M.R.O. 14

MADRAS RECORD OFFICE.

Government of Madras.

Revenue **DEPARTMENT.**

G.O. No. 470 Press ~~Mis.~~

371-372

Dated 26 — 2 — 1867.

Not to be folded or roughly handled

Proceedings of the Madras Government, Revenue Department,
26th February 1867.

No. 371. Read the following Proceedings of the Madras Government in the Public Works Department:—

Communicating report from Consulting Engineer, Madras Irrigation and Canal Company, for consideration of the question of the amount of water rate, per acre, which may be imposed upon the land to be irrigated from the proposed canal for a first and second crop. (Here enter 21st February 1867, No. 518.)

No. 372. ORDER THEREON, 26th February 1867, No. 470.

Miscellaneous.

Referred to the Board of Revenue for report on the question of water rate, after communication with the Collector and Officiating Director of Revenue Settlement.

(True Extract.)

(Signed) J. GROSE,
Under Secretary to Government.

To the Board of Revenue, with Proceedings Public Works Department, No. 518.

Exd. S. T. Augustin.

No. . Read the following letter from the Consulting Engineer Irrigation and Canal Company, to the Secretary to Government, Public Works Department, dated Madras, 30th January 1867, No. 111:—

* With Sketch Map.

1. I have the honor to submit the Report* on the project for a canal from Walavapore, on the Toombuddra, to Bellary, which was called for in Proceedings Madras Government of the 13th ultimo, No. 3,926 A.

2. *Anicut.*—The Toombuddra at Walavapore is divided into two branches by an island. Its bed throughout is composed of granitic rock, varying, however, a good deal in character and in level, and a native anicut served for many years to raise the water for the purpose of supplying a channel on either bank. This anicut was built entirely of dry stone, and, as much water passed through, and as the crest though formed of very massive stone was repeatedly damaged, the Government, about twenty years ago, constructed a masonry dam across the Walavapore branch, a few feet below the native work. Across the other, or Koregul branch, the native is still the only anicut, and during the recent, as in many previous, freshes, the crest was washed away for a considerable length, and to a depth of from half a yard to 2 feet. It is proposed to construct across the Koregul branch a masonry weir, similar in character to that which has proved suitable to the circumstances of the river at the other branch. The details, however, necessarily differ, for, at the Walavapore branch, the masonry anicut stands on rock, the level of which varies but little, and is, on the average, not more than about 11 feet below the crest; the bed of the river in the Koregul branch is at the deep channel 19·80 feet below the crest of the Walavapore dam, and 21·80 below that of the proposed Koregul masonry weir. Where the river bed is not more than 10 feet below the crest of the proposed weir, a simple wall, 5 feet wide at top, vertical on the down-stream side, and with a batter of 1 in 4 up-stream, has been provided. At the deep channel a top width of 7 feet, and at the next deepest place (17½ feet below crest) a width of crest of 6 feet are allowed, and, as a protection to the rock below, an apron with its junction with the wall at 5 feet below crest, and with a slope of 1 in 8, has been provided at each of the deeper portions of the overfall. The anicut wall is intended to be built with burnt granite stone in chunam, the thicker portions having a concrete core, or hearting, with bond stones at intervals. The coping is to be formed with granite stones 1 foot square and 4 feet long, laid along either edge of the crest, and connected by cross stones the length of the width of the crest, the joints being dovetailed so as to prevent the possibility of the lower edge stones being moved, without disturbing those on the upper edge. The space between the stones is to be filled in with concrete, and the surface plastered, and rubbed hard and flush. It is thought that this arrangement of the coping will be as substantial and effective as, and at the same time much more economical than, the use of whole stones laid across the crest, and I think that the plan is worthy of a trial.

3. *Lengths of Walavapore and Koregul Anicuts.*—The length of the present Walavapore anicut is 1,015 feet, that of the Koregul branch will be 1,545 feet, and of this 1,295 feet are to be in a straight line.

4. *Amount of Estimate.*—The estimate for the Koregul anicut is Rupees 81,000, of which Rupees 33,560 are for sloping aprons. The principal rates are, Rupees

Rates.

4-12-0 per cubic yard for rubble masonry, Rupees 3-12-0 for concrete, Rupees 25 to 37½ for cut-stone, granite bond stones 9 Annas a cubic foot. Hammer-dressed covering stones of aprons 8 Rupees a cubic yard, rubble filling of aprons 1 Rupee a cubic yard.

5. The mode of quarrying stone in this part of the country for building purposes is by burning, and in preparing the estimate it has been assumed that such stone as is required for the anicut works, can be obtained for Rupees 1½ to 1¾ a cubic yard. It is probable that such stone will be obtainable for less than these rates, as there are quarries in the immediate neighbourhood of the anicut; and Mr. Gordon has ascertained that at Hospett, which is not more favorably situated, burnt stone has recently been delivered at 1 Rupee the cubic yard. The Superintending Engineer, 3rd Division, has sent me a list of rates from the Officer in charge of Military Buildings Range, Bellary, and it is there shown that Rupees 1-6-0 to 1-8-0 are the rates for gneiss, the stone in question, per cubic yard. Similarly, the rate at Bellary for rubble masonry is Rupees 3-6-0 a cubic yard, against Rupees 4-12-0 allowed in the anicut estimate. Chunam is obtainable ten miles from Walavapore, in a direction east by south. It is delivered at Hospett for Rupees 8 a candy of twenty parahs, and it has been assumed that it will cost Rupees 10; and, lastly, bricklayers or builders are paid 8 to 10 Annas at Bellary, and it is supposed that they will require 12 Annas at the anicut. I consider, therefore, that the rates allowed in the anicut estimate are sufficiently ample; and the estimates for the project generally have this advantage, that they have been prepared at a time when labor of all kinds has become extremely costly, owing to the high price of provisions, and any change may be expected to show a downward, rather than an upward tendency.

6. *River freshes.*—The information which I have been able to obtain for the purposes of the present report regarding the maximum height of the Toombuddra freshes at Walavapore, is not as extensive or definite as I could wish. The October fresh of this year, however, was higher than any which has occurred since the Soonkasala anicut was commenced, and its level is clearly shown on the head sluice of the Buswana channel at 11 feet 9 inches on its gauge. There have been several freshes since the sluice was built, marking the gauge between 11 feet 9 inches and 12 feet 1 inch, and there is a mark of a fresh at 13 feet 4 inches, and this, which corresponds with 8 feet 10 inches on the crest of the present Walavapore anicut, is the highest which I could find, and it appears to be the highest with which the villagers are acquainted.

7. *Modifications of the Anicut arrangements recommended.*—It is not intended, at present, to alter in any way the Walavapore anicut, but it will have been noticed above (paragraph 2) that the Koregul anicut has been designed with its crest two feet higher than that of the other branch. This additional height will not be required for the supply of 3,00,000 cubic yards an hour, which the canal is intended, in the first instance, to carry, and the only advantage which would result from constructing it at this level at once, would be the future avoidance of the removal of the coping, were that placed on the lower level. The expense, however, of this extra work would be but small, and as the extra height would throw much more work on the Walavapore anicut, and might, on this account, be deemed objectionable, I think it will be better to make the Koregul anicut correspond in level with that across the Walavapore branch. The walls, however, can be built just as they would be, up to this level, were the extra 2 feet intended to be added at once, and they will then at any time be ready to carry the higher crest. In the next place, 5 feet appear to me to be somewhat too little for the width of the crest as a minimum, and, as the cost of increasing this width to a uniform width of 7 feet need not be great, it would be as well to make this alteration. The action on the crest does not vary according to the height of the wall, and there is not, therefore, any sufficient reason for making the higher parts of the weir 7 feet broad at top, other parts 6 feet wide, and the rest 5 feet. As before mentioned, for 10 feet high and less, the top width has been arranged at 5 feet with an up-stream batter to the wall of 1 in 4, or the wall for 10 feet would be 5 feet at top and 7½ feet at base, giving an average of 6¼ feet. If then for that height the wall be built 7 feet thick throughout, the additional sectional area will be only 7½ square feet, or an increase of less than one-eighth, while the part of the wall most liable to injury will he strengthened in the proportion of 7 to 5. The cost of coping the wider crest would also be increased, but not very materially, for concrete would form the greater part of the additional contents, and though the length of the cross stones would be increased 2 feet, or 1 foot, the area of the dressed surfaces would remain as at present.

Lastly, the sloping aprons are not, I think, as suitable as water cushions. Their cost is large as provided for in the estimate, and I believe that this cost would be largely exceeded before they could be made permanently efficient. Very massive and carefully fitted stone would be necessary to stand the overfall of 5 feet on to the upper part of the apron, and it may be doubted whether 8 Rupees a cubic yard would suffice for such work as would be required. On the other hand, the position of the rock, forming the river bed, is such as to make the construction of the secondary wall easy and efficient, and at the deepest channel I should recommend that a wall be built about 36 feet distant from the centre line of the main wall. For a length of 30 feet only this wall would be 12·69 feet in height, and the average height of the 182 feet in length requisite would be about 7½ feet. This would place the crest of the subsidiary wall 10 feet below that of the weir, the water falling over which would, at the deepest part, have a very effective water cushion, while the overfall from the lower wall would be about as favorably circumstanced as that at the main wall, where the latter is not more than 10 or 11 feet in height. If the lower walls have a top width of 5 feet, and a batter of 1 in 4 on the up-stream side, their cost, exclusive of coping, would be about 7,000 Rupees, and were they coped in the same way as the Walavapore anicut, the additional expense would be 4,200 Rupees, or altogether Rupees 11,200, and I believe they would be more efficient than the aprons at Rupees 33,560.

8. *Other head works. Offtake channels.*—These consist of a channel, a head sluice to the main canal, and a scouring sluice. The nature of the river bank is such, that the only favorable ground for connecting the main canal with the river is the depression, a part of which is occupied by the head of the Buswana channel.

The offtake for the canal supply is to be close to that of the channel just named, and 600 yards above the Walavapore anicut; it has been laid out on a flat S curve, and with a length of 1,310 yards to the centre line of the head sluice, keeping below the Buswana channel. The sill of the head sluice is to be 8½ feet below the crest of the present anicut, and the plan shows five vents of 12 feet, and 7 feet high. It is proposed to divide the vents into three bays by shutter frames, and these will offer some obstruction; and, even without taking into account the diminution of water-way which they will occasion, I think the co-efficient ·606 is as high a one as it would be prudent to adopt. The head of water with the river, flush with the anicut crest, will be 1 foot, and the discharge through the sluice would be 2,72,347 cubic yards, which is considerably less than that which is required. Mr. Gordon used Beardmore's formula, $v = 7 \cdot 5 \sqrt{h}$, and as that expression gives a discharge of 3,00,604 cubic yards for a head of 6 inches only, it appeared to him that he had made ample provision for the augmented supply of of 5,00,000 cubic yards an hour, which is contemplated in the future; but, independently of the reasons given above for adopting a lower co-efficient, there is the position of the head sluice at right angles to the offtake channel, and the draught at the scouring sluice, which will tend to reduce the head somewhat, and it appears to be advisable, therefore, to increase the area of the head sluice waterway. This can be done without any very material alteration of the design, for, in the first place, the top of the vents is 6 inches below the proposed maximum level of the water in the canal, and the level can be made the same; in the next place the sole of the main canal is 2½ feet below sill of sluice, and, if 1½ feet of this difference be removed, the area of the vents will, by these alterations, be increased to 60 square yards, and the discharge, with 1 foot head, to 3,50,000 yards, while the raising of the anicut at some future time 1 foot only, would, supposing water to be available, enable 4,95,000 cubic yards to be passed by the head sluice whenever the river was not below the top of the anicut.

Head Sluice.

Scouring Sluice.—The position and circumstances of the offtake channel render a scouring sluice necessary to prevent silting, and one with two vents, each 12 feet wide and 4 feet high, and with the sill 3 feet below that of the head sluice, has been provided for. If, however, the sill of the head sluice be lowered 1½ feet, it will be advisable perhaps to lower that of the scouring sluice, and this alteration will not only increase its discharging power, but will perhaps be an advantage by reducing the difference of level between the rear apron and the river below. The roadways of the head and scouring sluices will be 18¼ feet above the crest of the Walavapore anicut, or 9$\frac{5}{12}$ feet above the highest fresh, referred to in paragraph 6 above.

Estimates.—The estimate for the offtake channel amounts to Rupees 68,000, and that for the head and scouring sluices to Rupees 42,000. The former has been prepared after a careful examination of the ground, and of the nature of the soil through which the Buswana channel close by has been cut. The latter, however, is much less deep, and it is uncertain, in ground varying in level so much, what the exact average level of the rock or harder soil will be found to be. The rate allowed for rock, a proportion only of which is likely to be solid, is Rupees 1-4-0 a cubic yard, that for decayed rock 3½ Annas, and for the surface soil 2½ Annas. Extra lift has been separately allowed for, the item being Rupees 6,417-5-0, and baling Rupees 1,500, and contingencies 6,260-4-0, are other items, so that altogether I am of opinion that there is a fair prospect of this channel being executed within the estimate.

The rates for work at the sluices are similar to those entered in the anicut estimate, and I have already explained the data on which they have been based. The allowance, Rupees 2,000, for sluice shutters and lifting gear is, however, I think insufficient, and I would add Rupees 3,000 on this account, as also Rupees 6,000 for protective aprons and retaining walls in rear of the scouring sluice; for, from an inspection of the site, of some trial pits, and of the river bank in the neighbourhood, it appears doubtful if, when the excavations are taken out, rock of a sufficiently hard description to stand the action of water, at so high a velocity, will be met with.

9. *Probable cost of Anicut and Head Works.*—Although I have suggested some alterations of the anicut arrangements which will involve increased expense, other of these alterations will reduce the cost, and it may probably be safely assumed that the amount of Mr. Gordon's estimate will be sufficient: with then the modifications of the sluices above recommended, the cost of the head works will be,

Anicut	Rupees	81,000
Offtake channel	,,	68,000
Head and scouring sluices ...	,,	51,000
Total Rupees		2,00,000

10. *Main Canal, 1st Section.*—The 1st Section of the main canal commences at the head sluice, and is seven miles in length, it being intended that it, with the head works, shall form one executive charge.

Character of the Country.—The country through which this section of the canal runs may be said to consist almost entirely of primitive rock, chiefly granitic, in various stages of decay. The surface soil is either sandy or somewhat improved by the washing down from the higher ground of the more soluble particles of decayed rocks. Near the river the lands in the valleys between the spurs have been greatly improved by alluvium conducted to the surface by the Buswana channel. The width of ground available for the new canal is very limited, and in order to obtain the least expensive line the Buswana channel was made so extremely crooked that it has been found impracticable to keep clear of it, and the line for the canal crosses it no less than thirteen times, while at two other places the two lines are in such close proximity, as to interfere with one another. A head sluice has been provided for the Buswana channel in the left bank of the new canal at the first intersection, which occurs at 800 yards in the first mile, and diversions or straight cuts have been estimated for elsewhere; but I think it would be in every way advantageous to bring all the lands at present under the Buswana channel into connection with the new canal. In the first place it would simplify the arrangements considerably; the supply of the lands now well commanded would be improved, while those on the upper side of the channel which are now badly supplied, and for which the water has to a great extent to be raised artificially, would be very much

Interference with Buswana channel.

Transference of the Irrigation recommended.

benefited. It is certain, moreover, that the construction of a permanent masonry weir across the Koregul branch of the Toombuddra will place the whole supply on a so much more favorable footing, and tend to increase the cultivation on the left bank of the Buswana channel; that it would be on the one hand unfair to take this increase as belonging to that channel, and on the other hand it would be needlessly inconvenient and expensive to pass the required water from the new canal under the old channel. The present extent of cultivation under the Buswana channel is shown in the margin,* and, if the transfer of the irrigation be approved, the sum allowed for diversions, &c., can be devoted to the construction of irrigation sluices and channels for its supply. In either case it will be advisable to make a slight addition to the capacity of the main canal, either as far as the proposed new head sluice if the cultivation be not transferred, or for a somewhat greater distance if the Buswana channel be altogether superseded. Of course, the average area at present irrigated from the Buswana channel would, were this source of supply superseded, be irrigated from the new canal without charge.

* 530 Acres on the average of 18 years, maximum, Fusly 1274, 672 Acres.

11. *Arrangement of the 1st Section.*—The circumstances of the 3rd, 4th, and 5th Sections of the canal have obliged Mr. Gordon to economize the fall of the canal as far as possible, and, in examining the arrangements of the 1st Section, I have had to take this into account. It is, of course, impossible for me to say that all the details which have been affected by this consideration are, as at present proposed, the very best which are possible, for such a thorough investigation would occupy almost as long as the preparation of a new project. I have, however, tried, for the sake of comparison, one or two alternative arrangements of the upper part, and I have found that, without modifying the fall over a considerable length, the effect of which on lower miles would, as Mr. Gordon has ascertained, more than counterbalance the advantages in the upper sections, no benefit of moment could be obtained. I propose, therefore, in reporting on this and other sections to avoid suggesting any alterations of general design or arrangement, and to confine suggestions for modifications to such details as appear to require to be changed in order to secure the objects for which the project has been investigated.

12. *Depth of water and fall of Canal in 1st Section.*—The depth of water throughout this section for a full supply will be 10 feet. The falls of the several miles are as follow:—

M.	Yds.			
0	to 1·880	1·50	feet per	mile.
1·880	to 2·0	0·25	,,	,,
2·0	to 2·1480	0·92	,,	,,
2·1480	to 4·1260	0·40	,,	,,
4·1260	to 5·1300	0·25	,,	,,
5·1300	to 6·1240	0·42	,,	,,
6·1240	to 7·0	0·18	,,	,,

where the cutting is deep, as in the first 1½ miles, and part of the third mile, the fall has been made great, elsewhere fall has been economized as much as possible. After the cross sections of the several miles had been prepared, the requirements of lower parts of the canal led to the modification of some of the gradients, but it was found on calculating the discharge that a corresponding alteration of cross section had not been made. Thus, in the part from 1½ to 2 miles the rock cutting, shown in the cross section as 60 feet wide, requires to be widened to 90 feet. From 4·1260 miles to 5 it will be necessary to add 24 feet to the width, 51 feet, of the deeper part of the channel. In the 7th mile a length of 500 yards had a depth of water of 8 feet only, except for a width of 9 feet in the centre, but this section gives a discharge of only about two-thirds of the full quantity, and, therefore, the full depth will be given over the whole bottom width, which is 118 feet. The discharge provided from the other parts has been found to be sufficient, except in the first 1½ miles, where, by Beardmore's formula,* it is over the 300,000 yards, but by Dubuat's 285,000. The latter is adopted by Neville, and it is, from its form, likely to be more correct for varying data than the more simple one given by Beardmore, and, as the sufficient capacity of the upper part of the canal is of very great importance, and as the part of this section below 1½ miles will, with the alterations above alluded to, have a full sectional area, it has been thought advisable to widen the first 1½ miles 3 feet 2 inches, which will increase the cost by $\frac{1}{15}$th.

* $v = 55\sqrt{2f \times \text{H.M.D.}}$

13. *Height of Banks above full Canal level.*—The height of the banks above full water level will, in this section, be 6 feet as a minimum.

14. *Amount of Estimates for Earth-works.*—The amounts of the estimates for earth-works in the several miles, with the additions referred to in the preceding paragraph, are as follow:—

	Rs.	A.	P.	Rs.	A.	P.
1st Mile—Estimate	1,23,949	9	0			
Add $\frac{1}{15}$	6,523	10	1			
				1,30,473	3	1
2nd Mile—Estimate	1,20,481	9	10			
Add $\frac{1}{15}$ on upper half ...	3,170	9	1			
Add for widening lower half.	22,000	0	0			
				1,45,652	2	11
3rd Mile—Estimate	...	...	...	2,09,029	6	6
4th do. do.	...	...	...	1,43,305	1	6
5th do. do.	85,615	12	6			
Add for widening from 4·1260 to 5	6,666	10	8			
				92,282	7	2
6th Mile—Estimate	...	...	...	49,888	11	4
7th do. do.	34,967	7	6			
Add for 500 in length of extra cutting	15,138	14	3			
				50,106	5	9
				8,20,737	6	3
Contingencies... ...				82,262	9	9
Total... ...				9,03,000	0	0

15. *Rates.*—The rates allowed throughout are 1-4-0 per cubic yard for rock excavation, 3½ Annas for decomposed rock, and 2½ Annas for surface soil. These rates are those for a lead of 20 yards, and a depth and lift of 1 yard, and wherever these are exceeded, 2 Pies additional are entered, under the name "extra lift," for every additional yard in depth of excavation or height of lift, and for extra lead. The allowances on this account vary from Rupees 7,566 in the first

mile, to Rupees 437 in the seventh. The number of trial pits put down in this section is thirty-nine,* or an average of 5⅔ per mile. I examined a great many of them, but all are more or less, and some of them almost entirely, filled up, and I cannot say, therefore, what is the exact nature or degree of hardness of the rock at the bottom of them. Judging, however, from the many pits I have inspected in other miles, I believe that a very considerable proportion of the excavation, put down as rock at the maximum rate, will be readily taken out with the pick and crowbar, for the trial pits are seldom more than 3 to 4 feet diameter at the bottom, the material taken out is in no case hard rock, and it is evident that what may be very difficult to get at at the bottom of such a pit, may be easily removed in a wide cutting. If the whole of the rock excavation were to require blasting, the rate, Rupees 1-4-0, would probably suffice, in all cases except where the quantity to be removed was but small, and if, therefore, any considerable portion can be more easily removed, the average rate will prove more than fully ample. It is, perhaps, to be regretted that at least a few trial pits of larger size were not carried down to bed level, or at least into solid rock, so as to afford direct evidence of the material met with; it is, however, quite certain that nothing harder than gneiss will be found, and as this can be burnt and carried some distance for 1 Rupee, blasting on a large scale ought not to be more expensive. The decomposed rock of the estimate is such as comes out readily with the pick in the form of fine gravel, with occasionally thin layers of coarse gravel or small lumps of quartzose rock. Such material abounds over a very large area of this part of the country, and is generally found within a short distance of the surface. When acted upon by water it leaves a considerable amount of coarse or fine quartz sand, and in this form occurs much too frequently for agricultural purposes on the surface. The surface soils of this section are all easy to excavate.

