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MADRAS RECORD OFFICE.

Government of Madras.

_____ DEPARTMENT.

Public Works

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Dated 31-10- 1946.

Not to be folded or roughly handled

Proceedings of the Madras Government, Public Works Department,
31st October 1366.

No. 728. Read the following letter from the Consulting Engineer Irrigation and Canal Campany :—

Reports, for the information of Government, the result of his inspection in September 1866, of the works of the Madras Irrigation and Canal Company. } (Here enter 1st October 1866, No. 70.)

No. 729. ORDER THEREON, 31st October 1866, No. 3,474.

CIVIL WORKS, No. 135

1. The Government have perused this report with much interest, and they resolve to forward copies of it to the Right Honorable the Secretary of State for India, and to the Agent of the Madras Irrigation and Canal Company for communication to the Chief Engineer.

2. The suggestions and remarks of the Consulting Engineer should receive the early attention of the Company's Officers.

3. Adverting to paragraph 15, the Government observe that an estimate of Rupees 420 for a road on either side of the bridge at the cutting in the 20th mile of the Company's Canal was sanctioned in the Order of the 19th November 1864. Rupees 178 were expended on the work up to the 30th April last, and the balance of the estimate has this year been placed at the disposal of the Superintending Engineer of the 3rd Division, who should take measures for completing the work with as little delay as practicable.

4. The Consulting Engineer's suggestion in paragraph 28 that a *District* road be constructed south-west of the road from Paramancherla to Nagatore will be considered in the Revenue Department.

5. Captain Mullins' remarks in paragraphs 48 to 50 are very apposite, and they will doubtless commend themselves to the consideration of the Company's Manager and Chief Engineer.

(True Extract.)

(Signed) CHARLES A. ORR, Colonel, R. E.,
Secretary to Government.

To the Consulting Engineer for Irrigation and Canal Company.
,, Manager for do. do.
,, Superintending Engineer, 3rd Division.
,, Revenue Department.

Exd. T. O'Connor.

Read the following letter from the Consulting Engineer, Irrigation and Canal Company, to the Secretary to Government, Public Works Department, dated Madras, 1st October 1866, No. 70 :—

1. I have the honor to report, for the information of Government, the result of my inspection, in September, of the works of the Madras Irrigation and Canal Company.

2. Soonkasala Anicut and Headworks.—At the time (the 6th and 7th) of my visit, there was a little more than one foot of water passing over the crest of the dam, and, except at the old breach, there has been apparently no damage to the anicut itself from the freshes of the current year. At the old breach a sloping apron was completed some weeks before the first fresh of the season, and, as already reported, this apron failed. The failure, however, has proved to be only partial, and at no time did the damage proceed so far as really to endanger the main wall above, though this damage at an early period of the freshes may well have occasioned much anxiety. On the morning of the 7th, the Chief Engineer and myself crossed, in a basket boat, to the foot of the apron, and examined its condition. We found that the stone and its concrete and masonry covering had been washed out, to a depth of about twelve feet, below the crown of the dam, over the space included between the main, and first parallel retaining-wall, and that the central part of the latter had been destroyed to a depth of from three to four feet below its original level. The materials displaced have been piled up irregularly on the lower part of the apron, forming in rear a steep slope with channels through the debris, through which the overfall water was escaping without creating any further disturbance. Probably the lower part of the apron, with its second retaining wall, has received no further damage than that resulting from the rolling over it of the stone washed out from the upper part. There is now, therefore, a rough water-cushion receiving the overfall at the old breach, and it is evident that so soon as the depth of water in this cushion became sufficient to break the force of the water, the extension of damage was stopped. The maximum height to which the freshes rose this year was to four feet three inches above the crown of the dam, an extreme flood being about eight feet. What height of fresh tries the anicut most is uncertain, and it is dependent upon the rapidity of the rise; but it is perhaps tolerably certain that from the time that the dam is drowned, or when the water below is level with, or above the top of the anicut, the action upon the weir becomes very slight, and that upon the bed or works below it, unappreciable. The failure of the sloping apron has shown that such a work is not adapted to the circumstances of this anicut, for it is stated to have been very carefully constructed, and it had every advantage from the time which elapsed between its completion and its trial. It is now intended to clear away the rubble stone, and to re-build the main wall of the anicut, founding it upon the rock instead of, as heretofore, on rough stone thrown into the lower part of the deep channel in the river bed. This is the only safe plan, and it is only to be regretted that, when the apron work had been put a stop to by the

Proceedings of the Madras Government, No. 2,641, dated 22nd August 1866.

upon the bars at the points of contact; 4th, by placing a winch at the south end of the work, and arranging a rope or chain from the winch to the ends of the capstanbars, in such a manner that the power may be transmitted to the outer ends of two or more bars at once, either for opening or closing the revolving-shutters. By the aid of a winch three or four men would be enabled to work the shutters—at present it is very difficult to apply the power of a sufficient number of men to open or close any of them.

5. First Section, Main Canal, 1st to 18th Miles. *General state.*—This section may be considered to be in fair working order, and quite able to carry a much larger supply than is at present required. Slips occurred this year, soon after the admission of water, in the 4th and 6th miles, and to a less extent in some other places, but the requisite repairs were executed, and the leakage generally is but small compared with what it was when the section was first opened. The revetments in some parts of the 4th mile are too low, being little more than three feet above bed level, and they should be raised to at least two feet above half supply, or six feet above bed level. The calingulah above Yedarur, in the 6th mile, leaks a great deal, and the leakage should be stopped by puddling in front. The culvert in the 9th mile, which was under repair at the time of my visit last year, is now in good order. The leakage is considerable, but not such as to prevent its being a useful and convenient crossing. The approaches at both sides want some little improvement, and the ground in rear of the north-bank should be levelled from the culvert to the old tank-bund, which is used as the road-way from Singaram. The work remaining to be done is—1st, completing cuttings to their full width; 2nd, taking out rock where above bed level; 3rd, correcting irregularities in the bed level; 4th, completing revetments; 5th, raising the banks in some places, and in most of the miles levelling the top and sectioning the embankment. For much of this remaining work there is no immediate necessity, but I think it would be advantageous, both here and elsewhere, that the top of the banks should be levelled so as to admit of the Divisional or Assistant Engineer riding along them without loss of time, so that frequent inspections may be made, and that every portion of the line may come under constant notice.

6. I have suggested to the Chief Engineer that, both in the first and other sections, where the banks are incomplete, and their top level will be more than four feet above water level, and, as at present intended, of considerable width, that it will be an economical and convenient arrangement to form a towing-path at two and a half feet above full canal level, and to make that the fixed level for the top of revetments. This path to be five feet wide, and the bank in rear to be carried up, to the full height of six feet above water level, on a reduced section, with a top width of three or four feet. In some places also there is ground above bed level at the toe of the bank, and the deep water is at a distance, and, as the cost of cutting a channel, fifty or sixty feet wide,

through these small ridges will be very trifling, it will be advisable to do so in due course.

7. *Cultivation.*—The wet cultivation under the canal, in this section, generally looks much more thriving than was the case last year, and, as the season has been an unfavorable one, this shows, I think, that the ryots have benefited by the experience of last year, and have improved their management of wet cultivation. Nidajood is the village where the area is the largest, and where the state of the crops is the most promising. There is still a good deal of dry cultivation on land commanded by the canal, and this, I have little doubt, will for the most part be converted ere long.

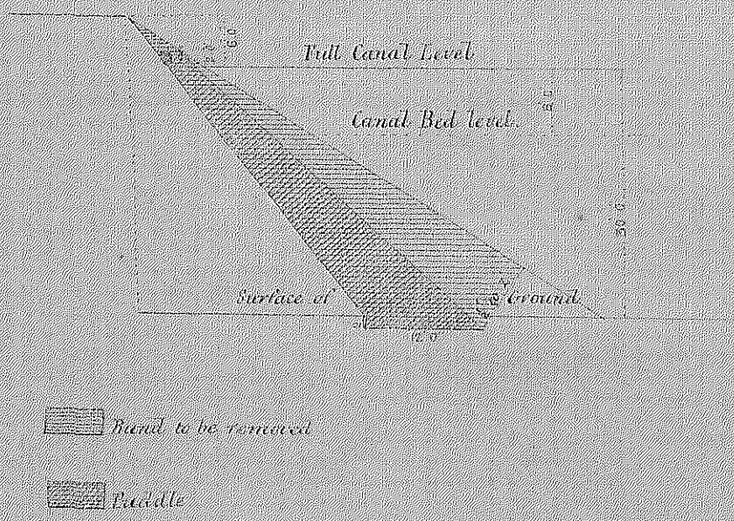
8. Hendry Aqueduct.—The side walls have been completed to eight and a half or eight and three-quarter feet above bed level, and the banks and masonry revetment walls above and below are in good order, and there is little or no leakage under them. The leakage through the arches, spandrils, and abutments of the aqueduct continues much the same as last year.

9. Second Section, Main Canal, 18th to 32nd Miles. *General state.*—The state of this section is at present a matter of serious difficulty, and it is to be feared that much additional expense will have to be incurred before its embankments will become sufficiently free from leakage to enable it to carry a full supply of water, without constant danger of breaching. The breaches, which occurred this year in the 25th and 27th miles, have cut off the supply from all the lower miles until after the middle of September, a date subsequent to which no wet cultivation of this season can be commenced, and it is certain that, at whatever cost may be found really necessary, the whole of the section must be placed in a really safe state, or the cultivation below it—and that above will never exceed an insignificant area—will be liable to lose its supply. This leakage also in many miles is so considerable as to cause a serious waste of water. As has been mentioned in previous reports, the soil of this section of the canal is for the most part of a description which does not admit of a water-tight bank being formed without the exercise of much care and discretion in the execution of the work, and unfortunately the imperative necessity for obtaining a non-porous bank has not been duly kept in view during the progress of the work. In some miles, or portions of miles, there was no good soil immediately in front or in rear of the line of canal: in other parts there was a sufficient quantity of good soil for the centre of the bank, while the greater portion consisted of gravel, kunkur or shale, with more or less earth intermixed. Generally speaking the most has not been made of these materials, for had a core of good soil carefully rammed been placed in the centre of the banks, and carried up above full water level, and had the porous materials been placed on the two faces, and used only to give weight, and resistance to pressure, it his probable that the embankments themselves would have been fairly free from leakage. In very many places moreover, the core should have been founded at two or three feet below the natural surface of the ground, so as to prevent leakage between the base of the bank and that surface. Even with all these precautions there can be no doubt there would have been, for a considerable time at least, a very appreciable amount of leakage through the sub-soil; but this would have entailed little or no risk of the safety of the banks. As it is, whatever materials the pits afforded have been placed indiscriminately in the banks and the consequence is that, even where there is much good soil in them, they are intersected by strata of gravel or other porous material, and leaks show themselves both low down and high up, and as it cannot be ascertained with any degree of certainty at what point, or level of the inner face, the water finds admission, it is most difficult to devise means of stopping the leaks, except where the indraught is so great and localized, as to denote, by eddies on the surface of the water, where the porous stratum crops out on the interior slope. The measures at present, therefore, being taken are rather with a view to prevent breaches arising from the soaking of the rear and lower parts of the banks, which would lead to slips, and the method adopted appears to be successful. This is carry the leakage out of the bank as directly as possible by inserting masses of packed dry rubble stone on the rear slope, or at the toe of the bank, and in some cases the leaks have been diminished, as an indirect result of this operation, by the subsidence of the banks, the concurrent tendency to slip being counteracted by the weight of the mass of stone. Generally suitable stone for these protective works is abundant, and the process is not, therefore, costly; and as, without thus diminishing risk of breaching, the water could not be passed down to the lower miles of the canal, while without the presence of water the lower embankments cannot be tried and their necessary settlement effected, it is advisable that this temporary work should be proceeded with.

10. Means of stopping Leakage.—The means of permanently putting a stop to leakage have formed the subject of much consideration and discussion during the course of the inspection, which I have made with the Chief Engineer; it appears to me, and in this opinion, I think, Mr. Latham is disposed to concur, that the simplest, most efficient, and probably most economical plan will be to do now what should have been done at first, *viz.*, to provide a core of good soil wherever it is found that there is any considerable leakage, and to carry this along over the whole length of defective banks, running it well into those parts which are found to be water-tight. The position of the core, however, will have to be somewhat different to that which it would have occupied had it been formed concurrently with the bank, as to place it now in the centre would involve the removal and re-placement of too large a quantity of material. It is proposed, therefore, to cut down the bank on the inner side, making the side of the cutting as steep as possible, consistently with stability. As the core will be of smaller dimensions than the centre of the bank, if formed only of good soil well rammed, would have been, it should be thoroughly well puddled, and its base, which should be laid at two feet* below the original surface of the ground, should be from nine to twelve feet thick according to the depth of water. The top width of the core should be three feet, and its level two feet above full water level; one face of the core should be in contact with the scarped bank, and over the other, at every half foot of raising, should be laid good soil to the proper section of the inner slope, this soil being well wetted, and rammed hard; and lastly, the revetment should be re-laid over all. This arrangement will, I think, remedy the defects of the banks, and it is certainly much cheaper than a wall, which would require a cross section of about two-thirds of the proposed puddle core.

* Or more if necessary.

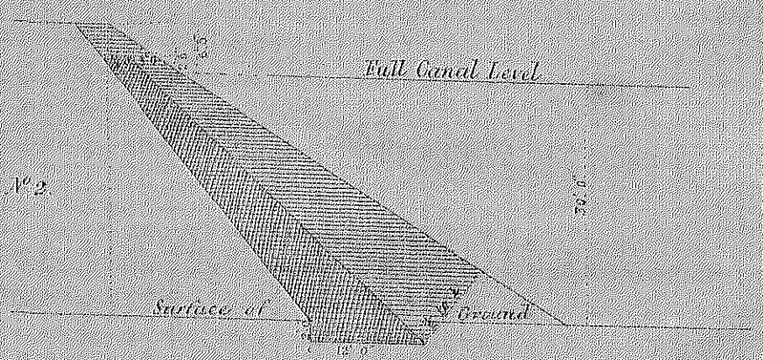
11. I have gone carefully into the question of the cheapest and best way of inserting the puddle core, and I find that the cheapest plan is as shown in this Section No. 1.



The cost of this, for a depth of thirty feet of water, would be as follows :—

	Rs.	A.	P.
Removing bank and revetment 18 cubic yards, at 2 Annas	2	4	0
Puddle, 9⅓ cubic yards, at 3 cubic yards the Rupee	3	2	5
Re-placing soil, 8⅔ cubic yards, at 6 cubic yards the Rupee	1	7	0
Do. revetment, 9⅓ cubic yards, at 4 Annas	2	5	6
Contingencies	0	15	1
Cost of one running yard	10	2	0

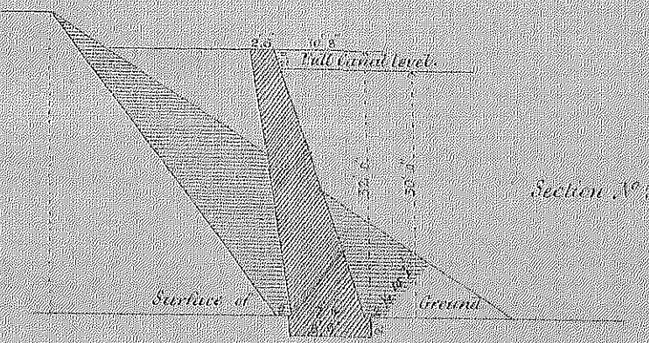
It will, however, perhaps be better to provide for a somewhat thicker covering of soil on the outside of the puddle, so as to preserve it from drying rapidly, and cracking. In the above section this covering comes to nothing at the top, and Section No. 2 places the puddle one yard more towards the centre of the embankment.



