Public Works (1897) Department.

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G.O., No. 550 I

DATED 14 June 1897

14/6/97

[Despatch Abstract.]

Notes of Inspection. Govt of India letter forwarding a copy of the — in the Madras Residency during December 1896 by Mr T. Higham C.I.E. Inspector General of Irrigation, Comptd to the Chief Engineer for Irrigation for report on certain questions dealt with in the Notes of Inspection.

D/14

BACK PAPERS.

G.O.	No.	Department.	Date.	G.O.	No.	Department.	Date.

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IRRIGATION.

Government {1897} of Madras.

PUBLIC WORKS.

Recd. } 1897. *Enclosures*

Regd. *Spare copies*

G.O., No. 550 I., 14th June 1897.

JUNE.

Notes of Inspection

Government of India letter forwarding a copy of the — in the Madras Presidency during December 1896 by Mr. T. Higham, C.I.E., Inspector-General of Irrigation, communicated to the Chief Engineer for Irrigation for report on certain questions dealt with in the notes of inspection.

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

Irrigation.

Read—the following paper:—

From N. F. MACKENZIE, Esq., Under Secretary to the Government of India, Public Works Department (Civil Works—Irrigation), to the Joint Secretary to the Government of Madras, Public Works Department, Irrigation Branch, dated Simla, 1st May 1897, No. 128 I.

In continuation of Public Works Department letter, No. 40 I., dated the 4th February 1897, I am directed to forward, herewith, for information and for such consideration and action in the directions suggested, as His Excellency the Governor-in Council may think necessary or desirable, a complete copy of a note dated the 30th January 1897, on a tour of inspection in the Madras Presidency during December 1896, by Mr. T. Higham, C.I.E., Inspector-General of Irrigation.

Enclosure.

Note by the Inspector-General of Irrigation, on a tour of inspection in the Madras Presidency during December 1896.

1. Leaving Rangoon on the 24th November by one of the British India coasting steamers, I arrived at Vizagapatam on the 29th and at once proceeded by rail from Waltair to Rajahmundry (Dowlaishweram) arriving on the following morning.

My subsequent movements were as below—

Date.	Place.	Principal object of inspection.
November 30th—December 1st ..	Dowlaishweram	Gódávari headworks.
December 2nd—4th	Bezwada	Kistna do.
,, 5th—8th	Nandyal to Cuddapah ..	Kurnool-Cuddapah Canal.
,, 9th—11th	Madras.	
,, 12th—16th	Trichinopoly	Cauvery head works.
,, 17th—22nd	To Periyar and back ..	Periyar works.
,, 23rd	Madras	Had an interview with His Excellency the Governor.

Gódávari Head Works.

2. On the morning of 30th I went up the river and saw the site finally proposed for the East Coast Railway bridge over Gódávari, when I met Mr. Walton. The plans of the river and a note by Mr. Bell were shown to me. It is proposed to cross the river about 2 miles higher up than proposed by Mr. Bell by 57 spans of 150 feet, giving a clear waterway of 8,700 feet. As far as the Gódávari head works are concerned, no objection can be made to these proposals.

3. On 1st December I went over the fine and interesting head works of the Gódávari, and saw the head regulators of the Eastern, Central and Western canals. As the level of anicut crest is not sufficiently high to maintain the supplies required for the canal, rail stanchions about

2 feet high have been fixed into the masonry at intervals of from 8 to 10 feet, and the water level is held up 2 feet by means of planks, which are removed as the river begins to rise The labour of fixing and removing these planks is very great; there is an immense amount of leakage, while the permanent iron stanchions are very objectionable. An estimate, amounting to Rs. 1,33,000, for raising the crest wall 2 feet was therefore submitted to the Government of India and sanctioned in their letter, No. 4, I., dated 13th January 1896. A few chains only of this work have been done, and I am very strongly of opinion that the work should not be continued. The danger of permanently increasing the height of the anicut, without very large additions to the stonework downstream, has been very clearly shown at Bezwada, and there is the further objection that it causes a shoaling of the river upstream. It will be much better that the extra 2 feet required should be secured by means of falling shutters, or a moveable weir, following the practice which has been adopted on the Sone canals at Dehree, the Lower Ganges canal at Narora, the Agra canal at Okla, the Sirhind canal at Rupar, and the Chenab canal at Khanki, in all of which the full height required is obtained by means of falling shutters, which can be lowered as the river rises. Probably the Sone canal pattern would be found most suitable for Dowlaishweram. The principal difficulty with such shutters is the raising, which is generally effected after laying the crest dry by means of the undersluices. At Dowlaishweram the power of the undersluices is not sufficient for this, but the shutters can no doubt be raised with 1 foot of water on the crest, and with much less risk and trouble than is involved in the present practice of fixing planks, while they can be designed to fall automatically as the river rises as at Dehree, or under control by means of a let-go arrangement, as at the other headworks mentioned above. The former plan will probably be preferred.

Kistna Head Works.

4. The extraordinary flood in the Kistna on the 6th August 1896 was the highest on record and caused a serious breach, 450 feet in length in the left river embankment above Bezwada, while the right embankment and the important headworks of the Kistna canals were in serious danger. The river embankments on both sides below Bezwada were also seriously breached in a great many places.

The maximum flood levels at site of anicut, when at 6 P.M., on night of the 6th August, are shown below, the mean sea level being the datum line. The reduced revel of the present crest of anicut is 49·25 feet, while that of the zero of the anicut gauges, the readings of which are quoted in the reports of the local officers, is 26·25.

Position of Gauge.	Maximum flood level, 1896.			Previous maximum levels, July 1882.
	Left bank, Bezwada.	Right bank, Sitanagaram.	Mean.	
Above anicut	67·55	67·55	67·55	66·29
Below anicut	66·25	64·95	65·60	65·50
Afflux ..	1·30	2·60	1·95	·79

The levels for July 1882 are probably the maximum then recorded, and not the mean of right and left banks. As regards the levels downstream of anicut, it will be seen that the maximum of left bank level in 1896 was 0·75 foot above the record of 1882, but if the mean level be taken, the difference is only 0·1 foot. Some heading up probably occurred on these gauges, owing to the obstruction caused by the left bank training works of the railway bridge (a matter to be presently referred to), and allowing for this it is possible that the volume of the flood was not actually much greater than in 1882, though the Executive Engineer has estimated the flood discharge of August 1896 at 762,000 cusecs, against 611,000 in 1882. It may be noted that Colonel Mullins in his "Irrigation Manual" has estimated the two great Kistna floods of 1874 and 1882 at 736,000 and 770,000 cusecs, respectively.

5. In 1882 the upstream gauge on right bank registered 0·66 foot more than that on the left, and if 66·29 be the reading of the former, the mean gauge will have 65·96, against 67·55 in 1897, so that there was an increase of about 1·6 foot in the latter year. This rise may be partly due to a fuller discharge, but it must be attributed mainly to the fact that the crest of the anicut has been lately raised 3 feet, which probably accounts for at least 1 foot of the increased afflux. As at the Gódávari this increase in the height of the anicut has been found necessary to maintain the large supplies now required for the canals, but in the form in which it has been carried out is open to the most serious objections. The rise of 1 foot or more in the flood level immediately above the anicut is the least of evils resulting from this raising of the crest. The river

bed must in time shoal up the level of the new crest, but the worst consequence is the severe action on the anicut due to the increased afflux. There is a sheer drop of 3 feet on to the anicut talus, which has been neither strengthened nor lengthened to resist this heavy action. I am very strongly of opinion that 2 feet at least of the new work should be removed altogether before next flood season. This will leave the crest 1 foot above its old level, which may be accepted if the downstream apron is extended as proposed below. The supply here as at Dowlaishweram should be held up to any higher level required by falling shutters, which can be thrown down whenever floods have to be passed.

6. The total length of the anicut from flank to flank is 3,714 feet, the length exclusive of undersluices, etc., being 3,341 feet. The Bezwada Railway bridge is situated about half a mile downstream, and consists of 12 spans of 300 feet each. It is not, however, built opposite the anicut, but as it were *en echelon*, the centre of the bridge being about 250 feet to the south or right of the centre of the anicut. Thus to bring the bridge opposite the anicut, 3 spans should be taken off the right end and added to the left. As it is the left undersluices, and adjacent length of weir are apparently masked by the left upstream training embankment, which connects the flank of the undersluices with the bridge end. Major Baddeley, the Superintending Engineer, who was on the spot during the high flood of August 6th, has written in very strong terms of the danger to which the anicut is exposed by the existence of this embankment, and has very earnestly recommended that it be removed, and the bridge be lengthened by 3 spans on the south end, even if the cost be debited to the canal and not to the railway. Mr. Upcott who visited Bezwada on the 20th and 21st August was of opinion that there was no *primâ facie* evidence that the lengthening of the bridge was necessary to ensure the safety of the anicut, and that the case should be more carefully considered when the present state of the river had been more fully examined. One of the principal objects of my visit was therefore the consideration of this important question.

7. Major Baddeley has stated the case for lengthening the bridge in paragraphs 8 to 12 of his letter No. 1244 K., dated 13th August 1896, and in paragraph 7 of his letter No. 1826 K., dated 5th October 1896. Briefly the dangers which he apprehends may be thus stated :

(*a*) Owing to the obstruction caused by the north training embankment and the insufficient waterway of the bridge the river is silting up on both sides, and this silting will continue until the river, unable to discharge freely through the contracted channel, will rise during floods to a dangerous height above and below the anicut.

(*b*) The effect of the contraction at the bridge is to produce back currents and whirlpools which in 1895 scoured out a hole 50 feet deep below the Bezwada undersluices, which will have increased during 1896, and if this works back and takes down the undersluices, a breach into the canal and a total failure of the headworks of the Eastern delta system may be anticipated.

