.	
1. Kollipara	1,000	Second.
2. Penumudi	3,000	First.
3. Pallapatla	1,000	Second.
Total Rest-houses...	5,000	.....

The total cost of West Bank channel and its branches, etc., will be :—

	Rs.	Rs.
Canal		3,03,630
Channels and branches		1,09,370
Minor branches		30,000
Rest-houses		5,000
Irrigation	3,23,145	
Navigation	1,17,580	
Drainage	7,275	
Total...	4,48,000	Total 4,48,000

MASULIPATAM,
7th April 1874.

(Signed) D. McNEIL-CAMPBELL, Lieut., R.E.,
7th Range Officer, Kistna.

(Signed) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

17 of B. 1.

Specification Report to accompany Plan and Estimate for improving and prolonging Nullur tank supply channel from West Bank channel.

	Rs.
Estimate amount to	1,250
Comprising the following items :—	
19,068 Cubic yards of earth-work	1,250
Masonry works	...
Compensation	...
Total Estimate...	1,250

This channel is to supply 2,500 acres of land, it will leave the West Bank channel about 34½ miles from its head, and will run in north-easterly direction to the tank at Nallur, a distance of 2½ miles ; it will be supplied by a sluice of 11 vents of 0 span level of floor being 8·3 ; the channel will be 4 feet wide, side slopes two to one, and have a fall of 8 inches a mile, and running 3 feet deep will discharge 41·1 cubic feet a second. The banks will be 2 feet 6 inches above level of water, 2 feet 6 inches thick at top, with side slopes of one and a half to one, the lunkahs will be 6 feet wide.

(Signed) D. McNEIL-CAMPBELL, Lieut., R.E.,
7th Range Officer, Kistna.

No. 7.

KISTNA DISTRICT, WESTERN DELTA.

Statement showing the Area commanded, the present and the intended area of irrigation, and the anticipated cost of the works shown below.

Names of Works.	Area commanded by each channel and by each of the principal branches.	Proposed Acreage.	PRESENT AREA OF IRRIGATION.		INCREASED AREA OF IRRIGATION.		COST OF PROPOSED WORKS.				Remarks.
			Acreage.	Assessment.	Acreage.	Assessment.	Irrigation.	Drainage.	Navigation.	Total.	
				Rs.		Rs.	Rs.	Rs.	Rs.	Rs.	
Bank Canal called in the Collector's statement "Karakatta Channel" direct and under small channels ...	116·13	32,500	8,877	46,487	23,623	...	2,40,085	7,275	1,17,580	3,64,940	*N B.*—In these estimates the cost of Rs. 38,490, of a flood bank which will protect the whole of the Western Delta, has been included, as it will be constructed in connection with the left bank of the canal.
Vellettur channel.	50·61	20,000	3,917	17,976	...	...	...	...	...	...	
Nallavada supplied by Vellettur channel ...	...	...	2,389	9,140	...	...	...	...	...	...	
			6,306	27,116	13,694	...	18,590	...	...	18,590	
Isakapally channel ...	50·5	22,500	2,685	13,240	19,815	...	64,470	...	...	64,470	
Total...	227·24	75,000	17,868	*86,843	57,132	...	3,23,145	†7,275	1,17,580	4,48,000	

* The sum of 1,428,203, 92 and 261 collected from dry crops watered at Rupees 2 per acre are included in the assessment column No. 5. The acreage given in column 4 is for land irrigated in the delta during Fasli 1281 or 1871-72.

† Cost of five inlets into West Bank channel only is shown in the absence of the estimate for Bhattiprole drain, which is the principal receptacle of all the minor drains in the area commanded by this main duct and its branches.

N. B.—It will be found that this statement will be somewhat modified by the remarks in the note on the estimates.

MASULIPATAM,
7th April 1874.

(Signed) D. McNEIL-CAMPBELL, Lieut., R.E,
7th Range Officer, Kistna.

(Signed) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

No. 8.

KISTNA DISTRICT, WESTERN DELTA.

Statement showing the Outlay already incurred and that now proposed on the under-mentioned works in Western Delta.