* Besides 28 on trial lines.

16. *The Canal is double-banked generally.*—Where the water in the canal is entirely in soil, the numerous small drainages are intended to be admitted through openings in the upper spoil bank. In the fifth, sixth, and seventh miles, where the water surface comes above ground, regular double-banks will be formed. There is only one culvert, near the lower end of the fifth mile, and this is combined with an inlet. As, however, some drainage will in other parts accumulate behind the right bank, unless some passage for it be given, I have suggested the introduction of small masonry openings with self-acting shutters opening into the canal for the admission of such drainage whenever it rises above the level of canal water.

17. *Masonry works and their Cost.*—The masonry works of the section and their estimated cost are shown below:—

					Rs.
No. 1 Bridge,	3rd	class,	at lower end of	2nd mile ...	5,750
,, 2 Do.		do.	in	3rd ,, ...	5,750
,, 3 Do.		do.	in	5th ,, ...	7,600
,, 4 Do.		do.	in	7th ,, ...	7,600
Culvert and inlet			in	5th ,, ...	9,700
No. 1 Waste weir,	length	70 yards	in	1st ,, ...	3,500
,, 2 Do.		50 ,,	in	3rd ,, ...	2,500
,, 3 Do.		100 ,,	in	5th ,, ...	5,000
		Total of Masonry Estimate...			47,400

The design for No. 1 bridge shows five arches of 30 feet span each, and it is intended to build it with three arches only at first, and for which the estimate provides, and to add two arches at some future time, should the canal be required to carry 500,000 instead of 300,000 cubic yards per hour. The width of roadway for third class bridges between parapets is 12 feet, and the gradient of the approaches 1 in 12 to 15.

The other masonry works are simple in design, and call for no special remark.

Rates. The rates vary but slightly from those allowed for the anicut and head works.

18. *Extra works.*—The subjoined works are provided for in the estimate under the name of extra works:—

	Rs.	A.	P.
Six diversions of the Buswana channel	12,525	15	6
Catch-water drain	762	10	6
Contingencies	1,221	7	0
	14,500	0	0
To which I have added the amount for a head sluice to the Buswana channel...	3,200	0	0
Total...	17,700	0	0

because this head sluice, which was included in the masonry estimate, will be required if the diversions are needed, and not so if the cultivation under the channel be transferred to the new canal.

19. *Total estimated cost of the 1st Section, seven miles.*—The total estimated cost then of the 1st Section, main canal, stands thus—

Earth-works	Rupees	9,03,000
Masonry works	,,	47,400
Extra-works...	,,	17,700
	Rupees	9,68,100
	or per mile	1,38,300

20. *Number of Crossings.*—Across the present Buswana channel there are no less than twelve bridges. Four have been provided across the new canal, and I think these will be found sufficient. Stone being very abundant there was a great inducement to construct the numerous small bridges, with covering stones for the spans, across the old channel, and there are four of these close to Bussapoor. All the four bridges are placed close to the four villages situated on the right bank of the Canal, and they are equally convenient whichever direction may be required to be taken after crossing.

General description, 8th to 15 miles.

21. *Second Section Main Canal, 8 to 17 miles.*—At less than 200 yards from the commencement of the section, the line crosses the Mookartee nullah, the first considerable cross drainage met with, and for which an aqueduct of five arches of 20 feet span each has been provided, the width at canal bottom being 62 feet, and at water surface 75 feet. The bed of the

nullah corresponds very closely with the line of the springing of the arches, but it is intended to lay the masonry foundations 9 feet below this level on a bed of concrete 4 feet thick. About 500 yards below the aqueduct site is the anicut, by which the Ryah Calava crosses this drainage, and it is this dam which has caused the elevation of the bed of the nullah and, with a view to the removal of the obstruction, Mr. Gordon was disposed to advocate the giving the Ryah Calava new supply from the main canal. On considering this point, however, it has appeared to me that it would not be wise to do so, for the channel, which is at present supplied from the Hosscotta anicut, would absorb a large quantity of water, some 3,000 cubic yards an hour, which can be much more profitably employed in irrigating fresh land. I understand that the Superintending Engineer of the 3rd Division is contemplating the improvement of the Ryah Calava, and if, in carrying out such improvements, he can manage, either by substituting an aqueduct for the anicut, or by modifying the latter by giving additional sluice vents to keep down the bed level, the aqueduct designed by Mr. Gordon will probably answer its purpose; but, if the anicut be maintained as at present, I think it will be better to lengthen the aqueduct to the extent of two arches. The additional cost of the work would then be about 13,000 Rupees.

	Acres.
Average cultivation	1,683½
Maximum do.	1,971

The amount of water passing down the Mookartee nullah is limited generally to the drainage of less than 30 square miles of country, for the Dunnaikankerra tank, which intercepts the upper drainage, very rarely fills. Were that tank to fill and breach the proposed aqueduct, with even seven instead of five arches, would not be able to pass the flood, and some part of the canal bank would have to give way, and it might be arranged that this should happen opposite a weir 200 yards in length, which is to be placed 1,000 yards below the aqueduct. In this mile the canal crosses the Buswana channel for the last time, and in the 9th mile it rounds the northernmost spur of the Sundoor hills, and takes an east by north course almost parallel with that channel. In the 10th mile a small drainage is admitted into the canal, the right bank being turned some little way up the two sides of the nullah, and the estimates provide a third class bridge for the bandy track between Hospett and Mellapoor, which at the crossing would be submerged. A short diversion of the road will, I think, render the construction of the bridge unnecessary. Just below this a waste weir of 100 yards crest has been provided, and a similar work of equal length at the lower end of the mile. A third class bridge will be built 600 yards from the bottom of this mile, opposite Amravutty. In the 12th mile the line crosses the road from Hospett to Chitwady, where a second class bridge will be built, and then passes just to the north of the Tahsildar's Cutcherry and sweeps round the north and east sides of Hospett, commencing a curve to the eastward on entering the 13th mile, and then joining the bund of the ruined Anantsaingoody tank, just before entering which a weir, 100 yards in length, is to be placed. The old bund is to be repaired and the drainage is to be passed under the canal, ordinarily, by a culvert, but, in case of very heavy rainfall, provision for admission of flood-waters by an inlet, in connection with the culvert, has been made. The line of canal in sweeping round Hospett cuts across the Camlapore road, and it again crosses it at the lower end of the 13th mile; a diversion, therefore, for this road has been arranged from the point where the Bellary road leaves Hospett, and a roadway for it will be formed over the south end of the inlet culvert. On leaving the old tank the line contours high ground, and is, for a length of 500 yards in the 14th mile, single banked; at the lower end of this part a weir of 100 yards has been provided for, and a similar work, 250 yards in length, is to be placed near the termination of the mile. At the beginning of the 15th mile a small drainage is admitted, and the line then runs nearly due east to a saddle, through which a cutting was partially excavated many years ago.

The other masonry works provided for these eight miles are a culvert of five vents of 5 feet each in the 11th mile, and culverts each of one vent of 4 feet in the 12th mile.

22. *Trial Pits.*—There are seven or eight trial pits in each of these miles. In the 10th mile, for a length of 400 yards, rock has been found, also for 500 yards in the 11th mile, for 400 yards in the 13th mile, and for 200 yards in the 15th mile.

23. *Nature of Soil.*—The surface soil is for the most part brown regar (cotton soil) overlying decomposed granitic rock, which generally is so far decayed as to come out as fine gravel. This gravelly and, to a greater or less extent, porous material is in most places found above bed level, and it will, at least for some time after the admission of water, occasion much absorption. In no case has any really solid rock been taken out of the pits, and I think that, as in the 1st Section, what is difficult to remove from the bottom of a trial pit will be readily excavated in open cutting. The rock at the end of the 15th mile may certainly be easily removed.

24. *Height of Banks.*—The banks will be 6 feet above full canal level, except where a road is carried along the top. Shingling has been provided for the interior slopes where necessary.

25. *General description, 16 and 17 miles.*—I have divided this section into two parts, because, on leaving the deep cutting in the 16th mile, the character of the country changes very materially. The line in these two miles takes a south-easterly direction, re-crossing in the 17th mile the Camlapore road, for which a second class bridge will be given, as also, at the beginning of the 16th mile, a third class bridge for the Humpee road. The canal in these two miles skirts high ground falling in a north-easterly direction. There is no surface soil similar to that found above the cutting, and the subsoil is decomposed granitic rock, mostly so far gone as to come out readily as gravel. The ground is bare and waste generally, but there is some cultivation near the Camlapore road. The canal is to be single banked, and in many places the banks will be high. At only one place, about the middle of the 17th mile, did I see any soil likely to make a water-tight bank. The estimate provides in the 16th mile for a bank 6 feet above water, 6 feet wide at top and with slopes of 2 to 1, the inner slope being pitched to 3 feet above water level, and, in the 17th mile, for a bund 3½ feet above water, 18 feet wide at top, with 2 to 1 slopes, the inner shingled. In both these miles when the head of water against the banks will exceed 4 or 5 feet, I should recommend the insertion of a watertight core. In

the 17th mile I think a sufficiency of good earth for this purpose may be obtained with a little trouble, but in the 16th mile probably the cheapest arrangement will be to insert a masonry wall as a core, and this need not be very thick, if care be taken to raise the bank equally and regularly in front and rear, consolidating it, as far as may be practicable, foot by foot, and keeping the height of the wall only a little in advance of the earth-work. For a length of, altogether, about 800 yards such a wall 2 feet thick at top averaging 12 feet in height, and with front and rear batters of 1 in 12 will be needed, and the cost will be about Rupees 14,400. In the 17th mile, probably, an addition of Rupees 5,000 to the estimate will provide sufficiently for the formation of a core of selected soil where most needed.

26. *Water-spread.*—The water-spread where single banked will be very small, the maximum width in the valleys being from 200 to 260 yards, and no valuable land will be submerged.

27. *Masonry works.*—The masonry works, other than the bridges already referred to, in these-last two miles of the 2nd Section, are three waste weirs of 100 yards in length each.

28. *Trial Pits No.* 15.—The trial pits show rock, too hard to be excavated in a confined space, in 300 yards of the 16th, and in 750 yards of the 17th mile; all the other excavation will be in decomposed rock, corresponding with loose, or compact, gravel.

29. *Fall of Canal, 2nd Section.*—The way in which the fall of the canal in this section has been arranged is as follows:—

M. Yds.				
From	7·0	to 7·880	feet 0·18	per mile.
,,	7·880	to 7·1280	,, 0·20	,,
,,	7·1280	to 8·0	,, 0·16	,,
,,	8·0	to 9·0	,, 0·25	,,
,,	9·0	to 9·960	,, 0·27	,,
,,	9·960	to 9·1360	,, 0·55	,,
,,	9.1360	to 10·0	,, 0·27	,,
,,	10·0	to 10·1000	,, 0·16	,,
,,	10·1000	to 11·0	,, 0·34	,,
,,	11·0	to 12·0	,, 0·17	,,
,,	12·0	to 12·380	,, 0·15	,,
,,	12·380	to 12·780	,, 0·55	,,
,,	12·780	to 13·0	,, 0·15	,,
,,	13·0	to 13·520	,, 0·23	,,
,,	13·520	to 13·1120	,, 0·25	,,
,,	13·1120	to 14·0	,, 0·23	,,
,,	14·0	to 14·1360	,, 0·20	,,
,,	14·1360	to 15·0	,, 0·75	,,
,,	15·0	to 15·300	,, 1·25	,,
,,	15·300	to 16·100	,, 0·28	,,
,,	16·100	to 16·540	,, 1·25	,,
,,	16·540	to 16·1440	,, 0·20	,,
,,	16·1440	to 17·0	,, 1·00	,,

30. *Depth of water and capacity of Canal.*—The depth of water will be 10 feet throughout the section, except for a length of 500 yards in the 15-16 miles, where 12 feet are allowed, and the canal is intended to carry 300,000 cubic yards an hour.

31. I have checked the cross sections for capacity in the case of four differing falls. They are all somewhat under the full size required if Dubuat's formula be used, but there is generally an excess of capacity by Beardmore's formula. As in this section it is of less importance that the projected cross sections should be very accurate and sufficient, because all that will happen, if they are somewhat small at the intended depth, will be that a rather greater depth will be assumed by the water, I do not propose making any addition to the estimates on account of widening.

32. *Amount of Estimates for Earth-works.*—The amounts entered in the estimates for the earth-works of the several miles of this section are shown below, and I have added the sums which appear necessary,* to render the banks in the 16th and 17th miles safe.

* *Vide* paragraph 25 above.

					Rs.	A.	P.
8th Mile, Estimate ...	...	...	...		39,889	1	10
9th do.	do.	...	...	... ...	40,963	1	4
10th do.	do.	...	...	... ...	63,837	8	8
11th do.	do.	...	...	... ...	77,661	12	8
12th do.	do.	...	...	... ...	47,403	4	8
13th do.	do.	...	...	... ...	61,571	11	10
14th do.	do.	...	...	... ...	37,755	11	0
15th do.	do.	...	...	... ...	54,161	5	0
16th do.	do.	...	55,867	9 4			
	Add	...	14,400	0 0			
					70,267	9	4
17th Mile, Estimate ...			95,221	10 4			
Add		...	5,000	0 0			
					1,00,221	10	4
					5,93,732	12	8
Contingencies...	...	...			59,377	3	4
					6,53,110	0	0

33. *Rates.*—The rates included in these estimates are similar to those for the 1st Section, and, judging from the material taken out of the trial pits, I am of opinion that they are likely to prove sufficient, and that but little rock will be met with, which should cost as much as Rupees 1¼ per cubic yard to excavate.

34. *Masonry works and their cost.*—I have already noticed the masonry works in giving a general description of this section of the canal. A list of them, with their estimated cost, is subjoined, and I have added Rupees 13,000 to the estimate

for the Mookartee nullah aqueduct, on the supposion that its waterway will have to be increased by the addition of two arches :—

			RS.
Aqueduct over Mookartee nullah		65,100	
Add for two additional arches ...		13,000	
			78,400
No. 1 Bridge, 3rd class, five 24 feet arches for Mellapoor			84,000
No. 2 do. do. three 30 feet do. do. Amrawutty			6,280
No. 3 do. 2nd do. three 24 do. do. do. Hospett ...			9,180
No. 4 do. 3rd do. one 60 do. arch in 16th mile ...			4,120
No. 5 do. 2nd do. one 60 do. do. for Mulpungoody			5,480
Allowance for centrings and scaffoldings for the above five bridges...			10,000
Culvert and inlet in 11th mile			15,400
Do. in 12th mile			8,120
Do. in do. do. at Hospett			8,980
Culvert and inlet with bridge in 13th mile, Anantoaingoody			27,900
Nine waste weirs, total length 1,050 yards, at Rs. 55 ...			57,750
Total for masonry...			2,26,710

35. *Rates.*—The rates vary from Rupees $4\frac{1}{4}$ to $4\frac{1}{2}$ for rubble masonry. Rupees 8 per cubic yard are allowed for hammer-dressed stone work; for the aqueduct in eighth mile a lining of stone slabs with asphalte joints is allowed, the rate* being Rupees 6 per square, and for the culverts a coating of asphalte to the vents is to be given, the estimated cost being Rupees 30 per square. The rates for masonry appear to be sufficient.

* For the joints

36. *Extra works.*—Under this head the following works, not forming part of the canal itself, are provided for :—

	RS.	A.	P.
Road diversion from Amrawutty in 7th and 8th miles, length 2,300 yards	575	0	0
Drainage into Mookartee nullah, 7th mile, 700 lineal yds.	328	2	0
Diversion of road opposite weir, No. 2, 10th mile, 350 lineal yards	284	6	0
Bridge over nullah in 10th mile above canal (will probably be unnecessary)	3,380	0	0
Diversion of road to do.	100	0	0
Excavation and ramming, &c.	50	0	0
Diversion of drainage in 11th mile	257	13	0
Formation of road on north bank of canal, 11th and 12th miles	332	8	0
Diversion at cutting 400 lineal yards	325	0	0
Do. of road in 13th mile, 800 do.	650	0	0
Formation of do. on bank, 900 do.	225	0	0
Drainage at back of bank, 13th mile	257	13	0
Diversion of stream in tank, do.	1,050	0	0
Deepening stream in 15th mile, 3,200 lineal yards ...	500	0	0
Embanking do. exclusive of excavation, 5,200 lineal yards ...	812	8	0
Ramming do. 8,400 do.	131	4	0
Masonry in fall of stream, 259 cubic yards, rubble stone in chunam	1,165	8	0
120 Cubic yards stone pitching	120	0	0
Contingencies...	1,155	2	0
Total of extra works...	11,700	0	0

37. *Total estimated cost of the 2nd Section.*—The total estimated cost of the section is for :—

	RS.
Earth-works	6,53,110
Masonry works	2,26,710
Extra works	11,700
	8,91,520
Length 10 miles, or per mile	89,152

38. *Stop gates and extra sluices in weirs.*—The only additional works which appear to be requisite in the 2nd Section are stop gates to isolate any part of the canal, the banks of which may be in danger of breaching, or may have given way. To take off the supply above, the nearest weir should have sufficient sluice opening. The bridges and deep cuttings will generally be the most economical sites for stop gates, and I should recommend the first to be placed at the Amrawutty bridge in the 10th mile, the weir, 500 yards above, being furnished with extra vents. The second may be at the bridge at the beginning of the 16th mile, vents being added to the 250 yards weir at the bottom of the 14th mile.

3rd Section Main Canal. Miles 18 to 26.

39. *General description.*—At the end of the preceding section the canal was approaching the range of hills which run continuously from Inglagy, a village about four miles east of Hospett, in a direction due east to Darojee; and a few yards from the beginning of the 18th mile, the direction of the canal changes from south to east, and runs throughout the section through a very difficult country, in which there is generally very little surface soil, much gravel, and a superabundance of boulders, with some solid rock appearing above ground. The sub-soil is, as a rule, decayed granitic rock, varying from something not more difficult of excavation than ordinary gravel, to what is only a little less hard than solid rock. In comparatively few places will solid undecayed rock have to be taken out, and then, for the most part, for seatings for walls, weirs, and other masonry works. The chief difficulty will be the almost entire absence of soil capable of being formed into a water-tight bank, and while inspecting the line and examining the trial pits, I have noted a great many places for which the ordinary embankment provided would not be likely to prove suitable, owing to the circumstance just referred to; and the experience gained in the somewhat similar, but less difficult, 2nd Section of the Kurnool Main Canal, leads to the conviction that it will be better to face the difficulty in the first instance, and to provide works which, though more expensive, may be expected to be fairly free from leakage.

40. I will now endeavour to give a description of these miles, and to mention each part in which a modification of the banks or arrangements appears to be necessary. In the 18th mile, after passing through two short but rather deep cuttings, the line crosses the Jalikerry Hulla, the drainage of which is intended to be received, by a bank, with a wall in its centre carried to 4 feet below water, or 6 feet above bed level. Two weirs of 140 and 50 yards length, respectively, are provided on the sides of the hill on the left bank, to discharge surplus water. This Jalikerry Hulla, however, is the main rainfall feeder of the Camlapoor tank, and while, on the one hand, it would not do to cut off this supply without compensation from the

canal, it would be clearly bad policy to stop water which would be comparatively useless, and on the other hand to give, instead, water of considerable value. On this account I should recommend the abolition of the small and lower weir, and the construction of a wall across the drainage, with a sufficient number of vents* to pass the flood waters during the few days in the year on which heavy rain falls. The extra expense of this arrangement will be but trifling, and it will be satisfactory as regards the tank supply, and economical to the canal. The vents should be placed 3 or 4 feet below bed level, and then but little silt will be brought into the canal. From this nullah, for a length of 500 yards, the canal will be in from 3 to 6 feet cutting, and, bad as is the soil, perhaps a little care in the selection of the best that is to be had for a core will suffice. For nearly 500 yards below a wall 2 feet thick at top, with a front batter of 1 in 6, backed with 4 feet of punned earth, and behind that the spoil from excavation has been provided. The rest of this mile and the beginning of the next are occupied by a waste weir, 215 yards in length, which might be shortened without risk. The bed level is then lowered 2 feet, giving a depth of 12 instead of 10 feet of water for a deep cutting, 700 yards in length, through a saddle into the basin of the old ruined Hagalubatina tank. The maximum depth of cutting will be 46 feet, and, from the six trial pits which have been sunk, it has been estimated that rock will be found, on an average, about 6½ feet from the surface: the pits, though stopped by what is shown on the section as rock, had yielded nothing which would cost more than half a Rupee a cubic yard to remove. From the outfall of the cutting to the tank bund, no work is required: the bund is to be raised and strengthened. The tank holds no water, and there is no catchment basin beyond that which might be expressed in square yards, and, unless it were intended to construct catch-water drains beyond the saddle, it is difficult to understand the object to be gained by making the tolerably large bund which still exists. Leaving the south end of the bund, the canal is obliged, for a length of 300 yards, to cross low ground; an ordinary pitched bank, with two to slopes, is provided for this part. The soil is highly porous, and in some places this bank would have to rest on sheet rock. It will be necessary to substitute the bank, Section F, which has been described above, for bank Section A. The additional cost may be taken as Rupees 9,000; about 100 yards of deep cutting then occur, and beyond this to the end of the mile, 100 yards, and for 930 yards in the 20th mile, the embankments require to be altered to Section F. The addition to cost will be 3,000 and 27,900 Rupees respectively; and for 120 yards, immediately above the waste weir of 100 yards, and for 223 yards at the end of the mile, the change will involve an extra expense of 40 Rupees a lineal yard, or Rupees 13,720. In the 21st mile for the first 477 yards the same change is required, and, of these, 277 yards will cost 40 Rupees a yard, and the remaining 200 yards 30 Rupees a yard. For the next 546 yards there will be a rocky cutting, at

* Five vents of 4 feet width by 4 feet in length.