8. As regards (*a*) I am of opinion that there are no real grounds for apprehensions. The flood levels abstracted in paragraph 4 above show that the maximum flood level below anicut in 1896 was only 0·75 foot higher than in 1882, while the difference was probably much less if the mean of right and left bank levels be taken. If we assume that this was entirely due to the obstruction downstream and that the flood discharge in 1896 was no greater than in 1882, the effect on the level upstream would be almost inappreciable. As shown in paragraph 5 above the mean level upstream was only 1·6 foot higher than in 1882, in spite of the fact that the water-way over the anicut had been solidly blocked by the addition of 3 feet on the crest. The effect of a raise of 0·75 foot in the downstream flood level would be not to block the water-way to that extent, but merely to increase *pro tanto* the height of the drowned, and to decrease the height of the undrowned portions of the discharge over the anicut. The additional afflux due to this cause would be practically unappreciable. If, on the other hand, it be true that the volume of the flood discharge was actually greater than in 1882, the higher levels both above and below the anicut will have been partially due to this cause, and the effect of the bridge works will have been by so much even less than indicated above. I am therefore of opinion that any increase in the height of flood levels above the anicut, as compared with those of 1882, that was not due to an increase in the volume of the flood discharge, must be attributed entirely to the raising of the anicut crest, and was wholly independent of any obstruction caused by the bridge works.

If this be admitted, the extent to which silt may have been deposited in any of the spans of the bridge or below the apron near the Bezwada undersluices is immaterial. The only effect of increasing the number of spans would be either to increase these deposits of silt or to decrease the depth of scour in those spans on which the set of a flood may be heaviest. It has not, however, been stated that the maximum scour at the bridge was greater than was contemplated when the bridge was designed, nor is the safety of the bridge now in question. As regards the effect of the bridge on the flood levels immediately below and above the anicut, I have no hesitation in expressing an opinion that the water-way at present provided is sufficient.

9. As regards objection (*b*) it may be noted that in the original design for the bridge it was proposed to build it opposite the anicut. Subsequently the Engineer-in-Chief (Mr. Spring) decided to place it as now built. The papers in the Madras Public Works Secretariat show that the change was approved by the Chief Engineer, Irrigation Works (Mr. Walch), after personally discussing the matter with Mr. Spring. It is evident, too, that the present position was proposed

because all the river charts on record showed plainly that the main channel of the river on rounding the Sitanagram bluff had always run in the direction of a line joining the centres of the anicut and bridge as now constructed, and not at a less acute angle with the line of the anicut. The location of the bridge finally adopted involved, therefore, less disturbance of the natural course of the river. It is obvious, however, that water must at all times cross the anicut at right angles, and that in an extraordinary flood like that of August last with 18 feet over the crest of anicut there would be a very strong set in this direction for some distance after passing the crest, so that the short distance of only half a mile between the anicut and the bridge might be insufficient to allow the flood to accommodate itself to the change of direction. The flood waters impinging on this back and forced suddenly to change their course would naturally produce the strong back currents, eddies and swirls which were seen by the officers on the spot. Mr. Upcott remarks that the contraction of the water-way would, by checking the velocity, prevent these eddies, but the eddies are not a consequence of the high velocities, if uniform, but of the changes and interruptions of velocity resulting from the blocking of the left side of the channel. No doubt eddies are caused by the meeting of the waters passing through the undersluices and over the weir, but these have always existed, and will be no greater on the left than on the right bank when the conditions in this respect are identical. I see no reason, therefore, for doubting the assertion of the very competent observers on the spot that, over and above these ordinary eddies, a great back-swirl was set up by the obstruction caused by the left embankment, which might, if continued long enough, or if frequently repeated, endanger the safety of the left end of the anicut and undersluices. The existence of such a swirl is clearly indicated by the levels given in paragraph 4, which show that the water on left bank below anicut stood 1·3 foot higher than on right bank. There is of course nothing extraordinary in the level on one bank of a river being slightly higher or lower than that on the other during a high flood, according to the position and volumes of the main currents, but in this case the levels upstream of the anicut were identical (in 1882 there was a difference of 0·66 foot) so that the discharge was as nearly as possible evenly distributed over the whole length of the anicut. The great difference in the levels immediately downstream shows, however, how the water must have piled up above the left embankment, and is a measure of the violent eddies and swirls which must have occurred between the anicut and bridge The remedy proposed by the Superintending Engineer to remove the embankment and lengthen the bridge on the north end by 3 spans would, no doubt, reduce this action, but it is my opinion only on this account, and not because the waterway at the bridge as in itself insufficient, that the lengthening of the bridge can be recommended. The same object might be almost as effectively attained by removing 2 or 3 spans from the south and adding them to the north end, though this would be open to obvious objections on other grounds.

10. There is little doubt that this left embankment tends to set in motion new forces during the flood season which must be reckoned with by those responsible for the safety of the canal head-works, but the question is whether the difficulties cannot be met by some less heroic and expensive measure than that of lengthening the bridge by 3 spans, which would probably cost something between 7 and 8 lakhs of rupees. It is however first necessary to consider what damage has actually occurred which may be wholly or partially attributed to any change in conditions since the bridge was constructed. Major Baddeley refers only to a hole 50 feet deep which was scoured in 1895 below the apron near the Bezwada undersluices. It may here be noted that the anicut is protected on the downstream side by an apron of loose stone which extends for an average distance of 170 feet beyond the retaining wall at the foot of the talus. Ever since the construction of the anicut, scour holes have been formed annually downstream of this apron, more especially on the right and left flanks or near the lines of the undersluices. The normal reduced level of the bed beyond this apron is 26·25, and the depths of scour are measured downwards from this datum. Plans and sections showing the positions and depths of these scour holes since January 1891 were examined by me. The hole referred to by Major Baddeley when measured in January 1896 had a length in a direction square to the line of anicut of 330 feet, and a width in a direction parallel with anicut of 400, the maximum depth being 50·3 feet at about the centre of figure, or 160 feet beyond the end of apron, and 200 feet from the dividing wall of the undersluices. In November 1896 the position and dimensions were about the same, but a sounding of 56 feet was recorded. The plans for January 1891 to 1894 show large holes below the flanks only of the weirs. On the right side these holes varied in depth from 50 to 60 feet. On the Bezwada side the scour was much less, being *nil* in January 1893, and never exceeding 35 feet in other years. The exact changes that have since taken place would be conveniently shown by super-imposing on one sheet the plans of successive years, but the conclusion that I derived from an examination of them was that since the construction of the bridge the scour holes on the left flank have increased both in extent and maximum depth (the soundings having increased from 35 to 55 feet), that there are frequent scour holes below the central portion of the anicut of which there were but traces before, and that the depths of scour on right flank have decreased from between 50 and 60 to 40 feet. It is the increased scour on the left flank more particularly that has caused the Superintending Engineer's apprehension, but although it is only right that this matter should be carefully watched the depths recorded on this side after the great flood of 1896 were less than occurred regularly on right side before the bridge was constructed.

Moreover, although the downstream eddies no doubt tend to produce these holes the severe action on the weir itself, due to the raising of the crest already referred to, has probably been a far more important factor, and until this has been eliminated, by cutting down the crest as proposed in paragraph 5 above, it cannot be said to what extent the action is due to the bridge training works. Finally, it may be said that these holes, which occur below all anicuts in sandy beds, are of no importance, however great the depth, provided that they are kept at a sufficient distance from the retaining wall of the *talus*, and are not allowed to cut back. I understand that the practice has been to fill them up with sand only every cold weather to a surface sloping down from the 26 25 feet level. If the apron were extended over this filling for a distance of 30 feet, or to 200 feet beyond the retaining wall, by means of concrete or masonry blocks, 4 feet × 4 feet × 2 feet, built *in situ* and laid to a slope of about 1 in 5, these scour holes would, in my opinion, cease to be a danger to the work. This would take seven rows blocks, costing about Rs. 50 only per run of 4 feet, or Rs. 12·5 per foot run, so that the whole length of anicut could be protected at a cost of not more than Rs. 50,000, which might be expended gradually. This system has been found very successful in Northern India. If preferred, loose stone might be employed, large stones, such as these in the present apron, being laid over a stratum of small stuff; but in this case the apron should be extended at least 50 feet, and the blocks will, I think, be found more satisfactory.

11. I should mention here that a very nasty hole was scoured in the talus of the anicut, the general dimensions being 75 feet in line of anicut and 45 feet transversely, the depth varying from 1 to 12 feet, and the edge of the hole being only 18 feet from the left undersluices and 15 feet from the wall of the anicut. This hole cannot, however, be attributed to the contraction below the anicut. It did not occur during the high flood when the effects of that contraction would be most marked, but was first observed on the 3rd July when the levels of the upstream and downstream gauges were 55·90 and 50·45, respectively, *i.e.*, when the depth over the anicut was nearly 12 feet less than on August 6th. It was probably due to the displacement of stones by floating timber; an accident to which all weirs are liable. It has been thoroughly repaired, and was filled up with small stone, overlaid with stones 2 feet deep, which were topped with Portland cement concrete 2 feet thick on upstream side tapering down to 2 feet on the downstream.

12. In regard to the penultimate paragraph of Mr. Upcott's report, I understand that Major Baddeley recommended the strengthening of the right embankment because it will be absolutely necessary to maintain it intact unless or until the bridge is lengthened, when it would of course be dismantled. Even if it were decided to lengthen the bridge the work could not be completed before next floods, and in the meanwhile the embankment must be maintained to the height and section that may be be advised by the responsible Irrigation officers.

13. My general conclusion therefore is that there has been no contraction of the water-way at the Bezwada bridge such as would affect appreciably the levels above the anicut. By lengthening the bridge the violent action which now occurs below the left end of the anicut would probably be materially reduced, but there is no evidence that this action has hitherto caused any serious damage, though it may do so in time and must undoubtedly be guarded against. I consider, however, that the safety of the anicut and undersluices will be far more securely assured by cutting down the upper 2 feet of the present crest and strengthening the works in the manner proposed in paragraph 10 above, than by lengthening the railway bridge, and this at less than one-tenth the cost, but the left training embankment should be made secure against overtopping by the highest flood and against the violent action that takes place along its water face.

14. It remains to consider what other works are required to ensure the safety of the head works during an extraordinary flood, and which must be undertaken whether the bridge is lengthened or not. The weak points are the head sluices or regulators on each bank. As regards those on the Sitanagaram side or Western delta canal, it appears that owing to apprehensions felt as to their safety, a second regulator was commenced in 1895 a chain or two below the existing work so as to take its place in the event of failure. The chamber referred to in paragraph 4 of the Superintending Engineer's No. 1244 K., dated 13th August 1896, is the length of canal lying between the two regulators, and the construction of the retaining walls proposed was in progress during my visit. This lower regulator was only partially completed when the flood occurred, but it was of considerable service, as by the insertion of planks, water was held up 2·65 feet in the chamber. The head on the upper regulator was 13·85 feet, which is almost as much as it can stand with safety, and if it had not been for the lower regulator, it would have been necessary either to increase this head or to have increased the canal supply from 11·20 to 13·85 feet, which would have increased the number of breaches, and also have brought into the canal a very large quantity of silt. If the lower regulator had been completed, the canal might have been closed altogether or the supply reduced to the minimum required. The work is, however, in active progress and should be completed before next flood season. The other works in the Western delta head sluice referred to in paragraph 7 of the Superintending Engineer's letter, No. 1244 K., dated 13th August 1896, were also in hand.

