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Government of Madras.

Public Works DEPARTMENT.

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587-588-A

Dated 28—9—1864

Not to be folded or roughly handled

No. 587. Read the following letter from Captain J. MULLINS, R. E., Consulting Engineer for Irrigation and Canal Company, to Colonel C. A. ORR, R. E., Secretary to Government, Department Public Works, dated Madras, 9th September 1864, No. 93:—

SIR,

1. I have the honor to submit, for the sanction of Government, the estimates amounting to Rupees 8,04,500 and their accompaniments as per margin* for the 9th section of the Main Canal (144th to 178th mile) together with the letter No. 980, of the 20th ultimo, from the Agent to the Irrigation and Canal Company, transmitting the estimates to this Office. The exact length of the canal in this section will be 34 miles and 52 chains.

* 1. General Plan of Anicut.
2. Head and under-sluice.
3. Scouring do.
4. Aqueduct.
5. Do.
6. Do.
7. Do.
8. Do.
9. Do.
10. Do.
11. Do.
12. Lock.
13. Do.
14. Do.
15. Do.
16. Calingulah.
17. Do.
18. Do.
19. Do.
20. Culverts.
21. Do.
22. Do.
23. Do.
24. Do.
25. Irrigating sluice.
26. Do. do.
27. Do. do.
28. Public road bridge.
29. Cross sections.
30. Longitudinal section.
31. Sketch map.
1 Detailed estimate of masonry works.
1 Abstract do.
1 Detailed estimate of earthwork.
1 Abstract for do.

Alteration of lower part of 8th section.

† P. M. G. No. 1,232, dated 15th May 1863.

2. As mentioned in paragraph 2 of my letter No. 65, of the 5th ultimo, the 8th section as sanctioned† extended to the 146th mile, but the line has been modified by the Chief Engineer and, as now arranged, the 9th section will commence at miles 143 and chains 23, immediately below the lock, which will bring the 8th section of the canal down to the proper level for receiving a fresh supply of water from the Kúndar.

9th Section. Estimates provide for Kundar Anicut with under-sluices and for head sluice Plans Nos. 1 and 2.

3. The estimates now submitted provide for an anicut across the Kúndar at Rajoly, with a length of 1,000 feet and a height of 5 feet. The west or south wing of the anicut has been, however, by mistake omitted, as noticed in paragraph 7 of the Agent's letter. The river at this place is very favorable for the formation of a weir, the bed being composed entirely of blue limestone of excellent quality, the general level of which is above the proper bed, and it forms therefore a low dam at present, with a few places, however, sufficiently low to drain the upper part of the river. At the north end of the anicut there will be an under-sluice of four vents of 6 feet 6 inches × 7 feet to be worked by revolving shutters of the same description as those which have been fitted to the sluices of the Soonkasala anicut, and, in close proximity thereto, will be the head sluice of six vents of 2 feet 9 inches × 5 feet. The sills of the under and head sluices will be on the same level, and 7 feet below the crown of the anicut, so that, with the water flush with the crest of the dam, the latter sluices will be capable of discharging into the canal 77,000 cubic yards of water per hour. The vents of the head sluices will be regulated by gate shutters worked by screw gearing, and the size of the vents is sufficiently small to render it probable that this arrangement will prove efficient.

Level of under and head sluice road-ways differ. Plan No 2.

4. The top of the under-sluices will be 13 feet above the crest of the anicut, but the road-way of the head sluice is only 10 feet above the same level, and if the latter be sufficient, the object in making the former 3 feet higher is not clear, and as it adds to the length of the pivot shaft of the revolving shutters, it would seem advisable to make the road-ways of the two sluices the same.

Public road-way provided over head sluice.

5. A road-way is provided over the head sluice in connection with a crossing at the tail lock of the 8th section. The general arrangement of these works and their relative positions will be seen in plan 1. The clear width of road-way over the sluice is 11 feet, that on either side to the ends of the retaining walls, which have a parapet on the outer face, 13 feet,

and beyond these walls, on the top of the embankments, 15 feet. These dimensions are, I think, sufficient for the accommodation of the traffic. I have no plan of the bridge over the tail bay of the 8th section lock, as the Chief Engineer has submitted no revised estimate for the altered arrangement of the lower part of that section, but, judging from the sketch, the road-way of that bridge will be sufficiently wide.

Section of the Anicut.

6. The section of the anicut provides for a single wall 5 feet wide at top, 7 feet at base, and 5 feet high, the rock being benched out to receive the masonry. This section is well adapted to the locality, and the limestone is of such excellent quality that a very durable work may be anticipated. I do not find any provision in the estimates for benching out the rock to form the foundations for the wall. This is really an important item, and great care should be taken that every part of the wall is properly founded, otherwise weakness may be shown where least expected, and what would cost a Rupee or two in the first instance to make good work, may lead, if neglected, to the expenditure of many hundreds of Rupees to repair damage.

Scouring sluice, Plan 3.

7. At miles 143 and chains 28 a scouring sluice with four vents of 3 feet × 5 feet and the sill two feet below the sole of the canal has been provided. The design is good, but it is defective in one important point, for the shutter is intended to work simply against a shoulder and not in a groove, and were the water in the river to rise to a higher level than that in the canal, as indeed it is shown to be in the section at A A, and as it will sometimes certainly be, the shutter would be blown out into the canal, and the influx of water would lead to serious damage. From what I have observed of the action of scouring sluices placed in positions similar to that intended in the present case, I am disposed to suggest that the construction of this work be at any rate postponed, if not omitted altogether. Very generally scouring sluices so circumstanced, by increasing the draught at the head sluice, bring into a canal much solid matter, which would otherwise remain in the river, and they carry off less than is so brought in, and my impression is that the minimum clearing is required in a channel to which the minimum quantity of water is admitted. It is quite true that a scouring sluice can, by bunding off the canal below it, be made to clear the canal above it in certain states of the river and so effect, at a small cost, a clearing which would perhaps, by manual labor alone, amount to a great deal, but in a canal of this description whenever the river is in the requisite state of fresh, the canal will be required for its proper use of conveying water and traffic, and therefore I think in the present case such a work will be of no advantage but rather the reverse.

Principal dimensions of the canal.

8. The canal is intended to carry 60,000 cubic yards of water per hour, with a depth of five feet of water, the width at sole being 50 feet and at surface 70 feet. The fall of the upper part is four inches (·326) per mile, and with these data Beardmon's formula (mean velocity $55\sqrt{H.M.D.} \times 2f$). gives 60,566 cubic yards per hour as the discharge, but the quantity by Stoddard's tables would be cubic yards 51,933.

The side slopes of the canal will be 2 to 1. The minimum height of the embankments above water surface will be 3 feet; the standard sheet of cross sections in embankment is not quite accurate, the water line having been misplaced, and so I cannot say whether, when the level of the ground is below the sole of the canal, any increase to the margin of 3 feet is intended to be allowed, but at any rate care should be taken that the embankments are carefully made up after settlement to at least this level.

Revetments to interior slopes of canal.

9. No revetments of this description have been provided for, and the canal being double banked throughout, such work will not generally be necessary. It should however be remembered that much of the soil is extremely bad, and where the banks are carried across deep gullies, of are from other causes very high, it will be found good economy, if stone be at all near, to revet such portions, because, with such soil in such situations, the earth-work does inevitably undergo so considerable a change of form, that there are great risks of unequal settlement, and

consequently of the water finding a passage through the bank and occasioning a breach, and this is not guarded against fully by the fact that the section of the earthwork would in itself be sufficient under ordinary circumstances. The revetment, on the other hand, while allowing of vertical settlement greatly checks horizontal movement, and so prevents the formation of cracks which would endanger the safety of the bank.