The cost of this arrangement would be—

	Rs.	A.	P.
Removal of bank and revetment, 20⅔ cubic yards, at 2 Annas	2	9	1
Puddle, 9⅓ cubic yards, at 3 yards the Rupee	3	2	5
Re-placing 11⅓ cubic yards earth, at 6 yards the Rupee	1	14	0
Do. revetment, 9⅓ cubic yards, at 4 Annas	2	5	4
Contingencies	1	0	2
Cost of one running yard	10	15	0

Lastly, to show by way of comparison what the cost of a masonry revetment wall would be, Section No. 3 is subjoined :—



the cost would be—

	Rs.	A.	P.
Removing bank and revetment, 16⅓ cubic yards, at 2 Annas	2	0	9
Wall, 6⅔ cubic yards, at 2¾ Rupees	18	0	5
Re-filling behind wall, 13½ cubic yards, at 6 yards the Rupee	2	4	4
Do. in front of wall, 2⅓ cubic yards do.	0	6	9
Contingencies	2	3	9
Cost of one running yard	25	0	0

Such a wall, with careful filling in behind, would, I have no doubt, be water-tight. The wall section is about as small as would be safe, and as its centre of gravity just cuts the inner edge of its base, the full strength is made available to resist the pressure of the bank in rear, and it would of course be necessary to tamp the earth thoroughly, so that the pressure of water in the opposite direction might be transmitted to the bank at once. The much greater cost, however, precludes, I think, the adoption of the wall where a puddle core can be inserted as shown in the Section No. 2.

12. Probable Cost of stopping Leakage.—The cost of stopping leakage cannot be estimated with any approach to accuracy without a detailed examination of the banks throughout the section, which cannot be fully made until the water has reached the end of the 32nd mile. It is probable, however, that the average height of the banks which required to be made water-tight is less than the 36 feet shown in the above sections, and perhaps, therefore, 16,000 Rupees a mile will suffice for

the arrangement given in Section No. 2, and, if one-third of the whole length of the section require to be dealt with, Rupees 80,000 will be the approximate cost. The estimates already sanctioned amount to Rupees 13,76,415, and I have now in the office a supplemental estimate, Rupees 4,20,950, the submission of which is delayed until the receipt of information as to the quantities of work already done, only that remaining to be done being shown in the comparative Statement received. I have also just submitted for sanction two estimates amounting to Rupees 4,709, for closing breaches in the 25th and 27th miles, and, therefore, the probable cost of the section, exclusive of remedial measures in connection with leakage, stands thus:—

No. 62, dated 13th September 1866.

Estimates already sanctioned	Rupees	13,76,415
Do. submitted for sanction	,,	4,709
Do. to be submitted	,,	4,20,950
	Rupees	18,02,074

and the length of the section being 14¼ miles the average cost per mile becomes Rupees 1,22,921, to which the probable addition for the modification now recommended will average, say, Rupees 6,000 a mile, making altogether Rupees 1,28,921 a mile; and even should the five miles, I have supposed to require puddling, be found to need doubling, the outlay on this account will still form an insignificant addition to the ultimate cost, and as there can, I think, be little doubt of the vital importance of stopping leakage wherever found to prevail to any considerable extent, the requisite estimates, whether in accordance with the plan suggested above or not, should be prepared and submitted for sanction as soon as possible, and afterwards carried out with all possible despatch, in order that, on the admission of water in 1867, it may be sent down to the lower sections without fear of accident.

13. Masonry and Core Section Walls.—The walls which for a very considerable portion of this section take the place of ordinary embankments, have been noticed in former reports. The masonry walls were in most cases too slight, and their mode of construction rendered it highly probable that they would leak greatly. Up to the date of my last report only one of the high walls had been tried, and the leakage was great, and though the quantity of water passing through it decreased considerably from the maximum, which occurred at the first admission of water, it is still very considerable, and the backing, while it tends greatly to the safety of the wall, does not influence the leakage. Similarly the other walls, which have since been reached by the water, leak more or less, and in all cases to such an extent as to waste more water than can be spared. Thus the tank at the fifty feet wall, in the 26th mile, sunk some eleven or twelve feet during the time* the supply was cut off by the breach in the 25th mile. The rubble walls, with an earthen core, answer well where the execution has been sufficiently careful; but it was noticed last year that in some places, where they were then in progress, enough care was not being shown in the selection of earth, in founding the core wall below the original ground surface, and in thoroughly wetting and ramming every layer, and the result is that these core walls in some places leak considerably. It was also remarked that the masonry and core walls were not well adapted for forming a junction with each other, and though, in the 26th mile where the change from the masonry to the core section was first made, the junction was carefully executed, the leakage is great, and the core has sunk considerably, and it will be necessary to take down and re-construct the damaged part. In the 28th mile, where a similar junction has been effected with much less care and an insufficient overlap, it would not be surprising were a failure to occur. I also noticed that the earth-work of the core section walls, executed since my last tour of inspection, was much softer than it should have been if thoroughly well rammed. It is true there had been heavy rain, but if this earth-work is to prevent the passage of canal water horizontally, it ought not to admit rain too readily vertically, and though it might naturally have been expected that it would be muddy and wet after rain, its being soft and porous shows that it was not properly consolidated. The considerable length of wall of this section, at the lower part of the 28th and first part of 29th mile, was particularly opened to this objection.

Proceedings of the Madras Government, 24th October 1865, No. 3,191, Report paragraph 16.

*About five weeks.

Proceedings of the Madras Government, 15th May 1865, No. 1,317, Report paragraph 37.

Proceedings of the Madras Government, 24th October 1865, No. 3,191, Report paragraph 18.

14. This section of the canal has suffered from the restriction of expenditure, and it is in a less advanced state than it should be, considering for how long a time the first section has been ready to supply it, and that the third section also is much more complete. The cuttings are more specially behindhand, and even the thirty feet widths, which it was resolved, when funds were likely to run short, to take out first, are not in all cases sufficiently complete to admit of water passing unimpeded. Moreover, where these cuttings are of any depth, the narrow width is insufficient for even the present requirements of the canal, for the state of the banks obliges the head of water to be restricted, and the supply, owing to leakage, becomes so much reduced, that the filling of the tanks occupies a very long time. I have suggested to the Chief Engineer that it will be a good plan to widen these cuts, while the water is running at high velocities through them to the tanks below, as thus the cost of excavation will be much reduced, and, what is of more importance, a large quantity of silt will be carried down and deposited in the tanks above the walls and embankments, and probably reduce the leakage at these points. Similarly channels below the cuts into the tanks may be formed at a very small cost, where the soil is not actual rock, and thus the filling, in this and future years, may be facilitated, and the course of the water regulated.

15. I will not lengthen this report by noticing in detail the state of the banks and masonry works in each mile, but I may mention that the bridge at the cutting in the 20th mile has been completed and opened for traffic. North of this bridge the roads now belong to the Kurnool Municipality, and I hope they will receive the attention which they require before long. On the south side the Department of Public Works should, as was arranged when the bridge was ordered to be built, make a junction with the Kadrabagh road. I may add that this bridge affords an opportunity now of making a

Proceedings of the Madras Government, No. 2,574, dated 5th September 1864.

loop-drive for the residents of Kurnool, which would be very much superior to tha which formerly existed, and which was interfered with by the canal. The deep cutting in the 20th mile has made considerable progress during the year, and, except where the hard rock occurs near the upper end, it is not far from complete.

16. Water expected to reach the end of Second Section and enter Third Section at end of September.—Should no further accident occur to the banks, it was expected that the water would reach the commencement of the third section by the end of September.

17. *Cultivation.*—Considering the late date at which water was admitted into the section, and the uncertainty as to the continuance of a supply, perhaps it is not surprising that the area of land converted from dry to wet cultivation is but small. In the neighbourhood of Kurnool, and between this and Kadrabagh, and at the latter village, there are some promising crops. Lower down the sharp slope of the ground, its small width between the ravines, and the labor therefore of forming paddy fields, will tend to postpone any alteration in the mode of cultivation, until the profitableness of irrigated crops has been demonstrated. Indeed, the water, at the time of my inspection, had not reached the first open ground at Podoor, in the 29th mile, below Kadrabagh. Below that there will be a fair amount in the villages, of which Sultanpore is the most considerable, lying in the small piece of territory belonging to the Nizam on the south side of the Toombuddra, and here the villagers seem anxious to make use of the water as soon as it can be supplied to them.

18. Third Section, Main Canal, 33rd to 43rd Miles. *General state.*—This section is much more advanced than that above it. The embankments in the 33rd and 34th miles are generally very high, and they have settled considerably, and no doubt further extensive settlements will occur when the water reaches them for the first time. Their behaviour will depend upon the way in which the materials of which they are composed happen to have been arranged. They contain a large proportion of water-tight soil, with some gravel, and a good deal of a white soluble earth. The 35th mile is chiefly in cutting, and no difficulty is likely to occur in passing down the water, though, as the sub-soil is almost entirely kunkur, a considerable portion of the supply will be absorbed. At the lower end of the mile, immediately above calingulah No. 18, a length of core wall has been built since my last visit. From the 36th to the 39th miles the banks are of considerable, but not excessive, height; the soil is black cotton, resting on limestone. The only work recently done is the bottoming out of the canal to a width of thirty feet, and these cuttings are for the most part very shallow, so that a large supply can be sent down without widening them. In the 38th mile the masonry wall has a leak through a weep-hole, which is running like a sluice. This wall has no backing except a little black cotton soil two to two and a half feet high, which is useless. All along this part of the canal there is more or less water from rain-fall drainage. Calingulah No. 19, in the 39th mile, has had a bank of soil placed in front to stop leakage. An apron or water-cushion is needed in rear. The cutting at the lower end of the mile has made good progress, though there is still a great deal of work to be done. As seemed not improbable last year, the hard conglomerate rock at the surface proved to be only a stratum

Proceedings of Madras Government, 15th May 1865, No. 1,317, Report paragraph 52.

one to two feet thick, below which there is tolerably compact gravel. The higher parts of the masonry walls at the upper end of the 40th mile will need backing; they are not safe at present. The banks below this to the cutting at Malayála are very massive, and, except at a few places, they are complete. Settlements going on satisfactorily. The cutting—a short one—is out to thirty feet width, and the widening can be cheaply executed when the canal water is sent down into the tank below.

In my first report* it was noticed that from the end of the cutting for a short length the embankment would require a clay core to prevent leakage, the soil being gravel with very little earth. This core does not appear to have been inserted, and the bank leaks much, even with the small head of water now against it, and it will require to be puddled at once. The leak is just opposite the east face of the village. The deep sluice at the lower end of the mile was discharging to a small extent, and the shutters were put down by the Chief Engineer. The differential pulleys, with which this sluice is fitted, are an excellent raising power, but they will be none too powerful when the head of water is greater. Before the sluice is used to discharge any considerable quantity of water the waste channel must be revetted strongly, immediately opposite the vent, or the fields will be injured. It will also be necessary, I think, to increase the capacity of the channel to some extent. Thence to the end of the section there is drainage water all along, and a larger supply than is likely to be sent down this year, can be conveyed without difficulty. Altogether, though it is probable that the high banks, in the 33, 34, 41, 42, and some other miles, may give considerable trouble, and demand careful watching until they have settled down, and taken their ultimate form, the passage of water through this section will be a much easier and quicker work than it has proved to be in the second section.

*Proceedings of Madras Government, No. 2,438, 24th August 1864, Report paragraph 57.

19. *Distribution and Cultivation.*—There is as yet no wet cultivation under the canal in this section, and the distribution works are at present confined to the irrigation sluices in the canal bank. I hope the Chief Engineer will be able to arrange for the cutting of the necessary channels, so that they may be ready by the 1st June next at latest. The earlier they are in readiness to distribute water, the sooner will applications for water be sent in, and the larger will be the area which will be brought under wet cultivation.

20. Fourth Section, Main Canal, 44th to 60th Miles. *General state.*—At the time of my inspection last year, it was hoped that, even if the whole section could not be got ready for this year's cultivation, at least that part of it down to Puggydial, in the 53rd mile, could be sufficiently completed, and when, owing to the failure of funds, the works below Puggydial were stopped, provision was made for advancing those above this point. The arrangements have been so far successful that a small supply could at once be passed down, and, except at the tank in the 51st mile, where the opening left at the nullah has been closed by a bank of comparatively small section, and to a height some three feet lower than was wanted for this season, while the revetment is but little above bed level, the works are sufficiently advanced to carry a half supply without risk. There is drainage water in the canal all along this portion, and the tanks in the 47th and 51st miles are full to bed level, so that the earth-works have obtained a considerable seasoning, and, when the canal water

reaches the beginning of the section, three or four days will suffice to pass it along as far as Puggydial. There is nevertheless plenty of work to be done, much of which would be the better for not being postponed. Thus in the 48th mile the banks are irregular, and where the soil is soft they get much cut up and washed down, and the longer this goes on, the greater will be the quantity of material to be re-placed. The tank banks should be fully completed, so that they may have time to settle before they are subjected to the additional head of water, and it is certainly running an unnecessary risk to have the part of that in the 51st mile, which was most liable to accident, much weaker than any portion either above are below, added to which the revetment here is much lower than at other places where it was less needed. Moreover, where the banks have cracked in settling, the earth-work should be assisted in consolidating and finding its bearing, and this can be done much more cheaply and efficiently while there is water close by, than in the dry season. Again, in the 46th and 52nd miles the calingulahs have been furnished with powerful under-sluices, which are intended to discharge all surplus water, and at the latter mile all water which is sent down will, until a further length of canal is opened, be allowed to escape, and it is of importance as regards economy, and very necessary also, that all work required to confine the surplus water to its proper and intended line of outfall should be complete, before the sluices are brought into use; and in order that this may be done efficiently, it is necessary to calculate the discharge and the velocity due to the fall of the country, so that the designs may be consistent with the circumstances. At Puggydial the fourteen feet culvert which is to form a roadway as well as a drainage channel is approaching completion, and the work and materials are much better than those of the culverts previously built. It will be a matter of some difficulty to form and maintain a good roadway, as the subsoil is shale in nearly horizontal courses and probably either concrete or a paving of stone on edge will be needed, for gravel would not be likely to stand. There is hardly any double banked canal below Puggydial in the fourth section. The banks are, or will be, generally very high, and there is a great deal of work to be done to complete them. In the 54th mile, two openings in the bank had been left. The upper one has been closed to about bed level; the lower one is still open. Similarly in the 55th mile there is a gap in the bank at the 35th chain; the earth-works are half to three-quarters done, and the revetments about half. In the 56th mile, much earth-work remains to be done, and the revetments are still less advanced. In the 57th mile, the bank has been closed and water retained, but the earth-works are very irregular and some parts are not much more than three feet above present water level; the Chief Engineer has directed this to be attended to. The soil is generally good, but at the low parts of the bank I observed that some shale and gravel have been put much further into the bank than is at all safe, and in one or two places they form a layer right through, and would probably cause a leak, if not a breach. Such materials should be confined entirely to the faces of the banks, where they may be made very useful. The revetments in the greater part of this mile not yet commenced. In the 58th mile, the opening at the large Vagú has not been closed, but the earth-works and revetments are well advanced. The banks in the 59th mile are rather behindhand, and they and the revetments are irregular in height. The eight feet culvert in this mile has its abutments up to level of springing. The calingulah is two-thirds done. The bridge in the 60th mile has made but little progress since last year.