	OUTLAY TO 1872-73. Original.	Amount of Estimates now framed.	Total proposed outlay.
	Rs.	Rs.	Rs.
Bank Canal	1,87,008	3,26,450	5,13,458
Vellettur channel	19,014	18,590	37,604
Isakapalli do.	13,562	64,470	78,032
Kistna river bank	4,935	38,490	43,425
Total...	2,24,519	4,48,000	6,72,519

THIS is proposed from a statement submitted to Controller by the District Engineer.

MASULIPATAM,
7th April 1874.

(Signed) D. McNEIL-CAMPBELL,
7th Range Officer, Kistna.

(Signed) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

Statement showing the Discharge, Velocity, etc., of the different Channels estimated in connection with the West Bank Channel—Formula used

$$V = 0.916 \sqrt{2f} \times H. D.,$$

four-fifths of the surface velocity is taken as mean velocity, and the bottom velocity is taken by subtracting the surface velocity from double the mean velocity.

No. of Divisions.	No. of Main Ducts.	No. of Branches.	Names of Channels.	Distance from head of main duct.	Bottom width.	Side slopes.	Full of Channel.	Depth of water.	Area of cross sections.	Hydraulic mean depth.	Surface Velocity.	Mean Velocity.	Bottom Velocity.	Discharge required in feet per second.	Actual discharge in feet per second.	Discharge in Cubic Yards per hour.	Area in square miles under command of mixed water.	Proposed Acreage.	Proposed Acreage per square mile.
																			At end and at head direct irrigation.
B.	B. 1 from A. 3	1	West Bank Channel—	13¼	81·00	2 to 1	0·58	6·25	584·37	5·36	2·85	2·28	1·71	11·25	1,332·36	1,776·48	227·24	330·60	
			Do. to Kolipara branch ...	20½	75·00	...	0·58	6·25	540·87	5·31	2·54	2·27	1·7	10·50	1,241·89	165,518·8	...	...	
			Do. to Kollar channel ...																
			Do. to Vellettur do. branch duct... ...	26	60·00	...	0·58	6·25	459·12	5·15	2·77	2·22	1·67	900·00	1,005·93	134,123·8	...	75,000	
			Do. to Jagajern do. ...	30	40·00	...	0·58	6·25	384·35	5·00	2·24	1·86	1·36	600·00	787·81	105,041·3	...	57,500	
			Do. to Isakapalli channel.	33½	49·00	0·58	6·25	384·35	5·00	2·24	2·05	1·36	562·50	787·81	105,041·3	...	37,500	
			Do. to Nallur do. ...	34½	25·60	0·44	5·00	175·00	3·69	1·6	2·05	1·23	225·00	257·00	34,266·6	...	35,000		
			Do. to Vigneswaram do. ...	37½	25·00	0·28	5·00	175·00	3·69	1·8	1·64	0·98	187·50	229·25	30,566·6	...	12,500		
			Do. to Pottineraka do. ...	39	25·00	0·19	5·00	175·00	3·69	1·8	1·31	0·98	97·50	189·00	25,200·00	...	10,000		
			Do. to terminus ...	45½	25·00	0·08	5·00	175·00	3·69	0·8	1·09	0·81	45·00	122·50	16,333·3	...	4,000		
		3	Kolipara do. ...	13½	Existing channel answers its purpose well													500	
		4	Kollar branch ...	20½	22·00	0·75	3·5		191·5	2·67	2·3	1·88	1·38	187·50	186·76	24,901·3	38·16	12,500	327·57
		8	Vellettur do. from 1¼ miles	26	28·00	0·83	4·5		144·00	3·34	2·8	2·15	1·61	300·00	309·6	...	50·61	20,000	395·17
			Below calingnah at 1¼ miles...		20·40	0·60	4·5		130·5	3·25	2·5	1·89	1·42	240·00	246·64	...		16,000	
		12	Jagajeru do. ...	30	4·00	0·58	3·0		30·00	1·72	1·6	1·29	0·97	37·50	38·7	...	9·12	2,500	274·12
		14	Isakapalli channel ...	33½	...	...	...		...	...	...	...	...	...	...	...	...	...	...
		35	Do. to Arayapalli branch.		44·00	0·58	3·75		193·12	3·18	2·4	1·75	1·31	337·5	357·96	45,061·3	50·5	22,500	441·58
			Do. to No. 1 branch ...		40·00	...	3·75		178·12	3·13	2·4	1·74	1·30	307·5	309·92	41,322·8	...	20,500	...
			Direct irrigation up to this point—																
			Do. to No. 2 branch ...	1 to 1	17·00	...	3·75		91·87	2·72	2·2	1·62	1·22	142·5	148·82	19,842·8	...	9,500	...
			Do. to No. 3 do. ...	...	8·00	...	3·75		58·12	2·30	1·8	1·49	1·13	82·5	86·59	11,545·3	...	5,500	...
			Do. to No. 4 do. ...	...	3·00	...	3·75		39·37	1·99	1·6	1·39	1·04	22·5	54·72	7,629·3	...	2,000	...
			Do. to terminus ...	...	3·00	...	3·75		39·37	1·99	1·6	1·39	1·04	7·5	54·72	7,629·3	...	500	...
		36	Arayapally branch ...	1¼	4·00	0·75	2·50		22·5	1·48	1·2	1·35	1·02	30·00	30·6	4,080	9·5	2,000	444·44
		38	No. 1 Ulipolum do. ...	5¼	9·00	0·75	3·00		45·00	2·00	1·7	1·58	1·19	71·25	71·1	9,480·0	10·67	4,750	443·33
			Do. to its first mile drop ...	7½	16·00	0·75	2·00		40·00	1·66	1·4	1·27	0·95	56·25	56·8	7,573·3	...	3,750	...
		40	No. 2 Allaparru branch ...	7½	10·00	0·66	3·00		48·00	1·63	1·3	1·24	0·93	60·00	62·4	8,320·0	9·00	4,000	444·44
			Do. to its first ¾ mile drop.	...	15·00	0·66	2·00		38·00	1·59	1·3	1·21	0·90	45·00	50·16	6,688·00	...	3,100	...
		42	No. 3 Kuchinapudy branch ...	9½	6·00	0·75	3·00		36·00	1·85	1·5	1·41	1·06	56·25	54·52	7,269·3	...	3,500	448·72
			Do. to its first 1¼ mile drop.	...	11·00	0·75	2·00		30·00	1·60	1·3	1·21	0·91	37·50	41·41	5,521·3	...	2,500	...
		44	No. 4 Prignam branch ...	12½	3·00	0·75	3·00		27·00	1·64	1·3	1·24	0·93	22·50	5·25	5,145·0	8·33	1,500	451·45