Total fall of the canal in the section.

		M. Ch.	
* Lock No. 1, 8 feet.			
Do. „ 2, 10 „		0-38	Distances between the Locks.
Do. „ 3, 10 „		0-41	
Do. „ 4, 12 „		1-39	
Do. „ 5, 10 „		0-70	
Do. „ 6, 10 „		1-75	
Do. „ 7, 8 „		0-30	
Do. „ 8, 10 „		1-18	
Do. „ 9, 18 „		1-59	
	91		

10. The total fall of the canal from end to end of the section will be 98·47 feet. Of this 7·47 feet are overcome in the first 26 miles by an average fall of ·287 of a foot per mile, and the remainder in the lower 8⅝ miles by 9 locks with drops totalling* 91 feet, so that this lower part will be a still water canal whenever the irrigation sluices are not drawing.

Arrangements are favourable for navigation.

11. From the preceding paragraph it will be seen that the country has allowed of arrangements favourable for navigation, the fall being concentrated, thus leaving 26 miles out of the 34⅝ unobstructed by locks, while the sites for the locks in the lower part are on the whole more convenient than would have been the case had the distances been more equally divided.

Main items of the estimate.

12. On referring to the end of the abstract estimate it will be seen that the estimated cost of this section is made up of three main items.

Masonry works,	Rupees	4,86,318	or per mile	Rupees	14,035
Ferry boats,	„	2,400	do.	„	69
Earthworks,	„	2,87,510	do.	„	8,299
Tools,	„	5,000	do.	„	144
Road diversions,	„	23,242	do.	„	670
Total Rupees		8,04,500			

Total per mile Rs. 23,217

The item for masonry works comprises—

12	Aqueducts for passing drainage estimated to cost	1,76,507
1	Do. for a road-way...	3,875
9	Locks	2,13,139
*6	Lock weirs or calingulahs	10,214
2	Public road bridges	13,357
15	Culverts	31,884
	Kúndar Anicut at Rajoly	5,030
	Head sluice	10,200
	Under sluice	6,878
	Scouring sluice	3,350
33	Irrigation sluices	11,884
	Total.....	4,86,318

Of the above the item for 33 irrigation sluices, Rupees 11,884 requires to be included in a separate estimate, as such sluices belong to distribution and not to main supply.

Estimated cost of lockage per foot of lift.

13. The total difference of level to be effected by lockage being 91 feet, and the estimate cost of the locks Rupees 2,13,139, the cost per foot of lift will be Rupees 2,342.

Masonry works.

14. Taking the masonry works in the order mentioned in the abstract shown in paragraph 12, the first to be noticed are the aqueducts.

Aqueducts, Plans Nos. 4 to 11.

The general arrangement of these is similar to that of works of the same class already sanctioned by Government. The waterway in all except the large aqueducts over the Vaikalair* and at miles 167 and chains 21, where it is contracted from 50 feet to 23 feet, will be 25 feet or half the average water width of the canal. The walls on the towing path side are arranged with cells, divided by vertical cross walls generally, but in two cases by horizontal cross walls also, which is, I think, the better and safer plan. The towing paths are shown unprotected by any sort of railing or parapet and this requires to be remedied.

* 149 miles, 20 chains, 12 arches of 30 feet.

The piers of the aqueducts with 30 feet arches are 5 feet thick or one-sixth of the span, and this is running the dimensions rather close to what is barely safe, especially in the aqueduct for the Vaikalair, the piers of which are 13½ feet high to the springing. In the smaller aqueducts with 20 feet arches and piers only 6 feet high, a thickness for the latter of 4 feet or one-fifth of the span has been allowed, and therefore either there is a deficiency of strength in the one case or an excess in the other.

Locks.

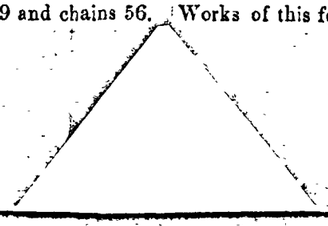
15. The plans of these are generally similar in design to many now in course of construction. In one point there is a considerable improvement, the walls above the upper gate being made 3 feet above the water level, and those below the gates one foot above that level whereas in previous plans no margin was allowed. The dimensions of the upper retaining wall and perhaps also those of the side walls in some cases might be modified with advantage. The lock at miles 176 and chains 60 has a 12 feet drop, and in case of water getting behind the retaining wall above, the lower part would be subjected to the pressure of a head of 17 feet of water, and its thickness at the centre, the widest part, is only 5 feet ; the same thickness is allowed in the lock of 8 feet drop at miles 169 and chains 22. Again, the side walls of the two locks differ in thickness at the junction of the floor invert by 3 inches only, the difference in height being 4 feet. These are the first lock plans in which the admission and emission valves have been shown, their general arrangement can be understood, but the details are not exhibited, nor is the position of the fall from the upper to the lower level shown.

Lock calingulahs or weirs.

16. The design for these is new. They consist of a body wall with its crest 1 foot 6 inches below the surface of the canal water, the regulation of the discharge being effected by planks working in masonry piers 9 inches thick and 6 feet apart a foot-path 2 feet wide being found upon the piers. The water after passing the crest is to flow over an apron of rubble stone in chunam half a yard thick, laid on 6 inches of concrete. This apron is terminated by a retaining wall 2 feet thick and 2 feet deep, beyond this a horizontal rubble stone apron, of similar thickness to the sloping apron and 10 feet wide, is shown, and the whole is completed by another retaining wall 2 feet by 2 feet deep. The wing walls are of the usual description.

The stability of a calingulah of this form is, I think, extremely doubtful, and I anticipate very considerable additional outlay for strengthening and for protecting the earthworks beyond the wing-walls. The water after descending a slope of 3 to 1 will go far beyond the masonry walls before losing its increased velocity, and its action on the slopes of the weir channel will be great.

Another point which is worth considering is the level of the sill or crest of the dam, which in these plans it is proposed to place 3½ feet above the sole of the upper reach of the canal. If this arrangement be carried out, there will inevitably be much difficulty in preventing the silting up of the canal above the lock. That experience has shown this to be the result of similar arrangements, there are I believe many instances to prove, and I think weirs thus built have had to be altered at a considerable cost to keep the channel clear. I should be disposed, therefore, to construct in lieu of these calingulahs a drop of the form shown in the sketch attached to the calingulah designed for miles 169 and chains 56. Works of this form are durable, they kill the



velocity due to the fall within a short distance, they can be easily regulated, and including front and rear pitching and a good bridge ; the cost at the Chief Engineer's rates would be about Rupees 1,900 against Rupees 1,770, and the great essential, a discharge at the level of the canal sole, would be obtained. In this particular case the quantity of water to be passed down is, taking the irrigation sluices above into account, 22,000 cubic yards per hour, and the drop sketched would discharge 39,000 cubic yards, a sufficient margin, and yet the side walls are but 8 feet apart instead of 26 feet 3 inches in the original design, and the facility for bridging is therefore great, and it becomes worth while to consider the advisability of bridging the tail bays of some of the locks, an arrangement which has doubtless been discountenanced by the Chief Engineer in some part owing to the expense which would be occasioned by the bridging of the waste channel with the ordinary description of weir ; in the example under notice it would be three or four thousand Rupees. The last three locks have no calingulahs, all the irrigation water being supposed to be expended above.