The side spans have been filled in with earth, and, in the middle of the centre span, a pier has been built with the intention of forming a temporary bridge, which will not now be required. These expenditures, on temporary works, unfortunately absorb a great deal of money. The culvert, a short distance below bridge, is nearly up to springing level, and much silted.

21. Work to be done—Fourth Section should be pushed on if the Canal is to be opened in 1867, and below the 60th Mile.—The above remarks will suffice to show that there is none too much time, before the commencement of the irrigation season of 1867, to get the fourth section into proper working order. Except at the culvert at Puggydial there is no work going on, and the Chief Engineer is unable to do any thing but emergent work until he receives further instructions from the Board of Directors. It is to be regretted also that the best season for the earth-works will be gone before any further progress is made with the embankments, and that, as in other miles higher up, revetments will be of necessity laid on unconsolidated banks, and will slip and require re-building.

22. *Distribution Works.*—The Officer in charge is engaged in investigating and estimating for these, and much information, as regards the fall of the country, has been put on paper. It will take some little time to complete the estimates and plans for any one of the irrigation sub-divisions, into which the section has for convenience been sub-divided. The fall of the country is much greater than I had imagined. It varies from twenty to thirty-five feet a mile, the soil being red or black cotton with shale as the substratum, the rock being generally not far from the surface, and in some parts cropping out. The Chief Engineer intends using the natural drainage channels, which have in most parts gone down to rock, to carry the water down to the levels most suitable for distribution by artificial channels, and this arrangement, though objectionable in a flat country, is in the present case likely to be an efficient one, if only the details and circumstances be duly considered and provided for. From the supplying nullahs falling contour channels will be arranged, dividing the country into moderate areas, over which the water will be distributed by minor direct channels.

The channels laid down and the capacity of which vary from 4,000 to 6,000 cubic yards an hour were intended to run one and a half feet deep with a fall of one and a quarter to two feet a mile, but on investigation it was found that, by reducing the depths to one foot, the velocity, with a fall of six feet a mile, would not exceed two miles an hour, which will not be excessive for red soil, one and a half miles an hour will be better for black cotton soil, and on the other hand, where the shale is at or very close to the surface, the fall corresponding to a velocity of four or five miles an hour may be given. Small channels with a small depth of water may be taken at almost any slope. If these principal distribution channels be completed before the commencement of the next irrigation season, so that the ryots may see that certain areas are provided for, and so that, after the applications for water are sent in, there may be time for the arrangement of the necessary minor channels, it is probable that 1867 may see a considerable extent of land under cultivation for, in addition to the fields which now are under dry cultivation, there is a great deal of waste with a red soil, very suitable for paddy, and the

people may be disposed at any rate to try this, even if they should be disinclined at first to give up their dry crops on the lands where they have been successfully cultivated. As has however been remarked before, the demands for water will be trifling until the people see it running through the lands of their villages. The population of this part of the Kurnool District is small, and the villages are far apart. When a new and successful cultivation has been established however, even on a small scale, no doubt the ryots will be able to offer attractive terms to the population beyond the Toombuddra and Kistna.

23. Canal Crossings.—The communications across the canal in this section which have already been provided, or which it is intended to construct, are shown in the following Statement:—

No.	Miles and chains.		Villages accommodated.	Class.	Description.	For what traffic.	Remarks.
1	44	13	Nagatore, &c ...	1st.	Bridge	All kinds.	
2	45	9	Condapragatoro...	3rd.	Culvert, 8 feet.	Foot passengers and cattle.	
3	47	15	Nagatore, Kistna ferry and fields.	2nd.	Bridge, 9 feet.	All kinds. ...	In lieu of an abandoned 8 feet culvert. P. M. G., No. 1,317, 15th May 1865, Report paragraph 61.
4	48	54	Muchmurri... ...	3rd	Culvert. 8 feet.	Foot & cattle.	
5	52	31	Puggydial	2nd.	Culvert, 14 feet.	All kinds.	
6	56	74	Bolawaram and Lutchmapooram.	3rd.	Bridge, 5 feet.	Foot & cattle.	In lieu of ferry.
7	58	38	Bolawaram and Patapad.	3rd.	Culvert, 8 feet	Do.	
8	59	23	Japad and road...	1st.	Bridge	All kinds.	

No. 3 has been included in a supplemental masonry estimate now in this office. No. 6 has to be estimated for when an approved design has been prepared.

24. There will thus be eight crossings in 17 miles, of which four will carry all kinds of traffic, and the other four foot-passengers and cattle only. The villages are very far apart, and there are no made roads. I have at different times ridden over the country on both sides of the canal, and I think these crossings will suffice for the accommodation of the cart traffic, and provide convenient access to the fields. The culverts all require more or less work to be done to them to render them easily accessible, the direct ramps are either cut up by the drainage, or where there is slate rock the soil is washed away, leaving a surface not always easy for any one on foot to climb over it; what seems to me necessary, after an examination of a number of these culverts, is a comparative flat for 20 to 30 yards above the upper face of the culvert, and thence a ramp for traffic and a separate inlet for drainage, so that the former may not be injured and, where there is rock, the inlet water may be with advantage taken in at a vertical fall somewhat recessed, and then with a little management there would be hardly any silt.

25. Fifth Section, Main Canal, 61st to 72nd Miles. *General State.*—Is much the same as that noticed in my last report, and very little has been done, except at the Teragopila aqueduct in the 63rd mile. The section could be got ready in three or four months to carry much more water than will be needed during the next year or two. There is not very much work to be done any where except in the 63rd mile, but nearly all along there is some work, and it would require some energy to put some of the culverts to rights, and complete others, in the time named.

26. I will confine my remarks to the few works requiring notice. In the 61st mile a short length of a 14 feet culvert has been constructed. This work is to take the place of an eight feet culvert which failed last year. In the 63rd mile the Teragopila aqueduct has made considerable progress; the piers and abutments are up to springing level, and the wings for the most part are some feet higher; one-third in width of the arches has been turned. The work is good, and the design suitable,* and the material, a laminated limestone, is all that could be wished for in the construction of excellent masonry at a moderate cost, and, after a careful inspection, I could see no trace of unnecessary work in stone dressing, the only highly dressed stones being the skew backs and the quoins. As the Progress Report, however, shows the expenditure, on the about $\frac{3}{8}$ths or $\frac{3}{4}$ths finished work, is double the estimate, and I gather from what the Chief Engineer mentioned regarding the rates of the work done, and those to be allowed for completion, that $\frac{5}{8}$ths to $\frac{7}{8}$ths of the expenditure incurred should have sufficed for the work done. This question of cost, however, will be gone into when the revised estimate comes under review. The embankments above and below the aqueduct are far from complete, and I think especially after the experience of the difficulty at the Kadrabagh aqueduct, arising from the hasty completion of heavy banks, funds should have been provided for completing these banks to full section, and giving them the benefit of one monsoon at least before putting on any revetments. A considerable quantity of revetment, with the joints pointed, has been executed since last year on the right bank below the aqueduct, and much of this has gone by a slip of the earth, as might have been expected, and what object was to be gained by revetting there, when much of the embankment is not half done, it is difficult to imagine, especially as a good many months would have been necessary for the completion of the aqueduct itself. Moreover, at these banks, as in so many other places, the vast difference in stability gained by carrying up the earth-work in section has been lost sight of. This is a matter of importance in all earth-works, but for banks which are required to settle equally and regularly, and be as water-tight as possible, it is essential that due care in this respect should be taken. If an irregular bank of small section be first formed, and then subsequently raised and widened, slips are almost inevitable, and cracks also, and there is then no getting at the interior to consolidate loose parts. If, on the other hand, banks are built up foot by foot and of the full width, every settlement occasions an advantageous consolidation, and the solidity of the bank increases in every direction from the surface inwards. At the lower end of the mile also the mistake of stratifying the bank with porous shale has been committed, and this should be corrected.

Paragraph 41 of Report. Proceedings Madras Government, No. 3,191, 24th October 1865.

* Except perhaps that the wings have hardly enough grasp of the banks.

27. The eight feet culvert in the 64th mile is going to pieces. It was built or designed prior to the double banking of the canal here, and is not now required, if the little drainage can be turned down to the Vagu without difficulty, and this

will be considered by the Chief Engineer. If re-built it will form a crossing. The sides and top of the similar culvert in the 66th mile should be puddled, while there is water to be had closely: the masonry is indifferent, and a thick bank of puddle is the only way of making up in some measure for porous construction. The ground in rear of the right bank of the canal requires, in many places, to be brought into communication with the culverts, so that drainage may not accumulate.

Instead of an eight feet culvert in the 67th mile, one of fourteen feet is to be built, and judging from the flood marks of this year's drainage, the alteration was quite necessary.

28. Canal Crossings.—The crossings provided or recommended for this section are—

No.	Miles and Chains.		Villages accommodated.	Class.	Description.	For what traffic.	Remarks.
1	60	29	Jupad and fields	3	Culvert, 14 feet.	Foot and cattle.	
2	61	9	Do.	3	Do. 8 ,,	Do.	
3	61	52	Teragopila and Tegadancha	3	Do. 8 ,,	Do.	
4	62	49	Teragopila...	1	Aqueduct, one arch	All kinds.	
5	63	75	Bunnur and fields ...	3	Culvert, 8 feet.	Foot and cattle.	Dependent upon its reconstruction.
6	65	42	Jutur and Rudravuram.	3	Do. 8 ,,	Do.	
7	66	79	Lingala Rudravuram and Toorcheala road.	2	Do. 14 ,,	All kinds.	
8	69	20	Pamalapad	2	Bridge, 9 ,,	Do. ...	In lieu of ferry.
9	70	37	Kumbalpilly	3	Culvert, 8 ,,	Foot and cattle.	
10	71	36	Yerragudur and Mittacondal	1	Bridge	All kinds.	

No. 5 is doubtful, but it can be dispensed with, if not required for drainage, without difficulty, and the twelve miles of the section will then have nine crossings, of which four will pass all kinds of traffic. The approaches to the culverts of this section require improvement equally with those of the preceding section. No. 8—a bridge in lieu of a ferry—will be a great improvement, and the change was suggested by the Chief Engineer, who has shown, throughout the discussion of the subject of crossings, a desire to make due provision for the wants and convenience of the villagers. Before quitting this subject, I may remark that the Teragopila aqueduct will be a first-rate crossing, but that the track from the village is, both in wet and dry weather, extremely bad, and it would be well were this levelled, sectioned, and drained, and were a district road laid out south-west to the road from Parmanchcrla to Nagatore.

29. Bowanassy Station Buildings.—These require immediate attention, as some of them have been already much injured by the monsoon, and all the thatched buildings are more or less in need of repair. These are many of them permanent buildings, the cost of which has been debited to Capital, and there are others which it would be a pity to allow to go to ruin, though they are for temporary purposes only; as when the works are re-started there will be a demand for such accommodation.

30. Distribution Works.—I believe some progress was made prior to the reduction of the establishments in levelling and surveying for distribution channels, but I have not heard with what results. There is no one available at present to go on with this important work.

31. Sixth Section, Main Canal, 73rd to 91st Miles. *General state.*—In March last year the works in the upper six miles of the section, which will carry irrigation water, were being pushed forward, while below this only a little contract work was in progress, and was to be stopped as soon as possible. I saw the head works again in September 1865, and I find that some progress has been made at these since then, though all work has for sometime been stopped. The upper gates of the head lock have been hung, but the sill has not been completed. The valves also have been fitted in their places—the timber of their vertical shafts is indifferent, and the capstan heads have been made, like those at Soonkasala, with the bolts at the corners of the bar sockets, and this arrangement is found to destroy the bars. All the wood work of the valves and shutters wants coating with paint or tar.

The canal banks below lock, when the bed is at or above ground level will certainly leak much, and cause trouble and expense, if made entirely of loose shale and kunkur, as is now the case in some places. The drainage requires to be conducted to culverts Nos. 1 and 2; at present it goes any where. From the lock to culvert No. 3, but little work has been done since last year, but below this the banks are well advanced. Wherever shale occurs the errors of the second section have been repeated, and a some places the materials have been thrown down, so as almost to ensure great leakage. There is a cutting of some depth between Culverts three and four, and there is fair soil at the top for nine to twelve inches, below which there is nothing but red shale. If the former has been made use of as a core for the banks, this will do, but if not so used, there will be much leakage, even with the small depth of water above ground level.

The outfall channel of culvert No. 4 wants cutting out more, as there are eighteen inches of water standing on floor at lower end.

A few months' work would suffice to complete the canal down to the end of the 78th mile, beyond which there will be no water carried for irrigation by the main line.

At lock No. 2, in the 79th mile, there are some bar iron rails, and other movable property, lying about, liable to be stolen.

32. From this point to the 85th mile I rode along the line; there has been nothing done during the last year, and there is consequently nothing to report, except that care appeared to have been taken to shut out drainage from the partly-formed portions of canal.

33. Valapanoor Station Buildings.—These buildings need attention; the terraced roof leaks, and the verandah roof, being too lightly timbered for the span, has sagged, and should be supported. I told the peon in charge to put struts under two or three of the valley rafters, which looked as if the next shower would bring them, and much of the roofing, down together. The spouts of the terraced roof discharge from much too great a height on to the roof of the verandah.

34. Distribution Works.—The estimates for distribution channels in connection with this section, which, in Proceedings Madras Government, No. 800, dated

23rd March 1865, were ordered to be returned for revision, have not yet been re-submitted for sanction.

35. Seventh Section, Main Canal, 92nd to 114th Miles. *Head Works.*—The anicut across the Caulee was completed to about five feet in height after my inspection in March 1865. This is half the full height. The dam is in good order, and, though it was reported that it had suffered from the freshes of 1865, coping and masonry valued at Rupees 210 being washed away; the damage has been repaired, and I did not see any signs of injury from this year's freshes. The bed of the river has been much changed, and the rock, on which the anicut is built, has proved to be quite unable to stand the overfall; and of course, were the weir twice as high, the effect of the overfall would be greatly increased. An apron is provided for in the estimate, but I believe the Chief Engineer has not yet decided upon the works to be done to render the anicut and head works complete and secure.