15. On the Bezwada or Eastern delta side there is no second or ancillary regulator, and in order to avoid subjecting the existing regulator to an excessive head the depth of water admitted into the canal as measured on the rear gauge was 12·9 feet, and this has resulted in a very heavy silt deposit in the upper reach of the canal. A second regulator is very necessary on this side, but to construct it on the ordinary pattern with small vents would lead to a great loss of head, which cannot be spared in view of the extensions of irrigation which are contemplated in the Eastern delta. The Superintending Engineer, therefore, proposes to build two piers, in the line of the piers of the existing bridge below the head sluices, with suitable flank walls, and to have three large sluice gates of 40 feet span, constructed in accordance with Stoney's patent. This will be more costly than sluices of the ordinary type, but under the conditions that obtain at the site will be the most suitable form of regulator. Unless something of the kind is made, there will always be a danger of the head regulator failing in such a flood as occurred in August last, so that apart from the advantage of being able to control the amount of flood water passed into the canal the matter may be regarded as one of great urgency, and the necessary plans and estimates should be prepared at once. If preferred, the sluices might be constructed on the principle proposed by Colonel Smart referred to in paragraph *infra*, which is said to be less expensive than Stoney's system, and in the situation proposed could certainly be worked without any risk of failure, but this is a detail to be considered when the plans are under preparation.

16. The works required at Bezwada are therefore—

(*a*) Substitution of falling shutters for the upper 2 feet of anicut.
(*b*) Extension of the apron downstream of the anicut and undersluices.
(*c*) Raising and strengthening the left training embankment between anicut and bridge.
(*d*) Completion of the lower regulator and connected works in the Sitanagram side.
(*e*) Construction of a lower regulator on the Bezwada side, consisting of three 40-feet sluices.

Of these (*a*), (*d*) and (*e*) may fairly be charged to the Capital account of the canal, and (*b*) might also be so charged, unless the Local Government prefers to charge it to Revenue; (*c*) should apparently be carried out at the cost of the railway, as part of the bridge works.

I understand that no estimate has yet been sanctioned by the Government of India for the work now in progress in the Sitanagram side, and that the outlay already incurred is held under objection. It appears to have been thought that under the orders conveyed in Government of India letter, No. 95 I., dated 8th May 1896, estimates for new works for which no provision was available from the current sanction for the Kistna canals could not be considered or sanctioned until the construction estimate had been formally closed on 31st March 1898. This is, however, a misapprehension. In the letter referred to, the Government of India declined to sanction an addition of Rs. 8,00,000 in a lump sum to the existing sanction for the Kistna canals to provide generally for unforeseen contingencies, but there is nothing in those orders to prevent the submission of specific estimates even before the closing of the construction estimate for works that may be urgently required. Such estimates will be considered on their merits, and if the safety of the canal works is involved, no time should be lost in submitting them for the orders of the Government of India.

Kurnool-Cuddapah Canal.

17. The Kurnool-Cuddapah canal was constructed under a 5 per cent. guarantee by the Madras Irrigation Company, which was incorporated under an Act of Parliament in 1858. The work was commenced in 1859, and virtually completed in 1871. As explained at length in the monograph forwarded by the Government of Madras with their No. 456 I., dated 10th June 1882, the undertaking was a financial failure, and difficulties arose which resulted in the acquisition by the Secretary of State of the Companies' rights and interests in the canal. This was effected in 1882, the sum paid on account of purchase of the canal amounting to £1,742,246. The capital outlay standing to the debit of the canal at end of the year 1887–88 amounted to Rs. 2,16,44,795 and to Rs. 2,17,00,550 at the end of 1895–96. In the former year the working expenses exceeded the gross revenue by Rs. 79,424, and the Government of India in their Resolution No. 33 I., dated 26th February 1889, remarked that it might be economical to close the canal as an irrigating system, merely keeping it in repair so as to be ready to be put in working order again if a season of drought should create a sudden demand for water. The Government of Madras was asked to "consider the question and formulate such proposals as may seem to them expedient with a view to putting a stop to the constant drain on the Treasury which the maintenance of the canal on its present footing entails." In their reply, letter No. 236 I., dated 15th May 1889, the Government of Madras strongly deprecated closing the canal, but promised to reduce the cost of the Navigation establishment by Rs. 3,000, and to effect other petty economies, especially by abandoning the telegraph line along the canal. They remarked that the principal way by which the working expenses might be reduced was by the entire abandonment of navigation, and that this would be recommended were it not that the Guntakal-Bezwada Railway, then approaching completion, crosses the canal at about the middle of its course, and it was "considered advisable to wait and see the effect of the complete opening of the line on the navigation, which may possibly then develope so as to avoid the loss now accruing on that account." This view was accepted by the Government of India, and no further communications on the subject have been received within the seven years and more that have since elapsed.

18. I struck the canal at the railway crossing (Nandyal) and travelled down it to the tail at Cuddapah, a distance of 88 miles, accompanied by Mr. Hughes and the Superintending Engineer Mr. de Winton. It is unnecessary to describe the works in detail, but it was obvious that the earthwork and masonry, as originally constructed, was of a very inferior class for canal work, and an extraordinary amount of leakage occurs, both through the banks and lock walls. The canal is maintained in very fair order, considering the small sum that can be spared for its maintenance, and I infer from a perusal of previous Inspection Reports by the Chief Engineer, Madras Irrigation Works, that matters are gradually improving, and that the banks and works are now in a much better condition than they were when first taken over in 1882.

19. When the canal was taken over by Government in 1882, a forecast of the probable revenue receipts and charges for the six years ending 1887 was made by the Chief Engineer, and will be found in the Proceedings forwarded with Madras Government endorsement No. 185 I., dated 26th February 1883. This forecast is compared below with actuals to end of 1895–96 :—

Year.	Forecast of 1882–83.				Actuals to end of 1895–96.			
	Area irrigated during year.	Gross Revenue.	Direct working expenses.	Net Revenue.	Area irrigated during year.	Gross Revenue.	Direct working expenses.	Net Revenue.
	ACRES.	RS.	RS.	RS.	ACRES.	RS.	RS.	RS.
1882–83 ..	20,000	72,750	1,45,541	— 72,791	17,834	76,023	1,33,410	— 57,387
1883–84 ..	22,000	90,000	2,38,446	— 1,48,446	19,674	42,896	1,81,710	—1,38,814
1884–85 ..	24,000	96,000	2,19,385	— 1,23,385	25,261	1,32,286	2,02,520	— 70,234
1885–86 ..	26,000	1,07,000	2,16,895	— 1,09,895	22,801	85,000	1,90,944	—1,05,944
1886–87 ..	28,000	1,16,000	1,48,420	— 32,420	22,676	65,964	1,84,921	—1,18,957
1887–98 ..	29,917	1,26,000	1,48,420	— 22,420	21,927	65,518	1,41,440	— 75,922
Total 6 years.	149,917	6,07,750	11,17,107	— 5,09,357	130,173	4,67,687	10,34,945	—5,67,258
1888–89 ..	..	..	..	..	34,999	77,727	1,43,046	— 65,319
1889–90 ..	..	..	..	..	21,851	78,959	1,19,566	— 40,607
1890–91 ..	..	..	..	..	24,848	1,23,566	1,50,439	— 26,873
1891–92 ..	..	..	..	..	73,500	1,42,722	1,23,199	+ 19,523
1892–93 ..	..	..	..	..	30,766	1,48,281	1,58,105	— 9,824
1893–94 ..	..	..	..	..	31,424	1,29,440	1,32,472	— 3,032
1894–95 ..	..	..	..	..	33,540	1,13,055	1,01,681	+ 11,375
1895–96 ..	..	..	..	..	32,903	1,39,751	98,824	+ 40,907
Total 8 years.	..	..	..	..	287,831	9,53,482	10,26,732	— 73,250

Unsatisfactory as have been the financial results attained, it will be seen from this table that the loss during the six years following the acquisition of the undertaking by Government was not much more than 13 per cent. in excess of that anticipated when it was taken over, and that in later years there has been a steady improvement, so that during the last five years the gross revenue has exceeded the direct working expenses by Rs. 60,279, or an average of rupees 12,056 per annum. The indirect charges for collection of revenue and on account of leave and pension allowances have not, however, been included in the table above, and may be taken as averaging about Rs. 10,000 per annum, so that it may be said that during the last five years the canal has just, but barely, paid its working expenses.

20. There is no doubt that the capital account of the canal has been enormously swollen in consequence of the complications which arose in connection with the Company. The Chief Engineer for Irrigation, in a note dated 20th February 1883, estimated the intrinsic value of the canal works, which stood on the books at over Rs. 2,16,00,000, at Rs. 1,25,00,000, but details of this estimate were not given, nor has it ever been formally accepted. Apart from this, however, this canal has been very heavily weighted by the enormous capital expenditure actually incurred in providing for navigation. It may be noted that the entire supply of the Kurnool-Cuddapah canal is carried in a single channel as far as the 75th mile only, at which point the greater part of the supply is passed into a line of nallahs or rivers, which cross and recross the canal. The last 117 miles of the canal may be considered as divided into four sections of unequal length, each section being almost a still-water channel, carrying only as much water as is required for navigation and the irrigation effected from it. By means of suitable works in the nallahs or river beds, the supply is reinforced at the head of each section from these channels. The entire supply is thus divided between two channels, and the consequent loss by absorption must be very great. In these four sections there are no less than 42 locks. It is obvious that if it had not been considered necessary to provide for navigation, it would have sufficed to substitute for these 117 miles of navigable canal with their 42 locks, a few ordinary rajbahas taking off from the rivers so as to command the areas to be irrigated. Had this been done, the capital outlay would probably have been reduced by at least Rs. 25,00,000, and there would have been a great saving in the cost of maintenance and in the loss of supply due to absorption.