Public road bridges, Plan No. 28.

17. There are two of these works, both however will be of the same design, the only difference being that the canal is in rather deeper cutting in the one case than in the other. There will be one arch of 40 feet span affording, after providing for a towing path 4 feet wide, a clear waterway of 30 feet.

Culverts, Plans Nos. 20 to 24.

18. These are of the ordinary description. None of them are intended for crossings. Out of the total number 15, there are four of 6 feet and one of 8 feet, all the rest are 2 and 3 feet.

Irrigation Sluices, Plans Nos. 25 to 27.

19. Of these there are 33 to be built, the largest being for 5,000 acres. They will be regulated outside the embankment, and in each case provision is made for a high level channel as well as for those on the level of the sluice floor. As some of the sluices on the canal are built to regulate from the inner and some from the outer end, and the two arrangements have not yet been tested, perhaps the better plan is not yet ascertained, but before the sluices included in this estimate are commenced, probably the Chief Engineer will have had opportunities of determining whether any modification admitting of the water being shut off from the sluice is desirable.

RATES FOR MASONRY WORKS.

	Rs. A. P.		Rs. A. P.
Rubble stone in chunnam per cubic yard.	4 12 0	to	2 12 0
Cut stone per cubic yard	13 0 0	to	8 0 0
Do. per cubic yard	*12 0 0	to	2 8 0
Do. per square feet	0 6 0	to	0 4 0
Arch work per cubic yard	4 12 0	to	3 8 0
Stone covering do.	5 12 0	to	4 2 0
Beam stone per cubic feet.	0 0 0	to	0 4 0
Rough pitching per cubic yard.. ..	2 14 0	to	2 2 0
Puddle per cubic yard	0 0 0	to	1 0 0

* The rate Rupees 12 per square yard entered for some of the work to the head sluice and under-sluice at Rajoly appears to be a mistake, and a reference has been made to the Agent.

Earthwork rates.

20. All that can be said of the rates until the commencement of operations in the part of Cuddapah in which this section lies, is that they appear ample, and from paragraph 6 of the Agent's letter it will be seen that Colonel Cotton hopes to be able to do the work at lower rates The correction of errors in this estimate has changed its amount from Rupees 4,87,118 to Rupees 4,86,318.

21. The rates only of the earthworks call for any remarks. They appear to be fully sufficient throughout, and though perhaps, in the absence of a liberal use of trial pits, 3 and 4 Annas for black cotton soil and kunker may not be found to leave too wide a margin,

See for instance 151st and 152nd miles and below.

care will be required to prevent the actual payment of excessive rates, though within the estimate allowance.

There are a few errors in the estimate, but their extent is so small,* that though marked in pencil, it has not seemed necessary to make any alteration.

* Involving a decrease of Rupees 124-7-5.

Road diversions and crossings.

22. A list of the crossings has been furnished and forms one of the enclosures of this letter. For convenience I have numbered the items of the List in red ink, and though,

Cons. Engineer Sand C Co.

with reference to the Order of Government No. 2,438, of the 24th August 1864, paragraph 4, the required communications across the canal will be carefully ascertained by the local officers of the Department of Public Works and the Company, it may be useful to note here the few remarks which an examination of the list has led me to think necessary.

In No. 3—Malliamulla and Chagulmarry appear to be on the same side of the canal.

The communication between Malliamulla and Dudanala has been stopped, and as the nearest crossing above is 1¼ miles distant, and that below 2 miles, it may be of importance to ascertain what the extent of the inconvenience will be.

In No. 5—The diversion of the Kurnool and Cuddapah road in the 151st mile does not seem to be as well laid out as it might be, and I have marked in pencil what appears to be a better line, and the longitudinal section shows that the ground is fairly favorable and if that be found to be the case the abrupt diversion should be avoided.

159th mile.

No. 11.—The proposed diversion of the Kurnool and Cuddapah road here is entirely for the purpose of obtaining a site for the bridge where the canal is in deeper cutting, and as unless the advantages be very considerable these loop diversions are objectionable, I have calculated as far as was practicable what the cost of adhering to the present line would be. The bed of the canal is 102·91, and the level of the present road 103·56. At the proposed site the bed of the canal is 102·84, and the ground level 109·22. At the former place the approach to a bridge with road-way level 125·91 would be 22·35 above ground at the bridge, and with approaches at gradients of 1 in 50 the length of these would be 370 yards each. The average height of embankment would be 3¼ yards and the cubic contents with side slopes of 2 to 1 would be 40,237½ cubic yards (370 × 54⅓ × 2), which at the rate allowed for the Canal at this part with an addition of six piers for extra height would cost 2 Annas a yard or say Rupees 5,000. The estimates allow for the Chief Engineer's proposed diversion, Rupees 1,990, as marginally noted, but as the ground is 109·22 and the bridge will be 125·84 the least quantity of earth required will be for an embankment averaging 2⅞ yards in height, and this gives (277 × 3⅓ × 2) = 19,320 cubic yards, which at the same rate, 2 Annas, would cost Rupees 2,415. The cost therefore on the present line would be—

	Rs.	A.	P.
In Earthwork Estimate.			
Substratum and metalling	975	0	0
In Bridge Estimate.			
Earthwork of approaches cubic yards 12,052½ @ Rs. 0-1-0	753	4	1
Metalling 1,396⅓ square yard @ Rs. 0-3-0	261	14	0
	1,990	2	1

Earthwork	Rupees	5,000	0 0
Road surface 740 × 6 = 4,440 @ 5 Annas... ...	„	1,387	8 0
	„	6,387	8 0

The cost on Chief Engineer's diversion.

Earthwork	Rupees	2,415	0 0
Road surface 1,100 × 6 = 6,600 @ 5 Annas... ...	„	2,062	8 0
	„	4,477	8 0

Showing a difference at these rates in favor of the diversion of nearly 2,000 Rupees. I do not know why the rates for the approaches in the bridge estimate are entered at 1 Anna for earthwork and 3 Annas for metalling, for the former should be higher than that for the canal and not much lower as is the case, but if these rates be adopted the cost of the present line would be—

Earthwork	Rupees	2,500	0 0
Metalling	„	832	8 0
	„	3,332	8 0

Chief Engineer's diversion.

Earthwork	Rupees	1,207	8 0
Metalling	„	1,237	8 0
	„	2,445	0 0
Difference in favor of latter	„	887	8 0

Before however the diversion is accepted as requisite, I think it shou'd be ascertained more carefully what the saving to the Company would be.

Some roads leading from Yazedewarapully in the 160th and 161st miles have been stopped, some can be led to the bridge in the 159th mile, but the village may require some means of communication across the canal in its immediate neighbourhood.

No. 20.—This diversion of the main road in the 168th mile of the canal or 23rd mile of the road has formed the subject of a lengthened correspondence. The Chief Engineer was under the impression that the road had not been formed and that the diversion therefore would cost a mere trifle, and perhaps this was the case when the Officers of the Company surveyed the line of the canal though the road had been formed prior to my inspection of the line in June last. The Superintending Engineer, 3rd Division, estimates the cost of the alteration at Rupees 3,600, and the Chief Engineer thinks this a great deal too much, but in the estimate he enters no less than Rupees 11,000 for this purpose, and I do not at all understand on what ground this has been thought necessary. The correspondence is contained in the packet forming Enclosure No. 3, and I have not received an answer to my letter No. 122 of the 20th July to the Agent.

No. 23.—The proposed ferry for all these village communications seems very inadequate, and as the nearest bandy crossing is 3½ miles north, the tail bay of the lock in the 171st mile requires, I think, to be bridged.