36. In August 1865 there was a high fresh in the Caulee, which was considered to show that the present level of the head sluice and wings is too low. I tried to find some marks of this fresh, but all the evidence afforded by the works seemed to negative the idea of a very high fresh. The east wing of the anicut is not connected with the right bank of the canal, and the ground there is more than six feet below the top of the wall. No water apparently passed through this gap, for had it done so, the side slope of the canal must have been guttered. The east wing of the head sluice again is not joined to the left bank of the canal, and the ground there is some nine or ten feet lower than the top of the wall, and here the water did find its way into the canal, though only to a small extent. It would seem, therefore, that the highest fresh rose to somewhere between six and nine feet below the top of the head-sluice walls, and as the depth of water running in was small, and as none passed over any but the lowest ground, I think the fresh did not rise to within eight and a half feet of the top of the walls, which would be equivalent to nine feet on the floor of the under-sluices, or about four feet over crest of weir. Raising the anicut five feet will add something less than five feet to the height of such a fresh, but, without information as to the difference of level of the head and tail water in August 1865, I have no means of judging what the exact height would be. It is certainly very desirable that the masonry works should be at least four feet, and the banks connected with them six feet above maximum flood level, and the Chief Engineer intends that the margin of safety for the canal bank shall be that just named. I believe that, if most of the bank is not now that height, it can be made so without extra expense. In the reports,* however, received at the time, it was said that the fresh had risen to 19 feet† or 17½ feet on the sill of under-sluices, and the section recently received makes the level of that fresh 14½ feet on head-sluice, or 17½ feet on under-sluice, sill, which would be equivalent to 12⅓ feet on the crest of the anicut. It is of importance, therefore, that the level of maximum flood in the Caulee should be reliably ascertained, in order that on the one hand the head works may not be made too low, or on the other some six or seven feet too high. I do not know on what information the level of the freshes of 1865 was fixed, but unless the river was seen at the time by a competent Officer, I should be disposed to consider the report very far from accurate, and if the area, square miles 207, of the drainage basin, and the character of the rain-fall in that part of the country be considered, the improbability of such a fresh will be sufficiently great to show the necessity for a careful examination of the evidence in support of it.

* Chief Engineer's Report for September 1865.

† Do. letter No. 1,000, 22nd November 1865.

37. *General state of the Section.*—But very little work has been done since March last year, and no mile is complete, while the masonry works have hardly been commenced. I should not have thought it worth while to make an inspection, had not it appeared advisable to ascertain whether the extent of silting would account, to any considerable extent, for the great difference in the quantities of earth-work provided for in the sanctioned estimate and in a revised estimate now in this office, and regarding which I am in correspondence with the Chief Engineer through the Agent. I suggested that the officer now in charge of the section should accompany me, but as it would have put the Chief Engineer to considerable inconvenience had this officer, who is now at Kurnool, been deputed to go down the line of canal, I made the inspection by myself.

38. In the correspondence which has taken place, it has been shown that the section on which it is proposed to complete the canal differs but slightly in the quantities required, from that on which the sanctioned estimate was founded, but the quantities of the revised estimate are cubic yards 19,99,136 against cubic yards 14,60,132 in the original, and after taking into account all causes of excess due to changes of arrangement, there remained in many miles such very large quantities unexplained, that it seemed to me impossible to account for them by any silting up of cuttings, or washing down of banks. The Chief Engineer had no other explanation to give, and, as he had mentioned in his letter on the subject "that the "effects of monsoons on untrimmed work, not carefully constructed so as to protect "itself from silt and scour, reaches 15 per cent. in banks, and possibly 30 per cent. "in exposed cuttings, and that it is therefore of no use endeavouring too closely to "reconcile expenditure on such works with the estimate;" a conclusion which, even had it been capable of reconciling the differences, was one which was entirely opposed to my own experience, I thought the best plan would be to see some of the miles in which the differences were the greatest.

39. I inspected the 92nd to 99th miles, in five, out of which the differences are very large, and I found the amount of silt no where very great, and certainly quite insufficient to account for much more than a tithe of the quantities unaccounted for. In the same way the 105th to the 110th, and the 112th and 113th miles were examined, with similar results. I also observed that, in most cases, the actual quantity of silt both in the main and outside cuttings is ascertainable with quite sufficient accuracy; and that, at all events in many of the miles, there can be no difficulty in determining, within a narrow margin, what the actual quantity of work done amounts to.

40. The 103rd mile has been measured twice, once in May 1865, and again in August 1866, by different Officers, and making allowance for 2,803 cubic yards done between these dates, the former measurement gives cubic yards 30,958, and the latter, 30,251, as the quantity executed, that paid for being cubic yards 40,958. Now the difference, 707 cubic yards, between the above measurements is probably a very near indication of the amount of silting in the fifteen months,* and it is

* Two Monsoons.

2½ per cent., and, so far as I could form a judgment without detailed measurements, I should say that the silting altogether does not exceed five to six per cent. on the work really done, which would be perhaps three per cent. on the total quantities required for the canal as designed.

41. The measurements of the 92nd and 93rd miles have been taken, and I have informed the Chief Engineer that I consider it necessary that the calculations should be completed, and the work actually done ascertained, and I have now to add that this course should be followed for every mile in which the differences are great, and work should not be resumed in the section until the examinations have been completed, and it has been made quite clear what work has been already done, and what is still required.

42. An examination of the cross section of the 103rd mile furnished to this office, shows that some extra and unnecessary work has been done by taking earth from outside cutting, where the main cutting was more than sufficient for the formation of the banks. This will of course require to be taken into account, and whatever excess is due to this cause should be shown distinctly. The top width of embankments throughout is, in the revised cross section, ten feet, and this, even if necessary in some soils where the canal bed is above ground level, is not required where the canal is in cutting, and the width should be reduced therefore to six feet in such cases, unless the main cutting will produce earth for a greater width. The neglect to leave berms at the top of the side slopes of the canal, where in cutting, has induced the Chief Engineer to make these side slopes, and those of the embankment above, continuous, and this arrangement is, under the circumstances, advantageous; but where the depth of cutting is considerable, the top of the bank will be on an inconvenient level for the towing path and, in such cases, a berm should be formed in the embankment at two feet or two and a half feet above full water level. This will occasion no extra expense, and it will be a convenience.

43. Much less care has been taken than should have been the case in protecting the unfinished works of this section from injury. In some places banks have been placed across the ends of open cuttings, but some were too slight, and some ignored the circumstances and lie on the ground, and so many of them have been breached. The failure also to connect the head works with the canal banks was a great oversight, though fortunately no damage was in consequence sustained.

44. I shall probably have to report very fully on the works in this section, when the revised estimates come to be submitted, and I will therefore add nothing at present to the general remarks above made.

45. Eighth Section, Main Canal, 115th to 143rd Miles. *General state.*—My object in inspecting this section was rather to notice how the works had stood than to see what had been done since my last visit, for I knew that, very soon after March 1865, the expenditure had been curtailed, and that there could not be therefore much progress to report. In paragraph 140 of my last report on this section, it was noticed that this was the only part of the canal where the work had been properly laid out for the people, and the embankments thrown up in section, and I am glad to be able to say that very generally the work done has stood well, that there is very little silting and washing

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down of banks, and that all necessary care has been taken to prevent the admission of outside drainage, or to carry it across the line, where this was requisite, without injury to the canal. The state of progress of this section is so much in advance of the 7th section, through which its supply will have to be received, that on the re-commencement of work it will not be necessary at first to do more than employ all the local labor that may be available, and proceed with the masonry works in such a way as to allow of all the materials being carted to the sites during those months, in which alone cartage can be economically done.

46. The lock weirs of this section are the works which are the least satisfactory, and I am afraid that much money will be spent unnecessarily before they will be rendered really efficient. In some a single vent sluice has been placed since I last visited the canal, and this is certainly a great improvement; but the wing walls are in all cases of very inadequate length, and estimates either for the modification of those calingulahs which have been commenced, and in some cases completed with the exception of the aprons, or for the construction of the uncommenced weirs on a better design have not been received.

47. Donapad Station Buildings.—These leak very much. The wood work of the roof is much too light, and not properly arranged. The walls at the western end are much bulged, and look as if they were coming down. The wooden verandah pillars inserted between the columns, to compensate for insufficient breast-summers, are some of them rotten, and one has given way, thus endangering the roof above. The condition of the main building is very far from what should be the case, looking to the date of its erection and the cost.

48. Method of executing Earth-works, and their Consolidation.—There is much room for improvement in these respects, and work executed since last year is little if at all better than that before done. I may instance the embankments connected with the Kadrabagh aqueduct which have settled greatly, dragging down and cracking one wing and causing a considerable leak. These banks settled five or six feet; had they been properly consolidated they need not have settled more than a few inches, they would have been more water-tight, the pressure on wings and retaining walls would have been small comparatively, and the cost of consolidation would have been saved ten times over, and much risk avoided. The embankments near the Teragopila aqueduct are just as bad, they have been thrown up without regard to conditions of stability, and they must give trouble. One considerable piece of revetment has been destroyed, and this is but the beginning of difficulties. The earth thrown in behind the lower abutment of the aqueduct also has not been rammed, though the only proper plan to adopt in such fillings in, even where the masonry works are not to carry water above them, is to ram them so tight as to keep out all wet. It is to be hoped that when works are re-commenced, attention to the plain rules by which alone efficient work can be obtained will be enforced, and that where bad work is done in opposition to instructions, its re-doing at the cost of those whose duty it may have been to see it properly done will be required. No officer is fit to be entrusted with the executive charge of canal works who does not know that a bank made of materials which would be suitable for a filter will not retain a head of water; that the only way of obtaining regular settlements of masses of earth-work in embankments is to build them up foot by foot of the

full width; that the object of a water-tight core is defeated if this be founded on a ground surface composed of gravel; that where porous material is plentiful and water-tight soil scarce, the latter should be carefully placed in the centre of the bank to form a water-tight core, and the former on the faces, where, especially on the inside, it may be very useful; that earth-works at their junction with masonry must not be allowed to settle as they like, but must be rammed hard; that expensive revetments should not be laid on loose unsettled banks, except in cases of acknowledged necessity; that where good and suitable soils, such as gravel, kankur, laterite, &c., are easily procurable, it is culpable negligence to lay revetments on soft and soluble soil, such as loams and black cotton soil, instead of on a backing of thoroughly rammed suitable material, which in many cases may be made to be almost as good as concrete; that it is proper to find out what material is to be taken out of the cutting for the canal which must be executed, before obtaining material from elsewhere, and that it is not right to obtain either soil for banks, stone for revetments or masonry works, &c., and pay for it as a separate charge, when the canal formation would have afforded such material, and which, when not thus used, is wasted. I might greatly extend this list, but I will only add that it is the duty of every Executive Officer to know what his works should cost, and what they are costing.

49. I believe the Chief Engineer is fully alive to the errors to be guarded against in the future, and I desire that his hands may be strengthened, so that he may introduce and strictly carry out a system of personal responsibility which may obviate, or at least reduce to an insignificant amount, the waste of time and money, which the very great short-comings of many of the Officers in charge of Divisions and Sub-divisions have occasioned. It will be essential that transfers of executive charge should take place as seldom as possible, and that upon each transfer the in-coming officer should satisfy himself, and formally report that he has done so, that the state of progress corresponds with the expenditure shown in the accounts, and that the estimate rates have not been exceeded. There is no difficulty in doing this if the work be carried on properly, but it would be impossible to do so in very many miles at present, because a great expenditure of time would be necessary to measure up work.

50. Similarly with stores and all other property of the Company; if these be suitably arranged and properly accounted for, a very short time is required for such an examination as would prevent any serious mistakes being made. Hitherto the Company has been in the habit of requiring security from most of their employés, but, in too many cases, these have left the service, and have had their security refunded long before errors have been detected. The accounting generally has been much improved during the last two years, and now that arrears have been brought up, and there is a prospect of all unadjusted items being disposed of within a few months, it may be hoped that, if all concerned are made clearly to understand that "profit and loss" will not be allowed to compensate for want of ordinary care and attention, and that "inefficient balance" will be permitted to be used only for its legitimate purpose, and not as a means of getting rid of the necessity, for an indefinite period, of accounting for expenditure, which either ought not to have been incurred at all, or should have been debited at once to its proper head of charge,

there will not be a recurrence of the difficulties which have entailed so much trouble, and have occupied the time of a far larger office establishment than would have been necessary, had the duties of those entrusted with expenditure been from the first understood, and their obligations enforced.

51. Chief Engineer's Staff.—The Executive Establishment at the disposal of the Chief Engineer has been so greatly reduced, that he is not now in a position to prepare for the commencement of work except on a very restricted scale, much less to take up and go on with the works of the first eight sections. I may add that, in my opinion, the establishment is even too small to look after the admission of water where that is going on, and to take care of the canal works, buildings, and property generally. Probably some few of the Engineers, who were lately in the Company's employ, will return, but most of those who will conduct the works in the future will be new to the country and to the work, and much care will be needed to prevent their falling into mistakes during the time they are becoming acquainted with their duties. They will have before them a sufficient warning of what to avoid, but their work will require, owing to the state in which they will generally find it, a very great amount of care, to prevent on the one hand the perpetuation of errors, and on the other to effect the speedy transformation of what has been done in order that future progress may be readily ascertainable, and the risk of over, or double, payment avoided. It would be no easy task for experienced and capable officers to deal with some of the sections; it will be extremely difficult for those who have never been employed on similar works, and who have never had to deal with every kind of work in detail. The Chief Engineer is giving careful consideration to these matters, and he proposes to resume work sufficiently gradually to enable him to control the proceedings of his Assistants, and, considering how much remains to be done to partially utilize the supply even for the first five sections, or 72 miles of the canal, it is to be hoped if the Company desire to find their position improved at the commencement of the next irrigation season, but little time will elapse before the Chief Engineer is provided with funds and establishment.

52. *Revised Estimates.*—Revised Estimates are now in this office for the following portions of the canal works:—

	Estimate at present sanctioned.			Revised Estimate.		
	Rs.	A.	P.	Rs.	A.	P.
Received 16th July 1866, 2nd Section, Main Canal. Earth-works and masonry ...	13,76,415	0	0	17,97,365	0	0
Do. do. 3rd do. Earth-works and masonry	5,84,240	0	0	8,08,420	0	0
Do. 10th August 1866, 4th do. masonry	1,09,460	0	0	1,82,870	0	0
Do. 1st March 1866, 7th do. Earth-works	1,13,960	6	0	4,00,830	6	0

The information furnished with them, as to the causes of increase in the quantities of work, is in all cases defective, and in some the quantities of work really done have not been ascertained, so that I am not able to submit them for

sanction, and it is doubtful how soon the Chief Engineer will be able, with his present staff of Assistants, to obtain the information required. It is, however, especially necessary that the requisite examinations should be made, and the positions of each section clearly ascertained, before the resumption of works, so that henceforth there may be no difficulty in fixing responsibility should unnecessary expenditure be in the future incurred.

Consulting Engineer's Office
Irrigation and Canal Company
Madras 1st October 1866.

No 170

From

Captain John A. Hallen R.E.
Consulting Engineer I. and C. Co.

To

Colonel C. A. Orr R.E.
Secretary to Government P.W.D.

Sir,

I have the honor to report for the information of Government, the result of my inspection, in September, of the works of the Madras Irrigation and Canal Company.