21. But, however much the capital account of the canal may have been swollen by these and other preventable causes, there is now little doubt that it could never pay financially, even if the capital cost were one-fiftieth of the present amount. Broadly it may be stated that the people will not irrigate more than 30,000 acres per annum, and that the revenue derived therefrom barely suffices to cover actual working expenses. I have been unable to ascertain that any estimate was made of the area that would be annually irrigated when this project was first sanctioned, but in paragraph 79 of the monograph it is stated that the arable area commanded was 321,515 acres, while distributaries had been provided for an area of 196,227 acres. Irrigation nominally commenced in 1863–64, when 18 acres were irrigated. In the great famine year of 1876–77, it amounted to 90,285 acres, and in the following year to 50,918 acres, but, excepting these two years, the irrigated area never exceeded 20,000 acres until 1884–85. In the dry year 1891–92 it amounted, as shown in paragraph 19 above, to 73,500 acres, and an area of about the same extent is anticipated in the current year, 1896-97, which has also been a year of great drought, insomuch that relief works have actually been started in the Cuddapah district. Excepting these dry years the annual average area may be taken at about 30,000 acres, for a canal that has cost over 2 crores of rupees.

22. The principal reason that has been advanced for this short irrigation is that the canal tract comes under the influence of both the south-west and north-east monsoons, and in ordinary years so large an area of dry crops can be raised without resort to canal irrigation that the people are very unwilling to turn to wet cultivation or rice-crops. The revenue management of the canal is in the hands of the District officers. The system differs from that in force elsewhere in Madras, in that the water-rate is levied only in respect of lands for which water has been applied for, a new application being required for each crop, while penal rates are levied when water is taken, which has not been formally applied for. This system was apparently necessary when the canal was administered by the Company, and I presume that it has been found desirable to retain it, so as to avoid all semblance of a compulsory rate in a tract where artificial irrigation is so rarely obligatory. One objection to it is the inducement that it offers to illicit irrigation, but this has been to a certain extent checked of late years by the appointment of special Deputy Collector, and it is to this that the improvement in the returns during the last five years is perhaps mainly due. In order to encourage the extension of wet cultivation, specially favourable rates are offered in the case of lands that have not been wet cultivated for ten years, under what are called the Cowle rules, the rates being reduced by 50 per cent. for first five years, and by 25 per cent. during the succeeding five years. In the case of waste lands taken up under the "block" rules, irrigation is free for the first five years, while half rates only are charged during the next five, subject to a minimum rate of 8 annas per acre. These rates are on the areas actually irrigated, but in subsequent years the charge will be on the entire extent of the block, with a minimum of one rupee per acre. Up to the end of 1895, the area of waste lands allotted under these rules amounted to 1,331 acres, and application for 1,429 acres were under consideration.

23. The measures thus taken by the Civil officers under the control of the Board of Revenue to encourage the extension of irrigation are no doubt appropriate, and it is sufficient to note them, but it is a matter for consideration how far the short irrigation is due to causes over which the Engineers have any control, *i.e.*, to insufficiency of the supply during periods of strong demand, or to an inadequate system of distribution. Failure of the supply at a crisis not only prevents the irrigation of considerable areas for which water is in demand, but is certain to engender a want of confidence in the canal on the part of the cultivators which may be one of the causes of their unwillingness to resort to it. I am afraid that such failures have not been infrequent. In paragraph 43 of the monograph already referred to, the full supply at head of the canal is stated to be 3,000 cusecs. In statistical statement 1-A of the Madras Irrigation Administration Reports it is given as 1,468 cusecs, but the maximum actual discharge is 945 cusecs—Administration Report, 1895–96. The maximum *average monthly* discharges have been 862 cusecs in November 1894, and 891 in November 1895, and I was informed that the canal could not possibly carry more than 1,000 cusecs. I understand that if a larger supply than this could be drawn off at the head when water is available, much of it might be stored in the large tanks which exist at the upper end of the canal, so as to maintain the supply when the river was low.

24. Another question of probably greater importance is that of the sufficiency of the distributaries.

As remarked in paragraph 21 above it was reported in 1882 that distributaries had been provided to command 196,227 acres, but I understand that many of these have been since abandoned, and that the distributaries command mainly only the wet lands. Thus when the cultivators of dry lands suddenly want water, they cannot get it, without first making more or less temporary arrangements for leading it to their fields. I was told that a complete plan of the distributary system was under preparation, but unfortunately I was not able to see it; the importance of improving the distributary system was pointed out, however, by the Chief Engineer for Irrigation as long ago as 1883, and as far as I could ascertain there has since been retrogression and not progress in this matter.

25. Improvements in the direction suggested in the last two paragraphs will involve an additional charge to the Capital account, and it is of course a question whether on a canal, like this, where the normal demand for irrigation is so small, any further expenditure would be justified. It can possibly be shown that this would only be throwing good money after bad, but the question is one that should at least be considered. The canal cannot irrigate at present anything like the area for which designed, and it is significant that the irrigated areas in 1891–92, and the present very dry year have fallen so far short of that of 1876–77. It is probable, moreover, that if the irrigation can be made more certain not only will the areas increase, but the Revenue officers will be justified in enhancing the fixed assessment when the settlements are revised, on the ground of the security or insurance afforded by the canal, and such enhancement will be fairly creditable to the canal. It is at any rate my duty to point out these defects and how far the carrying and distributary capacity of the canal falls short of the original designs, though I cannot say to what extent it may be feasible or desirable to provide a remedy.

26. I now come to the question of navigation. As noted in paragraph 17, the Government of Madras stated as long ago as 1889, that they would recommend the abandonment of navigation were it not for the approaching completion of the Guntakal-Bezwada Railway. This railway has since been completed, but the traffic on the canal is still practically *nil*. According to statement II-D. of the Irrigation Administration reports for 1894–95 and 1895–96, the up and down traffic in those years amounted to 1,952 and 1,727 tons respectively, or a mean of 1,840 tons per annum. That is on an average 5 tons or say 7 bullock carts per diem on a canal nearly 200 miles in length. It cannot be said that the tolls are prohibitive, for navigation is free, and no attempt is made to levy tolls. For this petty traffic 42 locks have to be maintained. They are worked very economically, only one man being kept at each lock. The pure navigation charges have, however, been returned at Rs. 10,102 in 1894–95, and Rs. 16,791 in 1895–96, and if to this be added the cost of upkeep of boats, which is charged to tools and plant, the total will average over Rs. 11,000 per annum. If navigation were abandoned, the cost of maintenance of the canal would probably be also reduced in many other ways, as will be understood by what has been said in paragraph 20 above. The Superintending Engineer is desirous of starting a Government service of boats so as to encourage traffic. I am afraid that this will only add to the working expenses, and is more likely to discourage than encourage private enterprise in the matter. I am told that Messrs. Binny and Co., who own most of the boats on the canal, and are at present using them for the transport of water-pipes to Kurnool, had some idea of starting a service for the general public, but after enquiry, gave it up. If navigation cannot be developed under the present system of exemption from all tolls, little is to be expected from a Government service. Such navigation plant as there is, is very old and will shortly require renewal if navigation is to be maintained. There may be something to be said on the other side, but I am of opinion that the Government of Madras should be invited to reconsider the question of the entire abandonment of navigation on this canal.

27. It will be seen from paragraph 19 that the working expenses have been considerably reduced since 1890–91, and I am of opinion that they are remarkably low for a navigable canal of such length, and can only be further reduced by the entire abandonment of navigation. The canal is no doubt of great benefit to the districts traversed as an insurance against drought, and in very dry years is of immense value, and as it now pays its working expenses, its maintenance involves no charge on the state, since the interest on the capital charge is a permanent liability that would not be lessened by abandoning the canal. But the very narrow margin by which the gross revenue exceeds the working expenses would be appreciably increased by the abandonment of navigation, and it is possible that the financial position would be somewhat improved by a moderate addition to the capital cost, as suggested above in paragraphs 23 and 24, while it is certain that this would considerably increase the efficiency of the canal as a protective work. Lastly, it may be said that there are indications of a gradual extension of the irrigated area which may be attributed to the appointment of a special Deputy Collector and other arrangements made by the Revenue officers, and which warrant a hope that by careful nursing the net revenue of the canal may gradually improve, though it is hardly likely ever to exceed on an average Rs. 70,000 or Rs. 80,000 a year.

Madras.

28. On the morning of the 10th December I visited the Government workshops and saw some gearing for heavy sluice gates which has been designed by Colonel Smart, R.E., in consultation with the Executive Engineer, Workshops division. One large gate, 35 feet by 6 feet, was mounted and subjected to the full pressure to which it will be exposed in practice, and was easily lifted by a boy at a winch handle. The system adopted is to run the gate on large rollers attached to the gate itself and not on rollers fixed in travelling carriage as in Stoney's patent. The rollers are mounted on disc bearings. In addition to the gate alluded to above, two pairs of rollers were placed on the bed of a lathe, and a load of 24 tons placed on them. This was moved with a pull of only 24 lb., so that the moving force was only $\frac{1}{1000}$th part of the load. I also saw a model of a sluice designed by Colonel Smart on the same principle for the Periyár outlet. It is claimed that under this system the co-efficient of friction is as low as with Stoney's patent, while the cost will be less than half. Another advantage claimed is that the rollers will travel with the gate and will not remain below it when the latter is open, and so will be less liable to injury by silt or drift. This may be an advantage in some situations, but as to the reduced cost, if the quality of the work is the same in both cases, there is no reason why saving in cost should be much more than the amount of the royalty due on the patent. Large sluice gates that can be easily worked are required in many situations in Madras, and particularly on the works on the Cauvery for which Colonel Smart is now preparing estimates. The mechanical details of his gearing, which differs essentially from Mr. Stoney's, have been carefully worked out, and I consider that it may fairly be given an extended trial.

29. On the morning of the 11th I was taken over the harbour by Mr. Wilson, one of the Commissioners. There is said to be about 2 feet of silt in the entrance, and Sir A. Rendel has advised that this should be cleaned by means of a suitable pump dredger, but nothing has yet been decided. It is also in contemplation to construct an unloading dock for lighters on the south side of the harbour.