No. 24.—This ferry is 3¾ miles from the proposed ferry No. 23 and about four miles from the lock in 171st mile. It would be better to bridge either the lock in the 172nd or that in the 173rd mile.

No. 25.—A ferry is not at all adapted for this place. There is a considerable cart traffic from Cazeepett to the westward, and as the lock in the 177th mile has no weir, the bridging of the tail bay will alone be required, and the difference of cost of this and the establishment of a ferry would be very small.

No. 26.—The ferry in the 178th mile will do very well if the Chief Engineer prefers it to bridging the tail lock into the Pennair.

Level of Pennair high floods not given.

23. The level of the Pennair floods is not marked either upon the longitudinal section or upon the tail lock, so that I cannot say whether the lock walls are on a proper level, or whether the lower reaches of the canal will be within reach of the flood water.

Letter No. 688 of 16th ultimo, attached to Agent's letter No. 1,066, 30th idem.

24. The Superintending Engineer has stated that the "masonry works provided for "the main line of canal from Jungalpully to "the Pennair are calculated to meet all requirements of communication and irrigation." Colonel Hemery will no doubt re-consider the communications in preparing the general scheme of roads, and this is necessary in the last 10 miles of the canal where there is no masonry work intended, under the arrangements submitted by the Chief Engineer, to provide a crossing.

25. The 9th section of the canal promises to be remunerative, and before the works can be sufficiently advanced to make use of it, there will be a supply of water for this section in the Kundar from the water thrown in at the 73rd mile of the canal, I would recommend therefore that sanction be given for Rupees 7,92,616 under the head main supply, and for Rupees 11,884 under distribution, leaving those points in the project, which the Government may consider to require modification, to be settled afterwards.

with reference to the Order of Government No. 2,438, of the 24th August 1864, paragraph 4, the required communications across the canal will be carefully ascertained by the local officers of the Department of Public Works and the Company, it may be useful to note here the few remarks which an examination of the list has led me to think necessary.

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The communication between Malliamulla and Dudanala has been stopped, and as the nearest crossing above is 1¼ miles distant, and that below 2 miles, it may be of importance to ascertain what the extent of the inconvenience will be.

In No. 5—The diversion of the Kurnool and Cuddapah road in the 151st mile does not seem to be as well laid out as it might be, and I have marked in pencil what appears to be a better line, and the longitudinal section shows that the ground is fairly favorable and if that be found to be the case the abrupt diversion should be avoided.

159th mile.

No. 11.—The proposed diversion of the Kurnool and Cuddapah road here is entirely for the purpose of obtaining a site for the bridge where the canal is in deeper cutting, and as unless the advantages be very considerable these loop diversions are objectionable, I have calculated as far as was practicable what the cost of adhering to the present line would be. The bed of the canal is 102·91, and the level of the present road 103·56. At the proposed site the bed of the canal is 102·84, and the ground level 109·22. At the former place the approach to a bridge with road-way level 125·91 would be 22·35 above ground at the bridge, and with approaches at gradients of 1 in 50 the length of these would be 370 yards each. The average height of embankment would be 3¼ yards and the cubic contents with side slopes of 2 to 1 would be 40,237½ cubic yards (370 × 54⅓ × 2), which at the rate allowed for the Canal at this part with an addition of six piers for extra height would cost 2 Annas a yard or say Rupees 5,000. The estimates allow for the Chief Engineer's proposed diversion, Rupees 1,990, as marginally noted, but as the ground is 109·22 and the bridge will be 125·84 the least quantity of earth required will be for an embankment averaging 2⅞ yards in height, and this gives (277 × 3⅓ × 2) = 19,320 cubic yards, which at the same rate, 2 Annas, would cost Rupees 2,415. The cost therefore on the present line would be—

	Rs.	A.	P.
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In Bridge Estimate.			
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	1,990	2	1

Earthwork	Rupees	5,000	0 0
Road surface 740 × 6 = 4,440 @ 5 Annas... ...	„	1,387	8 0
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	„	4,477	8 0

Showing a difference at these rates in favor of the diversion of nearly 2,000 Rupees. I do not know why the rates for the approaches in the bridge estimate are entered at 1 Anna for earthwork and 3 Annas for metalling, for the former should be higher than that for the canal and not much lower as is the case, but if these rates be adopted the cost of the present line would be—

Earthwork	Rupees	2,500	0 0
Metalling	„	832	8 0
	„	3,332	8 0

Chief Engineer's diversion.

Earthwork	Rupees	1,207	8 0
Metalling	„	1,237	8 0
	„	2,445	0 0
Difference in favor of latter	„	887	8 0

Before however the diversion is accepted as requisite, I think it shou'd be ascertained more carefully what the saving to the Company would be.

Some roads leading from Yazedewarapully in the 160th and 161st miles have been stopped, some can be led to the bridge in the 159th mile, but the village may require some means of communication across the canal in its immediate neighbourhood.

No. 20.—This diversion of the main road in the 168th mile of the canal or 23rd mile of the road has formed the subject of a lengthened correspondence. The Chief Engineer was under the impression that the road had not been formed and that the diversion therefore would cost a mere trifle, and perhaps this was the case when the Officers of the Company surveyed the line of the canal though the road had been formed prior to my inspection of the line in June last. The Superintending Engineer, 3rd Division, estimates the cost of the alteration at Rupees 3,600, and the Chief Engineer thinks this a great deal too much, but in the estimate he enters no less than Rupees 11,000 for this purpose, and I do not at all understand on what ground this has been thought necessary. The correspondence is contained in the packet forming Enclosure No. 3, and I have not received an answer to my letter No. 122 of the 20th July to the Agent.

No. 23.—The proposed ferry for all these village communications seems very inadequate, and as the nearest bandy crossing is 3½ miles north, the tail bay of the lock in the 171st mile requires, I think, to be bridged.

No. 24.—This ferry is 3¾ miles from the proposed ferry No. 23 and about four miles from the lock in 171st mile. It would be better to bridge either the lock in the 172nd or that in the 173rd mile.

No. 25.—A ferry is not at all adapted for this place. There is a considerable cart traffic from Cazeepett to the westward, and as the lock in the 177th mile has no weir, the bridging of the tail bay will alone be required, and the difference of cost of this and the establishment of a ferry would be very small.

No. 26.—The ferry in the 178th mile will do very well if the Chief Engineer prefers it to bridging the tail lock into the Pennair.

Level of Pennair high floods not given.

23. The level of the Pennair floods is not marked either upon the longitudinal section or upon the tail lock, so that I cannot say whether the lock walls are on a proper level, or whether the lower reaches of the canal will be within reach of the flood water.

Letter No. 688 of 16th ultimo, attached to Agent's letter No. 1,066, 30th idem.

24. The Superintending Engineer has stated that the "masonry works provided for "the main line of canal from Jungalpully to "the Pennair are calculated to meet all requirements of communication and irrigation." Colonel Hemery will no doubt re-consider the communications in preparing the general scheme of roads, and this is necessary in the last 10 miles of the canal where there is no masonry work intended, under the arrangements submitted by the Chief Engineer, to provide a crossing.

25. The 9th section of the canal promises to be remunerative, and before the works can be sufficiently advanced to make use of it, there will be a supply of water for this section in the Kundar from the water thrown in at the 73rd mile of the canal, I would recommend therefore that sanction be given for Rupees 7,92,616 under the head main supply, and for Rupees 11,884 under distribution, leaving those points in the project, which the Government may consider to require modification, to be settled afterwards.