Bank Sections, Bank F.

20th mile.

21st mile.

the lower end of which a weir 175 yards in length is proposed to be given; and thence to the end of the mile, with the exception of a length of 180 yards, for which a weir is provided, and 100 yards of cutting, the embankment will need to be formed on Section F, instead of O, or A; a small length of core wall has been included in the estimate for the bed of a nullah, this will diminish the expense. The whole extra cost for the mile will, therefore, be about as follow:—

277	lineal yards	at 40 Rupees	.. ..	Rupees	11,080
200	do.	at 30 ,,	... ...	,,	6,000
457	do.	at 30 ,,	... ...	,,	13,710
				Rupees ...	30,790

22nd mile.

For the first 297 yards the estimate provides bank F Section, which had better be extended for 58 yards, costing about 33 Rupees a yard. For the next 172 yards I think, with a little care in selecting earth for a core, an ordinary bank may be made serviceable, and below this the core wall provided for a length of 118 yards, requires extending upwards for 70 yards, the extra cost of which will be about 20 Rupees a yard. For the 957 yards of this mile below the waste weir of 80 yards, perhaps the cheapest arrangement that can be proposed is the insertion in the bank of a core wall, with its top 2 feet wide and 8 feet above bed level, batter on both sides 1 in 8, and foundation 3 feet deep. Its average height would be 10 feet, and the cost per yard 24 Rupees. The additions to be made then to the estimated cost of the mile will be—

58	lineal yards	at 33 Rupees	... ...	Rupees	1,914
70	do.	at 20 ,,	... ...	,,	1,400
957	do.	at 24 ,,	... ...	,,	22,968
				Rupees ...	26,282

23rd mile.

On entering this mile the line runs north-east along the bund of a ruined tank, and then turns north-west along the face of a spur, which it sweeps round, and at the half mile passes through a saddle with a maximum cutting of 31 feet. The spur just alluded to is composed of highly porous gravel, and decayed rock, but there is some tolerably good soil in the low ground below the bank, and Mr. Gordon thinks that he can obtain enough to make a watertight core, so I will not recommend any additional works at this part. Below the cutting, however, the banks are very high, and the soil very bad, and there is no better to be had, and there seems to be no alternative but to provide for walling, on a section similar to that called bank F, at a cost of Rupees 40 a yard, for 750 yards, adding 30,000 Rupees to the estimated cost of the mile.

24th mile.

This mile also runs over extremely porous soil, and the bed level is generally above ground. This can hardly be avoided in the first 500 yards of the mile, but below this I think the line might be carried with advantage, and without any important increase of length, higher up the slope, to the eastward. It will be needful to add 40 Rupees a yard to the estimates for the

first 500 yards, and 20 Rupees a yard thence up to the junction with a rocky hill 500 yards below, supposing the line to be taken higher up; below the cutting near this hill, and the commencement of the cutting at the lower end of the mile, there are 540 yards of heavy embankment, with no suitable soil, which will cost Rupees 45 a yard for walling. The additions to this mile are, therefore,

500	lineal yards	at 40	Rupees	Rupees	20,000
500	do.	at 20	,, ...	,,	10,000
540	do.	at 45	,, ...	,,	24,300
			Rupees ...		54,300

25th mile.

At the beginning of this mile a cutting, in which the depth of water is increased to 12 feet, commences, leading to a short tunnel through a saddle, the summit of which is 106 feet above canal bed. It is proposed to carry the open cuttings until a depth of 81 feet is reached, and the tunnel to connect these will be only 154 yards in length. It will, I think, probably be found advisable to terminate the open cuttings at a depth of 48 feet, and lengthen the tunnel 32 yards at the upper, and 25 yards at the lower end, but this will depend upon the nature of the soil met with as the excavations progress. The whole length of deep cutting, including the tunnel, is 400 yards. The surface of this hill is gravel with much small, and some large, boulders of slightly decayed granitic rock, and the east slope shows much more rock than the west. There are no trial pits, and it would have been difficult to put any down, which would have afforded more information than is to be obtained from an inspection of the surface, without going to a great depth. I do not myself think that any large proportion of solid rock will be met with. The tunnel has been arranged with a depth of water 15·59 feet, its cross-section for waterway is a semi-hexagon of 18 feet side, width at water surface 36 feet. The rock above is supposed to form a flat segmental arch, with a rise of 4 feet. The fall through the tunnel is at the rate of 2½ feet per mile. The canal bed in the open cutting below is raised 3·59 feet above that of tunnel, to agree with the depth of water above the tunnel, and I think this part would require to be deepened and continued with the full fall to make the draught through the tunnel what it is intended to be; however, as the water can rise in the canal above the few inches, which would be necessary to give the head needed to overcome the obstruction, which acts somewhat as a bend in a pipe, it is of very little consequence whether the proposed arrangement be adopted or modified. On leaving the tunnel and lower cutting, the line of canal runs along the north face of a steep range of hill, the soil of which is not suited to form a water-tight bank. The 2 feet near the surface are composed of a hard conglomerate gravel, a variety of pudding stone, and below this there is decayed granitic rock. The depth of water will vary from 13½ to 21½ feet, and there does not appear to be any probability of obtaining soil, which might be used as a core, within a moderate distance, while a bank formed entirely of the local soil would run a great risk of giving way. In lieu, therefore, of the bank "A" provided, it will be necessary to substitute either one of the "Section F" form, or one on the "H" plan, which gives a core wall. The cost on the present line would add 45 Rupees a yard for 450 yards to the estimate, but I think by placing the canal higher up the slope, nearly half this great additional expense may be avoided, and I propose, therefore, to add only 450 × 25 = Rupees 11,250 on this account. Mr. Gordon's object in keeping low down was to leave room for the additional waterway, which would be necessary were the extra supply, 2,00,000 cubic yards an hour, to be carried, and unless the cutting on the hill face will stand at a steep slope, the higher alignment might involve, in the future, a large amount of excavation. This would perhaps negative an alteration of the line were it not that probably the extra supply may be carried with but little extra width, by making an addition to the depth, and this particular part of the line will offer considerable facilities for such arrangement. Thence to the Sunkulkerry nullah, the line will run over extremely rough and rocky ground where, for the first time, quartzite makes its appearance. There will be but little cutting, and that only on the right bank of the canal, and the left bank will be formed by walls. The bed of the nullah is composed entirely of rock, chiefly quartzite, and the estimates provide an aqueduct of three arches of 25 feet span. The arches are semi-circular, the springing line 10 to 19 feet above bed, the bottom width of canal between side walls 57 feet, and the depth of water 10 feet. The design of this aqueduct is bold and massive. Below the aqueduct and the walling, in lieu of embankment connected with it, a waste weir of 180 yards in length is to be built, and thence to the end of the mile there are 210 yards of embankment on the "A" Section. For the deep ravine, which this bank crosses, a wall inside the bank has been provided, and though there is no suitable soil on the line with which to form a core for the remaining yards, Mr. Gordon says that he can obtain it within a moderate distance below, and as the quantity necessary is but small, perhaps this will prove to be the case, and I will not, therefore, recommend a modification.

26th mile.

The line for the canal continues to follow an easterly course until nearly the end of this mile, where it changes to nearly due north, crosses the valley and the Camlapore and Darojee road, which is to be diverted, and for 192 yards beyond the end of mile, which length is included in the section, continues in a straight line up to the hills on the north side of the valley. This bank across the valley intercepts the drainage to the westwards from the Nellapore water-shed, and a small tank will be formed, averaging 200 yards in width and about half a mile in length; the little dry cultivation which will be submerged is almost valueless. At the beginning of the mile there will be 350 yards of bank laboring under the same disadvantages, as regards difficulty in obtaining soil for a core, as has been mentioned to be the case at the end of the preceding mile, and I will leave them to be dealt with in the same way. Then will come a cutting of 140 yards, maximum depth 23½ feet, across a spur; below this 450 yards of difficult ground, for parts of which a bank with a core wall, a solid masonry wall, and an inner masonry wall with soil backing are provided; 455 yards of embankment of the Section A follow; there are no trial pits here, but the surface soil is very sandy and gravelly, and there is no chance of any better soil being met with below, so that there appears to be no alternative but to provide for walling in continuation of the Section F immediately above. This will add 455 × 25 = Rupees 11,375 to the estimate. Below this a weir of 120 yards is allowed, then a length of 50 yards of

the II Section, with a core wall at a nullah, next 223 yards of bank Section A, a length of 45 yards of the H Section at the main drainage of the valley, and 119 yards of bank A to the hill. For this last part perhaps this bank will do, as for only a few yards will there be any considerable depth of water, and there special precautions can be taken by selecting enough good soil for a core. For the 223 yards, however, between the two H Sections, it will be better to continue the same form of bank, and as the height is less than at previous places noticed, Rupees 20 a yard, additional, will probably suffice.

41. *Trial pits.*—The number, fifty-seven, of trial pits put down in this section is less than might have been made use of with advantage. In the upper miles they are more numerous than in the lower, but in so hilly and irregular a country perhaps twenty or thirty to the mile would not have been at all too many. It may, indeed, be admitted that even double this larger number would not have sufficed for a close estimate, but every additional pit would have assisted in affording improved data. I must add, however, that very great care has been shown in the selection of the line, and that the one laid down on the Surveys has been fixed upon only after repeated investigations of the possible alternatives, wherever difficulties, such as the tunnel in the 25th mile, cuts through saddles, &c., had to be encountered.

42. *Fall of Canal.*—The falls in the section have been arranged as shown below:—

17·0	to 17·210	Feet 1·00	per mile.
17·210	to 18·35	,, 0·22	,,
18·35	to 18·470	,, 1·50	,,
18·470	to 18·1,225 in the Hagalubatina tank	,, 0·00	,,
18·1,225	to 20·377	,, 0·33	,,
20·377	to 20·1,259	,, 0·55	,,
20·1,259	to 20·1,537	,, 0·24	,,
20·1,537	to 20·1,737	,, 1·50	,,
20·1,737	to 22·738	,, 0·25	,,
22·738	to 22·1,000	,, 1·50	,,
22·1,000	to 23·1,710	,, 0·25	,,
23·1,710	to 24·257	,, 1·60	,,
24·257	to 24·411	,, 2·50	,,
24·411	to 24·528	,, 1·60	,,
24·528	to 25·330	,, 0·25	,,
25·330	to 25·493	,, 1·50	,,
25·493	to end of section	,, 0·25	,,

The capacity of this Section for discharge is practically determined by the dimensions of the deep cuttings, the position of which is roughly denoted by the considerable falls given in the above list. I have checked several of these, and find that the discharge is sufficient, except for the cross section given for the fall of 0·33 per mile, where, with the present bottom width, 75 feet, the capacity is only enough to pass 2,62,872 by Beardmore's formula, and 2,25,564 by Dubuat. It will be advisable, therefore, to increase the bottom width 6 feet by cutting away two berms of 3 feet each, which will make the discharge by Beardmore 2,91,509 cubic yards, and the difference will be readily adjusted by the canal.

43. *Depth of water and discharge.*—The depth of water generally will be 10 feet, in the deep cuttings it will be increased to 12 feet, and at the tunnel to 15·59. The discharge is intended to be the same as in the upper sections, though, doubtless, some few thousands of acres will be irrigated from the 3rd Section.

44. *Estimate for earth-works.*—The following are the amounts allowed in the estimates for the earth-works of the several miles, and they include walling where provided in connection with, or in lieu of ordinary banks. I have added the sums mentioned in paragraph 40 above

					Rs.	A.	P.
18th Mile, Estimate					91,095	13	11
19th do.	1,22,311	7	10				
Add 400 lineal yards extra walling	12,000	0	0				
					1,34,311	7	10
20th Mile, Estimate	53,281	1	2				
Add for 930 lineal yards walling	27,900	0	0				
Do. 323 do. do.	13,720	0	0				
					94,901	1	2
21st Mile, Estimate	71,896	4	5				
Add for 277 lineal yards walling	11,080	0	0				
Do. 657 do. do.	19,710	0	0				
					1,02,686	4	5
22nd Mile, Estimate	32,609	15	10				
Add for 58 lineal yards walling	1,914	0	0				
Do. 70 do. do.	1,400	0	0				
Do. 957 do. do.	22,968	0	0				
					58,891	15	10
23rd Mile, Estimate	1,05,944	4	8				
Add for 750 lineal yards walling	30,000	0	0				
					1,35,944	4	8
24th Mile, Estimate	1,13,136	2	0				
Add for 500 lineal yards walling	20,000	0	0				
Do. 500 do. do.	10,000	0	0				
Do. 540 do. do.	24,300	0	0				
					1,67,436	2	0
25th Mile, Estimate	1,95,681	10	7				
Add for 450 lineal yards walling	11,250	0	0				
					2,06,931	10	7
26th Mile, Estimate	1,40,331	4	0				
Add 455 lineal yards walling...	11,375	0	0				
Do. 223 do. do. ...	4,460	0	0				
					1,56,166	4	0
					11,48,365	0	5
Contingencies... ...					1,14,834	15	7
Total for earth-works...					12,63,200	0	0

		RS.	A.	P.
The total of Mr. Gordon's estimate without the additions recommended by me is		9,26,283	0	5
	Contingencies...	92,711	15	7
		10,19,000	0	0

45. *Rates.*—The rates generally are the same as those entered for the preceding sections, and I think they are sufficiently liberal. In some places tamped earth at the back of walls or on face of banks is provided, the rate being 6 Annas a cubic yard. Stone pitching is entered at 1 Rupee and shingling at 12 Annas a cubic yard, both very ample rates in a country which is covered with stone.

46. *Masonry works and their Cost.*—The masonry works of the section and their estimated cost are as follow:—

	RS.
Aqueduct Sunkulkerry Nullah...	44,500
Bridge No. 1 in the 21st mile 3-30 feet arches ...	6,280
Do. „ 2 in the 23rd mile...	4,120
Waste weir No. 1, 140 yards	9,380
Do. „ 2, 50 „	1,920
Do. „ 3, 215 „	14,405
Do. „ 4, 100 „	6,700
Do. „ 5, 175 „	2,400
Do. „ 6, 180 „	12,060
Do. „ 7, 80 „	5,360
Do. „ 8, 120 „	8,040
Do. „ 9, 180 „	15,525
Do. „ 10, 120 „	10,150
	1,40,840

47. *Rates.*—The rates are the same as those allowed for the 2nd Section, and there is nothing which would make any difference advisable.

48. *Extra works.*—Two trifling diversions of roads in the 21st and 26th miles are the only works of this description which are required, and their cost is estimated at Rupees 880.

49. *Crossings.*—As will be seen from the list of masonry works there are only two bridges for this section. The first is for the Papanaikenhully and Camlapore road, and the second for cattle, &c., going to graze on the hills. Besides these bridges the Sunkulkerry aqueduct, in the 25th mile, will afford a useful passage for cattle, &c., and these crossings will, I think, be fully sufficient for the wants of the very scanty population in the neighbourhood. Indeed, so bare are the hills, that when the lower lands of the valley are irrigated, a comparatively small area will furnish more fodder than is now obtainable from the whole of the wastes.

50. *Stop Gates.*—In this section also stop gates will be of great value, for there are many parts of the embankments which, even with great care in constructing them, will at first require careful watching and management, and it will be highly convenient to be able to shut off the water from any part which may be in danger without interfering with the miles some distance above. One of these may conveniently be placed at the cutting through the saddle in the 19th mile, above the Hagalabatina tank, and a second at the third class bridge in the 23rd mile. In both cases there are weirs within a convenient distance above, in which the additional sluices necessary can be provided.

51. *Probable total cost of the Section.*—Under ordinary circumstances the probable total cost of a section would be the sum of the estimates for the several descriptions of works, but in this section the difficulties which prevent accurate estimating are so great, that I think it will be advisable to add a per-centage to cover the cost of extra work, the description and extent of which will not be ascertainable until ground is broken all along, and until the actual requirements of each part have been ascertained. Thus, it will be quite impossible to judge beforehand how much of the ground surface will have to be removed to obtain a proper seat for banks, masonry walls, &c.; for, in preparing the estimates, it would not have been practicable to remove boulders, clear out the beds of nullahs, test the quality and extent of superficial rock, &c. In the next place, in the deep cuttings, it is uncertain at what slope the cuttings will stand, and though, where the rock is less hard than the rates suppose, there will be a saving on this account available, still it is very possible that the saving may not meet the cost of works. Again, in the cuttings along hill slopes, where those slopes are very steep, an addition to the batter given to the cutting will sometimes involve a material increase in the quantity of excavation, and it may be needful to put in retaining or revetment walls. On the other hand the rates for both earth-works and masonry are liberal, and it may be expected that rubble masonry will yield an important saving. The allowance of weirs is perhaps more than ample, calculated as they have been to discharge a foot of water as a maximum, and with this depth to pass a rain-fall drainage of quarter inch per hour equivalent here to a fall of 9 or 10 inches in the twenty-four hours, which is not far short of the annual fall of the district. Taking all these circumstances into consideration, I think an addition of 15 per cent. to the earth-work estimate will provide a sufficient margin to meet all contingencies of the nature to which I have referred, and it may be assumed that the cost of the section is not likely to exceed the total given below:—

	RS.
Earth-works, revised estimate...	12,63,200
Add 15 per cent.	1,89,480
Masonry estimate	1,40,840
Extra works...	880
Total probable cost...	15,94,400
Length 9 miles or per mile...	1,77,155

52. *4th Section Main Canal, 27 to 35 miles.*—On entering this section, the line of the canal runs along and up the drainage valley, the bottom of which is cut by the bed level at 250 yards, and at 800 yards the water surface and ground are on the same level, and the deep cutting may be considered to commence here; below this point the depth of water is to be increased from 10 to 15 feet. The surface inclination of the ground on the line selected is about 1 in 125. The depth of cutting at the end of the mile will be 38½ feet. There is only one trial pit in

General description.

this mile, and its depth is 5½ feet, but within a short distance of it a well, 11 feet deep, has enabled the character of the subsoil to be ascertained to that depth, and from these slender data it has been assumed that rock will be found from 6 to 7 feet below the surface throughout the cutting. My own opinion is that this assumption errs in providing for more solid rock than will be found, but at any rate the error is on the safe side. A bridge for the Darojee road, close to Nellapoor, is the only masonry work in the mile.

Mile 28. In this mile the line of canal passes the water-shed, and in the first instance it was intended to construct a tunnel 1,966⅔ yards in length, with deep cuttings at either end; but Mr. Gordon, with a view chiefly of saving time, has considered that it will be preferable to substitute open cutting for tunnelling all through the ridge, and the estimates provide for this arrangement. When this was determined upon, some small change in the line was made, and that for the open cutting is to be taken along the lowest ground and is about 115 yards longer than the tunnel line would have been. The summit, which is 105½ feet above bed level, is at 1,350 yards from the commencement of the mile. The inclination of the ground from the beginning of the mile to the summit is tolerably regular, and is at the rate of about 1 in 63. At the end of the mile the depth of cutting will be 81½ feet. There are two trial pits in this mile, one on the summit depth 10 feet, and one west of this point 9 feet deep; about 200 yards west of this latter point a well, a little over 11 feet deep, has been examined. The pits are noted as stopped by rock, but nothing resembling solid rock has been taken from them. In making the estimate it has been considered probable that rock will be found 8 to 9 feet from the surface everywhere.

29th Mile. Throughout this mile the deep cutting continues, and at the end the cutting will be 171½ feet deep. The surface is more irregular, and the average inclination is 1 in 82. There are four trial pits 7½ to 10 feet deep; the soil taken out is gravel and decayed rock, and except that the material at the bottom of the pits is hard, its nature has not been determined. Solid rock has been assumed as existing at depths varying from 7 to 13 feet from the surface.

30th Mile. For 520 yards in this mile the water surface is alternately above and below ground and, as the 15 feet depth is maintained up to this point, it may be convenient to consider it the end of the deep cutting. There are two trial pits in this part, the first 8 and the second 7½ feet deep. The supposed distance at which rock will be found is on the average 7 feet from the surface.