30. A distinctive feature of the Madras irrigation works is the number of petty works (tanks and small canals with their anicuts) for which neither capital nor revenue accounts are maintained. Out of 6,332,482 acres irrigated in the Madras Presidency during 1895–96, no less than 3,392,165 acres were irrigated by means of these works, the total expenditure on which amounted to Rs. 17,63,317. Although no revenue accounts are kept, the amount of the land revenue dependent on these works is approximately known, and for the year under reference amounted to Rs. 91,64,415. The annual expenditure includes a sum about Rs. 5,00,000 which is regularly allotted under what is called the Tank Restoration Scheme, for the systematic examination and survey of existing works, and for the execution of such improvements, extensions, or special repairs as may then be considered necessary. The parties in charge of these surveys work in direct communication with the Chief Engineer, and during my stay in Madras I was shown the system that is being followed There is a large scale map on which each drainage basin is indicated by a light tint as soon as it comes under survey. When the investigations are completed, a record is compiled giving full particulars of each work in the basin concerned, the areas irrigable from and the land revenue dependent on them, the principal levels for anicut crests, tops of embankments, surplus works, &c., that are to be maintained, and the new works or special repairs that are recommended. The record is then printed, in book form, and copies are available for the use of the Civil and Public Works officers concerned. A specimen copy of one of these books, for the Upper Noyil minor basin, accompanies this note, and will show how the record is maintained. The execution of the works proposed is subsequently carried out by the Public Works officer in whose division the work lies, and as each record is completed, the fact is shown on the large scale map by overlaying a darker tint on the area that has been thus investigated. The map then shows at a glance the areas under investigations, those in which surveys have not commenced, and those in which investigation have been completed. The smaller works, which may be defined generally as those irrigating less than 200 acres, are managed entirely by the Civil officers, though special works or repairs proposed in the restoration scheme are carried out by the Public Works officers. These works under Civil officers include no less than 25,184 tanks and 5,408 channels, while there are at present 2,870 tanks and 612 channels under the Public Works officers. The systematic method in which these petty but collectively important irrigation works are now brought under observation and improvement is very satisfactory, and leaves nothing to be desired.

Cauvery Canal System.

31. With their No. 922 W., dated 14th March 1896, the Government of Madras forwarded to the Government of India a copy of their Proceedings, No. 150 I., dated 10th February 1896, containing a memorandum by Colonel Smart, R.E., and a note thereon by Colonel Drake-Brockman, R.E., Chief Engineer for Irrigation, on certain new works proposed in the Cauvery delta, which pointed to a possible expenditure of over Rs. 1,40,00,000, and one of the objects of my tour was to obtain some information as to the object and scope of these proposals. They may be divided into two classes, viz.—

(*a*) Works not primarily intended for the extension of irrigation, but for a more effective control of the existing canal system. Colonel Smart estimated that these works would cost altogether Rs. 40,00,000.

(*b*) New irrigation works, intended for the development of new irrigation, and roughly estimated to cost Rs. 1,00,00,000.

32. Before considering proposals under class (*a*) it may be remarked that the principal channels which are comprised in the Cauvery system are not artificially constructed canals at all, but arms or branches of the Great Cauvery by which its floods are distributed over the whole of the delta. The capital expenditure hitherto incurred by the Irrigation Department has been almost entirely confined to the construction of anicuts, regulators, surplus weirs, and other works for establishing some sort of control over the distribution of the supply. Of these the Upper anicut was the first commenced, in 1835, and the total capital outlay incurred from that time to the end of 1895–96 has amounted to Rs. 18,11,489 only, including indirect charges. The total area irrigated in 1895–96 amounted to 987,103 acres, but the average area before the

commencement of these works, or of what is called "old irrigation" is taken as 778,019, so that the increase of area due to this capital outlay is estimated at 209,084 acres. The net revenue for the same year, after deducting Rs. 31,66,760, due to old irrigation, amounted to Rs. 13,81,657 equivalent to a return of 51·2 per cent. on the capital outlay The return for the previous year, similarly calculated, amounted to 45·1 per cent. These figures are no doubt open to criticism, but whatever allowance may be necessary there is no doubt that the outlay incurred on these works has been extraordinarily remunerative.

33. The control thus obtained over the rivers of the delta is, however, by no means complete. When the supply is short there are many channels that cannot get their fair share, while in seasons of high flood great and preventable damage is done owing to imperfect control. The settlement in the Tanjore district has recently been revised, and I am told that the assessments have been enhanced by something like Rs. 12,00,000, but that when the enhancement was made it was considered that it entailed an obligation to pursue an active policy in improving the canals, and the conditions under which irrigation is now carried on, and that this is the *raisin d'être* of the proposals now under consideration. Under all the circumstances it can hardly be considered obligatory that the new expenditure proposed should be shown to be directly remunerative. It has been possible to defer until now capital expenditure which in any new irrigation work would probably have been obligatory from the first, before a rupee of revenue could be earned, and when at length it becomes almost inevitable it is not so much as a means of creating additional revenue, but as an obligation imposed by the profits already earned. It may also be added that even if the additional outlay now proposed should be directly remunerative, so that a return of five or even ten per cent. were realized, which is quite possible, the result would nevertheless be to appreciably reduce the high percentages hitherto shown on an exiguous capital, percentages which cannot be maintained after the capital is expanded, however directly profitable may be the new expenditure. Any improvement in the control of the Cauvery waters will probably result in an increase of irrigation and of revenue by which the cost will be fully justified, but it is useless to insist that this should be demonstrated beforehand, and each proposal must be considered simply on its merits, as a means of controlling the supply or its distribution. If it had been necessary to show that the works already constructed would prove remunerative, they would probably never have been sanctioned, but the results actually attained may well be held to justify further expenditure in the same direction.

34. The Aganda or Great Cauvery bifurcates into two great channels at the head of the island of Srírangam. The right branch, known as the Cauvery, may be regarded as the main line of the Cauvery canals, while the left channel, known from this point as the Coleroon river, is the natural line of escape for the flood waters. There is no irrigation on the Coleroon above what is called the Lower Coleroon anicut, more than 60 miles below the offtake of the Cauvery, and this anicut forms no part of the Cauvery system. The first great work constructed by the British Government on this system was the Upper anicut across the head of the Coleroon. This anicut was built with its crest five feet above the river bed, so as to force low supplies into the Cauvery, and is the sole means of regulation at this point, which may be called the head of the Cauvery canal. There is no regulator across the Cauvery channel, but simply a masonry bar at bed level. The effect of the anicut is to cause shoaling upstream, to gradually raise the bed in the Cauvery channel, and to force into the latter an undue proportion of high floods. During the great floods of July 1896, it was estimated that 50,000 cusecs passed through breaches in the left bank of the Cauvery across the island of Srírangam into the Coleroon, causing great damage. Colonel Smart's first proposal is to regulate the supply between the two channels by cutting down the anicut to bed level, and erecting large sluice or draw-gates seven feet high. The Coleroon would thus be thrown entirely open in floods, whereas with a low river water could be forced into the Cauvery which now goes to waste over the anicut. In his memorandum Colonel Smart estimates the cost of fitting the existing work with Stoney's shutters at 10 lakhs. After discussing the matter with Mr. Hughes and Colonel Smart, I concluded that it would suffice to cut down the crest by 4 feet, and to use 6-foot gates, capable of being lifted 2 feet above the record flood-level of July 1896. The details of the design were settled. A new bridge will be required, independent of the existing foot bridge which will be dismantled. The piers will be at 40 feet interval and will be upstream of the present line of anicut, the new upstream curtain wells will have their upstream face about 28 feet above the corresponding face of the existing curtain wells, and to be sunk to a depth of 15 feet below the level of apron or 16 feet below the new crest, while the cross wells for the piers will be sunk to the same level as existing curtain well. The gates, which will be of 40 feet span and 6 feet in height, may be constructed on the plan proposed by Colonel Smart, and referred to in paragraph 28 of these notes. The cost has been roughly estimated at 6½ lakhs, which includes establishment and other charges. I consider that this work is very necessary, and that it should be carried out as soon as detailed plans and estimates have been sanctioned, and funds can be made available.

35. About 17 miles below the offtake above the Upper anicut the Cauvery again bifurcates into two channels, the Vennar to the right and Cauvery to the left, while surplus water passes over the Grand anicut on the left bank of the main channel and round the tail of the Srírangam island into the Coleroon.

The Grand anicut is an old native work which was remodelled under the estimate for Rs. 6,88,000 sanctioned by the Government of India in their letter No. 62 I., dated 17th February 1882, regulators being built under the same estimate at the heads of the Cauvery and Vennar channels. The Grand anicut and adjacent regulators constitute together a very fine work. The crest level of the anicut is 189—45 or 5·20 feet above the sill levels of the regulators, and water is held up over this 2·5 feet by falling shutters, which however do not work satisfactorily, because in this situation there are no means of laying the anicut dry, and the shutters cannot be easily manipulated or staunched. Here, as at the Upper anicut, greater control is required. A lower crest is desirable in floods so as to pass more water to escape, and prevent silt deposit above the regulators, while at other times a higher crest level is required to more fully utilize the supply, especially as the Vennar channel has a tendency to silt. It is proposed therefore to lower the crest by 1 foot, and to surmount it with draw-gates 5 feet high, to be worked in the same way as those proposed for the Upper anicut. These gates have not been designed in detail, but the cost is estimated at about 1½ lakhs, including establishment, and the improvement will, I think, fully justify this expenditure, though the work is less urgent than that proposed for the Upper anicut, which is the head of the whole system.

36. The sluices in the head regulators are worked by screws, and it was said that it was very difficult to move them under a full head of pressure. There appears to be no reason why the sills should not be raised 1·5 or 2·0 feet which would sensibly reduce the head of pressure, and would [illegible]d to keep silt out of the channel. The sluices might also at no great cost be made to run on [illegible] this might be tried on one experimentally and should result in a great reduction of the load on the screws.

37. In addition to the works proposed at the Upper and Grand anicuts regulators are required at the heads of many of the minor channels, or open dams are required in place of immoveable anicuts. These works all have the same object, a more effective distribution of the supply and greater security from floods. It is unnecessary to consider them in detail. When the Upper and Grand anicuts have been completed, these works, which are comparatively petty, can be taken up in order of urgency, and executed as funds may be available, and in the meanwhile a complete plan of all channels and drainages and of the areas depending on them is under preparation, so that all improvements of this kind may be undertaken systematically. It may be noted that the necessity for these surveys, with a view to the construction of additional regulating works, was recognized by the Government of India when the works at the Grand anicut were sanctioned in 1882, but that the matter appears to have remained in abeyance, pending completion of surveys by the Revenue Survey Department (See C. W.—I., Pros., May 1883, No. 1, and September 1883, Nos. 1 and 2).