Kombarala Anicut and headworks. 2 At the time (the 6th and 7th) of my visit, there was a little more than 1 foot of water passing over the crest of the dam, and, except at the old breach, there has been apparently no damage to the Anicut itself from the freshes of the current year. At the old breach a sloping apron was completed some weeks before the first freak of the season and, as already reported, this apron failed. The failure however has proved to be only partial, and at no time did the damage proceed so far as really to endanger the main wall above, though this damage at an early period of the freshes

P.W.D. G. No 2641 dated 22nd August 1866.

may

may well have occasioned much anxiety – On the morning of the 7th the Chief Engineer and myself crossed in a basket boat to the foot of the Apron, and examined its condition – We found that the stone and its concrete and masonry covering had been washed out, to a depth of about 12 feet below the crown of the dam, over the space included between the main, and first parallel retaining, wall, and that the central part of the latter had been destroyed to a depth of from 3 to 4 feet below its original level. The materials displaced have been piled up irregularly on the lower part of the Apron, forming in rear a steep slope with channels through the debris, through which the overfall water over escaping without creating any further disturbance. Probably the lower part of the Apron with its second retaining wall has received no further damage than that resulting from the rolling over it of the stone washed out from the upper part. There is now therefore a rough water-cushion receiving the overfall at the old breach, and it is evident that so soon as the depth of water in this cushion became sufficient to break the force of the water the extension of damage was stopped. The maximum height to which the freshes rose this year was 6 ft-3" above the crown of the dam, an extreme flood being about 8 feet. What height of fresh

fresh have the Aniout must be uncertain, and it is dependent upon the rapidity of the rise, but it is perhaps tolerably certain that from the time that the dam is drowned, or when the water below is level with or above the top of the Aniout the action upon the river becomes very slight, and that upon the bed or works below it comparatively. The failure of the existing apron has shown that such a work is not adapted to the circumstances of this River, for it is stated to have been very carefully constructed, and to have every advantage from the time which elapsed between its completion and its trial. It is now intended to clear away the rubble stone, and to rebuild the main wall of the Aniout, founding it upon the rock revealed by, as before, on rough stone thrown into the bed of the deep Channel in the river bed. This is the only safe plan, and it is only to be regretted that, when the Apron works had been let as a slop to lay the freshes of 1866, leaving but a comparatively small part of the work done it was afterwards resolved, instead of at once proceeding to take down and rebuild the main wall. The great accumulation of rock above the Aniout will, it is expected, enable the water to be dammed out without difficulty from the part of the river bed to be operated upon, and if this be the case the wall can be

be constructed sufficiently strongly to allow of the masonry drying, so as to prevent any risk of the mortar being washed out on the recurrence of the freshes next year.

3. State of the river bed. The action of the years freshes upon the river bed will not be ascertainable until the river has fallen below the crown, which probably will not be the case for some weeks, but, with reference to the order of Government No. 2573 of the 16th Ultimo, I may mention here that the Chief Engineer proposes, as soon as possible, to make a careful examination of the state of the bed, and to estimate for such protective works as may be considered immediately necessary, and it is intended that these shall include a short length of masonry apron of the description mentioned in his letter, provided with the floodings Madras Government above quoted, as also a length of water cushion, and upon the result of the trial of these two methods of protecting the river bed immediately below the Anicut will depend the selection of the system upon which any further similar works, which may be found requisite will be designed. It is my intention to provide Sanctioned as soon as the Chief Engineer informs me that the water has fallen sufficiently to allow of an examination of the

the bed, and the taking of the necessary longitudinal and cross sections, and I shall then be able to report more particularly on the state of the rock.

4. Head and Undersluices. The former are in good order, and require no notice. A small portion of the masonry revetment of the Channel immediately below had been damaged, and will be repaired. The undersluices are considered to require improvement. In the first place the stone flooring is too roughly fitted to be altogether safe, seeing for how long a period a violent discharge is maintained. It is quite clear whether the piers and abutments were founded upon the rock, or whether a mass of rubble masonry was built to the level of the underside of the flooring and the superstructure built upon this basement. If the latter, damage to the flooring might lead to the undermining of one or more piers and so to the destruction of the work. At any rate the importance of preventing a recurrence of the displacement of flooring stones cannot be doubted, and to keep down the cost of providing a safe flooring as far as possible the present stones should be carefully dressed and fitted, and the extra stone thus rendered necessary should be of large size and should be placed at the lower end of the vents. The

revolving

revolving shutters of these sluices also continue to be as unmanageable as ever, such as they have cost the Company a great deal of money, probably it will be best to make an effort to render them serviceable, 1st by readjusting them, so as to obtain a closer balance of pressure on the 2 valves & by strengthening the iron bars, which have all more or less shown signs of giving way from the effects of torsion. This can be done by fastening strong battens to the 4 sides, thus converting the square into an approximately circular section, and sheathing the whole built-up beam, thus formed, firmly together, 2d by altering the Capstan heads, so as to allow of sufficiently strong bars being used, and to remove the damaging action of the pockets upon the bars at the points of contact, 4th by placing a winch at the South end of the work, and arranging a rope or chain from the winch to the ends of the Capstan bars, in such a manner that the power may be transmitted to the outer ends of two or more bars at once, either for opening or closing the revolving shutters. By the aid of a winch 3 or 4 men would be enabled to work the shutters - at present it is very difficult to apply the power of a sufficient number of men to open or close any of them.

5 General state. This section may be considered to be in fair working order and quite able to carry a much larger supply than is at present required. Rain occurred this year soon after

1st Section Main Canal 1st to 18th miles.

4

soon after the admission of water, in the 4th and 6th miles, and to a less extent in some other places, but the requisite repairs were executed and the leakage generally is but small compared with what it was when the section was first opened. The revetments in some parts of the 4th mile are too low, being little more than 2 feet above bed level, and they should be raised to at least 2 feet above half supply or 6 feet above bed level. The Calingulak above Yedawa, in the 6th mile, leaks a great deal and the leakage should be stopped by puddling in front. The Culvert in the 9th mile, which was under repair at the time of my visit last year, is now in good order. The leakage is considerable, but not such as to prevent its being a useful and convenient crossing. The approaches at both sides want some little improvement, and the ground in rear of the north bank should be levelled from the Culvert to the old tank bund, which is used as the roadway from Singaram. The work remaining to be done is, 1st Completing cuttings to their full width, 2 taking out rock where above bed level, 3 correcting irregularities in the bed level, 4th Completing revetments, 5th raising the banks in some places, and in most of the miles levelling the top and sectioning

the

the embankments. For much of the remaining work there is no immediate necessity, but I think it would be advantageous, both this and ensuing, that the top of the banks should be levelled so as to admit of the Divisional or Assistant Engineer riding along them without loss of time, so that frequent inspections may be made, and that every portion of the line may come under constant notice.

6 I have suggested to the Chief Engineer that, both in the 1st and other sections, where the banks are incomplete, and their top level will be more than 4 feet above water level, and, as at present intended, of considerable width, that it will be an economical and convenient arrangement to form a towing path at 2½ feet above full Canal level, and to make that the fixed level for the top of embankments. This path to be 5 feet wide, and the bank in rear to be carried up to the full height of 6 feet above water level, on a reduced section, with a top width of 3 or 4 feet. In some places also there is ground above bed level at the toe of the bank, and the deep water is at a distance, and, as the cost of cutting a Channel 50 or 60 feet wide through these small ridges will be very trifling, it will be advisable to do so in due course.

7 Cultivation. The wet cultivation under the Canal in this section generally looks much more thriving than was the case last year, and as the season has been an unfavourable one, this shows, I think, that the ryots have benefitted by the experience of last year, and have improved their management of wet cultivation. Kidagoor is the village where the area is the largest, and where the state of the crops is the most promising. There is still a good deal of dry cultivation on land commanded by the Canal, and this, I have little doubt, will for the most part be converted ere long.

Tindey Aqueduct. 8 The side walls have been completed to 8½ or 8¾ feet above bed level, and the banks and masonry embankments walls above and below are in good order, and there is little or no leakage under them. The leakage through the arches, spandrils and abutments of the Aqueduct continues much the same as last year.

2 Section from Canal 18 to 32 Miles.

9 General state. The state of this section is at present a matter of serious difficulty and it is to be feared that much additional expense will have to be incurred before its embankments will become sufficiently free from leakage to enable it to carry a full supply of water, without constant danger of breaching. The breaches which occurred this year in the 25th and 27th miles, have

cost

cut off the supply from all the lower miles until after the middle of September, a date subsequent to which no such cultivation of this season can be commenced, and it is certain that, at whatever cost may be found really necessary, the whole of the Section must be placed in a really safe state, or the cultivation below it - and that alone will never exceed an insignificant area - will be liable to lose its supply. This leakage also in many miles is so considerable as to cause a serious waste of water. As has been mentioned in previous reports, the soil of this Section of the Canal is for the most part of a description which does not admit of a watertight bank being formed without the exercise of much care and discretion in the execution of the work and unfortunately the imperative necessity for obtaining a monsoon bank has not been duly kept in view during the progress of the work. In some miles or portions of miles there was no good soil immediately in front or in rear of the line of Canal; in other parts there was a sufficient quantity of good soil for the centre of the bank, while the greater portion consisted of gravel, kunkur, or shale, with more or less earth intermixed. Generally speaking the most has not been

been made of these materials, for had a core of good soil carefully executed been placed in the centre of the bank, and carried up above full water level, and had the porous materials been placed on the 2 faces, and used only to give weight, and resistance to pressure, it is probable that the embankments themselves would have been fairly free from leakage. In very many places moreover the core should have been founded at 2 or 3 feet below the natural surface of the ground, so as to prevent leakage between the base of the bank and that surface. Even with all these precautions there can be no doubt there would have been for a considerable time at least a very appreciable amount of leakage through the subsoil, but this would have entailed little or no risk of the safety of the banks. As it is whatever materials the soils afforded have been placed indiscriminately in the banks, and the consequence is that, even where there is much good soil in them, they are intersected by strata of gravel or other porous material, and leaks show themselves both low down and high up and, as it cannot be ascertained with any degree of certainty at what point, or level of the inner face, the water finds admission, it is most difficult to

to

to devise means of stopping the leaks, except where the withdrawals is so great and localized as to denote, by eddies on the surface of the water, where the forces draw in through on the interior slope. The measures at present therefore being taken are rather with a view to prevent the excess arising from the soaking of the head and lower parts of the banks, which would lead to slips, and the method adopted appears to be successful. The is to carry the leakage well of the bank as directly as possible by inserting rough of packed dry rubble stone on the rear slope, or at the toe of the bank, and in some cases the leaks have been diminished, as an indirect result of this operation, by the subsidence of the banks, the concurrent tendency to slip being counteracted by the weight of the mass of stone. Generally suitable stone for these protective works is abundant, and the process is not therefore costly; and as, whether this diminishing risk of breaking, the water could not be lapped down to the lower miles of the Canal, while without the presence of water the lower embankments cannot be tried and their necessary settlement effected, it is advisable that this temporary work should be proceeded with.

means of stopping leakages.

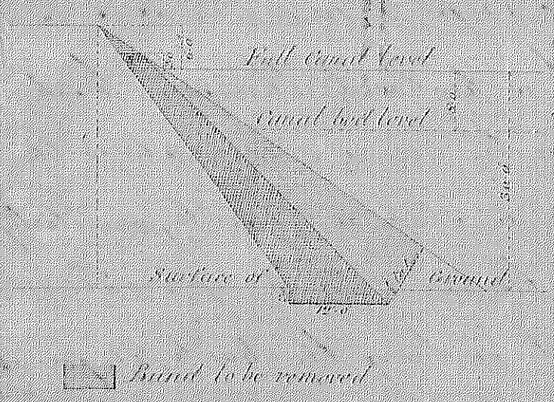
10 The means of permanently stopping a leak to leakage have formed the subject of much consideration and discussion during the course of the inspection, which I have made with the Chief Engineer; it appears to me and to the officer, I think, that the plan adopted is disposed to correct, that the simplest, most effective, and probably most economical plan will be to do more what should have been done at first, by to provide a core of good soil wherever it is found that there is any considerable leakage, and to carry this along over the whole length of defective banks, reaching as well into those parts which are found to be watertight. The position of the core however will have to be somewhat different to that which it would have occupied had it been formed concurrent with the bank, as to place it more in the centre would involve the removal and replacement of too large a quantity of material. It is proposed therefore to cut down the bank on the inner side making the side of the cutting as steep as possible, consistently with stability, so the core will be of smaller dimensions than the centre of the bank, if formed only of good soil well rammed, would have

been,

been, it should be thoroughly well puddled, and
its base, which should be laid at two feet* below
the original surface of the ground, should be
from 9 to 12 feet thick according to the depth of
water. The top width of the core should be
3 feet, and its level 2 feet above full water level;
one face of the core should be in contact with
the scarped bank and over the other at every half
foot of raising — should be laid good soil
to the proper section of the inner slope, this
soil being well wetted, and rammed hard,
and lastly the revetment should be relaid over
all. This arrangement will, I think, remedy
the defects of the banket, and is certainly
much cheaper than a wall, which would
require a cross section of about ⅔ rds of the
proposed puddle core.

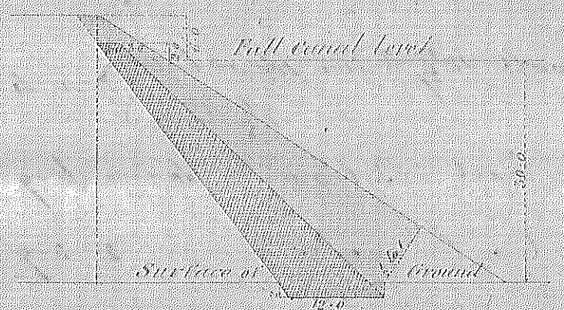
* or more if necessary.

10 (C) I have gone carefully into the
question of the cheapest and best way of
underlying the
puddle Core, and
I find that
the cheapest
plan is as shewn
in the section No 1



The

Section No 2



The cost of this for a depth of 30 feet of water
would be as follows.

Removing bank and revetment 18 Cubic yards at 2 Annas	2	4 —
Puddle 9 4/9 Cubic yards at 3 Rupees the Rupee	3	2 — 5
Replacing soil 8 5/9 Cyards at 6 Cyards do	1	7 —
do revetment 9 2/9 Cyds at 4 Annas	2	5 — 6
Contingencies		15 — 1
Cost of 1 running yard	10	2 —

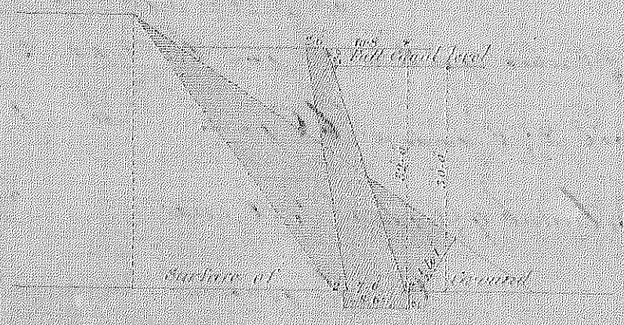
It will however perhaps be better to provide
for a somewhat thicker covering of
soil on the outside of the puddle,
so as to preserve
it from drying
rapidly, and
cracking. In the above section this covering
comes to nothing at the top and Section No 2
places the puddle 1 yard more towards the
centre of the embankment.

The cost of this arrangement would be,

removal of bank and revetment 20 5/9 Cyds at 2 annas	2	9 — 1
Puddle 9 4/9 Cubic yards at 3 yards the Rupee	3	2 — 5
Replacing 11 2/9 Cyds earth at 6 yards the Rupee	1	14 —
do revetment 9 3/9 Cyds at 4 annas	2	5 — 4
Contingencies	1	4 — 2
Cost of 1 running yard	10	15 —

Lastly

Lastly, to show by way of comparison what the cost of a masonry revetment wall would be, Section №3 is subjoined.