No. 588. From Captain J. MULLINS, R. E., Consulting Engineer, Irrigation and Canal Company, to Colonel C. A. ORR, R. E., Secretary to Government, Public Works Department, dated Madras, 27th September 1864, No. 108:—

SIR,

1. I have the honor to forward the accompanying plan* and estimate amounting to Rupees 1,285 of the wing wall of the Rajoly anicut, which was omitted to be included in the estimate of the 9th Section of the main canal, as noticed in paragraph 3 of my letter No. 93 of the 9th instant.

* With the Agent's letter No. 1,299 of the 23rd September 1864.

2. If the estimates of the 9th Section have not been disposed of, I would suggest the addition of the above sum to the estimate for the Rajoly anicut, otherwise it will remain a distinct item in the accounts.

No. 588A. ORDER THEREON, 28th September 1864, No. 2,807.

1. With these letters the Consulting Engineer Irrigation and Canal Company submits estimates amounting to Rupees 8,05,785 for the 9th section of the Company's main canal, viz., from the 144th to the 178th mile, Rupees 7,93,901 representing the proposed expenditure under the head "Main supply," and Rupees 11,884 under "Distribution."

2. The attention of the Chief Engineer will be drawn, through the Agent, to the omissions pointed out and the suggestions made in paragraphs 6, 7, 8, 9, 14, 15, 16, 19, and 21 of the Consulting Engineer's report.

3. In paragraph 16, Captain Mullins proposes to dispense with the weirs provided for in the estimates, and to substitute a drop in the form shown in a sketch submitted. The grounds of this recommendation are that by the former arrangement there will be much difficulty in preventing the silting up of the canal above the lock, and in order to keep the channel clear, constant alterations of the weirs, at a considerable cost, will be unavoidable; whereas by the latter, the velocity due to the fall will be broken within a short distance, and greater durability will be ensured. Captain Mullins also suggests the advisability of bridging the tail bays of some of the locks; but before sanctioning the adoption of these proposals, the Government request the Agent to obtain and submit the Chief Engineer's views thereon.

4. The subject of paragraphs 22, 23 and 24 will be referred to the Superintending Engineer, 3rd Division, with reference to paragraph 4 of Proceedings No. 2,438, dated 24th August 1864.

5. Agreeably to the recommendation in paragraph 25, the Government sanction the works in the 9th section of the Company's canal, the estimated cost of which is Rupees 8,05,785 in the aggregate.

(True Extract.)

(Signed) J. H. M. SHAW STEWART, Major, R. E.,
Deputy Secretary to Government.

To the Consulting Engineer, Irrigation and Canal Company.
" Agent for do. do.
" Superintending Engineer, 3rd Division.

Exd. S. T. Augustin.

588

Consulting Engineer's Office
Irrigation and Canal Co.
Madras 27th Sept. 1864.

No. 108.

From

Captain John Mullins R.E.
Consulting Engr. I. & Canal Co.

To,

The Secretary to Government
Public Works Department

Sir

I have the honor to forward the accompanying plan & Estimate amounting to Rupees 1285 of the wing wall of the Rajoly Annicut, which was omitted to be included in the estimate of the 9th Section of the main canal, as noticed in Para 3 of my letter No. 93 of the 9th Instant.

With the Agent's letter No. 1299 of the 23rd Sept. 1864.

2 If the estimates of the 9th Section have not been disposed of, I would suggest the addition of the above sum to the estimate for the Rajoly Annicut, otherwise it will remain a distinct item in the accounts.

I have the honor to be
Sir
Your most obed.t Servant
John Mullins Captain R.E.
Cons. Engineer I. and C. Co.

Comp.d Ch.C.

Chantlin Engineer's Office
Inspection Canal Company
Madras, 9 September 1864

No 93.

From Captain J. Mallinson R.E.
One Engineer Officer Canal Company

To The Secretary to Government
Khetpar Department.

Sir,

I have the honor to submit for the sanction of Government the estimates amounting to Rupees 804,500 and other accompaniments as per margin for the Khetpar section of the Main Canal (144 to 178 miles) together with the letter No. 98, dated 2nd ultimo, from the Agent to the Board.

Explanation and Canal Company Rupees
Military Reductions Public Works Office
the Khetpar Loop of the canal in this
section will be 34 miles and 82 chains

Alterations of Cover sent of Estimate

1 General Plan of Canal
2 Head and under Sluice
3 Aqueduct
4 Ditto
5 Ditto
6 Ditto
7 Ditto
8 Ditto
9 Ditto
10 Ditto
11 Ditto
12 Ditto
13 Ditto
14 Ditto
15 Ditto
16 Catchpit
17 Ditto
18 Ditto
19 Ditto
20 Culverts
21 Ditto
22 Ditto
23 Ditto
24 Ditto
25 Irrigating sluice
26 Ditto
27 Ditto
28 Kellie Road Bridge
29 Cross Sections
30 Longitudinal section
31 Sketch map
1 Detailed estimate of Masonry work
1 Ditto
1 Detailed estimate of Earth work
1 Abstract for Ditto

As mentioned in para 2 of my letter No 65 of the 3rd ultimo,

P.W.D. No 4232
9/18 May 1864

the Khetpar section as remeasured and tested by me in June last, and the line has been marked by the Chief Engineer and arrangements for the protection of the canal from the Sutlej will be carried out as detailed in para 3 of my letter No 98 of the 2nd instant.

Yours faithfully
J. Mallinson
Captain R.E.
Inspection Canal Company

Copy in a Letter to England
dated 25 Octr 1864 No 69.

No 888

No 108

From Col. [illegible] Dated [illegible] Sept.
Rec'd [illegible] No 4211
The Cons. Engr. Lahore

To
The Secretary to Government
2 D.P.W.

Dated 27th
Received 28th September

Encl. 2.

Forwards plan & estimate amounting to Rs. 1285 of the wing wall of the Rajoly Aqueduct &c.

No 2807 - 28th Septr. 1864

across the Nundar at Rajoly, with a length of 1,000 feet and a height of 5 feet. The weir or south wing of the Ameut has been however by mistake omitted as noticed in para: 7 of the Agents letter. The river at this place is very favorable for the formation of a weir, the bed being composed entirely of blue limestone of excellent quality, the general level of which is above the proper bed, and it forms therefore a low dam at present, with a few places, however, sufficiently low to drain the upper part of the river. At the north end of the ameut there will be an undersluice of 4 vents of 6'6"×7'0" to be worked by revolving shutters of the same description as those which have been fitted to the sluices of the Soonkasala Ameut, and in close proximity thereto, will be the Headsluice of 6 vents of 2'9"×5 feet. The sills of the undr and head sluices will be on the same level, and 7 feet below the crown of the ameut, so that with the water flush with the crest of the dam, the latter sluices will be capable of discharging into the canal 77000 cubic yards of water per hour.—

The vents of the headsluices will be regulated by gate shutters worked by screw gearing, and the size of the vents is sufficiently small to render it probable that this arrangement will prove efficient.—

4. The top of the undersluices will be 13 feet above the crest of the ameut, but the Roadway of the headsluice is only 10 feet above the same level, and if the latter be sufficient the objection in making the former 3 feet higher is not clear, and as it adds to the length of the pivot shaft of the revolving shutters, it would seem advisable to make the roadways of the two sluices the same.— Level of Undr & Headsluice roadways Diffce Plan No 2.