38. The Lower Coleroon anicut is no part of the Cauvery system, and was not inspected by me. It is proposed however to treat it in much the same manner as proposed for the Upper anicut, and for the same reason—the necessity for increasing the flood capacity of the Coleroon river. When details have been decided the cost of the alteration will be chargeable to (43) Minor Works.

39. The new irrigation works proposed or referred to in Colonel Smart's memorandum are—

(1) The Bhavani project.
(2) Pudukkóttai ,,
(3) Udaiyárpálaiyam project.

These are all tank projects, but the tanks will be fed from the Cauvery system, and it is proposed that each should have a supply channel capable of carrying 5,000 cusecs, so that between them they would dispose of 15,000 cusecs during high floods, and to this extent relieve the system. The Bhavani will store water for the benefit of existing irrigation as well as for new irrigation, and the Pudukkóttai will be fed from the Vennar, and afford a relief in times of flood. Neither of these projects is in a form in which any opinion can be formed on its merits, and No. 2 only is under investigation by Colonel Smart. The Bhavani project has been proposed for years, and will involve the construction of a high masonry dam, but no definite proposals have yet been made. I formed the conclusion that however useful these works may be, they are not likely to prove highly remunerative, and if they are sanctioned as additions to the Cauvery project they will, even if absolutely remunerative, greatly lower the percentage of return on the capital outlay. The Bhavani scheme is advocated on the ground that it is required for the benefit of the people who have been lately subjected to an enhanced assessment, and is on this account more urgent than the other two, and on the submission of definite proposals the case can be considered on its merits.

40. My general conclusions on the Cauvery proposals may thus be summarized. The proposed alterations of the Upper and Grand anicuts, estimated to cost about 7½ lakhs, should be taken in hand at once, or as soon as funds are available, and the same remark applies to the Lower Coleroon aqueduct, but this is an independent though equally urgent work, and the outlay proposed on it will not be chargeable to Loan or Imperial funds. A scheme for other regulating works required on the smaller channels, drainages, &c., should be drawn up by Colonel Smart during the period of his deputation under which individual works can be mentioned

from time to time in order of urgency. It will not be necessary, however, at this stage to estimate for all these works in detail, and rough estimates based on typical plans will suffice to show probable future requirements for these works. The scheme for the Bhavani project (which will involve an outlay of at least Rs. 50,00,000), should also be prepared and submitted for the orders of the Government of India as soon as possible, as its execution will materially affect the distribution of the grant under (49) for some years after sanction. The Pudukkóttai and Udaiyárpálaiyam projects can be taken up later, unless the Bhavani is found not to be feasible, in which case the Pudukkóttai can be considered. It may be regarded as certain that funds will not be available for more than one of these three projects within the next seven or eight years.

Periyár Canal.

41. On my arrival at Periyár on the 18th December the lake was full, and water was lapping over the bar of the escape (R. L. 144·0). When I left on the morning of the 20th, the level had risen to 145·5, so that there was a depth of 1·5 over the escape crest. On inspecting the dam I found that there was a very slight percolation throughout the entire length, mostly through minute pinholes, so that there was a thin film of water over the whole of the downstream face. The percolation water passess through a shoot, and apparatus has been put up for gauging it, but I was unable to take an observation as it was not in gear. I was told that with a full lake it had been found that the leakage amounted to 1 cusec in July last, and that a subsequent measurement showed only $\frac{3}{4}$ of a cusec. As far as I could judge by the eye there was more than a cusec on December 18th, but there is no reason why a daily record should not be maintained. The water should be passed continuously through a V notch, and the depth over the notch daily recorded. It is most important that the amount of percolation should be closely watched and recorded, so that it may be seen whether there is any tendency to increase.

42. In the sanctioned project it was proposed to make two permanent escapes, one on the right side of the dam, 420 feet in length, and a second on the left, 500 feet in length, the reduced crest level for each being 144·00. During construction, however, it was found that owing to a landslip the proposed left bank escape would not be safe, and the line of escape was therefore permanently blocked by what is practically an extension of the main dam, so that there is no escape on this bank. The escape on the right bank was made somewhat larger than estimated, but I find that I omitted to note the exact length of crest. As far as I remember it was 488 feet, whereas the aggregate length of the two escapes as originally designed was 920 feet. In paragraph 135 of the report on the project estimate it was shown that with this length of escape such a flood as that of November 1869, which was the maximum then on record and of which certain data were available, would cause the water level to rise to 153·15, and the dam has been calculated for a maximum flood level of 155·0, the top of the parapet being 158·0. The details of this calculation are given in table IV of the project report. The actual length of escape crest is however not much more than half of that then assumed, and it may also be noted that, as will be apparent from paragraph 43 below, the discharge through the tunnel will be less than 5 million cubic feet per hour, instead of 6 millions as estimated in table IV. No doubt the original estimate provided a wide margin for contingencies, and there may be later or more reliable data that have been held to justify this reduction in escape capacity, but they do not appear to be on record, and the matter is of such importance that further enquiry appears to be called for. If found necessary to increase the escape capacity, this could be done at no very great expense by cutting down the escape crest to a level of 143·0 or 142·0, and erecting fallen shutters, which might even be made to hold up the supply to 145·0 or 146·0. The highest level yet attained in the lake was on the 31st July 1896, when the water stood at 15 ·5 or 6·5 feet over the escape crest.

43. The discharge through the tunnel is calculated from the readings of a gauge placed above an overfall a few chains downstream of the lower end of the tunnel. The reading had been steadily 3·1 feet from the 15th July to the time of my visit, although the surface level in lake had varied from 150·5 to 136·8. It would thus appear that above a certain level the discharge is independent of the surface level of lake, and is not affected by a difference of nearly 14 feet in the working head. From the data given to me I do not think that the increase in the discharge theoretically due to this increase of head would amount to 3 per cent., and with the rough measure of gauging at present adopted such a difference would not be detected. I understand that the discharge with a 3·1 gauge at the overfall is estimated at a little over 1,300 cusecs only, whereas the contemplated full discharge of the tunnel was 1,500 cusecs. The method of gauging is, however, so rough that the discharge is possibly under or over estimated by 10 per cent. No pains should be spared to improve this record and ascertain the actual facts. The deficiency is attributed to the rough projections from the surface of the tunnel, which was hewn out of rock. To allow for these projections the cross section of the tunnel was made larger than was thought theoretically necessary, though no one could tell me what the actual dimensions were, but anyhow the co-efficients adopted appear to have been too low, and for a unique work of this kind there was no previous experience available for guidance. In paragraph 198 of the project report it was stated that "if, as is not unlikely, the water-supply is found greater than is now anticipated, the main tunnel can be enlarged at small expense," but enlargement would really be very difficult and very costly, and cannot be contemplated for the mere purpose of rectifying a deficiency of 200 cusecs. It could only be undertaken when there is no demand for water, or no water

available, and that would be during the unhealthiest season of year, March and April, when it was found necessary to suspend all operations during the period of construction. Nor is it probable that the irrigating capacity of the canal will be reduced in the proportion of 1,500 to 1,300, supposing the maximum discharge to be no greater than now estimated. It is only during the three months, July to September, and when water is passing out at the escape that such a discharge as 1,500 cusecs could be contemplated. At other times it will be necessary to husband the supply, and it is doubtful whether at such times more than 1,300 cusecs could ever be spared even though the capacity of the tunnel were doubled. The insufficient capacity of the tunnel is nevertheless a serious matter, as it will prevent the utilization of larger supplies than 1,300 cusecs, at a time that they might be available. The immediate enlargement must, however, be considered out of the question. If it is to be enlarged at all, it should be enlarged as Colonel Pennycuick contemplated in the paragraph of the project report already quoted, so as to take all the extra supply that would be required for the extension of irrigation south of the Vaigai, and this cannot be thought of for many years until a long experience has been gained of the water-supply that can be relied on as available.

44. There is, however, at present another serious difficulty. Not only is it impossible to increase the supply through the tunnel, so as to run more than 3·1 of the overfall gauge, but it it is equally impossible to reduce it, as the equilibrium sluice by which the supply should be regulated cannot be lowered. It was raised to 5 feet above the sill in July last, and it has jamed in such a way that it cannot be lowered, so as to reduce the size of the opening, and with a full lake it is quite inaccessible. The design and gearing of this sluice, which remains for months out of sight under a head of 30 or 40 feet of water, was novel and experimental, and in such a position is open to serious mechanical objections, as has been proved by the event. There is indeed a subsidiary front sluice, but this was not designed to stand the heavy head of pressure with a full lake and on this account cannot be worked. It is now proposed to rebuild the masonry connected with this front sluice, so that it may be capable of withstanding the maximum head of pressure, and to fit in it one of Stoney's gates, which should be ordered from England, and be specially designed by Mr. Stoney. Colonel Smart has already, with commendable promptitude, designed a sluice for this work, to the model for which I have already referred in paragraph 28 *supra*. The design has been very ingeniously and carefully worked out, but on discussing the matter the Chief Engineer and I agreed, that in such a situation, when so much depends on the efficiency of the sluice, which must nevertheless be inaccessible for many months in the year, it would be better to adopt Stoney's system which has now been subjected to prolonged practical tests. The only objection is that many months must elapse before the sluice and gearing can be obtained from England. But the Chief Engineer is of opinion that it will under any circumstances be almost impossible to make the necessary alterations in and additions to the masonry, and to construct and erect a gate on Colonel Smart's system, during the two or three months, March to May of current year, when an empty lake may be anticipated. This being so, there will be plenty of time to order a sluice from England, and to make all arrangements for pushing through the work when the lake is empty in 1898. It will, however, be necessary to work with the present sluice for another year. Although the design is unsuitable as a permanent arrangement, it should not be impossible as soon as the lake is empty (that is below the level of the outfall sluice) to introduce improvements in the gearing, which would render it less liable to failure in the next irrigating season. As I could not see what was wrong below, and no complete working plans were available, I am unable to say what should be done, but I would suggest that the two faces of the sluice should be very rigidly braced together, by iron frames in addition to, or in substitution for, the present tabular connections, and that the entire sluice should be lifted by means of two rack bars, firmly attached on opposite sides, which should be worked by two pinions on the same shaft so as to move simultaneously, while some improvement may possibly be made in the arrangement of the guides below. A competent mechanical expert should at any rate be sent to examine the sluice as soon as the water falls, and to make such alterations as will permit the sluice being worked until a more permanent arrangement can be carried out.