Statement showing the Discharge, Velocity, etc., of the different Channels estimated in connection with the West Bank Channel, etc.—(Continued.)

No. of Divisions.	No. of Main Ducts.	No. of Branches.	Names of Channels.	Distance from head of main duct.	Side slopes.	Bottom width.	Full of Channel.	Depth of water.	Area of cross sections.	Hydraulic mean depth.	Surface Velocity.	Mean Velocity.	Bottom Velocity.	Discharge required in feet per second	Actual discharge in feet per second.	Discharge in Cubic Yards per hour.	Area in square miles under command of anicut water.	Proposed Acreage.	Proposed Acreage per square mile.
																		Rs.	
			Direct (irrigation under the branch duct (Sakapalli channel) near the road, and near the head of 1st branch	...	...	...	...	...	...	...	...	...	...	...	...	...	14·2	6,250	440·13
			Do. at end ...	...	...	...	...	...	...	...	...	...	...	...	...	...	1·10	500	454·54
		17	Nallur tank supply channel ...	3·41	...	4·00	0·66	3·00	30·00	1·72	1·71	1·37	1·03	37·5	41·1	5,52·13	6·33	2,500	394·94
		19	Visweswaram channel ...	3·71	...	28·00	0·75	2·00	64·00	1·73	1·84	1·47	1·1	90·00	94·08	12,54·0	17·00	6,000	369·9
		21	Potumeru channel ...	3·96	...	16·00	0·75	2·00	40·00	1·60	1·76	1·41	1·06	52·5	56·4	7,530·	11·00	3,500	357·8
			Direct irrigation between the drain and West Bank channel from the head to Kallur channel head-sluice and at the end below Potumeru channel ...	...	...	...	...	...	...	...	...	...	...	...	...	...	38·36	500	13·

N.B.—The velocities shown in this statement have been calculated by a formula which differs somewhat from that used for the Godavery works. In reviewing the arrangements, the dimensions of canals and channels, etc., have been considered with reference to discharges obtained from Dubuats' Formula, but the information contained in the above statement will nevertheless be of value.