The rest of this mile will carry 10 feet of water and the cutting is moderate, and not much in excess of the requirements of the banks. At the point at which the depth of water is decreased to 10 feet, a sluice, to discharge 30,000 cubic yards of water for irrigation, will be placed for the lands of Chinnapoor, Devasundra, and other villages in the direction of Kumply. These sluices and a waste weir of 100 yards just above them are the only masonry works.

31st Mile. Near the beginning of this mile the line takes a southerly direction for about half a mile, the cutting being generally moderate, it then contours the slope, passing to the S.E. for 500 yards, and then about N.E. to the end of the mile. There are no difficulties, and the works will be of an ordinary and inexpensive character.

32nd Mile. This mile runs in an easterly direction, and, at about the middle, will pass through a saddle by a deep cutting 700 yards in length, the maximum depth being 35¾ feet. There are only two trial pits for the cutting, which show 7½ and 8 feet respectively of tolerably easy soil, below which nearly solid rock is supposed to exist, and has been allowed for accordingly. The work in the remainder of the mile presents no difficulties. There are to be two masonry works, a waste weir of 65 yards, and a bridge for the Darojee road.

33rd Mile. The general direction of the mile is S.E. by E., the ground is at foot of hills irregular, and generally on a level lower than is convenient, while the hill slopes are too steep and rocky to allow of the canal being carried along them. There are four or five short cuttings, the maximum depth of which is 16 feet, but for most of the mile the bed is above ground level. Except at one part an embankment of the "A" Section* has been provided, and as the soil is tolerably good, this section will be safe, if a little additional care be taken in forming the central part of the bank with the best soil available, and in carefully tamping it. To enable this to be done, however, I think some addition must be made to the estimate which allows only 2¾ Annas† on the average per cubic yard, including extra lift, for this part of the work. For a bank 21 feet high the sectional area is 1,071 square feet, and I should recommend the central and more carefully constructed part to be 6 feet wide at top, 2 feet above water level, and with a width of base of 18 feet. The sectional area of this core will be 204 square feet or say ⅕th of the whole area, and for this I would allow an additional 2 Annas a cubic yard. Near the lower end of the mile, for a distance of 250 yards, the depth of water will be unusually great, and, for a short distance, no less than 35 feet, the bed level being 25 feet above ground. Here a bank of the Section C‡ is allowed, and for this portion also it will be advisable to take additional precautions against leakage by making the central part of the bank of selected, and thoroughly tamped, soil. This core can have dimensions similar to those above allowed, namely, a top width of 6 feet at 2 feet above water level, and a base equal to the top width plus, say, ⅓rds the height. The total quantity of embankment is cubic yards 282,703, and one-fifth of this will be cubic yards 56,540, and the extra sum required will be, in round numbers, Rupees 7,100. A waste weir, 105 yards long, is the only masonry work.

* Nine feet wide at top slopes, 2 to 1 inner slope pitched, top 6 feet above water.

† Mr. Gordon supposes bank, as contrasted with pit, measurements, and adds ⅛th for shrinkage, so that the rate taken in the ordinary way would be 2½ Annas + ⅛ + the extra lift, or altogether 2½ + 5/24 + 5/16 = 3 11/12 Annas = 3 Annas and 2 Pies.

‡ Top width 6 feet, height above water 6 feet, outer slope 2 to 1, inner slope 3 to 1, and pitched.

34th Mile. This mile runs S.E. and S.E. by S. and commences with a deep cutting leading into the upper part of the basin of the ruined Devalapore tank. The depth of water is here increased to 15 feet. The length of deep cutting will be 300 yards, and the maximum depth 46½ feet. It is proposed to restore and raise the old bund of the tank, and to make its bed form a part of the line of the canal. The cost of doing this will be Rupees 48,000, and it will obviate the necessity for constructing 500 to 600 yards of very difficult embankment and walling, on ground very much below bed level. The new tank bund will be on the average 35 or 36 feet higher than the old one, and special care will be needed in the construction of the stop wall on the rock at the present breaches, so as to prevent leakage. On leaving the tank the line runs nearly due south, and its way is barred by the rocky hills between this point and the Darojee tank basin; a part of the same range, on the north flank of which the line has run for the previous 17 miles. The line for 600 yards runs up a ravine, and at the end of the first 100 yards the cutting will have increased from 0 to 27 feet, at 500 yards it will be 56½ feet, and at 600 yards 86½ feet. At this point a tunnel, 550 yards length, is to be constructed, for the lowest part of the saddle is 154¼ feet above bed level.

35th Mile. The tunnel continues for a length of 170 yards, and at its termination the open cutting will be 87½ feet in depth, and the water will reach the surface at 570 yards below. Bed level comes out 730 yards further down. There is no more work in the mile or section, for the water discharges from the cutting below the tunnel into a valley among the hills, at the lower part of which there is a ruined tank, the bund of which it is proposed partly to repair and raise, and partly to remove. The bund of this tank is at the commencement of the 5th Section, its area will be about 120 acres.

53. *Fall of Canal.*—The surface inclinations of the water in the several parts of this section are as follow:—

M.	Yds.			
26·0	to 26·300	... ...		no fall.
26·300	to 26·800	... ...	Feet 0·25	per mile.
26·800	to 27·340	... ...	,, 1·22	,,
27·340	to 28·780	... ...	,, 3·79	,,
28·780	to 29·0	... ...	,, 1·24	,,
29·0	to 29·520	... ...	,, 1·00	,,
29·520	to 31·300	... ...	,, 0·30	,,
31·300	to 31·1100	... ...	,, 1·00	,,
31·1100	to 31·1610	... ...	,, 0·50	,,
31·1610	to 33·0	... ...	,, 0·25	,,
33·0	to 33·380	... ...	,, 2·70	,,
33·380	to 33·780	... ...	,, 0·00 in tank	,,
33·780	to 33·1380	... ...	,, 1·50	,,
33·1380	to 34·170	... ...	,, 3·35	,,
34·170	to 34·720	... ...	,, 1·50	,,
34·720	to 34·1450	... ...	,, 0·25	,,
		and below this in tank	0·00	,,

54. *The arrangements for passing the water-shed near Nellapoor, and the hills into the Darojee Tank basin.*—The approach to the deep cutting in the 27th mile is intended to have a fall of 0·25 per mile, a bottom width of 105 feet, where in soil, with slopes of 2 to 1, and of 111 feet in rock with vertical sides, the depth being 10 feet. These dimensions are hardly sufficient. By Dubuat the discharge would be only 259,653 cubic yards instead of 300,000, and though Beardmore's formula gives 311,666 cubic yards, I think it will be hardly wise, as the cuttings below are amply capacious, to have these 500 yards at the upper end without sufficient section. I would recommend, therefore, that the depth be increased to 11 feet, which will add 11½ square yards of sectional area, or 5,722⅔ cubic yards of excavation, and the capacity will then be 292,100 cubic yards an hour, which will be sufficiently near. This alteration will add Rupees 7,153 to the estimate. The first part of the deep cutting is to have a fall of 1·22 feet per mile; the bottom width will be 38½ feet, and the sides are expected to stand at a batter of 1 in 8. The deepest part is to have a fall of 3·79 feet per mile, and a bottom width of 22¼ feet, the depth being 15 feet. Both these sections give ample capacity. At the top of the rock throughout there will be a berm of 1 yard left, and the cutting in the softer material will have slopes of 2 to 1. The rates allowed for the rock cutting vary from Rupees 1-1-0 a cubic yard for the top yard, to Rupees 1-8-0 for all the lower portion. It is assumed that, if less rock be found, and if, therefore, the sections of the cuttings have to be modified, and the side slopes increased, the lower rate which will then suffice will compensate for the increase in the quantity of excavation. In order to verify this hypothesis, so far as a supposed case can do, I have drawn a section of the cutting at the summit, and I have assumed that the bottom, 24 feet, will stand at 1 in 8 and cost 2 Rupees a cubic yard; the next 20 feet at ½ to 1, with 1 Rupee for the rate; the next 30 feet with side slopes of ¾ to 1, and 8 Annas for rate; the next 24 feet with 1 to 1 slopes, rate 5 Annas; the top 7½ feet, slopes 2 to 1, rate 2½ Annas, I have allowed also berms of 1 yard on either side at 44 feet, and 74 feet from the bottom, and berms of 2 yards at 98 feet, and I find the cost of 1 yard in length would be 478 Rupees, against about 471 allowed in the estimate. In fixing the rates Mr. Gordon has considered that the most economical, and, indeed, with steep sides, the only practicable way of clearing out the spoil will be to make use of a light railway, and it is evident that all the cuttings, at any rate to water level, can be taken out in this way at a moderate expense for transport. With efficient arrangements, I have but little doubt that the whole cutting may be executed for the sum allowed for it, at the same time I do not think that this portion of the project should be adopted as it stands, without further investigation of the subsoil; and though, if the opinion, as to the sufficiency of the cost of a cutting be admitted, the arrangements of the estimate may be allowed to stand for the present, it will certainly be advisable, before any expenditure on the cutting is incurred, that it should be more clearly ascertained that a through cutting is the most economical arrangement for getting from the west to the east side of this water-shed. It is manifest that the superiority of open cutting over tunnelling depends greatly upon the level at which solid or compact rock may be found. If this rock be at a great depth from the surface, the cutting is the cheaper method, but, if the rock be near the surface, a tunnel, under the higher part of the ridge, would be the more economical: now at the small tank bund near Nellapoor, and again at a point about 150 yards short of

the end of the 28th mile, the lines for the cutting and tunnel coincide, and at these points the depths of cutting will be 59 and 25 feet respectively. Here then the sinking of trial shafts will involve no useless expenditure, and I should recommend that shafts, 12 or 15 feet in diameter, be sunk, until really solid rock be met with, and that the surface of the rock be so far removed as to afford information as to its exact nature. The ordinary trial pits are all very well where the depth is small, and where they can be get down at least very nearly to bed level, but they may be stopped by a mere boulder, or thin stratum of rock, and there are plenty of instances in the trial pits along the line to show that, in some cases, a stratum of rock has just been missed, and that had the position of the pit varied by only 2 or 3 feet, its excavation would have been stopped at one-half or one-third the depth it has reached. The trial shafts should, therefore, be taken down until undecayed rock is met with, for while slightly decayed, but still very hard, rock forms very frequently only a layer between beds of decomposed rock, it is far more probable that that, which has retained its original color and texture, does not overlie rock which has been subjected to decomposition. Of course a very large boulder may occasion deception, but shafts, such as I have indicated, would be large enough to prevent small boulders from misleading. I do not know whether basaltic rock is likely to be met with in this ridge, though it occurs not very far off, and it is remarkable that at the saddle, which is to be cut through to pass into the basin of the Devalapore tank, the hill is covered with boulders of trap, and scarps of solid granitic rock appear not many yards away on either side, and yet the trial pit near the end of the 33rd mile shows that, under the boulders, there are many feet of soft material composed of entirely decayed rock, and coming out as fine gravel.

55. I pass on now to the works proposed for getting through the Darojee hills. I have already described these generally, and it may now be mentioned that the arrangements included in the estimate are an open cutting on either side of the saddle, with a bottom width of 30 feet, and fall 1½ feet per mile, depth of water 15 feet, and a tunnel 550 yards long section of waterway a semi-hexagon, with a side 16½ feet, and depth of water 14·07 feet. It will be seen here that the canal bed at the tunnel will be 0·93 feet above the bed in the cuttings, while the variation of cross section is not advantageous, and I have found that by the sacrifice of only 0·11 feet of fall in the whole length of 2,000 yards, the semi-hexagonal section can be carried right through, with a uniform fall of 2·94 feet per mile, and by this means 15 square yards of waterway sectional excavation will be saved, which for the 1,450 yards of cutting amounts to 21,750 cubic yards, of the value of Rupees 29,000, besides which there will be a considerable saving above water level by the reduction of the width therefrom 33½ to 32½ feet. I have mentioned this suggested modification to Mr. Gordon. As stated in the general description of this part of the canal line, there are no trial pits, and an opinion as to the description of subsoil which may be expected can be formed only from the appearance of the surface, and from the scarps of the adjacent hills. The ground at the beginning of the upper cutting has a very formidable appearance, for here, undoubtedly, solid rock comes out, but very little of it has to be cut down; as the ravine is ascended the surface has a much more promising appearance, and there is certainly much boulder and gravel, whatever there may be at a depth of some feet, and in fact no other solid rock appears on either side in proximity to the selected line. In the 34 and 35 miles, in which the cuttings and tunnels are situated, the estimate allows,

In the 34th Mile.

Rock excavation, open cutting, cubic yards ...		2,17,377
Do. tunnelling, cubic yards	20,942	

In the 35th Mile.

Rock excavation, open cutting cubic yards ...		1,14,636
Do. tunnelling ,, cubic yards ...	9,368	
		30,310
Rock work, cubic yards		3,62,313
Mixed excavation, cubic yards		20,140

so that more than 11ths are taken as rock, and the 1/18th of mixed excavation appertains entirely to the lower end of the cutting on the east side. There might be some difficulty in extending the tunnel on the west side, as the line is curved just there, but as a prolongation of the tunnel for 100 yards here would make the open cutting terminate with 30 feet less depth of excavation, and as the average contents per lineal yard would be 311½ cubic yards for the cutting, and 50 for the tunnel, it is probable that the latter would be the more economical. At the other end the circumstances for the prolongation of the tunnel are favorable, and the relative quantities of excavation are, 323 cubic yards for the cutting and 50 for the tunnel. It will of course be gathered from the remarks on the Nellapore saddle works, that the comparative advantages of tunnelling and open cutting depend entirely upon the nature of the soil, and that, therefore, in this case the ultimate length of tunnel should depend upon the results of the excavation up to certain points to which cutting may in any case be advisable, and on the information obtained from trial shafts, which here I should recommend being sunk at 100 yards above and below the present intended upper and lower ends of the tunnel. About 30,000 Rupees will be saved by altering the section of the waterway in open cutting, and this I propose to leave untouched, as the rate entered in the estimate for the tunnel is Rupees 5 only a cubic yard, and the above sum will just suffice to raise the rate to Rupees 6, which is not more than it is prudent to estimate it at. The position of this difficult work is particularly favorable for the transport of the spoil by tramway; both above and below there will be tanks where, below bed level, there will be abundant space for the deposit of material, and for the whole cutting the railways can be kept with favorable inclines.

56. *Estimates for earth-works.*—The estimates for earth-works in the several miles are given below, and the additions which I propose to make to them amount to an inconsiderable per-centage.

4th Section.

					Rs.	A.	P.	
27th Mile, Estimate Rupees			1,50,963	0 0				
Add for increasing depth for 500 yards ...	...		7,153	0 0				
					1,58,116	0	0	Para. 54 above.
28th Mile, Estimate	...		...	... ...	7,20,822	6	8	
29th do. do.	...		...	... ...	3,79,415	14	6	
30th do. do.	...		...	... ...	52,388	11	0	
31st do. do.	...		...	... ...	31,682	6	0	
32nd do. do.	...		...	... ...	1,42,595	8	6	
33rd do. do.	...		83,974	9 10				
Add for embankment cores			7,100	0 0				
					91,074	9	10	
34th Mile, Estimate	...		...	... ...	3,10,939	4	0	
35th do. do.	...		...	... ...	2,14,210	4	10	
					21,01,245	1	4	
Contingencies		...			2,10,754	14	8	
					23,12,000	0	0	

57. *Extra works.*—The extra works are few in number, and consist of a few short road diversions, the estimated cost of which is Rupees 3,430.

58. *Masonry works and their cost.*—The masonry works, as will have been gathered from the general description of the section, are not numerous; they are

	Rs.
The Nellapore bridge, 27th mile	4,100
,, Ooparhully do.	4,780
Culvert at do.	8,980
Repairing bund and sluice of Ooparhully tank to regulate stream	
Ooparhully sluices	500
Emptying sluice in Devalpoor bund ...	4,150
Waste weir No. 1, 100 yards ...	4,500
Do. No. 2, 65 do.	1,440
Do. No. 3, 105 do.	1,030
	1,660
Total masonry ...	31,140

59. *Total estimated cost of 4th Section, 9 miles.*—The total estimated cost of the works of the section is, therefore,

For earth works :	Rupees	23,12,000
Do. masonry works	,,	31,140
Do. extra works	,,	3,430
Grand total...	,,	23,46,570
Or per mile...	,,	2,60,620

60. *Crossings.*—Two bridges have been provided, and they afford all the accommodation required for road traffic. At Ooparhully, however, a considerable part of the village lands will be cut off by the canal, and were no other means of crossing than the nearest bridge, at 31⅝ miles, given, the distance to be traversed, in reaching fields within half a mile of the village, would be nearly three miles. It will be advisable, therefore, to construct a platform bridge at the bend in the canal at the beginning of the 31st mile, and this need not be an expensive structure, as the canal is there in 7½ feet cutting, and the approaches can be formed, at a very little additional cost for extra lead, out of spoil. Mr. Gordon agrees with me that this extra crossing is required.

61. *Stop Gtaes.*—A stop gate may be conveniently arranged in connection with the additional bridge for Ooparhully above referred to.

62. *5th Section, Main Canal, Miles* 36 *to* 50.—With this section the line of canal enters comparatively open country. At the bund of, what has been named, Cheetah tank, the line is but 300 to 500 yards from the edge of the waterspread of the Darojee tank, but the difference of level between the crest of the tank weir and full canal is 40 feet. The depth of water for discharge will be 8 feet. The rocky hills here are very steep, and there is no gentle gradation between the flat ground and the hills. The canal has, therefore, to be taken along on much lower ground than is convenient, and for rather more than 2½ miles, it skirts these hills, and its general direction is south-west. In the 36th and 37th miles, the depth of water will vary from 15 to 27 feet, and though there is tolerably good soil for banks, I am of opinion that it will be advisable to ensure their being watertight by additional care in the formation of the central part. To enable this to be done, I propose to give an additional rate, 1½ Annas a cubic yard, in order that the best earth available may be selected, and that this may be thoroughly rammed, water being applied if found needful. Taking the average depth of water at 21 feet, and allowing the core to be 2 feet above water, 6 feet wide at top, and 17½ feet wide at bottom, and providing also for trenching 2 feet for the foundation, the section of the core will be 34 square yards. The cost in the several miles will be—

36th, 37th, and 38th miles.

36th mile, lineal yards 960×34 = cubic yards 32,640, Rupees 3,060
37th mile, do. 1,760×34 = do. 59,840, ,, 5,610

38th mile. The first 680 yards of this mile are to have the bank of the "Section B" form, which provides a top width of 15 feet, slopes of 2 to 1, top 3 feet 5 inches above water level, the whole of the front part of the bank to two feet above water level, and to the line of the perpendicular from the rear edge of the top being of selected earth. The rate allowed in the estimate is, however, 2½ Annas a cubic yard, and, even taking into account that bank measurements are intended, it seems unlikely that any special work will be executed for this rate. The average depth of water will not exceed 15 feet, and to ensure the estimate being sufficient to enable a thoroughly watertight core to be made, it will be prudent to allow, at 1½ Annas a cubic yard additional, for cubic yards 15,640, which will give a core similar to that recommended for the preceding miles, and the cost of which will be Rupees 1,466-4-0. On either side of this core the best soil readily available may be placed, and on the inner face under the pitching, and on the outer side, the mixed earth and stones. In this mile there will be a waste weir 100 yards in length.

39th mile. This mile will be in moderate cutting throughout. Several small drainages, and one large one, the Wuddikerra-wunka,

are crossed; all these are feeders of the Darojee tank. The bed of the Wuddikerrawunka is only 4½ feet below the bed of canal, and as it would be somewhat difficult and expensive to construct an aqueduct, the drainage is intended to be admitted, and the single banked arrangement terminates immediately below the nullah, and, below, the canal will be double banked up to the middle of the 45th mile. The Wuddikerrawunka takes its rise at the Papanaikenhully watershed, and drains the valley to the eastward, and the southern slopes of the hills between that and Gardiganoor, so that the area * drained by it is inconsiderable. To discharge surplus there will be the weir of 100 yards in the preceding mile, and a large surplus work in the 41st mile, which will presently be described. The area of the waterspread, from the point where the canal quits the sides of the hills up to the commencement of the double banks, a distance of 1,500 yards, will be 143½ acres, so the width of the tank will be but small. It will probably not very often occur that the water received by these drainages will be in excess of what the canal can carry, and the weir in the 38th mile discharge, and perhaps the amount of water cut off from the Darojee tank will not be important; nevertheless to avoid risk on the one hand, or ground of complaint on the other, I would suggest the addition of four sluice vents * to the weir just referred to, by which any considerable quantity of water received can be passed on to the Darojee tank, and at the same time the safety of the banks will be ensured. The security of the bank across the nullah is to be obtained by the insertion of parallel masonry walls, 46 feet apart from centre to centre, founded 3½ feet below bed of nullah, and reaching to 3 feet above bed of canal; the interior slope of the bank also is here to be made 3½ to 1.

* About 30 square miles.

* Of the size of the one already provided.

In the lower part of the mile two culverts, and a first class bridge for the Bellary and Dharwar road are provided.

40th mile.

In this mile the direction of the line is nearly south-east, the canal will be in moderate cutting throughout. The soil is regur, or black cotton soil, generally to bed level, with some admixture of lime kunkur, and at the lower end of the mile there is some decomposed granitic rock. There are four trial pits in this mile.