45. The Periyár works were opened on the 10th October 1895, but the dam was not finally completed until the end of March 1896. A good deal of water was therefore necessarily run to waste during the cold weather, 1895–96, but 500 cusecs, or about one-third of the estimated full supply, was passed through the tunnel during the two months ending 15th December 1895. On the 20th February the water level stood at 117·0, or 2 feet above the highest point in the bed of the water-shed cutting, though no water was taken through the tunnel after 15th December. It was anticipated that 500 cusecs might be passed from 15th March, but as a matter of fact the water remained at this low level, until about the 15th June, and the sluice was not opened until the 21st June, when the water level stood at 127·0. In table No. VIII of the project estimate, it was estimated that 9,200 millions of cubic feet would enter the lake in the five months, January to May, of which 950 millions would be lost by absorption in the lake itself, leaving 8,250 millions available for irrigation. Unless 1896 was a very exceptional year, this anticipation is not likely to be realized, and unfortunately the records of the discharge observations of the Periyár river for the previous eight years cannot be found, so that it is at present difficult to estimate what the normal conditions will be during the first five months of the year. The contents of the lake between the 144 and 117 foot contours are estimated at about 6,030 millions

cubic feet, and a full discharge of 1,300 cusecs, with an addition made for absorption in the lake, would require 120 millions per diem, so that unless the supply in the tank is reinforced after it has fallen to 144·0 at the end of the north-eastern monsoon full supply could be run through the tunnel for 50 days only. In order to get over this cold weather period, it is therefore of the greatest importance to be able to regulate and even shut off altogether the supply at the sluice, while it will be necessary to utilize as much as possible all suitable tanks within the area to be commanded to store surplus water for the second crop.

46. The latest official estimate of the maximum irrigating capacity of the Periyár works is given in Madras Government Revenue Order No. 153, dated 15th February 1892, and is reproduced below :—

Particulars.	Area irrigated.		Irrigation revenue.		
	First crop.	Second crop.	First crop.	Second crop.	Total.
	ACRES.	ACRES.	RS.	RS.	RS.
I. Ryotwari occupied—					
(i) Dry	27,440	13,720	(a) 1,37,201	(b) 41,160	1,78,361
(ii) Wet	43,446	21,723	93,919	52,428	1,43,347
II. Ryotwari unoccupied, including tank beds ..	33,744	29,526	2,15,048	94,355	3,09,403
III. Minor imams—					
(i) Dry	4,847	2,424	(a) 24,236	(b) 7,271	31,507
(ii) Wet	5,041	2,520	..	5,437	5,437
IV. Whole imam and zemindari	..	8,000	..	(b) 24,000	24,000
Total ..	114,578	77,913	4,70,404	2,24,651	6,95,055

(a) Water-rate at Rs. 5 per acre. (b) Water-rate at Rs. 3 per acre.

The irrigation revenue, when not due to water-rates, (a) and (b), is enhanced land-revenue assessment.

In the forecast accompanying the revised project estimate of 1894 it was anticipated that the full area (192,431 acres) would be first irrigated in 1905–6, and that 19,262 acres would be irrigated in 1896–97 on which the indirect revenue would amount to Rs. 72,179. The revenue actually earned during 1896–97 will, however, be practically *nil*. This is due to the backward state of the arrangements for distribution, and to other difficulties connected with the introduction of enhanced revenue assessments and water-rates for lands already occupied and with the allotment of unoccupied lands. Ever since the 21st June last there has been a fine supply in the Vaigai river, but this has either been utilized on lands that pay no additional revenue or has been running to waste. The Periyár irrigation will be effected by means of 12 branch channels, which take off from the main Periyár channel, which itself takes off from the left bank of the Vigai, above the Peranai anicut. At the commencement of the year three of these branch channels had not been commenced, and many of the others were not complete or in working order. The project estimate, moreover, provided for 102 miles of distributaries from these branch channels which had not been designed, though it is admitted that the completion of these is necessary before the people can be expected to convert dry into wet cultivation. Before these could be designed it was also necessary to decide on the best manner of dealing with existing tanks. As shown in paragraph 45 above, it is most desirable to incorporate in the canal system all the larger and more important tanks, but on the other hand it is necessary to do away with the smaller and less efficient and to substitute direct irrigation. During the present year an Executive Engineer has been placed on special duty in connection with the completion of the distributary ; elaborate and detailed survey plans have been made of all tanks, and definite proposals have now been formulated. Out of 231 tanks in the Madura taluk it is proposed to retain 80 and to abandon 151, which cover an area of 3,189 acres, of which about 2,000 will become available for cultivation, while in the Mélúr taluk about 30 will be retained. It has also been decided (I think very wisely) that all minor distributaries that will serve more than 50 acres shall be constructed and controlled by Government. It is hoped that this important work may now be pushed on, so that it may be possible to utilize the supplies that will be available next May or June.

47. On the revenue side active measures are also being taken to encourage the development of irrigation. A Deputy Collector has been placed on special duty ; an allotment has been made for the grant of loans, from Rs. 20 upwards, for the conversion of dry into wet lands, and applications for irrigation and for allotments of waste lands have been invited. In order to further encourage the extension of wet cultivation, it has also been notified that no charge will be made for water used in converting dry land into wet during the first year unless a crop is sown, while for the first crop raised after conversion only half rates will be charged. Arrangements have also been made for supplying water to inam and zemindari tanks, on application, at special rates, viz., Rs. 4 per acre for first and Rs. 3 for second crops. I was not able to ascertain very

clearly to what extent the people were responding to these invitations, but was told that applications were coming in pretty freely, and the fine supplies that have been run since June last will no doubt be an encouraging object lesson.

48. It is too soon yet to form an idea of the financial prospects of the Periyár project. The conditions, both of supply and distribution, are so peculiar, and the available data so scanty, that all estimates of the irrigation and revenue that may be anticipated in future will be little better than guess work. The difficulty at present experienced in regulating or restricting the supply through the tunnel is a temporary one, and if it is remedied before irrigation is much developed, no great harm will have been done. The alleged deficiency in the discharging capacity of the tunnel is a more serious matter, as it cannot be rectified except at a great expense, and will probably reduce to some extent the efficiency of this great storage work. The experience of 1896 also indicates that the supply to the lake during the first five months of the calendar year may be much less certain than has been hitherto assumed. On the other hand, a fine supply has run without intermission from the 21st June to end of December, with a full lake at the commencement of 1897. There will no doubt be great fluctuations in the supply and in the irrigated area, which will be beyond all control, but I think it may reasonably be hoped that as soon as irrigation is fully developed, the net revenue will more than suffice to cover all interest charges, though the margin may be less than anticipated when the revised project of 1894 was submitted. There is, however, one point upon which some apprehension may be felt, viz., the extent to which Periyár water may be utilized on the old irrigation above the Peranar anicut, without any adequate return to Government. The supply available above all the anicuts will be far more ample and constant than before, and although measures can no doubt be taken to prevent the extension of irrigation or the excavation of new cuts, except upon conditions to be arranged beforehand, the established irrigation will be more secure than it has ever been, and will doubtless absorb no inconsiderable portion of the extra supplies, for which, as far as I can ascertain, no allowance has been made, and on which no return can be anticipated, unless it be in an eventual enhancement of the land-revenue assessment, in consequence of the greater certainty of the irrigation.

(Signed) T. HIGHAM.

30th January 1897.

Order—No. 550 I., dated 14th June 1897.

Communicated to the Chief Engineer for Irrigation who will report on the questions dealt with in paragraphs 23 to 26 of the Inspector-General's note.

(True Extract.)

Under Secretary to Government,
Irrigation Branch.

To the Chief Engineer for Irrigation.
" Superintending Engineers of Circles.
" the Superintending Engineer on special duty, Cauvery Completion estimates.
" the Examiner, Public Works Accounts.
" the Revenue Department.

Exd. W. D'Moss.

Public Works Department,

Irrigation Branch.

PROCEEDINGS OF THE MADRAS GOVERNMENT.

Notes of Inspection by the Inspector General of Irrigation in the Madras Presidency

Under date the

Read the following

From Govt of India, No. 128 I, dated 1st May 1897.
No. 550 I dated 14 6 97.

Communicated to the Chief Engr. for Irrigation who will report on the questions dealt with in paras 23 to 26 of the Inspector General's note.

Note
This G.O. should be issued 1st & then the G.O. on Cypr 4732 which follows

11/6/97

8/6/97

19/5/97

20 5 97

Issue

W&H

6/97

W&H

146

To The Chief Engr for I.
Superintendents of Circles
Superintending & Special Duty.
Canvey C. Estimates

Rec'd 31/5/97

Note - As per the this memorandum should be sent to Supdg Engr Trichy for report with Collr's memo dated 18/5/97

18/5/97

H.C/P.S - This should be reported urgent - the G.O. printed & issued as quickly as possible -

14/6/97

PUBLIC WORKS DEPARTMENT. 550/4

List of papers detained in circulation.

Current Number.	Date.	Subject.	When circulated.	To whom.
		Mr Higham's Notes of Inspections in the Madras Presidency in the Indian's letter	22/5	The Hon'ble Mr Bliss C.S.I.

W.H.

J

5/6/97

5/6/97

E. I. Form No. 1—1,000—2-2-97.

RS.

Works (189) Department.

CURRENT No. 4783

5009

From The Govt. of India

Order

No. 1283

Communicated to the Chf Engr for Irrigation who will report on the questions dealt with in paras 23 & 26 of the Inspector General's letter

11597 W.H. 9

Dated 1st May 1897

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SUBJECT.

Note by Mr T. Higham C.I.E. Inspector General of Irrigation on a complete copy of a tour of inspection in the Madras Presidency during December 1896.

O.S. 11

BACK PAPERS.

No.	Date.
231	6. 3. 97

FURTHER PAPE

No.	Date.

Note by T. Higham, Esq., Inspector General of Irrigation, on a tour of inspection in the Madras Presidency during December 1896.

1. Leaving Rangoon on the 24th November by one of the British India Coasting Steamers I arrived at Vizagapatam on the 29th and at once proceeded by rail from Waltair to Rajamundri (Dowlaisheram) arriving on the following morning.