(Signed) D. McNEIL-CAMPBELL, Lieutenant, R.E.,
Asst. Engineer in charge, 7th Range, Kistna.

(Signed) J. O. HASTED, Major, R.E.,
District Engineer, Kistna.

MASULIPATAM,
7th April 1874.

No. 398. ORDER THEREON, 19th December 1874, No. 3,572.

IRRIGATION, No. 24.

THE following estimates for portions of the work required for the completion of the scheme of irrigation in the Western Delta of the Kistna have been submitted by the Chief Engineer for Irrigation for entry in the Budget of 1875-76, and for transmission to the Government of India for sanction:—

	Rs.
Main Canal	5,83,700
Nizampatam Canal	29,300
Bank Canal	4,83,800

2. Until the estimates for the whole of this delta shall have been completed, and until the outlay due to drainage, and to the anicut and head works, etc., shall have been distributed between the three principal sections of irrigation, it will not be practicable to show clearly what the returns from each section, as regards the outlay now proposed, and with respect also to the total outlay from the beginning, will be, but the information now furnished appears to His Excellency the Governor in Council to render it sufficiently certain that the results of completing the canals, provided for in the estimates now under consideration, will be ample, and this conclusion is supported by the fact that the conditions of irrigation are not dissimilar to those of the neighbouring delta of the Godavery. The question whether the whole drainage of the delta should be deemed a part of the system of irrigation, as distinguished from an agricultural improvement, will be more fully gone into when the whole of the estimates of the Western and Eastern Deltas respectively come under review, and the arguments of the Chief Engineer for Irrigation will then be duly considered.

Bank Canal.
Nizampatam Canal.
Commamore Canal.

3. It has been observed in reviewing the Revenue Statements of the Kistna Delta for 1871-72 and 1872-73, that there is a considerable difference between the assessments, land and water, of the Eastern and Western Deltas, and a material variation between both and the Godavery. Further information in elucidation of the system prevailing in the Kistna has been asked for, and will make it more easy to estimate the gross returns due to irrigation, which may be expected from its extension. Looking, however, to the large outlay roughly estimated at 75 lakhs, which will be necessary to complete the delta system, it appears to be desirable that the actual circumstances of the lands in its several sections and sub-sections should be more particularly examined and reported on, in order that it may be ascertained, at least approximately, what revenue is likely to be obtained, on the one hand from water-rate on lands now under dry cultivation, and on the other hand in the shape of both water-rate and land assessment from those which have seldom, if ever, been cultivated at all, but which will be rendered fit for growing either wet or dry crops by the improvements contemplated, and especially by the drainage works.

Proceedings, Madras Government, No. 2,844, dated 7th October 1874.

4. On all matters connected with the design and scope of the works, the foregoing note and statements contain probably as much information as will be required by the Government of India, and the opinion of the Chief Engineer for Irrigation, that the way in which the estimates have been prepared by Lieutenant McNeil Campbell is very creditable to him, has been noticed with satisfaction.

(True Extract.)

(Signed) G. W. WALKER, Colonel, R.E.,
Secretary to Government.

To the Superintending Engineer, Kist
,, Chief Engineer for Irrigation.
,, Revenue Department.

Exd. S. T. Austin.

Spare Copies

IND

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1 Kenn 1874 Departmt

Govt. of [1874] Madras.

PUBLIC WORKS.

No. 4563

To

THE SUPERINTENDING ENGINEER,

KISTNA,

&c., &c., &c.

Dated December 19th.

Read. Encl.

G. O., 19th December 1874, No. 3,572

DECEMBER.

Nos 397-398

January 1875 N39 Ellis

rigation Works, Western Delta, Kistna
rict.—Passing orders on Note by the
Engineer for Irrigation submitting
ates for portions of the work re-
ed for the completion of the scheme of
ation in the Kistna District.

N 39

lered to be communicated
Board of Revenue, and that
Attention be called to para
of C.G. Madras
Subject to Con