5. A roadway is provided over the headsluice in connection with the crossing at the tail lock of the 8' section. The general arrangement of these works and their relative positions will be seen in Plan 1. The clear width of roadway over the sluice is 11 feet, that on either side to the ends of the retaining walls, which have a parapet on the outer face, 13 feet Public Roadway provided over Headsluice

13 feet, and beyond these walls, on the top of the embankments, 15 feet. These dimensions are, I think, sufficient for the accommodation of the traffic. I have no plan of the Bridge over the tail bay of the 8' section lock, as the Chief Engineer has submitted no revised estimate for the altered arrangement of the lower part of that section, but, judging from the sketch, the roadway of that bridge will be sufficiently wide.—

Section of the Ameut— 6. The section of the Ameut provides for a single wall 3 feet wide at top, 7 feet at base, and 8 feet high, the rock being benched out to receive the masonry. This section is well adapted to the locality, and the limestone is of such excellent quality that a very durable work may be anticipated. I do not find any provision in the estimates for benching out the rock to form the foundations for the wall.— This is really an important item and great care should be taken that every part of the wall is properly founded, otherwise weakness may be shewn where least expected, and what would cost a rupee or two in the first instance to make good work, may lead if neglected, to the expenditure of many hundreds of rupees to repair damage.—

Scouring sluice Plan 3. 7. At the 3rd-28 a scouring sluice with 4 vents of 3'0"×5'0" and the sill 2 feet below the sole of the canal has been provided.— The design is good, but the defective in one important point for the shutter is intended to work simply against a shoulder and not in a groove, and were the water in the river to rise to a higher level than that in the canal, as indeed is shewn to be in the section at A. B, and as it will sometimes certainly be, the shutter would be blown out into the canal, and the inflow of water would lead to serious damage.— From what I have observed of the action of scouring sluices placed in positions similar to that intended in the present case I am disposed to suggest that the construction of this work be at any rate post poned, if not omitted altogether.— Very generally scouring sluices are circumstanced, by increasing the draught

at

at the headsluice, bring into a canal much solid matter which would otherwise remain in the river, and they carry off less than is so brought in, and my impression is that the minimum clearing is required in a channel to which the minimum quantity of water is admitted. It might be true that a scouring sluice can, by bunding off the canal below it, be made to clear the canal above it in certain states of the river and so effect at a small cost, a clearing which would perhaps, by manual labor alone, amount to a great deal, but in a canal of this description whenever the river is in the requisite state of fresh, the canal will be required for its proper use of conveying water and traffic, and therefore I think in the present case such a work will be of no advantage but rather the reverse.

Principal dimensions of the Canal.

8. The canal is intended to carry 60000 cubic yards of water per hour, with a depth of 5 feet of water, the width at sole being 50 feet and at surface 70 feet. The fall of the upper part is 4 inches (.326) per mile and with these data Beardmore's formula, $\left(\text{mean velocity} = 55\sqrt{\text{h.m.}\times 2f}\right)$ gives 60566 cubic yards per hour as the discharge, but the quantity by Stoddard's tables would be cubic yards 51933.

The side slopes of the canal will be 2 to 1. The minimum height of the embankments above water surface will be 3 feet. The standard sheet of cross sections in embankment is not quite accurate, the water line having been misplaced, and so I cannot say whether, when the level of the ground is below the sole of the canal, any increase to the margin of 3 feet is intended to be allowed, but at any rate care should be taken that the embankments are carefully made up after settlement to at least this level.

Revetments to interior slopes of Canal.

9. No revetments of this description have been provided for and the canal being double banked throughout such work will not generally be necessary. It should however be remembered that much of the soil is extremely bad and where the banks are carried across deep gullies or are from other causes very high, it will be found good economy if stone be at all near, to revet such portions, because, with such soil in such situations, the earthwork does inevitably undergo so considerable a change of form that there are great risks of unequal settlement and consequently of the water finding a passage through the bank and occasioning a breach, and this is not guarded against fully by the fact that the section of the earthwork would in itself be sufficient under ordinary circumstances. The revetment on the other hand while allowing of partial settlement greatly checks horizontal movement and so prevents the formation of cracks which would endanger the safety of the bank.

Canal

10. The total fall of the canal from end to end of the section will be 98.47 feet. Of this 7.47 feet are overcome in the first 26 miles by an average fall of .287 of a foot per mile, and the remainder in the lower 8⅞ miles by gloches with drops totalling 91 feet, so that the lower part will be a still water canal whenever the irrigation sluices are not drawing.

are
nage

11. From the preceding paragraph it will be seen that the country has allowed of arrangements favorable for navigation, the fall being concentrated, thus leaving 26 miles out of the 34⅞ unobstructed by locks, while the sites for the locks in the lower part are on the whole more convenient than would have been the case had the distance been more equally divided.

ke

12. On referring to the end of the abstract estimate it will be seen that the estimated cost of this section is made up of 3 main items

Masonry works	Rs. 4,86,318	on per mile	Rs. 14035	Total per mile Rs. 23,217
Ferry boats	2400	—	69	
Earthworks	2,87,540	—	82.94	
Road diversions	16000	—	461	
	23242		670	
	Total 8,04,500			

the a

The items for masonry works comprises

12 Aqueducts for passing drainage estimated hereat	176,507
1 ditto for a roadway	3875
9 Locks	213139
6 Lock weirs or caliguelahs	10214
2 Public road bridges	13357
15 Culverts	31,884
Khindar Anicut at Rajoly	5030
Head Sluice	10,200
Under Sluice	6878
Scouring Sluice	3350
33 Irrigation Sluices	11884
	486318

Of the above, the item for 33 irrigation sluices, Rupees 11884 requires to be included in a separate estimate, as such sluices belong to distributions and not to Main supply.

13. The total difference of level to be effected by locks-age being 91 feet, and the estimate cost of the locks Rupees 213139, and the cost per foot of lift will be Rupees 2342.—

Estimated cost of lockage per foot of lift

14. Taking the masonry works in the order mentioned in the abstract shewn in para 12, the first to be noticed are the aqueducts.

Masonry works

The general arrangement of these is similar to that of works of the same class already sanctioned by Government. The water way in all except the large aqueducts over the Vaikalair and at 167-21, where it is contracted from 50 feet to 23 feet, will be 25 feet or half the average water width of the canal. The walls on the towing path side are arranged with cells, divided by vertical cross walls generally, but in two cases by horizontal cross walls also, which is, I think, the better and safer plan. The towing paths are shewn unprotected by any sort of railing or parapet and this requires to be remedied.—

Aqueducts
Plans Nos 4 to 11

The piers of the aqueducts with 30 feet arches are 5 feet thick

M. Ch.
169-20-12 arches of 30 feet

thick or 1/6 of the span, and this is running the dimensions rather close to what is barely safe, especially in the aqueduct for the Vaikalair, the piers of which are 15½ feet high to the springing. In the smaller aqueducts with 30 feet arches and piers only 6 feet high, a thickness for the latter of 4 feet or 1/5 of the span has been allowed, and therefore either there is a deficiency of strength in the one case or an excess in the other.—

Ks.