41st and 42nd miles.

In these miles the line takes a great sweep to the southwards, and, at the middle of the former mile, crosses the Narihulla, or Soondoor river, the main supply channel of the Darojee tank. For the first half mile the bed of canal is but little below surface, but on approaching the river the ground rises above water level, and continues at above the same height to the end of the mile. The crossing of the river has been arranged on an oblique line, just at the site of a ruined anicut. The river bed shows decayed rock, hard kunkur, conglomerate, granitic rock, and quartzite. The deeper part is 23 feet below full canal level, or 15 feet below bed level, and in high freshes the depth of water in the river is as much as 18 feet. The works proposed at this point are a waste weir, 400 yards in length, and arranged to discharge a maximum depth of 2 feet; in continuation a sluice of five vents of 3 feet by 4 feet, occupying a length of 33 feet, and then a masonry wall 2 feet above full canal level, 4 feet wide at top, and 12 feet at base, with an inside backing of soil 17 feet high and slope 2 to 1, and outside a mass of rubble of the same height with a top width of 3 feet, and slope 1 to 1. The weir at the upper end will be 14 feet in height, and the overfall is to be broken into two parts by an apron 6 feet wide, and 6 feet below the crest. This apron has the covering stones marked 6 inches thick, and this would, I think, need to be increased to 1 foot, and if bedded on a foot of concrete, whole stones being used, the apron would then be substantial enough. At the other end the height of overfall will be 11 feet, and there the fall is intended to be unbroken, and no apron is provided; but, judging from the rocks exposed in the bed of the river, aprons of some sort will probably be needed all along, and perhaps a masonry apron half a yard thick, bedded on half a yard of concrete, with a width of 8 feet, and, beyond this, packed rubble 4 yards wide, would be the minimum required for safety. Mr. Gordon calculates the area of the drainage basin of this river to be 192 square-miles, and the maximum drainage is taken at a quarter of an inch per hour, or six inches a day, actually running off. This gives a discharge of 4¼ millions of cubic yards per hour, and using the highest co-efficient, 0·667, the 400 yards weir would discharge 24,51,397 cubic yards, and the sluices* 1,27,066, to which may be added, say, 1,25,000, for the canal. It is perhaps very improbable that such a drainage will ever take place, as it is equivalent to a rain-fall of eight or nine inches in the twenty-four hours, and simultaneously over the whole area. As however the discharging capacity of the works, as designed, is only about 27,00,000, there is perhaps too wide a difference, added to which it would be in all respects desirable to discharge low freshes at once into the tank, instead of receiving them partially into the canal. If then works of the kind estimated for be ultimately adopted, I should recommend, in addition to the provision for aprons above referred to, the following modifications. The sluices are not at present placed in the deeper part of the bed, but at a part where their sills are 14 feet below water level. They can be placed so that the sills may be 20 feet below that level, and were the vents made 5 feet wide by 6 feet high, the head would be 17 feet, and twelve vents would discharge 1 million of cubic yards per hour, which added to the capacity of the weir and canal would make about 35,76,000 cubic yards altogether, a perhaps sufficiently near approximation to the maximum drainage, which is 4¼ millions. It would be advisable to provide the sluices in this case with a double set of shutters, the one in the gate form working on a horizontal hinge bar at the upper edge, and secured at the lower edge by two vertical bolts worked by levers, so that the whole sluice might be opened in a few minutes, and the other set would be ordinary hole shutters, to be put in to shut off the water, and allow of the closing of the gate shutters. The estimate for the weir and sluices, &c., of the present design is Rupees 36,800, and probably the cost of modifying the works, so as to make them in all respects sufficient and substantial would not be less than 23,200 Rupees, or altogether Rupees 60,000.

Area of drainage of basin.

* Co-efficient 628.

The chief objection to an aqueduct is the want of sufficient headway. It has been already said that the canal bed is 15 feet above the deeper part of the river, while high freshes in the latter rise to 18 feet. Even with small spans the thickness

of the arches and the flooring of canal over them could not be together much under 3 feet, so that in high freshes the water in the river would be 6 feet above the crown of the arches, and though doubtless it would be quite practicable to secure the aqueduct from injury, by giving suitable aprons and retaining walls, and revetting the bank, these works would be expensive. The road bridge has five spans of 40 feet, one of 20, and one of 12 feet, and therefore I should say the aqueduct would require 9—30 feet arches. The estimate for the Kaniga Wunka aqueduct, in the 45th mile, is Rupees 72,500, and that, which is of nearly corresponding elevation, has five spans of 20 feet each. Taking 20,000†Rupees as the cost belonging to wings, &c., the ~~100~~ 40 feet of span may be supposed to cost 52,500 Rupees, and 270 feet would, therefore, come to ~~1,41,750~~ 1,07,250, to which adding 20,000 for the ends, and 10,000 for protective works, the total cost would approximate to 1½ lacs. This being the case, I do not recommend an aqueduct, as I believe that very effective arrangements can be carried out for but little more than one-third of the cost of such a work.

† Approximated from the estimate cost of the ends of the Kaniga Wunka Aqueduct.

In the 42nd mile there will be no masonry works. The canal is in cutting throughout, the depth of excavation varying from 10 feet, for a few yards at the commencement, to 3 feet in the middle, and at the low end; the trial pits show regur in the first half mile, and this, with shingle and kunkur as substrata, in the lower half mile. Some catchwater drains will be needed above the right bank. They will be very inexpensive if cut so as to form a triangle, in plan, with the bank, with the apex at some distance, and no separate allowance for them is necessary.

43rd and 44th Miles.

The former takes a south-east by south course to pass to the south of the Tornagul hill. The cutting is for the most part just sufficient to form the banks; the soil is regur on the surface, and gravel with lime kunkur below. There will be only one masonry work, and that is a culvert, inlet, and waste weir combined, at the lower end of the mile, and this will be a costly work (Rupees 45,600) owing to the width of waterway at bottom being 200 feet. The work has been carefully planned, but it may be found practicable hereafter to provide for the discharge at a less cost by receiving the drainage into the canal, and discharging it by a waste weir with sluices, in connection with which arrangement two contour banks would be needed, which would be comparatively inexpensive. The 44th mile will be throughout in rather heavy cutting, the deepest part being at 520 yards, where the line passes through a spur or saddle 21½ feet above bed level. There are only three trial pits* here, which have been stopped at 7 and 11½ feet respectively, above bed level. Nothing really hard has been taken out of either of them, and probably a somewhat larger boulder than those taken out has stopped further sinking. At 240 yards from the end of the mile there is a fourth pit, which has been taken down 9 out of the 12 feet to bed level, the spoil is decomposed rock and gravel. At the commencement of the deep cutting, the depth of water will be increased to 10 feet. Mr. Gordon does not consider it as finally settled whether the line is to

* Two are in the same transverse line.

be taken south of the Tornagul hill, as estimated for, or to the north of it. The latter would involve high banks without suitable soil for their construction, and this is the cause of the selection of the line to the south. Several pits should be put down either to bed level or to undoubted solid rock in this mile, in order to determine more accurately what the nature of the substrata is. The masonry works are a bridge and a culvert. The

45th Mile.

preceding mile will run somewhat south of east, while in this the canal will curve round, with a radius of about 575 yards, until, at the end of the mile, its direction will be north-west by north. At the apex of the curve the line re-crosses the Dharwar road and, 150 yards below the Kaniga Wunka, the last of the considerable streams falling into the Darojee tank. Down to this point the canal will be in cutting a little in excess of the requirements of the banks, and the soil is dark and light brown, with but little gravel above bed level. The canal is to cross the Kaniga Wunka by an aqueduct of seven arches of 20 feet span each, the springing being 8 feet above bed of nullah, and the rise of arches, which are five centred, 4 feet. The bed of the nullah is flat, and it has been working southwards in recent years. This year's freshes spread for 100 yards, with a maximum depth of 6 feet, and an average of perhaps 2½ feet. The road bridge over the same stream has three arches of 40 feet span, so that the waterway provided under the aqueduct appears to be sufficient.

Part of 45th mile below aqueduct, and 46th and 47th miles.

The line runs in these miles along the foot of the hills, at the north-west end of which the Darojee tank bund terminates.

Here the soil has changed at once, from the regur of the plain to gravel mixed with only a small proportion of red earth. Most of the trial pits show nothing but gravel; a few have gone down to decomposed granitic rock, and at the beginning of the 46th mile a white conglomerate, of which lime is the cementing material, is exposed in one of the small nullahs, but below the level of canal bed. In the upper part of the 46th mile, the line may, with advantage, be taken somewhat higher up the slope of the hill. The banks in these miles will be high, and the soil is remarkably porous. In the lower part of the 45th mile, for a length of 310 yards, where single banking commences, the section given is of the "D" form, with a top width of 15 feet, at 4 feet above water level; I should recommend a decrease in the top width to 6 feet, and the formation of a core with soil brought from some little distance below, and perhaps this can be done without extra cost. No mere thickness of gravel will make these banks watertight; there must be a sufficient thickness of good soil, well rammed; a weir of 200 yards is intended to be placed near the bottom of the 45th mile. This is a very expensive work (Rupees 21,330), and in the 46th mile there is to be one of 175 yards (Rupees 9,720), and in the 47th mile one of 200 yards (Rupees 10,500), and as the only drainage which can possibly reach them is that from these hills, or from an area of, at most, a couple of square miles, I should recommend the retention of only the third* and the abolition of the first and second, whereby Rupees 31,050 will be saved, which may be devoted to making more provision, than the estimates contain, for securing freedom from leakage. In the 46th and 47th miles the bank is

* No. 6 in estimate. Nos. 4 and 5.

to be of the "B" Section, containing a large mass of selected earth in the inner part, with a top width of 15 feet, 3 feet 5 inches above water level.

The rates allowed in these miles are 3½ Annas for selected earth including ramming, and I hope they may suffice; but my impression is that when the work comes to be done, further outlay will be needed, owing to the distance from which good soil will have to be brought, and, if so, the saving on weirs may prove acceptable. At the lower end of the 47th mile the steepness of the hill slope leaves but little room for the canal, and to obviate heavy scarping it is intended to deepen the canal to 15 feet. At this part the embankment will be of the "F" Section, which has a masonry revetment, with punned earth immediately in rear.

48th Mile.

At 300 yards from the commencement of this mile the canal-line rounds the spur of the hill, and thus in 12 miles and 300 yards, or more, correctly, 12 miles less 400 yards, a point 3 miles and 400 yards in a direct line from the Cheetah tank will be reached. Here the F Section of embankment and the 15 feet depth of water are continued for about 400 yards, at the end of which a set of irrigation sluices† will be placed, and below these the canal is intended to carry 2,30,000 cubic yards of water only. Below the sluice site, the ground is somewhat broken and low, but beyond the half mile the canal will be in moderate cutting, increasing at the lower end to 8 feet in depth. Only just at the lower end of this mile is there any good soil for banks. From the sluices, for 1,200 yards, a regularly formed core of soil, which will have eitherto be brought from a distance or sifted near at hand must be provided. The saving on waste weirs will obviate the necessity of a separate charge on this accountbeing shown in this report.

† Provided for under, "distribution."

49th Mile.

In the first half mile there appears to be no soil suitable for banking. For 600 yards the banks are not high, the water being carried about half in and half out of soil. Thence for 600 yards the bed is mostly above ground level, after which cutting recurs, and at the end of the mile the depth is equal to that of the water, 10 feet; some gneiss occurs at the bottom of the mile at 4 to 5 feet above bed level, it is not very hard, and the rate, one Rupee, allowed for it seems sufficient. For the part of this mile where the embankment will be high an inner slope of 3 to 1 (section bank C) is allowed; it would be preferable to provide a less cross section with a part of it really watertight. Even if the cost be 6 Annas a cubic yard, instead of 3 Annas, the expense here will not be great, for 8 square yards on the average, or Rupees 1-8-0 per lineal yard will then be sufficient, and this for half a mile will amount to Rupees 1,320. Boulders appear on the surface in the lower half of this mile.

50th Mile.

In this mile there is generally more soil available for the embankments and, except at the commencement, where the rock of the preceding mile is continued, the subsoil is kunkur and clay shale. A weir, 350 yards in length, is intended to be constructed at the upper end of the mile. Rupees 3,000 extra will not be too much to allow for the collection of good soil for cores for banks.

63. *Fall of Canal.*—The surface fall of the water in the 5th Section is 4·60 feet, divided as follows:—

M. Yds.				
35·0	to 35·700	feet	0·00	per mile.
35·700	to 37·0	,,	0·10	,,
37·0	to 38·920	,,	0·20	,,
38·920	to 39·0	,,	0·25	,,
39·0	to 39·960	,,	0·30	,,
39·960	to 40·0	,,	0·50	,,
40·0	to 40·700	,,	0·25	,,
40·700	to 41·0	,,	0·66	,,
41·0	to 42·0	,,	0·25	,,
42·0	to 43·0	,,	0·35	,,
43·0	to 43·220	,,	0·50	,,
43·220	to 43·920	,,	1·36	,,
43·920	to 43·1320	,,	0·25	,,
43·1220	to 44·0	,,	0·80	,,
44·0	to 46·0	,,	0·25	,,
46·0	to 47·0	,,	0·30	,,
47·0	to 48·0	,,	0·40	,,
48·0	to 49·0	,,	0·20	,,
49·0	to 50·0	,,	0·25	,,

The falls are generally very slight, and in the upper part they are merely nominal, there, however, the depth of water is great, the width considerable, and the absence of fall is of little moment; but lower down a greater fall, if available, would have made considerable difference in the cost. The check calculations which I have made of six of the cross sections show that, for the small falls, the discharge will be sufficient according to Beardmore's formula, and somewhat deficient if Dubuat's rule be used. In one case the general section given for the fall of 0·20 per mile in the 38th, and part of the 39th mile gives about 1,00,000 cubic yards an hour short, but the longitudinal section shows that it is not applicable except at one or two points. It will be as well, however, that the arrangements of this part should be re-examined, so that, if any error exist, it may be remedied.

64. *Amount of Estimates for Earth-works.*—The estimates for the earth-works in the several miles are given below, with such additions as have been noticed as necessary:—

	RS.	A.	P.	RS.	A.	P.
Mile 36—Estimate...	46,249	3	0			
Add for cores... ...	3,060	0	0			
				49,349	3	0
Do. 37—Estimate	68,319	12	2			
Add for cores ...	5,610	0	0			
				73,929	12	2
Do. 38—Estimate	30,409	14	7			
Add for cores	1,466	4	0			
				31,876	2	7
Do. 39—Estimate				37,259	5	5
Do. 40 do.				31,191	0	5
Do. 41 do.				27,106	10	6
Do. 42 do.				34,500	6	3
Do. 43 do.				38,515	3	0
Do. 44 do.				79,903	10	0
Do. 45 do.				23,532	9	7
Do. 46 do.				23,482	14	6
Do. 47 do.				35,723	7	10
Do. 48 do.				35,252	7	3
Do. 49 do.	34,747	2	11			
Add for cores ...	1,320	0	0			
				36,067	2	11

		RS.	A.	P.	RS.	A.	P.
Mile 50—Estimate...	...	21,374	5	9			
Add for cores ...	...	3,000	0	0			
					24,374	5	9
					5,82,064	5	2
Contingencies...					57,935	10	10
					6,40,000	0	0

65. *Rates.*—The rates in these estimates vary for excavation from 1 Rupee for rock, to 2½ Annas for easy soil for banks, extra lead or lift and ramming being extra charges. Stone pitching ranges from 11 Annas to 1 Rupee a cubic yard; shingling 5 to 8 Annas. These rates appear likely to be sufficient, and they are very much higher than those of the Public Works Department.

66. *Extra works.*—The extra works consist of three road, and one drainage, diversion, the estimated cost of which is Rupees 3,050.

67. *Masonry works.*—The estimates for the masonry works are as follows, and to the weir works in the 41st mile, the addition recommended, in describing that mile, has been made :—

	RS.
Aqueduct 5-20 feet spans across Kainga Wunka	72,500
Bridge No. 1 in the 38th mile, 3-30 feet spans, 3rd Class	6,420
Bridge No. 2, Dharwar road, in the 39th mile, 1st Class	20,500
Bridge No. 3, 1-60 feet arch in the 44th mile	5,480
Culvert and inlet	9,000
Do. do. Tornagul	45,600
Do.	31,000
Do.	23,600
Do.	21,100
Emptying sluices, Cheetah tank	4,500
Waste Weir 100 yards	5,200
Do. No. 2 and sluices 36,800	
Add for sluices and aprons 23,200	
	60,000
Waste Weir No. 3, estimate included in culvert and inlet, Tornagul—	
Waste Weir No. 4, 200 yards...	21,330
Do. „ 5, 175 „	9,720
Do. „ 6, 200 „	10,500
Do. „ 7, 350 „	17,500
Total Masonry ...	3,63,950

68. *Number of Crossings.*—Three bridges have been provided for this section, and the course of the canal is such, that much fewer are needed than would generally be requisite for a length of 15 miles. The bridges are to be placed—No. 1, in the 28th mile for a village track and the use of cattle; No. 2, for the Dharwar road in the 39th mile, and No. 3, in the 44th mile for a diversion of the Dharwar road, and for sundry village tracks from Tornagul to the southwards. After carefully examining the Survey and the Atlas sheet however, I think that an additional third class bridge is needed, 200 yards above the lower end of the 40th mile, for the cross traffic from Darojee and Koreekumpa to Bussawapoor, Wudoor and the south, and to give access to the fields on either side of the canal, and that another bridge of the same class should be built at the lower end of the 49th mile, for communication between Tornagul, Juglagy, and Timapoor. These two bridges will add about 12,000 Rupees to the masonry estimate.

69. *Stop Gates.*—I should recommend three stop gates for this section; the first at the bridge in the 38th mile, the second at the deep cutting near Tornagul in the 44th mile, and the third just below the proposed irrigation sluices in the 48th mile. The proposed arrangements of the discharging works a short distance above these three points will admit of all the canal water being got rid of, if necessary.

70. *Single and double banks.*—The canal in this section will be single banked from the commencement to a little below the middle of the 39th mile, double banked from that point to the middle of the 45th mile, and single banked thence to the end of the section. The only considerable water-spread is that already noticed as measuring 143 acres. Elsewhere the spread is limited by the steep slope of the hill faces, along which the canal will be carried, and the greatest spread in the lower part of the section is in the 49th mile, where it is under quarter of a mile.

71. *Probable total cost of the 5th Section.*—The estimate for earth-works, given in paragraph 64 above, is ... ... RS. 6,40,000

To this I would add, in order to obtain the probable total cost of this description of work, the estimate amounts of Weirs, Nos. 4 and 5, not required 31,050

		Total of Earth-works ...	6,71,050
The estimate for masonry is	3,63,950		
Adding for two bridges	12,000		
	3,75,950		
And deducting Weirs Nos. 4 and 5	31,050		
		Total Masonry ...	3,44,900
		Extra Works ...	3,050
		Grand Total ...	10,19,000

Length of Section 15 miles; per mile, ... 67,880

72. *Capacity of Canal in 5th Section.*—The canal is extended to carry 270,000 cubic yards an hour from the commencement to the beginning of the 48th mile, and 230,000 cubic yards below that point. There will be a considerable spread of cultivation between the canal and Darojee tank, but the area available does not materially affect the capacity of the canal until the bund of Darojee tank has been passed, and just below that point a large irrigation sluice, to discharge about 40,000 cubic yards an hour, will be placed.

73. *6th Section Main Canal, miles* 51 *to* 66¾.—The capacity of the canal in this section is intended to be 230,000 cubic yards an hour from the beginning to nearly the end of the 54th mile; thence to the middle of the 55th mile, 120,000 cubic yards; below this to a little below the centre of the 57th mile, 90,000 cubic yards; from this point to the middle of the 64th mile, 80,000 cubic yards; and from there to the end of the section 50,000 cubic yards an hour.

General description.

51 and 52 Miles. Here the line runs E. N. E. crossing undulations, which involve 10 feet cutting near the beginning of the former mile, and a maximum of 25 feet near the end of that mile; at 640 yards in the 52nd mile bed level reaches the surface, and below that again the cutting increases up to 11 feet, and then falls to 7 feet. In the first half of the 51st mile, the soil to bed level is all kunkur and shale with, at most, a few inches of earth at the surface; beyond this the depth of earth, chiefly regar, increases gradually to 5 or 6 feet, below which kunkur and decomposed rock occur. In the deep cuttings from 4 to 12 feet of rock cutting have been allowed for in the estimate. There are nine trial pits in the 51st, and six in the 52nd mile. The depth of water will be 10 feet, except in the deep cutting, where 12 feet are intended to be given. The masonry works are a bridge for the Humphy road, and a waste weir, 200 yards, both in 52nd mile.

53rd Mile. The direction changes to N. by E. The depth of cutting varies from 3 to 9½ feet until, at the end of the mile, it increases to 12½ feet. There are eleven trial pits. The surface soil is regar throughout, and below decomposed granitic rock, most of which is soft. Five only out of the eleven pits have been carried down to bed level, but in no case has any thing approaching to solid rock been taken out. It appeared to me that a line carried further to the westward would have been cheaper.