Section №3

the cost would be,

Removing bank and revetment 16 31/81 Cubic yards at 2 annas — 2 — 9

Wall 6 5/9 Cubic yards at 2 3/4 Rupees — 18 — 5

Refilling behind wall 13 17/27 Cubic yds at 6 As Rupee — 2 — 4

— do — extent of wall 2 14/27 Cubic yds do " 6 9

Contingencies — 2 — 9

Cost of 1 running yard 25 — "

Such a wall with careful filling in behind would, I have no doubt, be watertight & the wall section is about as small as would be safe, and as the center of gravity just outside the inner edge of the base, the full strength is made available to resist the pressure of the banks in rear, and it would of course be necessary to tamp the earth thoroughly so that the pressure of water in the opposite direction might be transmitted to the bank at once. The much greater cost however precludes, I think, the adoption of the wall where a feasible core can be inserted as shown in the Section №2.

Probable cost of stopping leakage.

12 The cost of stopping leakage cannot be ascertained with any approach to accuracy without a detailed examination of the banks throughout the section, which cannot be fully made until the water has reached the end of the 37th mile. It is probable however that the average height of the banks which require to be made watertight is less than the 36 feet shown in the above sections, and perhaps therefore 16,000 Rupees a mile will suffice for the arrangements given in Section №2, and of one third of the whole length of the section requiring to be dealt with Rupees 80,000 will be the approximate cost. The estimates already sanctioned amount to Rupees 137,6,415 " and I have now in the office a supplemental estimate, Rupees 4,20,950 — " , the submission of which is delayed until the receipt of information as to the quantities of work already done, only that remaining to be done being shown in the Contractors Statement received. I have also put in submitted for sanction two estimates amounting to Rupees 4709 " for closing breaches in the 25th and 27th miles, and therefore the probable cost

№62 dated 13th September 1866.

cost of the Section, exclusive of remedial measures in connection with leakage, stands thus

Estimates already sanctioned Rupees —— 1376415

" submitted for sanction " —— 4709

" to be submitted " —— 1220958

Rupees 1802074

and the length of the Section being 14½ miles the average cost per mile to comes Rupees 122991 — to which the probable addition for the modification now recommended will average, say, 6000 Rupees a mile, making altogether Rupees 128991 a mile, and even should the 5 miles, I have supposed to require puddling, be found to need doubling, the outlay on this account will still form an insignificant addition to the estimate cost, and as there can, I think, be little doubt of the vital importance of stopping leakage wherever found to prevail to any considerable extent, the requisite estimates, whether in accordance with the plan suggested above or not, should be prepared and submitted for sanction as soon as possible, and afterwards carried out with all possible despatch, in order that, on the admission of water in 1867, it may be sent down to the lower Sections without fear of accident.

13 The walls which for a very considerable portion

Masonry and Core of Section walls.

P.W. C. 24 Oct 65 No 3191 report para 16.

portion of this section take the place of previous embankments, have been noticed in former reports. The masonry walls were in most cases too slight and their mode of construction rendered it highly probable that they would leak greatly after the date of any test before only one of the high walls had been tried, and the leakage was great, and though the quantity of water passing through it decreased considerably from the maximum, which occurred at the first admission of water, it is still very considerable, and the cracking, while it tends greatly to the safety of the wall, does not influence the leakage. Similarly the other walls which have since been reached by the water, both more or less, and in all cases to such an extent as to waste more water than can be spared. Thus the tank at the 50 feet wall in the 26th mile sank some 10 or 12 feet during the time the supply was cut off by the breach in the 25th mile. The rubble walls with an earthen core answer well where the execution has been sufficiently careful, but it was noticed last year that in some places, where they were then in progress, enough care was not being observed in the selection of earth, in founding the core wall below the original ground surface, and in thoroughly

× about 5 weeks

wetting

welling and ramming every layer, and the result is that these core walls in some places leak considerably. It was also remarked that the masonry and core walls were not well adapted for forming a junction with each other, and though, in the 26th mile where the change from the masonry to the core section was first made, the junction was carefully executed, the leakage is great, and the Core has sunk considerably, and it will be necessary to take down and reconstruct the damaged part. In the 28th mile, where a similar junction has been effected with much less care and an insufficient overlap, it would not be surprising were a failure to occur. It also noticed that the earthwork of the Core section walls executed since my last tour of inspection was much softer than it should have been if thoroughly well rammed. It is true there had been heavy rain, but if this earthwork is to prevent the passage of Canal water horizontally, it ought not to admit rain too readily vertically, and though it might naturally have been expected that it would be muddy and wet after rain, its being soft and porous shows that it was not properly consolidated. The considerable length of wall

P.W.C. 15th May 1865 ¶2131 report para 37

P.W.C. 24 Oct 1865 ¶3191 report para 18.

of this section, at the lower part of the 28th and first part of 29th mile, was particularly open to this objection.

11) This Section of the Canal has suffered from the restriction of expenditure, and it is in a less advanced state than it should be, considering for how long a time the first section has been ready to supply it, and that the 3d Section also is much more complete. The cuttings are more especially behind hand, and even the 30 feet widths, which it was resolved, when funds were likely to run short, to take out first, are not in all cases sufficiently complete to admit of water passing unimpeded. Moreover, where these cuttings are of any depth, the narrow width is insufficient for even the present requirements of the Canal, for the state of the banks obliges the head of water to be restricted, and the supply, owing to leakage, becomes so much reduced that the filling of the tanks occupies a very long time. I have suggested to the Chief Engineer that it will be a good plan to widen these cuts, while the water is running at high velocities through them to the Banks below, as then the cost of

excavation

excavation will be much reduced, and, what is of more importance, a large quantity of silt will be carried down and deposited in the tanks above the walls and embankments and probably reduce the leakage at these points. Similarly Channels below the cuts into the Tanks may be formed at a very small cost where the soil is not actual rock, and thus the filling in this and future years, may be facilitated, and the course of the water regulated.

15. I will not trouble them this report by noticing in detail the state of the bunds and masonry works in each mile, but I may mention that the bridge at the cutting in the 20th mile has been completed and opened for traffic. North of this Bridge the roads now belong to the Kurnool Municipality, and I hope they will receive the attention which they require before long. On the South side the Department of Public Works should, as was arranged when the bridge was ordered to be built, make a junction with the Hadrabagh Road. I may add that this Bridge affords an opportunity now of making a loop drive for the residents of Kurnool, which would be very much superior to that which formerly existed, and which was interfered with by the Canal. The deepening in the 20th mile has made considerable progress during the year and, except where the hard rock occurs near the upper end, it is not far from complete.

Water expected to reach the end of 2 Section and enter 3 Section at end of September.

16. Should no further accident occur to the banks it was expected that the water would reach the commencement of the third Section by the end of September.

17. Cultivation. Considering the late date at which water was admitted into the Section, and the uncertainty as to the continuance of a supply, perhaps it is not surprising that the area of land converted from dry to wet cultivation is but small. In the neighbourhood of Kurnool, and between this and Hadrabagh, and at the latter village, there are some promising Crops. Lower down the sharp slope of the ground, its small width between the ravines, and the labour therefore of forming paddy fields, will tend to postpone any alteration in the mode of cultivation until the profitableness of irrigated crops has been demonstrated. Indeed the water at the time of my inspection had not reached the first crop ground, at Sodoor in the 29th mile, below Hadrabagh. Below that there will

P.W. Cy No. 2574 dated 5th September 1864

will be a fair amount in the village, of which Sultanpore is the most considerable, lying in the small piece of territory belonging to the Rajah on the South side of the Goomtee, and here the villagers seem anxious to make use of the water as soon as it can be distributed to them.

18 General state. This section is much more advanced than that above the Sundurkee, 2 sections brain Canal 33 to 43 miles.
=ments in the 33rd and 34th miles are generally very high, and they have settled considerably, and no doubt further extensive settlements will occur when the water reaches them for the first time. Their behaviour will depend upon the way in which the materials of which they are composed happen to have been arranged. They contain a large proportion of watertight soil, with some gravel, and a good deal of a white soluble earth. The 35th mile is chiefly in cutting, and no difficulty is likely to occur in passing down the water, although, as the subsoil is almost entirely kunkur, a considerable portion of the supply will be absorbed. At the lower end of the mile, immediately above Calinjeekah No 18, a length of Core wall has been built since my last report. From the 36th to the 39th miles the banks are

of considerable, but not excessive, height, the soil is black cotton resting on limestone. The only work recently done is the bottoming out of the Canal to a width of 30 feet, and these cuttings are for the most part very shallow, so that a large supply can be sent down without widening them. In the 38th mile the masonry wall has a leak through a weephole, which is running like a sluice. The wall has no backing except a little black cotton soil 2 to 2½ feet high, which is useless. All along this part of the Canal there comes no less water from rainfall drainage. Calinjeekah No 19, in the 39th mile, has had a bank of soil placed in front to stop leakage. One apron or water cushion is needed in rear.

The cutting at the lower end of the mile has made good progress, though there is still a great deal of work to be done. As seemed most unfeasable last year, the hard conglomerate rock at the surface proved to be only a stratum 1 to 2 feet thick, below which there is tolerably compact gravel. The higher parts of the masonry walls at the upper end of the 40th mile wills need backing; they are not safe at present. The banks below this to the cutting at Malayala are very irregular and, except at a few places, they are complete.

P.W.R. Q 15th May 1865 No 1317 report para 52.

Settlements

Settlements going on satisfactorily. The cutting a short one-is wide to 30 feet width, and the widening can be cheaply executed when the Canal water is sent down into the South below.

In my first report it was noticed that from the end of the cutting for a short length the embankment would require a clay core to prevent leakage, the soil being gravel with very little earth. This Core does not appear to have been inserted, and the bank leaks much, even with the small head of water now against it, and it will require to be puddled at once. The leak is just opposite the East face of the village. The deep sluice at the lower end of the mile was discharging to a small extent, and the shutters were fast down by the Chief Engineer. The differential pulleys, with which the sluice is fitted, are an excellent raising power, but they will be more too powerful when the head of water is greater. Before the sluice is used to discharge any considerable quantity of water the waste Channel must be resected steeply, immediately opposite the west, or the fields will be injured. It will also be necessary, I think, to increase the capacity of the Channel to some extent. Thence to the end of the Section there is drainage water all along, and a larger supply than is likely to be sent down the river can be conveyed without difficulty altogether, though it is probable that the high banks, in the 33, 34, 41, 42, and some other, miles, may give considerable trouble, and demand careful watching until they have settled down, and taken their ultimate form, the passage of water through this Section will be a much easier, and quicker, work than it has proved to be in the 2d Section.

P.W.D. No. 2438 24 August 1864 report para 57

19 Distribution and cultivation. There is as yet no wet cultivation under the Canal in this section, and the distribution works are at present confined to the irrigation sluices in the Canal bank. I hope the Chief Engineer will be able to arrange for the cutting of the necessary Channels, so that they may be ready by the 1st June next at latest. The earlier they are in readiness to distribute water, the sooner will applications for water be sent in, and the larger will be the area which will be brought under wet cultivation.

4th Section Main Canal 44 to 60 miles.

20 General State. At the time of my inspection last year it was hoped that, even if the whole Section could not be got ready for this years cultivation, at least that part of it down to Peggy dial, in the 53 miles, could be sufficiently completed, and when,

owing

owing to the failure of funds, the works below Piggy dial were stopped, provision was made for advancing those above this point. The arrangements have been so far successful that a small supply could at once be passed down and, except at the Tank in the 51st mile, where the opening left at the Pullah has been closed by a bank of comparatively small section, and to a height some 3 feet lower than was wanted for this season, while the revetment is but little above bed level, the works are sufficiently advanced to carry a half supply without risk. There is drainage water in the Canal all along this portion, and the Tanks in the 47 and 51st miles are full to bed level, so that the earthworks have obtained a considerable seasoning and, when the Canal water reaches the beginning of the Section, 3 or 4 days will suffice to pass it along as far as Piggy dial. There is nevertheless plenty of work to be done, much of which would be the better for not being postponed. Thus in the 48th mile the banks are irregular, and where the soil is soft they get much cut up and washed down, and the longer this goes on, the greater will be the quantity of material to be replaced. The Tank banks should be fully completed, so that they may have time to settle before they are subjected to the additional head of water, and it is certainly, even now an unnecessary risk to have the part of that in the 51st mile, which was most liable to accident, much weaker than any portion either above or below, added to which the revetment there is much lower than at other places where it was first needed.

Moreover where the banks have cracked in settling, the earthwork should be pointed in consolidated and dividing its bearing, and this can be done much more cheaply and efficiently while there is water close by, than in the dry season. Again in the 46th and 52nd miles the Calingulahs have been furnished with powerful under-Sluices, which are intended to discharge all surplus water, and at the latter mile all water which is sent down will, until a further length of Canal is opened, be allowed to escape, and it is of importance as regards economy, and very necessary also, that all work required to confine the surplus water to its proper and intended line of outfall should be complete, before the sluices are brought into use; and in order that this may be done efficiently, it is necessary to calculate the discharge and the velocity

velocity due to the fall of the country, so that the designs may be consistent with the circumstances.

At Foggydeal the 4th pair Culvert which is to form a roadway, as well as a drainage Channel is approaching completion, and the work and materials are much better than those of the Culverts previously built. It will be a matter of some difficulty to form and maintain a good roadway, as the subsoil is shale in nearly horizontal courses and probably either concrete or a facing of stone on edge will be needed, for gravel would not be likely to stand. There is hardly any double banked Canal below Foggydeal in the 4th Section. The banks are, or will be, generally very high, and there is a great deal of work to be done to complete them. In the 54th mile two openings in the bank had been left. The upper one has been closed to about bed level; the lower one is still open. Similarly in the 55th mile there is a pipe in the bank at the 35 Chain; the earthworks are half done and the revetments about half. In the 56th mile much earthwork remains to be done, and the revetments are still less advanced. In the 57th mile the bank has been closed and water retained, but the earthworks are very irregular and somepasts are not much more than 3 feet above present water level: the Chief Engineer has directed this to be attended to. The soil is generally good, but at the low parts of the bank I observed that some shale and gravel have been put much further into the bank than is at all safe, and in one or two places they form a layer right through, and would probably cause a leak, if not a breach. Such materials should be confined entirely to the faces of the banks, where they may be made very useful. The revetments in the greater part of this mile not yet commenced. In the 58th mile the opening at the large rapid has not been closed, but the earthworks and revetments are well advanced. The banks in the 59th mile are rather low behind hand, and they and the revetments are irregular in height. The 8' Culvert in this mile has its abutments upto level of springings. The Cofferdam is $\frac{2}{3}$rds done. The Bridge in the 60th mile has made but little progress since last year. The side spans have been filled in with earth, and, in the middle of the centre span, a pier has been built with the intention of forming a temporary bridge, which

which will not now be required. These expenditures on temporary works unfortunately, above a great deal of money. The Culvert, a short distance below bridge, is nearly right opening level, and much silted.

21. The above remarks will suffice to show that there is now too much time before the commencement of the irrigation season of 1867, to put the 4th Section into proper working order. Except at the Culvert at Puggydial there is no work going on, and the Chief Engineer is unable to do anything but emergent work until he receives positive instructions from the Board of Directors. It is to be regretted also that the best season for earthworks will be gone before any further progress is made with the embankments, and that, as in other works higher up, retrenchments will be of necessity laid on unconsolidated banks, and will slip and require rebuilding.