15. The plans of these are generally similar in design to many now in course of construction. In one point there is a considerable improvement, the walls above the upper gates being made 3 feet above the water level, and those below the gates one foot above that level;— whereas in previous plans no margin was allowed. The dimensions of the upper retaining wall and perhaps also those of the side walls in some cases might be modified with advantage. The lock at M. Ch. 176-60 has a 12 feet drop and in case of water getting behind the retaining wall above, the lower part would be subjected to the pressure of a head of 17 feet of water, and its thickness at the centre, the widest part, is only 5 feet, the same thickness is allowed in the lock of 8 feet drop at M. Ch. 169-22. Again the side walls of the 2 locks differ in thickness at the junction of the floor invert by 3 inches only, the difference in height being 4 feet.— These are the first lock plans in which the admission and emission valves have been shewn, their general arrangement can be understood, but the details are not sufficient, nor is the position of the fall from the upper to the lower level shewn.—

Locks

Caliguelahs or weirs.—

16. The design for these is new. They consist of a body wall with its crest 1'6" below the surface of the canal water, the regulation of the discharge being effected by planks working in masonry piers 9 inches thick and 6 feet apart

a foot path 2'0" wide being formed upon the piers. The water after passing the ereet is to flow over an apron of rubble stone in chunam half a yard thick, laid on 6" of concrete. This apron is terminated by a retaining wall 2 feet thick and 2 feet deep, beyond this a horizontal rubble stone apron, of similar thickness to the sloping apron and 10 feet wide, is shewn, and the whole is completed by another retaining wall 2 feet by 2 feet deep. The wing walls are of the usual description.

The stability of a calingulah of this form is, I think, extremely doubtful, and I anticipate very considerable additional outlay for strengthening and for protecting the earthworks beyond the wing walls. The water, after descending a slope of 3 to 1 will go far beyond the masonry walls before losing its increased velocity and its action on the slopes of the weir channel will be great.

Another point which is worth considering is the level of the sill or ereet of the dam, which in these plans it is proposed to place 3½ feet above the sole of the upper reach of the canal. If this arrangement be carried out there will inevitably be much difficulty in preventing the silting up of the canal above the lock. That experience has shewn this to be the result of similar arrangements, there are I believe many instances to prove, and I think weirs thus built have had to be altered at a considerable cost to keep the channel clear. I should be disposed therefore to construct in lieu of these calingulahs a drop of the form shewn in the sketch attached to the calingulah designed for Pr. Ch. 169-56. Works of this form are durable, they kill the velocity due to the fall within a short distance, they can be easily regulated and including front and rear pitching and a good bridge, the cost at the Chief Engineer's rates would be about Rupees 1900 against Rupees 1770 and the great essential a discharge at the level of the canal sole would be obtained. In this particular case the quantity of water to be passed down is taking the

the irrigation sluices above into account, 22000 cubic yards per hour, and the drop sketched would discharge 39000 cubic yards, a sufficient margin, and yet the side walls are but 8 feet apart instead of 36' 3" in the original design, and the facility for bridging is therefore great, and it becomes worth while to consider the advisability of bridging the tail bays of some of the locks, an arrangement which has doubtless been discountenanced by the Chief Engineer in some part owing to the expense which would be occasioned by the bridging of the waste channel with the ordinary description of weir; in the example under notice it would be 3 or 4 thousand Rupees. The last 3 locks have no calingulahs, all the irrigation water being supposed to be expended above.

Public Road Bridges Plan No. 28

17. There are two of these works, both however will be of the same design, the only difference being that the canal is in rather deeper cutting in the one case than in the other. There will be one arch of 40 feet span affording, after providing for a towing path 4 feet wide, a clear waterway of 30 feet.

Culverts. Plans Nos. 20 to 24.

18. These are of the ordinary description. None of them are intended for crossings. Out of the total number 15 there are 14 of six feet and one of 8 feet, all the rectangles 2 and 3 feet.

Irrigation sluices. Plans Nos. 25 to 27.

19. Of these there are 33 to be built, the largest being for 5000 acres. They will be regulated outside the embankment, and in each case provision is made for a high level channel as well as for those on the level of the sluice floor. As some of the sluices on the canal are built to regulate from the inner and some from the outer end, and the two arrangements have not yet been tested, perhaps the better plan is not yet ascertained, but before the sluices included in this estimate are commenced, probably the Chief Engineer will have had opportunities of determining whether any modification admitting of the water being shut off from the sluices is desirable.

20. All

20. All that can be said of the rates until the commencement of operations in the part of Cuddapah in which this section lies, is that they appear ample, and from para. 6 of the Agents letter it will be seen that Colonel Cotton hopes to be able to do the work at lower rates. The correction of errors in this estimate has changed its amount from Rupees 487,118 to Rupees 486,318.

Rates for masonry work.

Rubble stone in chunam	₹ C.Yd.	4-12-4 2-12-
Cut stone	₹ C.Yard	13-0-5 8-0-
Do	₹ S.Yard	12-0-5 2-8-
Do	₹ S.ft feet	0-6-0 0-4-
Arch work	₹ C.Yd.	4-12-0 3-8-0
Stone covering	Do	5-12-0 4-2-0
Beam stone	₹ Cubic feet	0-4-0
Rough pitching	₹ C.Yd.	2-14-0 2-2-0
Puddle	₹ C.Yd.	1-0

21. The rates only of the Earthworks call for any remarks. They appear to be fully sufficient throughout, and though perhaps, in the absence of a liberal use of trial pits, 3 and 4 annas for black cotton soil and kunkers may not be found to leave too wide a margin, care will be required to prevent the actual payment of excessive rates, though within the estimate allowance.

Earthwork rates.

See for instance 151st and 152nd miles & below.

There are a few errors in the estimate, but their extent is so small, that though marked in pencil, it has not seemed necessary to make any alteration.

involving a decrease of Rs. 124-7-0.

22. A list of the crossings has been furnished and forms one of the enclosures of this letter. For convenience I have numbered the items of the list in red ink, and though with reference to the order of Government No. 2438 of the 24th August 1864 para. 4, the required communications across the canal will be carefully ascertained by the local officers of the Department of Public Works, and the Company, it may be useful to make here the few remarks which an examination of the list has led me to think necessary.

Road diversions and crossings.

In No. 3. Mallamulla and Chagulmary appear to be on the same side of the canal.

The communication between Mallamulla and Dudanala has been stopped and as the nearest crossing above is 1¾ miles distant, and that below

below 2 miles it may be of importance to ascertain what the extent of the inconvenience will be.

In No. 5. The diversion of the Kurnool and Cuddapah road in the 151st mile does not seem to be as well laid out as it might be, and I have marked in pencil what appears to be a better line, and the longitudinal section shews that the ground is fairly favorable and if that be found to be the case the abrupt diversion should be avoided.

159 miles. No. 11. The proposed diversion of the Kurnool and Cuddapah Road here is entirely for the purpose of obtaining a site for the Bridge where the canal is in deeper cutting and as unless the advantages be very considerable these loop-diversions are objectionable, I have calculated as far as was practicable what the cost of adhering to the present line would be. The bed of the canal is 102.91 and the level of the present road 103.56. At the proposed site the bed of the canal is 102.84 and the ground level 109.22. At the former place the approach to a bridge with roadway level 125.91 would be 22.35 above ground at the bridge, and with approaches at gradients of 1 in 50 the length of these would be 370 yards each. The average height of embankment would be 3¾ yards and the cubic contents with side slopes of 2 to 1 would be 40,237½ cubic yards (370×54½×2) which at the rate allowed for the canal at this part with an addition of 6 annas for extra height would cost 2 annas a yard or say Rupees 5,000. The estimates allow for the Chief Engineers proposed diversion, Rupees 1990 as marginally noted, but as the ground is 109.22 and the bridge will be 125.84 the least quantity of earth required will be from embankment averaging 27½ yards in height and this gives (275×34½×2) 19320 cubic yards which at the same rate 2 annas would cost Rupees 2,415. The cost therefore on the present

In Earthwork Estimate.
Substratum & Metalling — Rs. 975-0-0
In Bridge Estimate.
Earthwork of approaches
cubic yards 12,052½ @ 1 — 753-4-1
Metalling 1396⅔ square yards @ 3 — 261-14-0
1990-2-1

line would be,

Earthwork ——— Rupees 5,000—

Road surface 7½0×6-44½0 cubic yds @ 5 annas ⅓ ——— 1387-8-

6387-8-

The cost on Chief Engineer's diversion

Earthwork ——— Rupees 2,415—

Road surface 1100×6-6600 cubic yds @ 5 annas ⅓ ——— 2062-8-

4477-8-

Shewing a difference at these rates in favor of the diversion of nearly 2000 Rupees.— I do not know why the rates for the approaches in the Bridge Estimate are entered at one anna for earthwork, and three annas for metalling for the former should be higher than that for the canal and not much lower as is the case, but if these rates be adopted the cost of the present line would be

Earthwork ——— Rupees 2500

Metalling ——— 832-8-

3332-8-

Chief Engineer's diversion.