54th Mile. Direction E. by N. cutting heavy for the first half mile, when it becomes 7 feet in depth, and this will be the average depth of cutting to the end of the mile. There are six trial pits, all but two of which are down to bed level. The two pits which have stopped short of bed level met with hard material, which has been allowed for as rock in the estimate. The depth of water throughout will be 10 feet. Surface soil regar, 1½ to 2½ feet in depth, and decomposed rock below. Depth of water for discharge 10 feet. It is proposed to place an irrigation sluice 440 yards from the end of the mile.

55th Mile. General direction about S.E. In this mile also the cutting is heavy, it being hardly anywhere less than 5, and at one place as much as 11 feet. There are four trial pits; the surface soil (regar) varies from 1½ to 3 feet in depth, and below there is decomposed granitic rock, with some lime occasionally. Depth of water for discharge 10 feet. There will be a third class bridge at 500 yards from the commencement of the mile.

56th Mile. Direction E. by S. with a bend to N.E. at lower end. The cutting in this mile will, on the average, be moderate, and, except at the beginning, nowhere very much in excess. The depth of water at 800 yards is to be diminished from 10 to 8 feet. There are five trial pits, all of which are down to, and some below, bed level, and the soil is, with the exception of one place where there is a little soft decomposed rock, all regar. A weir of 200 yards is to be built in this mile. Depth of water 8 feet.

57th Mile. Direction N.E. curving to east. The cutting for 1,040 yards will be moderate, and nearly sufficient for the banks. Thence to the end of the mile it will be heavy. There are three trial pits; the surface soil is regar, 3 or 4 feet deep, and decomposed rock below. An irrigation sluice is intended to be built a little below the middle of the mile.

58th Mile. The line continues on a curve until, at the lower end, the direction is nearly S.W. The cutting will be very heavy, the maximum 18½ feet being at the half mile, after which it will decrease to 4½ feet at 300 yards from the end of the mile, and at the end it will be 6 feet. There are five trial pits; the surface soil is regar, below which decomposed rock, gravel, and kunkur, occur; the pits have been carried down to bed level at the deep cutting. An occupation bridge has been provided in this mile, and it is intended to build an irrigation sluice for a ridge channel 600 yards from the lower end.

59th Mile. The line for the canal takes a curve to the eastward, and north-east, the latter being the direction at the end. The cutting generally will be moderate. There are five trial pits, all of which have been carried considerably below bed level. Soil regur at the surface, and decomposed rock, mostly soft, but in two places somewhat harder, as the subsoil. A waste weir 200 yards, and an occupation bridge, will be the masonry works in this mile.

60th Mile. Curves in the first half mile change the direction to east south-east, and this continues to the close of the mile. The canal will be in moderate cutting throughout, and at the lower end will cross a considerable drainage to discharge the surplus, from which a weir of 200 yards has been provided for near the beginning of the next mile; five trial pits have been sunk, all to below bed level; all show 2 to 6 feet of regur, and decomposed rock below.

61st Mile. General direction nearly south-east. The first half mile will be in 5 to 6 feet cutting; in the latter half the cutting decreases to less than 3 feet. There are five trial pits, which show regur for a depth of about 4 feet, and soft decomposed rock below. A waste weir of 200 yards, already referred to, and a third class bridge are the masonry works of the mile. From the beginning of the section the canal is intended to be single banked all the way, but practically the cuttings are so deep that the water is seldom more than a few inches deep at the edge of the cutting, and the spread is perhaps generally not in excess of the width which a bank would occupy, and in most places there will be a second bank, in which openings for the admission of drainage will be left. In this mile occurs the first little water-spread for a length of 600 yards, and a maximum width of 180 yards.

62nd Mile. General direction south-east by south ending south-east. There will be moderate cutting, except for the lower 320 yards. At the lower end of the mile a considerable drainage will be received into the canal, and here a small tank, area 76 acres, will be formed. Near the commencement of the mile a waste weir, 100 yards, has been provided, but a better site is available between 200 and 300 yards lower down. Two irrigation sluices are proposed to be built, one above and the other below the present weir site. The regur surface soil is found everywhere, except just above the half mile, where gravel occurs, and decomposed rock forms the subsoil.

63rd Mile. The direction of the canal continues to be south-east. The cutting will be slight at the commencement, but at 480 yards will be 6 feet in depth, and reaching the maximum, 8½ feet, 200 yards below; at the lower end of the mile bed level will come above the surface, and a small water-spread will be formed, which will join a larger one in the next mile. There are five trial pits, and the surface soil is regur, with decomposed rock below in the upper part of the mile, and lime kunkur as the subsoil in the lower half mile. A waste weir 300 yards in length, an occupation bridge, and a second weir of 200 yards with sluices, will be the masonry works of the mile.

64th Mile. The same south-east direction is continued for 400 yards, below which the rest of the mile is on an S curve. The Hullipoor nullah will be crossed and received at 600 yards, and the tank formed with that at the end of the preceding mile, will have an area of 184 acres, and will submerge the small village of Hullipore. Surface soil regur 2 to 4 feet deep, below that decomposed rock and kunkur. At the lower end of the mile the line crosses that of the Government channel now under construction, and after a few yards again leaves it. The depth of water for discharge changes in this mile, at 520 yards, from 8 to 7 feet.

65th Mile. The direction of the line is to the south-east, and continues much the same in the following miles until it curves to the south and south by west at the end of the section. The soil changes here to a mixed soil with more sand, which will be good both for cutting and banking. The Government channel at the lower part of this mile meets with a good deal of gneiss, which is being blasted. The Bellary road will be crossed 400 yards above the end of the mile, and a first class bridge has been provided for, which, and a waste weir of 100 yards are the only masonry works. The cutting in this mile will be very small, and at the lower part, where it will be greatest, it nowhere exceeds 4 feet. Depth of water for discharge 7 feet.

66th Mile. Here the line of canal coincides with that of the Government channel for about 500 yards, below which the canal will pass to the southward of Captain Fischer's tank. Soil regur, approaching to silt, with decomposed rock below.

67th Mile. The section and the project, as far as investigated, and included in present estimates, end at the ¾ mile; the soil continues the same in this mile, and there is only one proposed masonry work, viz., a sluice for the supply of Bellary.

74. *The line selected for the 6th Section.*—The depth of cutting in many of the miles attracted my attention when walking over the line with the longitudinal sections to refer to, and it was certainly difficult to suppose that a larger and less direct line could not be found, the cost of which would be less. Mr. Gordon tells me, however, that trial lines were run in several instances in order to avoid deep cutting, but that the great distance to which the diversions must have been carried, to effect any considerable decrease in depth, would have occasioned an increase of length, which would have counterbalanced the advantage.

75. *Addition for rock cutting.*—It will, I think, be prudent, in the face of the rock cutting which has been found requisite on the line of the Government channel, to make an allowance for similar work in the 65th, 66th, and 67th miles, and I propose to add 3,000 Rupees to the 65th, 2,000 Rupees to the 66th, and 1,000 Rupees to the 67th mile on this account.

76. *Fall of Canal in 6th Section.*—The arrangements of the falls in this section are:—

M. F.				
50·0	to 50·1100	feet	0·24	per mile.
50·1100	to 51·440	,,	1·75	,,
51·440	to 51·840	,,	0·18	,,
51·840	to 51·1440	,,	0·50	,,
51·1440	to 52·380	,,	0·25	,,
52·380	to 52·1680	,,	0·50	,,
52·1680	to 53·820	,,	0·75	,,
53·820	to 54·960	,,	0·50	,,
54·960	to 55·800	,,	0·30	,,
55·800	to 56·1040	,,	0·18	,,
56·1040	to 57·1380	,,	1·50	,,
57·1380	to 59·60	,,	0·50	,,
59·60	to 61·40	,,	0·25	,,
61·40	to 62·880	,,	0·50	,,
62·880	to 63·720	,,	0·30	,,
63·720	to 64·260	,,	0·70	,,
64·260	to 66·1320	,,	0·50	,,

I have checked six of the cross sections, and in all cases the discharge by Beardmore's formula is sufficient; by Dubuat the quantities are at most $\frac{1}{15}$th short.

77. *Amount of estimates for Earth works.*—The estimates for the several miles amount to the following sums:—

					Rs.	A.	P.
51st Mile,	Estimate	...	...	...	73,726	11	5
52nd ,,	do.	...	...	...	48,633	2	7
53rd ,,	do.	...	...	...	28,324	11	7
54th ,,	do.	...	...	...	40,489	2	4
55th ,,	do.	...	...	...	11,304	6	9
56th ,,	do.	...	...	...	13,302	4	3
57th ,,	do.	...	...	...	12,628	9	3
58th ,,	do.	...	...	...	20,722	11	0
59th ,,	do.	...	...	...	10,615	8	11
60th ,,	do.	...	...	...	12,000	14	6
61st ,,	do.	...	...	...	10,807	1	9
62nd ,,	do.	...	...	...	19,235	12	6
63rd ,,	do.	...	...	...	13,463	11	2
64th ,,	do.	...	...	...	14,984	13	10
65th ,,	do.	...	...	14,518 10 7			
	Add for rock cutting			3,000 0 0			
					17,518	10	7

	RS.	A.	P.	RS.	A.	P.
66th Mile, Estimate	11,076	8	5			
Add for rock cutting	2,000	0	0			
				13,076	8	5
67th Mile, Estimate	5,281	14	4			
Add for rock cutting	1,000	0	0			
				6,281	14	4
				3,67,116	11	2
Contingencies...				36,783	4	10
Total...				4,03,900	0	0

I have added to Mr. Gordon's estimates of the last 3 miles the sums which it appears necessary to provide for probable rock cutting.

78. *Rates.*—The rates allowed for rock cutting in these estimates is Rupees 1-8-0 a cubic yard; excavation varies from 2½ to 3½ Annas a cubic yard, exclusive of extra lift and ramming; and the rates for embanking have an equal range. Stone-pitching, where required, is entered at 2 Rupees a cubic yard, and shingling at 6 Annas. These rates appear to be sufficient.

79. *Extra works.*—These consist of two road diversions, with a drainage culvert in connection with one of them, and the amount of the estimate is Rupees 3,000.

80. *Masonry works.*—The masonry works are shown in the subjoined list:—

		RS.
Bridge No. 1, 2nd Class, for Kumply road,	52nd mile...	6,280
Do. „ 2, „ „ „	55th „ ...	6,280
Do. „ 3, 3rd Class, occupation,	58th „ ...	2,250
Do. „ 4, „ „	59th „ ...	2,250
Do. „ 5, „ „	61st „ ...	2,250
Do. „ 6, „ „	63rd „ ...	2,250
Do. „ 7, 1st Class, Dharwar road,	65th „ ...	3,700
Regulating sluice	67th „ ...	1,000

Waste Weirs No. 1	...	200	yards.	
Do. „ 2	...	200	„	
Do. „ 3	...	200	„	
Do. „ 4	...	200	„	
Do. „ 5	...	200	„	
Do. „ 6	...	100	„	
Do. „ 7	...	300	„	
Do. „ 8	...	200	„	
Do. „ 9	...	100	„	
Lineal yards		1,700		
Lineal yards 1,700, at 50 Rupees			85,000	
Contingencies			8,500	
				93,500
				1,19,760

81. *Number of crossings.*—The number of crossings in a length of 15¾ miles is, it will be seen, seven. The accommodation afforded will, I think be sufficient, for though the greater part of the lands on either side of the canal are cultivated, the villages are few in number. The only place where it is perhaps possible that an additional bridge may be needed is at the beginning of the 53rd mile, but I do not think the probability sufficient to make an addition to the estimate on this account necessary.

82. *Estimates for Waste Weirs.*—I am not quite sure that the estimates for waste weirs would suffice for the construction of the length allowed, for some of the sites selected are not very favorable, and unless harder material, than has been exposed, be met with, the protective aprons and retaining walls may prove more expensive than has been supposed. However for the area of drainage, about 55 square miles, 1,700 yards of weir are a very full allowance, and I think that the aggregate length of the weirs may be reduced, and that the reduction will admit of the remainder being executed for a sum not exceeding that allowed.

83. *Stop Gates.*—A convenient site for the first of these works will be at the commencement of the 54th mile, just below the 200 yards weir, which will be half in that and half in the previous mile, and one other may be placed at the occupation bridge in the 63rd mile, just below the 300 yards weir.

84. *Total cost of 6th Section.*—The estimates for the several works of this section will be as follows:—

Earth-works	Rupees	4,03,900
Extra works	„	3,000
Masonry...	„	1,19,760
Total	„	5,26,660
Length 16¾ miles		
Estimated cost per mile	Rupees	31,442

85. *General observations. Canal intended for irrigation only.*—The canal has been projected as one of irrigation only, and navigation is not contemplated. It is probable that parts of it may be made useful for local traffic, and below the last tunnel in the 35th mile the canal down to Bellary, a length of 30 miles, may be navigated without difficulty. As however the distances by canal will be nearly double those by road, and as the cultivation under the canal will, for the most part, lie entirely on one side of the line and below the 47th mile, while there are no jungles near at hand from which a supply of firewood could be drawn for Bellary, it is not likely that the traffic on the canal will ever be considerable.

86. *Height of embankments.*—These generally will be 6 feet above water level, but in some cases where the thickness of the bank is, owing to the nature of the soil, to be increased, the margin above water is shown as 3 feet 5 inches only. I think it will be advisable that 4 feet should be taken as the minimum height above full canal level, and it might be better to allow 4½ feet.

87. *Depth of water to be discharged by waste weirs.*—It is intended that 1 foot on crest shall be the maximum discharge at the waste weirs, and their length has been fixed so as to pass a drainage of a quarter of an inch per hour from the full area of the country forming the catchment basin. This arrangement is a very safe one, and, in preparing the primary estimate, it is good as giving probably the outside cost of works of this class. In carrying out the project, it will perhaps be found advisable to vary the depth of discharge according to the circumstances of the site and of the canal in the neighbourhood.

88. *Pitching and shingling.*—The estimates provide for pitching and shingling, wherever such protective work is deemed necessary. The value of work of this kind in the several sections is as follows :—

			Rs.	A.	P.
1st Section	in 7th mile...		1,763	12	0
2nd ,,	in 8th, 11th, 12th, 14th to 17th miles... ...		13,877	10	0
3rd ,,	in 18th to 26th miles		44,758	12	0
4th ,,	in 30th, 32nd, 33rd, and 34th miles		11,854	0	0
5th ,,	in 36th to 41st and 50th miles		24,913	0	0
6th ,,	in 52nd, 56th, 59th, 60th, 62nd to 66th miles		25,281	10	0
			1,22,448	12	0
Add 10 per cent. for Contingencies...			12,251	4	0
		Total...	1,34,700	0	0

I have mentioned this here, because in the original estimates for the Kurnool Canal works there was little or no provision made on this account, and the omission has had to be made good, and has added largely to the cost of many of the miles. In the estimates for the Bellary works the rates allowed, more particularly in the upper sections in which stone is very abundant, are very liberal, and I have little doubt that a considerably larger quantity of this sort of work may, if needful, be executed without exceeding the total amount allowed.

89. *Admission of drainage.*—In some parts of the line there will be a greater or less water-spread, as for instance in the third section, and there the admission of surface drainge will need no special provision, but where the canal is in cutting, and the drainage will pass over an edge of the cutting into the canal, it will be requisite that its admission should be under regulation. Where the surface soil is regur, this precaution will be more particularly required, and I should recommend careful attention to this point from the first, so that slopes may not be cut up, and silt washed into the canal. The estimates make no special provision for work of this kind, and I do not think it necessary to alter them on this account, as the expense will form but a small fractional per-centage which can be met from contingencies.

90. *Bridges.*—I have in several parts of this report mentioned the class of bridge intended to be provided for the several crossings, but the accommodation provided by the several classes has not been stated. Generally, the width between parapets of the bridges of the

1st Class will be 22 feet, including a foot-path 4 feet wide.
2nd do. 18 feet, no foot-path.
3rd do. 12 do. do.

There are a few exceptions; the one arch bridge for Mulpungoody, in the second section, will be 16 feet between parapets. The similar bridge for the Bellary and Dharwar road in the sixth section will be 20 feet wide, and the bridge for the Darojee road in the same section will have the intermediate width of 16 feet.

91. *Fall of canal and level of surface of water at lower end.*—The surface fall of the canal from the head sluice at Walavapore to the end at 66¾ miles, will be 34·81 feet, or 0·521 feet per mile. The bed of canal at the Bellary end is 1 foot below the crest of the weir of Fischer's tank and, the depth of water being 7 feet, the surface of the canal water will be 6 feet above that of the tank when full.

92. *Arrangement of the fall.*—This has been determined by two considerations, first, the maintenance of such a level as would allow of the supply of the station and town of Bellary by gravitation and, secondly, the intention of extending the project at some future time across the Huggry; and the watershed between that river and Hindry, and the development of trans-Huggry irrigation. The effect of these considerations has perhaps been not much felt in the projection of the canal works above the 34th mile, but from near the commencement of that mile, the maintenance of the level has, there can be no doubt, occasioned a very considerable increase of expense, though there are no data on which an effective comparison of the cost of a lower line, as compared with that included in these estimates, could be made. I have already mentioned that the surface water of the canal at the 36th mile will be 40 feet above the crest of the waste weir of Darojee tank, and it has been ascertained that, were it proposed to carry the canal from near Devalapore eastwards, instead of passing by a tunnel and cutting into the Darojee tank basin, it would be necessary to sacrifice 50 feet of level, in order to obtain a good and fairly economical line of canal across the valley of the surplus drainage of the Darojee tank. Such a canal would thereafter have a course nearly parallel to that of the line selected, but between 4 and 5 miles further to the northward; and consequently the belt of country which would be excluded from irrigation by the adoption of the lower line would be, say, $20 \times 5 = 100$ square miles. Bellary itself would likewise be shut out from the benefits of a pure and abundant water supply. There is yet another arrangement which has been considered, and that is, after passing through the tunnel into Cheetah tank in the 36th mile, to lower the level so far as to allow of the Darojee tank being raised with safety, so as to be included in the line. It is thought that it would not be safe to add more than five yards to the depth of the Darojee tank, for the ground on which a part of its bund is situated is treacherous, and it might be difficult to obtain stability with a greater head of water. This plan would involve a sacrifice of level to the extent of 25 feet;* it would render the supply of all but the very lowest part of Bellary impracticable, and it would interfere prejudicially with the carrying out of the proposed trans-Huggry project, though to what extent is not at present ascertainable. On the other hand, it would do away with 12 miles of canal, estimated to cost 8,90,200 Rupees; it would convert the Darojee tank into a very efficient reservoir on a small scale, under which a very considerable area of the more valuable crops, such as sugar-cane, &c., might be cultivated. What the cost of raising and strengthening the Darojee tank bund would be, there is no estimate to show; its length is about 2½ miles, and, as nearly as I can judge, it would cost somewhere between five and six lacs of Rupees to raise it, supposing the work to be done in a most substantial manner, and taking the present height of bund to be, on an average, 30 feet above the ground outside the tank.

* More correctly 25 feet, less the fall of the canal from beginning of 5th Section to 47 Miles 300 yards, or 25·00—3·78 = 21·22 feet.

93. *Proposed future extension of the Project, or the Lower Bellary Project.*—From Walavapore to Bellary the proposed canal works have been called the Upper Bellary Project, a convenient name, which it may be well to adopt in future correspondence. Beyond the end of the sixth section, the proposed extension, or Lower Bellary Project, has not been regularly investigated, but some levels have been taken, and the general

circumstances of the country, and the requirements which they entail, are known. Should that extension be undertaken, it is proposed to increase the capacity of the upper Bellary Canal so as to carry from 5,00,000 to 6,00,000 cubic yards an hour, instead of 3,00,000 cubic yards, and this possible enlargement has been kept in view in designing the works above Bellary. The supply not utilized above the 68th mile would then be carried forward to the Huggry, which river would be crossed by an anicut, and thence the canal would make for the lowest point of the water-shed between the Huggry and the Hindry, which point is, so far as the investigations have as yet determined, 108 feet below the surface level of the canal water at Bellary or 101 feet below sole of canal at 66¾ miles. Such being the case, I should judge from the printed map that there will be no engineering difficulty, as regards level, in getting water into the valley of the Hindry, but looking to the large area of land available for irrigation on the right bank of the Huggry it appears hardly likely that, on economical grounds, it will be advisable to carry irrigation water across the water-shed into the Hindry valley.

94. *Additional items of cost of Upper Bellary project.*—To the estimated cost of the head works and of the several sections of the main canal, there are many additions to be made on other accounts, in order to arrive at the probable total cost of the project. Mr. Gordon's entries are the following:—

	RS.
Storage of 1,150 millions of cubic yards at 750 cubic yards per 1 Rupee	15,33,500
Distribution to 2,25,000 acres at 4 Rupees	9,00,000
Management, Home and Indian, 20 per cent ...	20,00,000
Preliminary Surveys	1,00,000
Plant and Office Stores	5,00,000
Buildings, Office, Stores, Workshops, Huts, &c. ...	90,000
Total...	51,23,500

I may say a few words on each of these items.

95. *Reservoirs.*—The construction of another large canal from the Toombuddra will make the provision of reservoirs more necessary than ever, and, indeed, it appears to be tolerably certain that the supply in the river will be insufficient for both the Upper Bellary and Kurnool canals for a portion of the seven months, during which water is allowed to be taken by the latter.

June to December inclusive.