Work to be done in 4th Section should be finished as of the Canal is to be opened in 1867 - and below the 4th route.

22. Distribution works. The officer in charge is engaged in investigating and estimating for these, and much information as regards the fall of the Country, has been put on paper - It will take some little time to complete the estimates and plans for any one of the irrigation subdivisions, into which the Section has for convenience been subdivided. The fall of the Country is much greater than I had imagined. The varies from 20 to 35 feet a mile, the soil being red or black cotton with shale or the subcretaceous, the rock being generally not far from the surface, and in some parts cropping out. The Chief Engineer intends using the natural drainage Channels, which have in most parts gone down to rock, to carry the water down to the levels most suitable for distribution by artificial Channels, and this arrangement, though objectionable in a flat Country, is in the present case likely to be an efficient one, if only the details and minutiæ be duly considered and provided for - From the sub-dividing Ridges existing Contour Channels will be excavated, dividing the country into moderate areas, over which the water will be distributed by minor direct Channels, The Channels laid down and the capacity of which vary from 4,000 to 6,000 Cubic yards an hour were intended to have 1½ feet deep with a fall of 1¼ to 2 feet a mile, but on investigation it was found that, by reducing the depth to 1 foot, the velocity, with a fall of 6 feet a mile, would not exceed 2 miles an hour which will not be excessive for red soil - 1½ miles an hour will be better for black Cotton soil, and on the other hand, where the shale is at or very

close

close to the surface, the fall corresponding to a velocity of 4 or 5 miles an hour may be given – Small Channels with a small depth of water may be taken at almost any slope – If these principal distribution Channels be completed before the commencement of the next irrigation season, so that the ryots may see that certain areas are provided for, and so that, after the applications for water are sent in, there may be time for the arrangement of the necessary minor Channels, it is probable that 1867 may see a considerable extent of land under cultivation for, in addition to the fields which now are under dry cultivation, there is a great deal of waste with a red soil very suitable for paddy, and the people may be disposed at any rate to try this, even if they should be disinclined at first to give up their dry crops on the lands where they have been successfully cultivated – It has however been remarked before, the demands for water will be helping until the people see it running through the lands of their villages – The population of this part of the District is scattered & small, and the villages are far apart – Where a new and successful cultivation has been established however, even on a small scale, no doubt the ryots will be able to offer attractive terms to the population beyond the

the Coombeddra and Kistna.

Canal Crossings. 23 The communications across the Canal in this Section which have already been provided or which it is intended to construct, are shown in the following Statement.

No.	Miles and Chains	Villages accommodated	Class	Description	For what traffic	Remarks
1	44 15	Nagatore &c.	1st	Bridge	all kinds	
2	45 9	Condaguagatore	3rd	Culvert 8	foot passengers & cattle	
3	47 13	Nagatore, Kistna ferry and pickets	2d	Bridge	all kinds	in lieu of an abandoned 8 feet Culvert B.M. G. No. 1317. 15 miles Report para 61.
4	48 54	Nuckrecaire	3rd	Culvert 8	foot & Cattle	
5	52 31	Nagayedal	2nd	Culvert 16	all kinds	
6	56 74	Bolavaram & Gollamcaptaram	3rd	Bridge 5	foot & Cattle	in lieu of ferry.
7	58 38	Bolavaram & Palapad	3	Culvert 8	—do—	
8	59 23	Japad & Road	1st	Bridge	all kinds	

No. 3 has been included in a supplemental Estimate now in this office. No 6 has to be estimated for when an approved design has been prepared.

24 There will thus be 8 Crossings in 17 miles of which 4 will carry all kinds of traffic, and the other 4 foot passengers and cattle only – The villages are very far apart & and there are no made roads. I have at different times ridden over the County on both

sides

sider of the Canal, and I think these
Crossings will suffice for the accommodation of
the Cart traffic, and provide convenient access
to the fields. The Culverts all require more
or less work to be done to them to render them
easily accessible: the direct ramps are either
cut up by the drainage or where there is
slate rock the soil is washed away leaving
a surface not always easy for any one on
foot to climb over it: what seems to me
necessary after an examination of a number
of these Culverts is a comparative flat for
20 to 30 yards above the upper face of the
Culvert, and thence a ramp for traffic and
a separate inlet for drainage, so that the
former may not be injured and, where
there is rock, the inlet water may be with
advantage taken in at a vertical fall
somewhat recessed, and therewith a
little management there would be
hardly any silt.

25 General State. As much the same as that noticed in my last report, and very little has been done, except at the Pergopila Aqueduct in the 63rd mile. The section could be got ready in 3 or 4 months

5th Section Main Canal 61 to 72 miles.

man the to carry much more water than will be needed during the next year or two. There is not very much work to be done any where except in the 63rd mile, but nearly all along there is some work, and it would require some energy to put some of the Culverts to rights, and complete others, in the time named.

26 I will confine my remarks to the few works requiring notice. In the 61st mile a short length of a 14 feet Culvert has been constructed. The work is to take the place of an 8 feet Culvert which failed last year. In the 63 mile the Pergopila Aqueduct has made considerable progress, the piers and abutments are up to springing level and the wings for the most part are some feet higher, one third in width of the arches has been turned. The work is good, and the design suitable, and the material, a laminated brier-stone, is all that could be wished for in the construction of excellent masonry at a moderate cost, and, after a careful inspection, I could see no trace of unnecessary work in stone dressing, the only highly dressed stones being the skew backs and the groins. As the progress report however shows, the expenditure, on the about $\frac{5}{8}$ or $\frac{3}{4}$ finished work, is double the estimate, and I gather from what the Chief Engineer mentioned regarding

× except perhaps that the wings have hardly enough of the banks.

Para 51 of report P.W.G. No. 3191 24th October 1865

regarding the rates of the work done, and those to be allowed for completion, that $\frac{5}{5}$ths to $\frac{3}{4}$ths of the expenditure incurred should have sufficed for the work done. The question of cost however will be gone into when the revised estimate comes under review. The embankments above and below the aqueduct are far from complete, and I think, especially after the experience of the difficulty at the Hadrabagh Aqueduct, arising from the hasty completion of heavy banks, funds should have been provided for completing these banks to full section, and giving them the benefit of one monsoon at least before putting on any revetments. A considerable quantity of revetment, with the joints pointed, has been executed since last year on the right bank below the Aqueduct, and much of this has gone by a slip of the earth, as might have been expected, and what object was to be gained by revetting there, when much of the embankment is not half done it is difficult to imagine, especially as a good many months would have been necessary for the completion of the aqueduct itself. Moreover at these banks, as in so many other places, the most difference in stability gained by carrying up the earthwork in section has been lost sight of. This is a matter of importance in all earthworks but for banks which are required to settle equally and regularly, and as watertight as possible, it is essential that due care in this respect should be taken. If an irregular bank of small section be first formed, and then subsequently raised and widened, slips are almost inevitable, and cracks also, and there is then no getting at the interior to consolidate both parts. For the other hand, banks are built up foot by foot and of the full width, every settlement occasions an advantageous consolidation, and the solidity of a bank increases in every direction from the surface inwards. At the lower end of the mile also the mistake of thickening the bank with porous shale has been committed, and this should be corrected.

27 The 8 feet Culvert in the 6th mile is going to pieces. It was built or designed prior to the double banking of the Canal here, and is not now required, if the little drainage can be turned down to the wagie without difficulty, and this will be considered by the Chief Engineer. If rebuilt it will form a crossing. The sides and top of the similar Culvert in the 66th mile should be puddled, while there is water to be had close by: the masonry is indifferent, and a thick bank of puddle is the only way of making up in some measure for

for future construction. The ground in rear of the right bank of the Canal requires, in many places, to be brought into communication with the Culverts, so that drainage may not accumulate.

Instead of an 8' Culvert in the 67th mile, one of 14 feet is to be built, and judging from the flood marks of this years drainage the alteration was quite necessary.

28 The crossings provided or recommended for this Section are

Canal Crossings

No	Miles and Chains		Villages accommodation	Class	Description	For what traffic	Remarks
1	60	29	Sepad & fields	3	Culvert 14'	foot & Cattle	
2	61	9	——do——	3	——do—— 8'	——do——	
3	61	52	Serapokila and Papadanda	3	——do—— 8'	——do——	
4	62	49	Serapokila	1	Aqueduct one arch	all kinds	
5	63	75	Bunnin & fields	3	Culvert 8'	foot and Cattle	Dependent upon its reconstruction.
6	65	42	Seetan & Rudramuram	3	——"—— 8'	——do——	
7	66	77	Longala, Rudramuram & Toorchenda road	2	——"—— 14'	all kinds	
8	69	20	Parnalepad	2	Bridge 9'	——do——	in lieu of ferry
9	70	37	Hambalpilly	3	Culvert 8'	foot & Cattle	
10	71	36	Yernagudda and Mettacondal	1	Bridge	all kinds	

No 5 is doubtful, but it can be dispensed with, if not required for drainage, without difficulty, and the 10 miles of the section will then have 9 crossings, of which 4 will pass all kinds of traffic. The approaches to the Culverts of this Section require improvements equally with those of the preceding Section. No 8 — a bridge in lieu of a ferry — will be a great improvement, and the charge was regarded by the Chief Engineer, who has shown, throughout the discussion of the subject of crossings, a desire to make due provision for the wants and convenience of the villagers. Before quitting this subject, I may remark that the Tengoola aqueduct will be a permanent crossing, but that the track from the village is both in wet and dry weather extremely bad, and it would be well were this levelled, sectioned and drained, and were a Pucka road laid out south west to the road from Sirmanchela to Ingatoor.

Bowanipy Station Buildings

29 These require immediate attention, as some of them have been already much injured by the monsoon, and all the thatched buildings are more or less in need of repair. There are many of them permanent buildings, the cost of which has been debited to Capital, and there are others which it would be a pity to allow to go to ruin, though they are for temporary purposes only; as when the works are restarted there will be a demand for such accommodation.

Distribution works

30 I believe some progress was made prior to the reduction of the establishments in levelling and surveying for distribution Channels, but I have not heard with what result. There is no one available at present to go on with this important work.

31 General state. In March last year the works in the upper 6 miles of the section, which will carry irrigation water, were being pushed on forward, while below this only a little contract work was in progress, and was to be stopped as soon as possible. I saw the head works again in September 1865, and I found that some progress had been made at those views then, though all work had for some time been stopped. The upper gates of the head lock have been hung, but the sill has not been completed. The valves also have been fitted in their places - the lowness of their vertical shafts is indifferent and the capstan heads have been made, like those at Soonkasala, with the bolts at the corners of the bar sockets, and this arrangement is found to destroy the bar. All the woodwork of the valves and shutters wants coating with paint or tar.

The Canal banks below lock, when the bed is at or above ground level, will certainly leak much, and cause trouble and expense, if made entirely of loose shale and kunkur, as is now the case in some places. The drainage required to be conducted to Culverts Nos 1 and 2; at present to go any where.

From the lock to Culvert No 3, but little work has been done since last year, but below this the

6th Section Main Canal 73 miles to 91 miles.

banks are well advanced - wherever shale occurs the cross of the 2nd section have been repeated, and in some places the materials have been thrown down, so as almost to ensure great leakage. There is a ceiling of some depth between Culverts 3 and 4, and there is fair soil at the top for 9 to 12 inches, below which there is nothing but red shale. If the former has been made use of as a core for the banks, this will do, but, if not so used, there will be much leakage, even with the small depth of water above ground level.

The outfall channel of Culvert No 1 wants nothing but more, as there are 18 inches of water standing on floor at lower end.

A few months work would suffice to complete the Canal down to the end of the 7 8th mile, beyond which there will be no water carried for irrigation by the main line.

At Lock No 2 in the 79 mile there are some bar iron rails, and other moveable property, lying about, liable to be stolen.

32 From this point to the 85th mile I rode along the line; there has been nothing done

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during the last year, and there is consequently nothing to report, except that care appeared to have been taken to check out drainage from the partly formed portions of Canal.

33 Three buildings need attention; the terraced roof Cutcherry, and the verandah roof, being too lightly timbered for the span, has sagged, and should be supported. I told the Peon in charge to put struts under two or three of the valley rafters, which looked as if the next shower would bring them, and much of the roofing, down together. The spouts of the terraced roof discharge from much too great a height on to the roof of the verandah. Talaiyanoor Station Buildings.

34 The estimates for distribution channels in connection with this Section, which, in Proceedings Madras Government No. 800 dated 23rd March last were ordered to be returned for revision, have not yet been resubmitted for sanction. Distribution works.

35 Head works. The Anicut across the Cauble was completed to about 5 feet in height after my inspection in March 1865. This is half the full height. The dam is in good order and, though it was reported that 7th Section Main Canal. 92 to 114 miles.

that it had suffered from the freshes of 1865, the spring and masonry marked at Rupees 210 - 0 - 0 being washed away, the damage has been repaired and I did not see any signs of injury from this year freshes. The bed of the river has been much changed, and the pooh, on which the Anicut is built, has proved to be quite unable to stand the rainfall, and of course, now the weir twice as high, the effect of the overfall would be greatly increased - the apron is provided for in the estimate, but I believe the Chief Engineer has not yet decided upon the works to be done to render the Anicut and head works complete and secure.

36 In August 1865 there was a high freshe in the Cauble, which was considered to show that the present level of the head sluice and weirs is too low. I tried to find some marks of this freshe, but all the evidence afforded by the works seemed to negative the idea of a very high freshe - The East wing of the Anicut is not connected with the right bank of the Canal, and the ground there is more than 6 feet below the top of the wall -

wall - No water apparently passed through this pier, had it done so, the side slope of the Canal must have been guttered. The East wing of the head sluice again is not joined to the left bank of the Canal, and the ground there is some 9 or 10 feet lower than the top of the wall, and here the water did find its way into the Canal, though only to a small extent - It would seem therefore that the highest fresh rose to somewhere between 6 and 9 feet below the top of the head sluice walls, and as the depth of water running in over a weir, and as more passed over any but the lowest ground, I think the fresh did not rise to within $8\frac{1}{2}$ feet of the top of the walls, which would be equivalent to 9 feet on the floor of the under-sluices, or about 4 feet over crest of weir.

Raising the ancient 5 feet will add something less than 5 feet to the height of such a fresh, but, without information as to the difference of level of the head and tail water in August 1865, I have no means of judging what the exact height would be. It is certainly very desirable that the masonry works should be

at

at least 4 feet, and the banks connected with them 6 feet above maximum flood level, and the Chief Engineer intends that the measure of safety for the Canal bank shall be that first named. I believe that, if most of the bank is not now that height, it can be made so. —

8 Chief Engineer's report without extra expense. In the report however of September 1865

9 do - letter of 22 Jan. but received at the time it was said that the fresh had risen to 19 feet or 17½ feet on the sill of sandsluices, and the section recently received makes the level of that fresh 11½ feet on head sluice, or 17½ feet on sandsluices, sill, which would be equivalent to 19½ feet on the crest of the weir. It is of importance therefore that the level of maximum flood in the basin should be reliably ascertained, in order that on the one hand the head works may not be made too low, or on the other some 6 or 7 feet too high. I do not know on what information the level of the freshes of 1865 was fixed, but only the weir was seen at the time by a competent officer, I should be disposed to consider the report very far from accurate, and if the area, I guess under 200 of the drainage basin, and the character of the rainfall in that part of the country be considered, the improbability of such a fresh will be sufficiently great to show the necessity for

a

a careful examination of the evidence in respect of it.