Earthwork ——— 1207-8-

Metalling ——— 1237-8-

2445—

Difference in favor of latter 887-8-

Before however the diversion is accepted as requisite, I think it should be ascertained more carefully what the saving to the Company would be.—

Some roads leading from Jazeerwarapully in the 160th and 161st miles have been stopped, some can be led to the bridge in the 159th mile, but the village may require some means of communication across the canal in its neighbourhood.—

N.20.— This diversion of the Main Road in the 168th mile of the canal or 23rd mile of the road has formed the subject of a lengthened correspondence. The Chief Engineer was under the impression that the road had not been formed and that the diversion therefore would cost a mere trifle, and perhaps this was the case when the Officers of the Company surveyed the line of the canal though the road had been formed prior to my inspection of the line in June last. The Superintending Engineer 3rd Division estimates the cost of the alteration at Rupees 3,600, and the Chief Engineer thinks this a great deal too much, but in the Estimate he enters no less than Rupees 11,000 for this purpose, and I do not at all understand on what ground this has been thought necessary. The correspondence is contained in the packet forming enclosure N.3, and I have not received an answer to my letter N. 122 of the 20th July to the Agent.—

N.21.— The proposed ferry for all these village communications seems very inadequate, and as the nearest bridge crossing is 3½ miles north, the tail bay of the lock in the 171st mile requires, I think, to be bridged.—

N.24.— This ferry is 3¾ miles from the proposed ferry N.23 and about four miles from the lock in 171st mile. It would be better to bridge either the lock in the 172nd or that in the 173rd mile.—

N.25.— A ferry is not at all adapted for this place. There is a considerable cart traffic from Cazeepett to the westward, and as the lock in the 177th mile has no weir, the bridging of the tail bay will alone be required, and the difference in cost of this and the establishment of a ferry would be very small.—

N.26.— The ferry in the 178th mile will do very well if the Chief Engineer prefers it to bridging the tail lock into the Pennair.

Level of Pennair high floods not given.

23. The level of the Pennair floods is not marked either upon the longitudinal section or upon the Tail Lock, so that I cannot say whether the lock walls are on a proper level, or whether the lower reaches of the canal will be within reach of the flood water.—

Letter N.1688 of 16th Oct. attached to Agent's Letter N.1066-36 infra.

24.— The Superintending Engineer has stated that the masonry works

"works provided for the main line of canal from Surgalpully to the Pennair are calculated to meet all requirements of communication and Irrigation". Colonel Kennery will no doubt reconsider the communications in preparing the general scheme of Roads, and this is necessary in the last 10 miles of the canal where there is no masonry work intended, under the arrangements submitted by the Chief Engineer, to provide a crossing.—

25.— The 9th section of the canal promises to be remunerative and before the works can be sufficiently advanced to make use of it, there will be a supply of water for this section in the Hundar from the water thrown in at the 73rd mile of the canal, I would recommend therefore that sanction be given for Rupees 7,92,616 under the head Main Supply, and for Rupees 11,884 under distribution, leaving those points in the project, which the Government may consider to require modification, to be settled afterwards.—

I have the honor to be
Sir,
Your most obedient Servant
[illegible] Captain
Com. Engrs for L.C. Company

Ed. Inc. Brock

Pro- 15 May 1864 Rs 20625
24 Augt 1864 - 2438-
7 Septr — " — 25 91 — .

Copy in as below to England.
Dy 25 October 1864 No 69.

Dated 9 Sept 1864
Rec 14 Sept 1864

850.

Plans - Pack 1-
Estimate P-2
List of Road Tenders P-2
Letter in original P3

No 587

Submits plans & Estimates for the 9th section of the Main Canal, amounting to Rs. 8,04,500

Bates
Engr

M. No 2807 - 28 Septr 1864

21 Sept 1864 - Rs 22 inf

No 2807

27

Proceedings of the Madras Government.
Under date the 28th September 1864.
Read the following

No 587

From the Consulting Engineer for
Irrigation and Canal Company.

Submits plans and Estimates for the 9th Section of the Main Canal, amounting to Rupees 8,04,500 — " — —

(Here Enter 9th September 1864 No 593.)

From Do —— Do ——

Forwards plan and Estimate amounting to Rs 1285 of the wing wall of the Rajoly Anicut &c.

(Here Enter 27 Sept 1864 No 598.)

With these letters the Consg Engr I & C. Company submits estimates amounting to Rs. 8,05,785 for the ninth section of the Company's Main Canal, viz. from the 144th to the 178th mile, Rs 7,93,901 representing the proposed expenditure under the head "Main supply," & Rs 11,884 under "distribution."

The attention of the Chief Engineer will be drawn, through the Agent, to the omissions pointed out & the suggestions to make in Paras 6, 7, 8, 9, 14, 15, 16, 19 & 21 of the

Consulting Engineers Report.

In Para 16 Captn Mullins proposes to dispense with the weirs provided for in the estimates, & to substitute a drop in the form shewn in a sketch submitted. The grounds of this recommendation are that by the former arrangement there will be much difficulty in preventing the silting up of the Canal above the lock, & in order to keep the channel clear, constant alterations of the weirs, at a Considerable Cost, will be unavoidable, whereas by the latter, the velocity due to the fall will be broken within a short distance, & greater durability will be ensured. Captn Mullins also suggests the advisability of bridging the tail bays of some of the locks; but before sanctioning the adoption of those proposals, the Govt. request the Agent to obtain & submit the Chief Engineers views thereon.

The subject of Paras 22, 23 & 24 will be referred to the Superintgr 3rd Div., with reference to Para 4 of Pro: No 2438, of 24th August 1864.-

Agreeably to the recommendation in Para 25, the Govt. sanction the works in the ninth section of the Company's Canal, the estimated cost of which is Rs ~~6,04,600~~ 8,05,785 in the aggregate.-

The Consg Engrs &c. &c. with 70 Letters. 1 List & 5 Estimates 1 Memo: 3 Plans 81 Encls.

Agent for do

Supt Engr 3rd Div. with 1 List

Dated 29th Sept.

Copy rec'd from Letter to England
of 25th October 1864 No 69

(13)

per P.V. 1864 Dispatch
No: 7 Gov.t for Septr.

No 2807.

No: of Government
of 28 Septr 1864

Estimates amounting
Rs. 8.35.785 for the
Irrigation Govt Main
Canal Sanctioned.

C.M. 2954/65

No 587 of 65

C. 21st Septr 1864 R. 22nd