The Bellary canal must be considered to have a secondary claim, and only so much water can be allowed to be admitted at the Walavapore head sluice as may be available after passing a full supply for the Kurnool irrigation. I might add that the supply of the Ryah Calava from the Hoscotta anicut, and of some other channels will have to be provided for, but, though they must not be lost sight of or neglected, practically a liberal supply passed down for Kurnool will ensure their obtaining the comparatively small quantity which they will be able to draw off. I think, therefore, that storage should, as Mr. Gordon intends it to do, form an integral part of the Upper Bellary project. Since my visit to the reservoir country in October 1865, the investigations into sites have made sufficient progress to show that three, which will admit of reservoirs on a large scale being formed, are available. The first, the nearest, and in all respects the one most suited to be first undertaken, is the Mudduk Masoor tank, which it is proposed to restore. I have described this in the letter as per margin, and since then the surveys and levels have been completed, and the estimates for the project will shortly be prepared. It has been found that, with a maximum depth of less than 100 feet, the water-spread will be 40 square miles, and the capacity 1,400 millions of cubic yards; and when it is considered that the main bund stands uninjured, and that there is a solid rock foundation on which to construct the works required to bund the valley by which the water now escapes, there can hardly be two opinions as to the advantages which this site affords. The value of the land within the water-spread contour has not been ascertained, though Mr. Gordon has been in communication with the Mysore Revenue authorities on the subject. It is said that a large part of the area is waste land, and that only a small portion of the remainder is highly cultivated. I am informed also that it has been found that the site on the Toonga, near Bágoli, is much more favorable than I had anticipated, and that the storage there will be cheaper than at Luckavully, which had been considered, next to the Mudduk Masoor tank, the most favorable site available. The rate of storage, cubic yards 750 per Rupee, entered by Mr. Gordon, is somewhat higher than that* which the Bombay Irrigation Department have found obtainable as yet, but in the Bombay Presidency the reservoirs investigated have been on a smaller scale, and I am disposed to think that, as three excellent sites, capable of storing collectively about 38,000 millions of cubic yards, have been investigated, the average cost of reservoirs for the Upper Bellary and Kurnool projects, will fall considerably within that at which it has been estimated. The 1,150 millions to be provided in connection with the Upper Bellary project represent 2,66,200 cubic yards an hour for six months. During the whole of this period, I believe the water in the Budra and Toonga rivers will suffice to compensate for loss by evaporation, but at Mudduk Masoor this will not be the case. The loss by transmission along the river beds cannot be estimated by me at present with any degree of accuracy, but I think it will be safe to assume that the whole supply of both the Kurnool and Bellary canals will be dependent for six months in the year upon reservoir water, and that one-and-a-half times the total quantity required during these months will need to be stored. Now this quantity for Bellary may be thus calculated. In addition to the river supply, supposed to suffice for six months, there will be about three months, during which the full quantity will be required for maturing the later portion of first crop, and irrigating the second crop lands; and, for the remaining three months, about two-thirds of a full supply may be considered sufficient. The total quantity of reservoir water required to reach the head sluice will then be 648 + 432 = 1,080 millions of cubic yards, to which, if one-half be added for loss and wastage en route from the reservoir site, this total becomes 1,620 millions, or 220 millions more than the Mudduk Masoor site alone will afford. The cost of storage, at 750 cubic yards the Rupee, will be 21,60,000 Rupees. A further allowance at this particular site on account of loss by evaporation would need to be made, but as the supplying river has always some water

No. 138, dated 8th January 1866.
Proceedings Madras Government, No. 224, dated 19th idem.

* 650 to 700 cubic yards per 1 Rupee.

in it, I do not think that more than five or six millions of cubic yards would be equired on this account.

96. *Distribution.*—The area of land which can be regularly irrigated is a point of very great importance, and it is at the same time one on which it is extremely difficult to offer an opinion, which can be demonstrated to be approximately correct. First, there is the unsettled point as to the requirements of the land itself, and though I myself believe that the evidence already obtained favors the presumption that an average of $1\frac{1}{2}$ cubic yards per acre per hour is neither much in excess of, nor much below the demand; nevertheless, it must be confessed that the data are far too incomplete to afford satisfactory grounds for forming a reliable conclusion. In the next place there is the absorption in the canal itself to be considered. That this will be great at first there can be no doubt, for the subsoil is throughout more or less porous; that it will diminish much after silt-bearing river water has been carried for a time is evident, but what the ultimate loss, after say ten years' use, will be, is a question which it is impossible to answer accurately. Owing to the slight fall of the canal, the carriage of silt to the lower parts will necessarily be a slow process. On the other hand, in the upper 20 miles or so, the deposit of silt will, at an early period, render the, at present, porous substrata non-absorbent; and, if it be remembered that for a lengthened period the full area of cultivation will not be irrigated, it may not be imprudent to consider that, by the time every cubic yard of water will be in demand, the length of canal bed still remaining porous will be but small, and the consequent loss of water not serious. It must not be lost sight of, moreover, that the maximum discharge of the canal will not differ greatly from the average, and that only when the quantity of water passing down the river falls below about 800 to 900 thousands of cubic yards an hour, and before the supply is supplemented from the reservoirs, will the maximum become liable to be affected. I should, therefore, say that the canal will, by the time its irrigation is fully developed, be able to water at least 1,50,000 acres. Mr. Gordon's rate per acre for distribution is four Rupees, and it is quite possible that this may prove sufficient: regarding, however, the present cost of labor, it will be wise to suppose that six Rupees an acre will be necessary, and the cost will then be nine lacs, which is the sum allowed for the larger area, 2,25,000 acres, which that officer has adopted.

97. *Preliminary Surveys.*—The sum, one lac, shown in paragraph 94 above, is the actual cost up to the present time of the investigations made, exclusive of some charges for contingencies, the apportionment of which has not been found practicable. Probably an addition of 20,000 Rupees will more than suffice to cover any further outlay, and 1,20,000 Rupees will then stand as the outside liability under this head.

98. *Plant and Office Stores.*—Mr. Gordon's allowance, five lacs, is about five per cent. on the total of his estimates, omitting management, Home and Indian. This proportion is, I think, sufficient, as the rates for work include provision for all ordinary working tools, and this item is to meet the expense of instruments, Office necessaries, and the Railway and other plant for the heavy works, such as the deep cuttings, tunnels, &c. At the same rate the item will become Rupees 5,35,000.

99. *Buildings, Offices, Stores, Workshops, Huts.*—I should have deemed the amount, Rupees 90,000, allowed on account of buildings of various kinds sufficient, but for the necessity which will certainly be found for the erection of cooly lines on a large scale. The population adjacent to the line of canal is very small, and labor will have to be collected from a wide area, and I am sure it will be found economical, as well as only justly considerate, to provide for the health of the laborers by laying out villages for them to reside in, with such simple arrangements for preserving health, as good drainage, proper water supply, &c. The expenditure on buildings in connection with the Kurnool works will, when estimates already sanctioned have been worked out, amount to Rupees 99,174, and for the Bellary project I would allow Rupees 75,000 for all buildings except huts, and one lac for hutting laborers, making altogether Rupees 1,75,000.

100. *Management, Home and Indian.*—The last additional item is management Home and Indian, including all establishments not paid from estimates. The cost on this account is shown in the margin* for the Kurnool works, and while it may be assumed that the Home charges debitable to one project will not much exceed five-eighths, and the Madras Agency three-fourths of those shown, when two projects of almost equal magnitude are under execution at the same time, it must be supposed likely that the other charges will be about the same for the Upper Bellary, that they have proved to be for the Kurnool works. The allowance on these accounts should therefore be—

* Up to 31st October 1866.

				Rs.	A.	P.
General Management,	Home...	...	...	3,48,949	4	11
Do.	Agent	...	...	4,02,575	13	1
Do.	Chief Engineer	...	...	2,42,644	12	5
Executive Establishment			Rs.	12,23,920	11	7
Deduct for part engaged in investigations other than for part of canal commenced...	...	...	,,	2,97,553	10	11
				9,26,362	0	8
			Total...	19,20,531	15	1
Expenditure on Construction		...	...	60,07,176	15	0
Do.	under floating heads of charge...			5,35,171	12	2
			Total...	65,42,348	11	2

Per-centage, Home charges	...	...	...	5·34
Agency do.	...	...	...	6·15
Chief Engineer	...	...		3·70
Executive Establishment	...	...	...	14·16
			Total...	29·35

	Rs.
Home Charges 3·34 per cent	3,81,970
General Management, Agency 4·61	5,27,210
Do. Chief Engineer's Department 3·70 ...	4,23,141
Executive Establishment 14·16	16,19,372
Total ...	29,51,693

which will be entered as 29,51,750 Rupees.

101. *Probable total cost of Upper Bellary Project.*—I am now in a position to be able to show the probable total cost of this project, the several items of which I have commented upon in detail.

		Rs.
1.	Anicut and head works	2,00,000
2.	1st Section, Main Canal, 7 miles	9,68,100
3.	2nd do. do. 10 ,, ...	8,91,520
4.	3rd do. do. 9 ,, ...	15,94,400
5.	4th do. do. 9 ,, ...	23,46,570
6.	5th do. do. 15 ,, ...	10,19,000
7.	6th do. do. 16½ ,, ...	5,26,660
8.	Storage of 1,620 millions of cubic yards	21,60,000
9.	Distribution to 1,50,000 Acres	9,00,000
10.	Preliminary Surveys	1,20,000
11.	Plant and Office Stores	5,35,000
12.	Buildings, including huts	1,75,000
13.	Management, Home and Indian	29,51,750
	Total ...	143,88,000

I have endeavoured, in forming this estimate, to make liberal provision for all probable requirements of a complete scheme down to Bellary, according to the arrangement of the project made by Mr. Gordon, and I think that, for the sum shown, the project can be carried out, and that, while it is very probable that it would be found practicable to execute the works for less, any increase of cost, so long as the price of provisions, and consequently the rates of labor, do not materially exceed those which have prevailed during the last two years, would have to be attributed to the absence of skilful management.

102. *Acknowledgements to Mr. Gordon.*—Having now finished that part of this report which refers more particularly to the professional aspects of the project, it becomes my pleasing duty to bring to the notice of Government how greatly I have been indebted to Mr. Gordon for the ready assistance he has afforded me in obtaining the information given in the preceding part of this letter. For three weeks, both on the line of canal and in the office, the greater part of that Officer's time and attention has been placed at my disposal, and made full use of, and he has throughout shown the greatest readiness to assist me in every possible way; and this also at a time when he would otherwise have been closely engaged in completing his own report which, with the plans and estimates, he was under engagement with the Company to have ready by the 31st December last. On learning that such was the case, I wrote to the Agent requesting that, under the particular circumstances, Mr. Gordon's time might be extended to the 15th January, and adding that I felt sure the Government would approve of this arrangement; to this Mr. Henslowe at once acceded.

103. *Probable returns.*—In estimating the probable returns from this project, I have made use, first, of the letter as per margin* from the Collector of Bellary as a special guide to the circumstances of the Bellary District, and secondly, of the Revenue Settlement papers of the Kurnool, Kistna, Godavery, and

* No. 60, dated 10th instant.
Received, 28th ,, Enclosed.

Trichinopoly Districts, which have been kindly lent to me by the Board of Revenue, in reply to a requisition for information regarding the gross and net value of dry and irrigated crops. When writing to Mr. Wedderburn immediately after receiving orders to proceed to Bellary, I was not aware of the nature and extent of the data which had been collected, and upon which have been based the Revenue demand in the several districts just mentioned; and I, therefore, asked that Officer only for information on a few leading points. It is, however, doubtful whether the Collector could have, in the very short time available, have furnished such statistics as have been obtained, after much detailed enquiry, in the Revenue Settlement Department.

104. *Prices of Paddy and Jonna, Bellary District.*—Mr. Wedderburn's letter shows that the present price of paddy, per garce, is Rupees 399¼, that the average price of the last five years† was Rupees 213 a garce, and that of the preceding five years‡ Rupees 132. Similarly, the present price of Jonna, the staple dry grain of the Bellary District, is Rupees 456 a garce, the average price of the last five years Rupees 278, and of the preceding five years 156 Rupees a garce.

† Fuslies 1271 to 1275 (1861-62 to 1865-66).
‡ 1856-57 to 1860-61.

106. *Agricultural charges or cost of cultivation.*—The Collector shows the charges per acre of wet cultivation to be—

	Rs.	A.	P.
Ploughing	6	0	0
Manuring	5	0	0
Seed	7	0	0
Sowing	0	12	0
Weeding	6	4	0
Reaping	4	8	0
Threshing	3	0	0
Total...	32	8	0

The details of cost of Jonna cultivation are not mentioned, but the total, Rupees 18-14-0, is given in the Memorandum at the end of his letter.

I suppose that these charges have reference to present prices, but, if so, they are lower than those in the Kurnool District, supposing their amount to vary about in direct proportion to the price of produce.

107. *Value of Produce.*—The value of the produce of one acre of paddy cultivation is, at present prices,

			Rs.	A.	P.
For the grain, 1,066 Madras seers			133	0	0
For straw, 50 bundles, at 12 Annas *			37	8	0
			170	8	0
Deduct charges, Agricultural	32	8	0		
Do. do. Assessment	6	8	0		
			39	0	0
Net value of produce ...			131	8	0
For Jonna—					
Value of grain, 333 Madras measures			47	8	0
Do. of straw			21	0	0
			68	8	0
Charges, Agricultural...	17	12	0		
Do. Assessment	1	2	0		
			18	14	0
Value of produce ...			49	10	0

Instead of showing, however, in the same way the value of the produce at the average prices of the other periods, and of the average of the ten years, it will be better to show what the net value is, after making the allowance which has been deemed necessary, in order to obtain a fair average, in revising settlements; and, as the Kurnool District is, of all those in which the Revenue Assessment has been revised, the most similarly circumstanced as regards position, soil, and climate, to Bellary, I have adopted the conclusions there arrived at, and acted upon, in order, by means of a comparison, to show what the difference between the net value of white paddy and jonna cultivation, respectively, is.

108. *Comparison of net value of produce from white Paddy and Jonna, respectively, in the Kurnool and Bellary Districts.*—The commutation or standard prices adopted for Kurnool are based on the prices which have ruled from 1839-40 to 1861-62, and they are Rupees 110 a garce for white paddy, and Rupees 105 a garce for jonna, Subsequently, to the last year included in those data, prices have continued to rise. although they were in 1861-62 50 per cent. nearly in excess of the standard derived from the average of 23 years, and the last quotation that I have been able to find shows that the price of paddy* at Kurnool was, in December last, Rs. 291 a garce, and that of jonna Rupees 328.

* Second sort.

The only years in which I can actually compare the two districts are 1856-57 to 1860-61. The prices in Kurnool were:—

	Jonna. White, Yellow, $130\frac{3}{5}$. 107.	Paddy. 1st sort, $150\frac{4}{5}$. 2nd sort, 133.
	119	142
Average in Bellary for same period	156	132
Do. of succeeding five years 1861-62 to 1865-66	278	213
Present price in Bellary...	456	$399\frac{1}{2}$

Per garce of 3,200 Madras measures.

The descriptions of soils which would be irrigated by the Walavapore canal are:—

1st,	Regar or black clay	Superior.
2nd,	do. do.	Ordinary.
3rd,	Museub or mixed regar.. ...	Superior.
4th,	do. do.	Ordinary.
5th,	do. do.	Inferior.

I will, therefore, take from the Kurnool Settlement papers the particulars for these five; I must, however, state that, whereas in Kurnool, for wet and dry cultivation alike, a deduction of one-fourth has been made from the gross out-turn of the crops; as a set-off against vicissitudes of season, &c., it appears proper, as the Upper Bellary project is not to be an imperfect system of irrigation, to alter the reduction in its case to one-sixth for paddy, which is the allowance that has been made in the Kistna and Godavery Districts. In this respect, therefore, I have altered, in making use of, the documents relating to Kurnool. First, for irrigated crops, white paddy. Commutation price 110 Rupees.

Gross value of out-turn.	Deduct $\frac{1}{6}$th for vicissitudes.	Remaining gross value.	Expenses of cultivation.	Net value of out-turn per acre.
RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.
30 4 0	5 0 6	25 3 4	11 8 1	13 11 3

It must be remembered, however, that in order to adapt this to the circumstances of future irrigation, either in Kurnool or Bellary, an allowance must be made for the cost of converting dry, into paddy, fields and, taking the average fall of the land at 20 feet per mile, I find that this cost would be for

Levelling	Rupees	8 6 5
Forming bunds, &c., ...	,,	1 9 7
		10 0 0

which at 10 per cent. per annum, the lowest value of money to a ryot, represents an annual charge of one Rupee per acre, so that the net value of produce above given will, after making this deduction, become Rupees 12-11-3. The corresponding particulars are for jonna. Commutation price 105 Rupees a garce.

Gross value of out-turn.	Deduct $\frac{1}{4}$th for vicissitudes of season.	Balance of gross value.	Agricultural charges.	Net value of produce.
RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.
7 10 10	1 14 8	5 12 2	3 5 4	2 6 10
Difference between value of net produce of wet and dry crops...				10 4 5

The next thing to be done is to determine what shall be taken as the standard prices in Bellary, for the water rate must be founded upon the benefits which would result to the ryot from the use of the water, and these benefits can be estimated only by a comparison of the net produce of irrigated and unirrigated crops. It is to be expected, and in every way to be desired, that present prices should go down; but it is at the same time improbable that they will ever again fall lower than the average of the five years ending 1860-61, when the price was Rupees 132 a garce for paddy, and Rupees 156 for jonna, or just one-third of the prices now prevailing. Bellary, too, is a country which is not at all likely, for many years to come, to have food to export; it will be on the contrary a food importing district, not only because a large area, 400,000 acres, is usually devoted to cotton produce, but because its dry crops are signally liable to perish or yield a very poor out-turn. The completion of the Railway to Bellary will, therefore, tend to raise prices in adjoining districts, but not to make much difference in this. I allude here of course to high average rates, not to the enormous prices of the past and present years. There may be expected then to be a higher average rate in the Bellary District than in any of the more favored localities where the rain-fall is more certain, and more abundant.

Now it so happens that the average price, Rupees 132 per garce of paddy, for the five years just referred to, was just 20 per cent. higher than the commutation rate adopted for Kurnool, and, as a garce of paddy weighs about three tons,

and could not be transported more than 100 miles for this difference, even by Railway, I think it will be safe to take Rupees 132 as a standard price for Bellary. The value of the out-turn from 1 acre will then be

Gross value of out-turn.	Deduct $\frac{1}{6}$th for vicissitudes.	Balance of gross.	Agricultural charges.	Value of net produce.
RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.
43 15 7	7 5 3	36 10 4	16 11 7	19 14 9
Deducting as before for conversion of fields				1 0 0
Net value of produce of 1 acre				18 14 9

In estimating the produce of jonna, it must be taken into account that this grain bears in Bellary a value relatively higher than that of paddy, while in Kurnool exactly the reverse is the case. Instead, therefore, of fixing the standard price of jonna at 20 per cent. above the commutation rate for Kurnool, it is necessary to make an adjustment for this peculiarity, and the standard, when corrected for the average of all the years for which I have data, becomes Rupees 158 a garce, which differs by 2 Rupees only from the average price of this grain for the five years ending 1860-61. The net value of the produce of an acre of jonna is, on these data, shown below:—

Gross value of out-turn.	Deduct $\frac{1}{6}$th for vicissitudes.	Balance of gross.	Agricultural charges.	Net return of produce.
RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.
16 7 4	4 1 10	12 5 6	6 14 0	5 7 6
Difference between value of net produce of wet and dry crops				13 7 3

There are one or two particulars which need explanation: first, the average yield of an acre of paddy is taken as 1,066 Madras measures, as stated by Mr. Wedderburn, and that of jonna at 333 measures. In Kurnool, for the five descriptions of soil selected, the out-turn is entered as on the average 880 Madras measures, but as all the Nunjah in this latter district is, or was then, under tanks, it does not appear to me that the difference is greater than we are warranted in expecting from land under direct river irrigation. Again the average yield of jonna for the same soils is, for Kurnool, 234 Madras measures, and the highest, for regar superior, 320 measures. If, therefore, there be any error in the comparison made between the produce of wet and dry cultivation in Bellary, it is on the safe side, and the difference in favor of irrigation may safely be taken to be not less than that shown above. It must be remembered also that in the Bellary District, and especially in that part of it which the project under discussion would more particularly affect, the out-turn of dry cultivation is probably below that of lands in the Kurnool District. In order to show clearly, however, the result of accepting the out-turns for Kurnool, and applying them to Bellary, I subjoin the necessary details:—

Paddy 880 measures to the acre.

Standard price 132 Rupees a garce.

Gross value of produce.	Deduct $\frac{1}{6}$th for vicissitudes.	Balance of gross.	Agricultural charges.	Value of net produce.
RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.
36 4 9	6 0 9	30 4 0	13 13 0	16 7 0
			Deduct for conversion...	1 0 0
				15 7 0
	Jonna, 243 measures, at 158 Rupees a garce.			
12 0 0	*3 0 0	9 0 0	5 0 0	4 0 0
Difference between value of net produce of wet and dry crops on these data ...				11 7 0

*25 per cent. as before.