37 General state of the Section. But very little work has been done since March last year, and no mile is complete, while the masonry works have hardly been commenced. I should not have thought it worth while to make an inspection, had not it appeared advisable to ascertain whether the extent of sliding would on account, to any considerable extent, for the great difference in the quantities of earthwork provided for in the sanctioned estimate and in a revised estimate now in this office, and regarding which I am in correspondence with the Chief Engineer through the Agent. I suggested that the officer now in charge of the section should accompany me, but as it would have put the Chief Engineer to considerable inconvenience had this officer, who is now at Kurnool, been deputed to go down the line of Canal, I made the inspection by myself.

38 On the correspondence which has taken place, it has been shown that the section on which it is proposed to complete the Canal differs but slightly in the quantities required from that on which the sanctioned estimate was founded, but the quantities of the revised estimate are Cubic yards 1999186 against

against Cubic yards 1460132 in the original, and after taking into account all excess of excess due to changes of arrangement, there remained in many miles such very large quantities unexplained, that it seemed to me impossible to account for them by any settling up of cuttings or washing down of bank. The Chief Engineer had no other explanation to give and, as he had mentioned in his letter on the subject "that the effect of moreover "an untrimmed work, not carefully constructed "so as to retain itself from side and ends "reaches 15 per cent in banks, and possibly "30 per cent in excavated cuttings, and that it "is therefore of no use endeavouring too closely "to reconcile excavations on such works with "the estimate", a conclusion which, even had it been capable of reconciling the differences, was one which was entirely opposed to my own experience, I thought the best plan would be to see some of the miles in which the differences were the greatest.

39 I inspected the 92 to 99 miles, in 5 out of which the differences are very large,

cargo, and I found the amount of settlement where very great, and certainly quite sufficient to account for much more than a ~~tenth~~ tithe of the quantities unaccounted for. In the same way the 105th to the 110th, and the 112th and 113th miles were examined, with similar results. I also observed that in most cases the actual quantity of silt both in the main and outside cuttings is ascertainable with quite sufficient accuracy, and that, at all events in many of the miles, there can be no difficulty in determining, within a narrow margin, what the actual quantity of work done amounts to.

40. The 103rd mile has been measured twice, once in May 1865, and again in August 1866 by different officers, and, making allowance for 2,803 Cubic yards done between these dates, the former measurements gives Cubic yards 30958 and the latter 30251 as the quantity excavated, that paid for being Cubic yards 30958. Now the difference 707 Cubic yards, between the above measurements is probably a very near indication of the amount of silting in the 15 months, and it is 2½ per cent, and, so far as I could form a judgment without detailed measurements, I

*2 monsoons

should say that the silting altogether does not exceed 5 to 6 per cent on the work really done, which would be perhaps 3 per cent on the total quantities required for the canal as designed.

41. The measurements of the 92nd and 93rd miles have been taken, and I have informed the Chief Engineer that I consider it necessary that the calculations should be completed, and the work actually done ascertained, and I have now to add that this course should be followed for every mile in which the differences are great, and work should not be resumed in the Section until the measurements have been completed, and it has been made quite clear what work has been already done, and what is still required.

42. The examination of the cross section of the 103rd mile furnished to this office shews that some extra and unnecessary work has been done by taking earth from outside cutting, where the main cutting was more than sufficient for the formation of the banks. This will of course require to be taken into account, and where lesser excess is due to this cause should be shewn

shown definitely. The top width of embankment is throughout it is, in the deepest cross section, 10 feet, and this, even if necessary in some soils where the canal bed is above ground level, is not required where the canal is in cutting, and the width should be reduced therefore to 6 feet in such cases, unless the nature of the ground will produce earth for a greater width. The neglect to leave **berms** at the top of the side slopes of the canal, where in cutting, has induced the Chief Engineer to make these side slopes, and those of the embankment also, convex, and this arrangement is under the circumstances, advantageous; but where the depth of cutting is considerable, the top of the banks will be an inconvenient level for the towing path and, in such cases, a **berm** should be formed in the embankment at 2 feet or 2½ feet above full water level. This will occasion no extra expense, and will be a convenience.

43. Much less care has been taken, than should have been the case, in protecting the unfinished works of this section from injury. In some places banks have been placed across the ends of open cuttings, but some were too slight and some ignored the circumstances and lie on the ground, and so many of them

have been broken. The failure also to connect the new works with the canal banks was a great oversight, though fortunately no damage was in consequence occasioned.

44. I should probably have to report very fully on the works in this section when the revised estimates come to be submitted, and I will therefore add nothing at present to the general remarks above made.

5th Section from its General state. My object in inspecting this
Canal–115 to 153 miles. section was rather to notice how the works had
stood, than to see what had been done since my
last report, for I knew that, every year after
March 1845, the expenditure had been curtailed,
and that there could not be therefore much pro-
gress to report. In para. 140 of my last report
Pm 4 15 May 15 to 1847 on this section, it was noticed that this was the only
part of the canal where the work had been properly
laid out for the people, and the embankments thrown
up in section, and I am glad to be able to say that
very generally the work done has stood well, that
there is very little silting and washing down of
banks, and that all necessary care has been taken
to prevent the admission of outside drainage, or to

carry off

carry it across the line, where this was requisite, without injury to the canal. The state of progress of this section is so much in advance of the 7th section, through which its supply will have to be received, that on the recommencement of work it will not be necessary at first to do more than employ all the local labor that may be available, and proceed with the masonry works in such a way as to allow of all the materials being carted to the sites during those months, in which alone carting can be economically done.—

46. The locks works of this section are the works which are the least satisfactory, and I am afraid that much money will be expended unnecessarily before they will be rendered really efficient.— In some a single recent sluice has been placed since I last visited the canal, and there is certainly a great improvement; but the lining walls are in all cases of very inadequate length, and Estimates either for the modification of those extinguishers which have been commenced, and in some cases completed with the exception of the aprons, or for the construction of the uncommenced ones on a better design have not been received.—

47. These locks very much— The wood work of the roof of the Donapáid Station Buildings—

Method of executing earthworks, and their Consolidation.

roof is much too light, and not properly arranged. The walls of the western end are much bulged, and look as if they were coming down— The wooden verandah pillars inserted between the columns, to compensate for insufficient breast summers, are some of them too thin, and one has given way, thus endangering the roof above.— The condition of the main building is very far from what should be the case, looking to the date of its erection and the cost.—

48 There is much room for improvement in these respects, and work executed since last year is little if at all better than that before. In many instances the embankments connected with the Kadra high Aqueduct which have settled greatly, dragging down and cracking over lining, and causing a considerable leak.— These banks settled 5 or 6 feet; had they been properly consolidated they need not have settled more than a few inches, they would have been moved water tight, the pressure on linings and retaining walls would have been small comparatively, and the cost of consolidation would have been saved 10 times over, and much risk avoided.—

The

the Embankments near the Teracopiba Aqueduct are just as bad, they have been thrown up without regard to conditions of stability, and they must give trouble. One serviceable piece of revetment has been destroyed, and this is but the beginning of difficulties. The earth thrown in behind the lower abutment of the Aqueduct also has not been rammed, though the only proper plan to adopt in such fillings in, even where the masonry works are not to carry water above them, is to ram them so tight as to keep out all wet. It is to be hoped that overhead works are recommenced attention to the plain rules by which alone efficient work can be obtained will be enforced, and that where bad work is done in opposition to instructions, its redoing at the cost of those whose duty it may have been to see it properly done will be required. No officer is fit to be entrusted with the executive charge of canal works who does not know that a bank made of materials which would be suitable for a filter will not retain a head of water; that the only way of obtaining regular settlements of masses of earthwork in Embankments is to build them up foot by foot of the full width, that the object of a water tight core is defeated if this be founded on a ground surface composed of gravel, that where porous material is plentiful and water-tight soil scarce, the latter should be carefully placed in the centre of the bank to form a water-tight core, and the former on the faces, where, especially on the inside, it may be very useful; that the works at their junction with masonry must not be allowed to settle as they like, but must be rammed hard; that expensive revetments should not be laid on loose unsettled banks, except in cases of acknowledged necessity; that where good and suitable soils such as gravel, Kunkar, Laterite &c. are readily procurable, it is culpable negligence to lay revetments on soft and volcable soil, such as loam, black cotton soil, instead of on a backing of thoroughly rammed suitable material, which in many cases may be made to be almost as good as concrete; that it is proper to find out what material is to be taken out of the cutting for the canal which must be excavated, before obtaining material from elsewhere, and that it is not right to obtain other soil for banks, alone for revetments

or masonry works &c, and pay for it as a separate charge, whereas the canal formation would have afforded such material, and which, when not thus used, is wasted. I might greatly extend this list but I will only add that it is the duty of every executive Officer to know what his works should cost, and what they are costing.—

49. I believe the Chief Engineer is fully alive to the errors to be guarded against in the future, and I desire that his hands may be strengthened, so that he may introduce and strictly carry out a system of personal responsibility which may obviate, or at least reduce to an insignificant amount, the waste of time and money, which the many great & hasty changings of many of the officers in charge of divisions and subdivisions have occasioned. It will be essential that transfers of Executive charge should take place as seldom as possible, and that upon each transfer the incoming officer should satisfy himself, and formally report that he has done so, that the state of progress corresponds with the expenditure shewn in the accounts, and that the estimate rates have not been exceeded. There is no difficulty in doing this if the work be carried

on properly, but it would be impossible to do so in very many cases at present, because a great deal of time would be necessary to ascertain it upon it.—

50. Simultaneously with stores and all other property of the Company, if there be suitably arranged and properly accounted for, a very short time is required for such an examination as would prevent many serious mistakes being made. Whether the Company has been in the habit of Exacting security from most of their Employés but in too many cases, these have left the service and have had their security refunded, long before errors have been detected. The accounting generally has been much improved during the last two years, and now the arrears have been brought up, and there is a prospect of all unadjusted items being disposed of within a few months, it may be hoped that, if all concerned are made clearly to understand that "Profit and Loss" will not be allowed to compensate for want of ordinary care and attention, and that "Insufficient Balances" will be permitted

permitted to be used only for its legitimate purpose, and not as a means of getting rid of the necessity, for an indefinite period, of accounting for expenditure, which either ought not to have been incurred at all, or should have been debited at once to its proper head of charge, there will not be a recurrence of the difficulties which have entailed so much trouble, and have occupied the time of a far larger office establishment than would have been necessary had the duties of those entrusted with expenditure been from the first understood, and their obligations enforced.

51. The Executive Establishment at the disposal Chief Engineers of the Chief Engineer has been so greatly reduced, Staff.—
that he is not now in a position to prepare for the commencement of work (except on a very restricted scale, much less to take up and go on with the works of the first 8 Sections— I may add that, in my opinion, the establishment is even too small to look after the admission of water where that is going on, and to take care of the canal works, buildings and property generally— Probably some few of the engineers, who were lately in the Company's Em-
ploy

employ will return, but most of those who will conduct the works in the future will be new to the country and to the work, and much care will be needed to prevent their falling into mistakes, during the time they are becoming acquainted with their duties— They will have before them a sufficient warning of what to avoid, but their work will require, owing to the state in which they will generally find it, a very great amount of care, to prevent on the one hand the perpetuation of errors, and on the other the speedy transformation of what has been done in order that future progress may be readily ascertainable, and the risk of over, or double, payment avoided— It would be no easy task for experienced and capable officers to deal with some of the sections; it will be extremely difficult for those who have never been employed on similar works, and who have never had to deal with every kind of work in detail— The Chief Engineer is giving careful consideration to these matters, and he proposes to resume work sufficiently gradually to enable him

him to conduct the proceedings of his executants; and, considering how much remains to be done, to partially utilize the supply even for the first 5 sections or 72 miles of the canal, it is to be hoped, if the Company desire to find their position improved at the commencement of the next irrigation season, but little time will elapse before the Chief Engineer is provided with funds and establishment &c.

52. Revised estimates are now in this office Revised Estimates for the following portions of the canal works.

	Estimated Cost of unexecuted Conclusions	Revised Estimates.
Received 16th July/66 2nd Section Main Canal		
Earthworks & Masonry	Rs. 1376415	Rs. 1797365
Received Do 2nd 3rd Do Do		
Earthworks & Masonry	" 581240	" 808420
Received 10th August/66 4th Do Do		
Masonry	" 109460	" 182870
Received 1st March/66 7th Do Earthworks	" 113906-6	" 409830-6

The information furnished with them, as to the causes of increase in the quantities of work, is in all cases deficient, and in some the quantities of work really done have not been accounted for, so that I am not able to submit them for sanction, and it is doubtful how soon the Chief Engineer will be able, with the present staff of Executants, to obtain the information required. It is however especially necessary that the requisite examinations should be made, and the positions of each section clearly ascertained, before the resumption of works, so that hence forth there may be no difficulty in fixing responsibility should unnecessary expenditure be in the future incurred.

I have the honor to be
Sir,
Your most obedient Servant,
Mackintosh Captain, R.E.
Consulting for L.P.C. Company

No. 3174 Public Works Department

PROCEEDINGS of the MADRAS GOVERNMENT.

Under date the 31st Octr 1866.

From
The Consulting Engineer
for Irrigation & Canal Communications

Read the following

(Here enter No. 70 dated 1 October 1866.)

The Government have perused this report with much interest, and they resolve to forward copies of it to the Right Honble the Secretary of State for India, and to the Agent of the Godavari Irrigation and Canal Communications, for communication to the Chief Engineer.

The suggestions and remarks of the Consulting Engineer should receive the early attention of the Company's Officers.

WOR

From
The Consulting Engineer
for Irrigation & Canal Communications
to
The Secretary to Govt
Public Works Department

Dated Ootacamund 1st October 1866.

Read the following Report

Recorded per Mr
Superintendent of Records
in connection with the
subject of the Report

Entered in Book
Folios

Examined & Entered
Sorter

Examined & Entered
Sorter

Items

Adverting to para 15, the Government observe that an Estimate of Rs. 4,20 for a road on either side of the bridge at the cuttings in the 20th mile of the Company's Canal was sanctioned in the Order of the 19th November 1864 — Rs. 178 were expended on the work up to the 30th April last, and the balance of the Estimate has this year been placed at the disposal of the Superintg. of the 3d Dn, who should be instructed for —

completing the work with little delay as practicable

The Commissioner of Salem in para 28 that a District road be constructed south west of the road from Canamaycherla to Nagalapuram will be considered in the Revenue Department —

Captain Mullins remarks in para 48 & 50 are very appropriate, and they will doubtless commend themselves to the consideration of the Company's Manager and Chief Engineer

To Superintg. 1st Cost with four copies of letter
" Manager. 2d Cost — Do — Do
" Superintg. 3d Dn Cost — Do — Do
" Revenue Dept Cost — with five copies of Do
Despatch last

Madras Irrigation and Canal Company's Works. Reading
relative to a letter from the Consulting
Engineer, reporting the result of his
inspection of — in September last.

A 728-729