In the next place, I have no data for calculating the proportionate amount of agricultural charges at the several prices of grain, and I have accordingly made them directly proportional to those prices. As, however, I found that the average cost of wet cultivation in Kurnool, as shown in the Revenue assessment papers, was higher than that in Bellary, as given by the Collector, after deducting from the latter the assessment and cost of ploughing, I have taken the former as the standard, lest it should turn out that Mr. Wedderburn's statistics under this head refer to other than the present high prices. Similarly, the Kurnool agricultural charges, which are also, though to a less extent for dry crops, in excess of Bellary, have been adopted. Lastly, in accordance with the principle adopted in all Revenue Settlement operations, the value of the straw has been left as a set-off against the cost of maintaining cattle for agricultural purposes. This arrangement, when prices are high, is always favorable to the ryot, and it is particularly so in the case of wet cultivation in such a district as Bellary, where there is really no grass, and where the out-turn of jonna straw is frequently extremely small. Mr. Wedderburn indeed makes the value of straw at present greater than the whole cost of cultivation, exclusive of the assessment; and if its value be reduced, in proportion to that of grain, to 4 Annas a bundle, it would still amount to Rupees 12-8-0 against Rupees 16-11-7, the cost of cultivation with Bellary quantities, and Rupees 13-13-0 that cost on Kurnool data.

For 132 Rupees a garce.				
Kurnool	Rs.	13	13	0
Bellary	,,	7	1	6

For 158 Rupees a garce.				
Kurnool	Rs.	5	0	0
Bellary	,,	3	12	5

109. *Proportion of difference of out-turn available for a water rate.*—This is the next point to be considered. The ryot must have considerable inducements to convert his dry lands into paddy fields; supposing then the above calculations of the relative value of the crops to be sufficiently accurate for the purpose, what part of the difference may be considered available to yield a return on the outlay which the project will entail? In discussing the question with Mr. Gordon, it was suggested by him

that the imposition of the full rate should be gradual, and that three years should be allowed to the ryot to acquire the art of effective wet cultivation. It is evident that, if this be done, a ryot will be the better able to pay a high rate eventually, and it would seem to be the interest of all concerned that such an arrangement should be made, and in such case, I would propose to take, as the primary full water rate, 75 per cent. of the difference, Rupees 11-7-0, obtained by adopting all details, except the standard prices, from Kurnool, and which rate would then be Rupees 8-9-0, or, rejecting small fractions, Rupees 8-8-0. This rate is less than 66 per cent.* of the difference, Rupees 13-7-3, which the adoption of Bellary quantities would give, and I have no doubt, myself, that the results deduced from those quantities show a difference less than it really would be, because, while the dry cultivation may require to be reduced to the standard of Kurnool, the proposed irrigation ought considerably to exceed that standard. It may be thought that the per-centage proposed to be taken is high, and undoubtedly it is so when compared with that which would be required to make irrigation works, in situations presenting only ordinary difficulties, pay handsomely; but in the present case there is no relief to be afforded without a heavy outlay, and as, if the one calculation be adopted, the ryot will obtain a profit of Rs. 9-4-9† per acre, instead of Rupees 4-5-6, and in the other case of Rs. 5-13-0, instead of Rs. 2-14-0, there can be little doubt but that the inducement offered is, according to either calculation, sufficiently great, especially if, as suggested, the incidence of the water rate be gradual; and I should propose that it be made Rupees 5 for the first, Rupees 7 for the second, and Rupees 8-8-0 for the third year. I should then recommend that this rate be retained for five years from the commencement of the third year, or seven years from the first acceptance of water, and that, thereafter, it should be revised, with reference to the average prices of these seven years.

* Rupees 8-15-6.

				RS.	A.	P.
† Net produce				5	7	6
Deduct land assessment...				1	2	0
				4	5	6
Add Rupees	13	7	3	4	15	3
—	8	8	0			
				9	4	9

Mr. Wedderburn puts the average consolidated wet and dry assessment at Rupees 6-8-0, from which, if the dry assessment, Rupees 1-2-0, be deducted, the water rate would be Rupees 5-6-0. Again, looking at the half net produce, to which the Government assessment has usually approximated in the newly settled districts, it will be seen that this plan would make the water rate and land tax combined Rupees 9-7-4,* or Rupees 7-11-6, from which deducting the land tax, Rupees 1-2-0, the water rate would be either Rupees 8-5-4, or Rupees 6-9-6. I judge, therefore, that while it may not be capable at present of demonstration that a higher water rate would be easily obtained, that recommended is not likely to be found in excess of what the ryots generally will be glad to pay to obtain immunity from the uncertainty which characterizes agricultural operations in Bellary, and which in very many years has been changed only into a certainty of almost utter failure of the crops. It may be added that, should the Upper Bellary project be carried out, it is probable that Revenue Survey,

* According to the yield adopted.

and Settlement, operations will precede the actual commencement of irrigation; and, if so, all the necessary data for forming a reliable opinion, as to the actual difference between the value of the outturn of wet and dry cultivation, will be then obtainable. Provided, therefore, my calculations be sufficiently accurate, not to give an erroneous, and a too favorable view of the returns which may be expected, and, on the other hand, to form a fairly reliable basis on which to negotiate, it will probably not make the project less acceptable to any one, should it be found, when more reliable and complete data shall have become available, that the water rate which has been proposed will admit of increase.

110. *Project provides for a perennial supply—2nd crops.*—The project, as estimated for, provides for supplementing the ordinary freshes of the Toombuddra with reservoir water, and it is supposed that, even should the supply be, in rare seasons, not absolutely continuous throughout the year, there will be, at any rate, water quite sufficient for two crops. The Government have recognized the principle, that the charge for a water supply for a second crop need not be less than that for the first crop, though in all cases in which the supply for the two crops is regularly taken, it has been usual to fix a commutation rate considerably below double the first crop rate, and, similarly, I should propose that Rupees 15, instead of Rupees 17, should be the double crop rate. I have supposed that 1,50,000 acres will be the area of the first crop, and it may be assumed as tolerably certain that the extent of second crop will be considerably less, for some first crop cultivation will be commenced late in the season. It will not perhaps be taking too sanguine a view, however, to estimate the area of the second crop at 1,00,000 acres, or two-thirds of that of the first crop, and the gross returns would then stand thus:—

1,50,000 acres at Rupees	8-8-0	...	...	Rupees	12,75,000
1,00,000 „ at „	6-8-0	...	...	„	6,50,000
			Total Rupees		19,25,000

or 13·38 per cent. on the amount of the estimate, Rupees 143,88,000.

In deciding what deduction must be made to obtain the net return, the data available are very insufficient. The cost of maintenance of the Jumna canal is said to be 6·8 per cent. on the cost of construction, and that of the Godavery works 7 per cent.; again, in terms of the area irrigated, for the former this cost is 7 Annas an acre, and for the latter 6·6 Annas. The nature of the works on which the capital outlay will, in this case, have been incurred, must be taken into account. It is evident that the maintenance of deep cuttings in rock can cost but little. Similarly, masonry walls, another heavy item, will absorb but a fractional per-centage of their cost for repairs. The works indeed which, make the canal costly are just of a description which will require but little repair, and I think that one and a half per cent. on capital cost, equivalent to Rupees 1-7-0 an acre, would suffice. In order, however, to err, if at all, on the safe side, it may be assumed that two per cent., or nearly two Rupees an acre will be needed, to which half per cent., or nearly 72,000 Rupees, must be added to cover the cost of the Home and Indian Establishments of the Company, a share of which would be debitable to this project, making altogether two and a half per cent., and the net returns will then be 10·88 per cent. on the outlay.

111. *Probable return from Canal above, without reservoirs.*—I have already expressed the opinion that the storage of water should form an integral part of this project, and to show that, not only will all the cultivation be placed upon a more satisfactory footing by this means, but that by providing water for the double crop a better return may be anticipated from the outlay, the cost of the scheme without reservoirs will now be given—

			Rs.
Estimate, including reservoirs	...	...	143,88,000
Estimated returns, gross	13·38 per cent.		
Net	10·88 ,,		
Amount allowed for reservoirs	...	...	21,60,000
Share of Management and Establishments...		...	5,57,500
			27,17,500
Estimate exclusive of storage	...	...	116,70,500
Estimated returns, gross	10·92 per cent.		
Net	8·42 ,,		

It must further be remembered that besides the great object of the project, the securing of as wide an area of cultivation as possible, it would be far more advantageous to the ryots to convert their lands for two crops than for one, and that, though the outturn from the second crop will generally be somewhat less than from the first, this defect will be more than compensated for by the great advantage of providing more constant employment for the cattle and field labor, which must in either case be maintained. I much wish that I had been able to forward, with this report on the canal estimates, the same full particulars for the proposed reservoir arrangements; nevertheless, notwithstanding the risk always attending the adoption of opinions based on personal conviction, rather than on ascertained facts, these opinions appear to me so far reasonable as to justify the hope that it will be found practicable to store sufficient water for the requirements of this project, and of the Kurnool works also, at a rate of cost not in excess of that which has been entered in the estimates now reported upon.

112. *Considerations favoring the adoption of the high level line, which has been estimated for.*—The considerations which favor the adoption of the line of canal, as selected by Mr. Gordon, though a canal on a lower level, would probably be cheaper, may be considered to require a short explanation. Seeing that an abundance of land for irrigation will, in any case, be available on the two sides of the Huggry, and that the irrigation of these lands will be as beneficial as, and more economical than, the carrying on of any water for irrigation into the valley of the Hindry, the reasons for a high level canal appear to be reduced to two.

First, the advantages which a supply of good water to Bellary will secure; second, the provision for a possible, future, line of navigation between Bellary and Kurnool, in connection with the Kurnool canal. As regards the first, it may be remarked that the population of Bellary is about 40,000; that the existing means of water supply have been deteriorating year by year for a long period; that there are extremely few wells from which water fit for drinking is obtainable, while the water of a large number of the wells is unfit even for washing, and the cultivation of gardens has, in several cases, had to be abandoned, because the water is found to kill instead of nourish vegetation. The water level is now 15 to 20 feet further from the surface than was the case some years ago, as the water marks on the many fine wells show. Last year, so extreme was the need of the inhabitants, that, as Major General McLeod informed me, but for a timely fall of rain in April last, which gave a supply of water to the fort ditch, and to the tank near the Travellers' Bungalow through Fischer's tank and channel, the bulk of the inhabitants would have had to quit Bellary. The establishment for the supply of the troops costs Rupees 834 a month, or Rupees 10,000 a year, and the Major General says that they are very badly off for water; that the erection of five additional-plunge baths has been sanctioned, but there is no water for them, and so the sanction is inoperative; that the Barracks and Family Quarters are to be furnished with kuskus tatties, but whence the water is to come is a problem yet to be solved. It is perhaps not probable that a water establishment could be entirely dispensed with were the canal constructed, but at any rate it would be capable of reduction to a very small monthly sum, just to look after the distribution, and, what is of greater importance, the troops would get five or six times as much water as is now obtainable, and that of good, instead of bad, quality. Supposing, then, the value of water to be supplied to the Military station to be Rs. 10,000, and that for the town Rupees 20,000, which amounts to only 9 Pies per head, per mensem, for the town population of 35,748, and allowing 36 gallons a head per diem, the supply required would be 371 cubic yards an hour about sufficient for 250 acres, the water rate on which would be 3,750. Therefore 26,250 Rupees would be the increase derivable from the supply to the town, in lieu of for agricultural purposes, and 5¼ lacs, the additional sum which may reasonably be spent in carrying the canal on the higher level, so as to command Bellary. I have stated, in paragraph 92, that probably between three and four lacs would be saved by lowering the level 21·22 feet at Darojee tank, and of the difference, Rupees 1,29,000, between the estimated cost of the fifth section and of that part which would be then superseded, as also out of the sixth section estimate, Rupees 5,26,660, perhaps one-third would be saved by increasing the fall from Darojee tank downwards, or altogether there would be a decrease of about five and a half lacs.

Such being the case, it does not appear that any great sacrifice need be made in order to supply Bellary. Very little need be said of the second reason: the line of navigation from Bellary to Kurnool. Should it be found that, after the irrigation canal has crossed the Huggry and approaches the water-shed, a separate navigation canal can be carried at a moderate cost to Kurnool, its construction would, doubtless, be desirable, and it would probably give a fair return on the outlay. This, therefore, may be taken as a second reason, but the first is, I think, of itself sufficient to make it very desirable that the high level should be retained.

113. *Rough estimate of Lower Bellary Project.*—Although, in the absence of a regular investigation, and of estimates founded thereupon, any information which can be given as to the probable cost of extending the Bellary canal works beyond that station cannot be deemed reliable, still the opinion of Mr. Gordon, who has for a long time past been engaged on similar investigations in the Bellary District, must be of some value, and I, therefore, subjoin the particulars of his rough esti-

mate to which he himself does not desire that any undue importance should be attached.

Increasing the capacity of the canal above Bellary	25	lacs.
Canal, Bellary to Huggry	12	,,
Weir across Huggry	2½	,,
Canal, Huggry to Hindry water-shed	36¼	,,
Supply channel from water-shed to Hindry	2¼	,,
Main irrigation channels	3	,,
Total ...	81	lacs*

* Or adding 25 per cent. for establishments, in round numbers, 100 lacs, exclusive of storage which would raise the total to 125 lacs.

114. *Cost of Upper Bellary Canal Project in terms of cubic feet per second at the Head.*—In conclusion, as affording a convenient means of comparison, the cost of a cubic foot per second at the head of the canal may be given, and as the supply is intended to be constant and to vary but little, it may be compared with other canals similarly circumstanced. The proposed discharge will be 300,000 cubic yards an hour, which are equivalent to cubic feet 2,250 per second; and the estimate being 14,388,000 Rupees, the cost of 1 cubic foot per second will be Rupees 6,395. To institute a comparison with the Kurnool canal, however, the cost of storage must be deducted, and the cost of 1 cubic foot per second will then be Rupees 5,187. For the Kurnool canal, taking 160 lacs as the total cost, exclusive of reservoirs, the discharge at the head being 3,000 cubic feet per second, the cost of 1 cubic foot becomes Rupees 5,333.

From the Collector of Bellary, to the Consulting Engineer for Irrigation and Canal Company, dated Camp, Hindupur, 10th January 1867, No. 60.

1. In reply to your letter of 19th December last, requesting to be informed what is considered, in the Bellary District, a fair average yield per acre of paddy in Madras seers, I have the honor to state, that 1,000 seers is a fair average yield.

2. The value of such grain, at present prices, is Rupees 133.

3. The value of the grain at the average rates of the last five years, is Rupees 71, and of the preceding five years, Rupees 44.

4. The average land tax, per acre, in the Hospett, Bellary, Alur, and Adonie Talooks is Rupees 1-2-0 per acre of dry, and Rupees 6-8-0 per acre of irrigated, cultivation.

5. The following is a detail of average charges per acre :—

	RS.	A.	P.
1. Ploughing	6	0	0
2. Manuring	5	0	0
3. Seed	7	0	0
4. Sowing, &c.	0	12	0
5. Weeding	6	4	0
6. Reeping	4	8	0
7. Threshing	3	0	0
Assessment	6	8	0
Total ...	39	0	0

6. The value of the straw obtained from one acre of rice cultivation varies according to the demand. The local price is at present Rupees 37-8-0.* It has progressively increased of late years.

* Average 50 bundles, at 12 Annas each, Rupees37-8-0.

7. The dry cultivation which obtains in the above Talooks, is chiefly jonna, sujja, and cotton. An acre of jonna, supposing it to arrive at maturity, uninjured by drought, while growing, or by blight, while earing, will give an average of measures 333 seers on the best mixed black and sandy soil, and 200 Madras seers on good red, and 150 seers on inferior red. Jonna is the most profitable crop on the best black soil; it alternates with cotton. The yield of cotton per acre depends entirely on the season. It is hardly ever a good crop on the lands in question from defect of moisture, but an average yield on the best black and sandy or mixed regar soil, would be Rupees 90.* The other cereal crop on black soil is corra, which will give, if it comes to a good crop, Rupees 43† per acre.

	RS.
* 6 Maunds of cleaned cotton at present price of Rupees 12 per maund of 25 lbs	72
18 Maunds of seed at 1 Rupee per Maund ...	18
Total ...	90
† 300 Madras seers at 8 per Rupee	37½
10 Bundles of straw at ½ Rupee each	5
Nearly ...	43

8. The question, however, is not between the actual out-turn of a full crop of paddy, as compared with that of other grain; jonna, for instance, will give one-third of the paddy return with a better straw for forage; but the question is whether the project of certain irrigation and cultivation at the large estimated cost, is worth being undertaken in view to the prevention of future famines, and death of valuable stock.

9. As regards the payment of an assumed water rate by the ryots, generally, for the whole acre watered, without difficulty, and with manifest advantage to themselves, it should be recollected that during the last six years, millions of money have been imported into this country to pay for cotton, of which Bellary with its cotton area of 4 lacs of acres has received a good share, that it is not likely that agricultural produce will ever recede in price, and that the assessment which might have been onerous or sufficient fifteen years ago, is now virtually reduced more than 50 per cent. by the alteration of the value of money, owing to its abundance and grain, owing in part to its scarcity. The population of Bellary is 39,308, viz :—

Mellor and Bruce Pettahs contain	21,773
Cowl Bazaar	13,975
The Cantonment	3,560
Total ...	39,308

Memorandum of probable gross returns and charges, &c., for the cultivation of one acre of Paddy, Cotton, and Jonna, &c., on wet and dry lands, respectively.

Kinds of Crop.		Value of produce per Acre.			Amount of charge per acre.	Profit per acre.	Value of grain, &c. at the average rates of last 5 years from Fusly 1271 to 1275.	Value of grain, &c. at the average rates of 5 years from Fusly 1266 to 1270.
		Value of Grain.	Value of Straw.	Total Receipts.				
		RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.
Wet ...	Paddy ...	133 0	37 8	170 8	39 0	131 8	71 0	44 0
Dry	Cotton ...	72 0	18 0	90 0	32 10	57 6	*150 0	38 0
Dry	Jonna ...	47 8	21 0	68 8	18 14	49 10	29 0	16 4
Dry	Korra ...	37 8	5 0	42 8	18 14	23 10	25 0	14 0

N. B.—The average rates of last and previous five Fuslies, are with reference to the value of grain only.

* During American war.

(Signed) A. WEDDERBURN,
Collector.

(True Copy.)

(Signed) J. MULLINS, Captain, R. E.,
Consig. Engr. for I. and C. Company.

Return showing the means and cost of the Water Supply, Bellary.

	Total number employed monthly.	Total monthly cost.	Remarks.
		RS. A. P.	
Puckallies	50	530 14 3	Exclusive of Rice money.
Draught Bullocks	16	158 0 0	Do. of Govt. Bullocks.
Water Carts only	5	16 4 0	
Water Carts complete ...	4	76 0 0	
Bheesties	2	14 0 0	
Coolies	8	39 0 0	
Total ...	...	834 2 3	

N. B.—The Watermen supplied to Garrison and Lock Hospitals are included in the total of Coolies. The probable requirements of the Artillery have also been calculated for.

BELLARY,
16*th January* 1867.

(Signed) R. D. THORPE, Captain,
Dy. Asst. Qr. Mr. Genl., C. Districts.

(True Copy.)

(Signed) J. MULLINS, Captain, R. E.,
Consg. Engr. for I. & C. Company.

Rec. 26-Feby. 1867 in Lr. 371.

Proceedings of the Madras Government, Public Works Department, 21st February 1867.

No. 405. Read the following letter from the Consulting Engineer for the Madras Irrigation and Canal Company:—

(Here enter No. 111, dated 30th January 1867.)

No. 406. ORDER THEREON, 21st February 1867, No. 518.

CIVIL WORKS, No. 60.

1. This report will be communicated to the Revenue Department, with a view to the question of the amount of water rate, per acre, which may be imposed upon the land to be irrigated from the proposed canal, for a first crop and for a second crop, being considered in that department.

2. The Consulting Engineer for Railways will be requested to ascertain, in communication with the Officers of the Madras Railway, the cost at which rock cuttings have been made for the formation of the line, reporting the length and depth of cutting in each case, as well as the character of the rock, and the rate per cubic yard at which it was got out, and whether by blasting or otherwise.

3. Application will be made to the Government of Bombay for information regarding the cost of the heavy rock cuttings on the Bhore and Thull Ghauts in that Presidency.

4. Communications will be addressed to the Government of Bombay and to the Commissioner for the Government of the Territories of His Highness the Maha Rajah of Mysore for the purpose of ascertaining whether the site of the old Tank at Mudduk Masur can be made over to the Madras Irrigation and Canal Company for restoration and enlargement, and on what terms; also whether there are any objections on the part of the Government of Mysore to the construction of a large reservoir by the Company on the Toonga at Bagoli.

(True Extract.)

Colonel, R. E.,
Secretary to Government.

To the Revenue Department.
,, Consulting Engineer for Railways.
,, ,, ,, for Madras Irrigation and Canal Company.

Exd. S. T. Augustin.

12 Copies Lr. to Bd. of Rev. under Pro. M. 2d. 518 } 200/10 27/4

26th Feby 67

Dec = 1867 Orders
Dirs of Govt for February
No 475

Proceedings in
the P. W. Office

Dated 21st May
Received 21st May 1867.

No 518.

From the Board of Revenue
dated 19th July 1867 C No
1927.

Communicating re-
port from Consulting Engrs. to
P.W.C. for consideration of the
question of the amount of water
rate, per acre, which may be im-
posed upon the lands to be irri-
gated from the proposed Canal
for a first and second crop.

No 470 - 26 Feby

A. 371 & 372

With order