My subsequent movements were as below—

Date.	Place.	Principal object of inspection.
November 30th—December 1st	Dowlaisheram . .	Godaveri head works.
December 2nd—4th . .	Bezvada . . .	Kistna ditto.
„ 5th—8th . .	Nandyal to Cuddapah	Kurnool-Cuddapah Canal.
„ 9th—11th . .	Madras . . .	
„ 12th—16th . .	Trichinopoly . .	Cauvery head works.
„ 17th—22nd . .	To Periyar and back .	Periyar works.
„ 23rd . . .	Madras . . .	Had an interview with His Excellency the Governor.

Godaveri Head works.

2 On the morning of 30th I went up the river and saw the site finally proposed for the East Coast Railway bridge over Godaveri, when I met Mr. Walton. The plans of the river and a note by Mr. Bell were shown to me. It is proposed to cross the river about two miles higher up than proposed by Mr. Bell by 57 spans of 150 feet, giving a clear waterway of 8,700 feet. As far as the Godaveri head works are concerned, no objection can be made to these proposals.

3. On 1st December I went over the fine and interesting head works of the Godaveri, and saw the head regulators of the Eastern, Central and Western Canals. As the level of anicut crest is not sufficiently high to maintain the supplies required for the canal, rail stanchions about 2 feet high have been fixed into the masonry at intervals of from 8 to 10 feet, and the water level is held up 2 feet by means of planks, which are removed as the river begins to rise. The labour of fixing and removing these planks is very great, there is an immense amount of leakage, while the permanent iron stanchions are very objectionable. An estimate, amounting to Rs. 1,33,000, for raising the crest wall 2 feet was therefore submitted to the Government of India and sanctioned in their letter No. 4 I., dated 13th January 1896. A few chains only of this work have been done, and I am very strongly of opinion that the work should not be continued. The danger of permanently increasing the height of the anicut, without very large additions to the stone work downstream, has been very clearly shewn at Bezvada, and there is the further objection that it causes a shoaling of the river upstream. It will be much better that the extra 2 feet required should be secured by means of falling shutters, or a moveable weir, following the practice which has been adopted on the Sone Canals at Dehree, the Lower Ganges Canal at Narora, the Agra Canal at Okla, the Sirhind Canal at Rupar, and the Chenab Canal at Khanki, in all of which the full height

required is obtained by means of falling shutters, which can be lowered as the river rises. Probably the Sone Canal pattern would be found most suitable for Dowlaisheram. The principal difficulty with such shutters is the raising, which is generally effected after laying the crest dry by means of the undersluices. At Dowlaisheram the power of the undersluices is not sufficient for this, but the shutters can no doubt be raised with one foot of water on the crest, and with much less risk and trouble than is involved in the present practice of fixing planks, while they can be designed to fall automatically as the river rises as at Dehree, or under control by means of a let-go arrangement, as at the other head works mentioned above. The former plan will probably be preferred.

Kistna Head works.

4. The extraordinary flood in the Kistna on the 6th August 1896 was the highest on record, and caused a serious breach, 450 feet in length in the left river embankment above Bezvada, while the right embankment and the important head works of the Kistna Canals were in serious danger. The river embankments on both sides below Bezvada were also seriously breached in a great many places.

The maximum flood levels at site of anicut, when at 6 P. M. on night of the 6th August, are shown below, the mean sea level being the datum line. The reduced level of the present crest of anicut is 49·25 feet, while that of the zero of the anicut gauges, the readings of which are quoted in the reports of the Local Officers, is 26·25—

Position of Gauge.	Maximum flood level, 1896.			Previous maximum levels, July 1882.
	Left bank, Pezvada.	Right bank, Sitanagram.	Mean.	
Above anicut . . .	67 55	67·55	67·55	66·29
Below anicut . . .	66·25	64·95	65·60	65·50
Afflux .	1·30	2·60	1·95	·79

The levels for July 1882 are probably the maximum then recorded, and not the mean of right and left banks. As regards the levels downstream of anicut, it will be seen that the maximum of left bank level in 1896 was 0·75 feet above the record of 1882, but if the mean level be taken, the difference is only 0·1 feet. Some heading up probably occurred on these gauges, owing to the obstruction caused by the left bank training works of the railway bridge (a matter to be presently referred to), and allowing for this it is possible that the volume of the flood was not actually much greater than in 1882, though the Executive Engineer has estimated the flood discharge of August 1896 at 762,000 cusecs, against 611,000 in 1882. It may be noted that Colonel Mullins in his "Irrigation Manual" has estimated the two great Kistna floods of 1874 and 1882 at 736,000 and 770,000 cusecs, respectively.

5. In 1882 the upstream gauge on right bank registered 0·66 feet more than that on the left, and if 66·29 be the reading of the former, the mean gauge will have 65·96, against 67·55 in 1896, so that there was an increase of about 1·6 feet in the latter year. This rise may be partly due to a fuller discharge, but it must be attributed mainly to the fact that the crest of the anicut has been lately raised 3 feet, which probably accounts for at least 1 foot of the increased afflux. As at the Godaveri this increase in the height of the anicut has been found necessary to maintain the large supplies now required for the canals, but in the form in which it has been carried out is open to the most serious objections. The rise of 1 foot or more in the flood level immediately above the anicut is the least of evils resulting from this raising of the crest. The river bed must in time shoal up the level of the new crest,

but the worst consequence is the severe action on the anicut due to the increased afflux. There is a sheer drop of 3 feet on to the anicut talus, which has been neither strengthened nor lengthened to resist this heavy action. I am very strongly of opinion that 2 feet at least of the new work should be removed altogether before next flood season. This will leave the crest 1 foot above its old level, which may be accepted if the downstream apron is extended as proposed below. The supply here as at Dowlaisheram should be held up to any higher level required by falling shutters, which can be thrown down whenever floods have to be passed.

6. The total length of the anicut from flank to flank is 3,714 feet, the length exclusive of undersluices, etc., being 3,341 feet. The Bezvada Railway bridge is situated about half a mile downstream, and consists of 12 spans of 300 feet each. It is not, however, built opposite the anicut, but as it were *en echelon*, the centre of the bridge being about 250 feet to the south or right of the centre of the anicut. Thus to bring the bridge opposite the anicut, three spans should be taken off the right end and added to the left. As it is the left undersluices, and adjacent length of weir are apparently masked by the left upstream training embankment, which connects the flank of the undersluices with the bridge end. Major Baddeley, the Superintending Engineer, who was on the spot during the high flood of August 6th, has written in very strong terms of the danger to which the anicut is exposed by the existence of this embankment, and has very earnestly recommended that it be removed, and the bridge be lengthened by three spans on the south end, even if the cost be debited to the canal and not to the railway. Mr. Upcott who visited Bezvada on the 20th and 21st August was of opinion that there was no *primâ facie* evidence that the lengthening of the bridge was necessary to ensure the safety of the anicut, and that the case should be more carefully considered when the present state of the river had been more fully examined. One of the principal objects of my visit was therefore the consideration of this important question.

7. Major Baddeley has stated the case for lengthening the bridge in paras. 8 to 12 of his letter No. 1244 K., dated 13th August 1896, and in para. 7 of his letter No. 1826 K., dated 5th October 1896. Briefly the dangers which he apprehends may be thus stated—

(*a*) Owing to the obstruction caused by the north training embankment and the insufficient waterway of the bridge the river is silting up on both sides, and this silting will continue until the river, unable to discharge freely through the contracted channel, will rise during floods to a dangerous height above and below the anicut.

(*b*) The effect of the contraction at the bridge is to produce back currents and whirlpools which in 1895 scoured out a hole 50 feet deep below the Bezvada undersluices, which will have increased during 1896, and if this works back and takes down the undersluices a breach into the canal and a total failure of the headworks of the Eastern Delta system may be anticipated.

8. As regards (*a*) I am of opinion that there are no real grounds for apprehensions. The flood levels abstracted in para. 4 above shew that the maximum flood level below anicut in 1896 was only 0·75 feet higher than in 1882 while the difference was probably much less if the mean of right and left bank levels be taken. If we assume that this was entirely due to the obstruction downstream and that the flood discharge in 1896, was no greater than in 1882, the effect on the level upstream would be almost inappreciable. As shewn in para. 5 above the mean level upstream was only 1·6 feet higher than in 1882, in spite of the fact that the water-way over the anicut had been solidly blocked by the addition of 3 feet on the crest. The effect of a rise of 0·75 feet in the downstream flood level would be not to block the water-way to that extent but merely to increase *pro tanto* the height of the drowned, and to decrease the height of the undrowned portions of the discharge over the anicut. The additional afflux due to this cause would be practically unappreciable. If, on the other hand, it be true that the volume of the flood discharge was actually greater than in 1882, the higher levels both above and

below the anicut will have been partially due to this cause, and the effect of the bridge works will have been by so much even less than indicated above. I am therefore of opinion that any increase in the height of flood levels above the anicut, as compared with those of 1882, that was not due to an increase in the volume of the flood discharge, must be attributed entirely to the raising of the anicut crest, and was wholly independent of any obstruction caused by the bridge works.

If this be admitted the extent to which silt may have been deposited in any of the spans of the bridge or below the apron near the Bezvada undersluices is immaterial. The only effect of increasing the number of spans would be either to increase these deposits of silt or to decrease the depth of scour in those spans on which the set of a flood may be heaviest. It has not, however, been stated that the maximum scour at the bridge was greater than was contemplated when the bridge was designed, nor is the safety of the bridge now in question. As regards the effect of the bridge on the flood levels immediately below and above the anicut, I have no hesitation in expressing an opinion that the water-way at present provided is sufficient.

9. As regards objection (*b*) it may be noted that in the original design for the bridge it was proposed to build it opposite the anicut. Subsequently the Engineer-in-Chief (Mr. Spring) decided to place it as now built. The papers in the Madras Public Works Secretariat show that the change was approved by the Chief Engineer, Irrigation Works (Mr. Walch), after personally discussing the matter with Mr. Spring. It is evident, too, that the present position was proposed because all the river charts on record shewed plainly that the main channel of the river on rounding the Sitanagram bluff had always run in the direction of a line joining the centres of the anicut and bridge as now constructed, and not at a less acute angle with the line of the anicut. The location of the bridge finally adopted involved, therefore, less disturbance of the natural course of the river. It is obvious, however, that water must at all times cross the anicut at right angles, and that in an extraordinary flood like that of August last with 18 feet over the crest of anicut there would be a very strong set in this direction for some distance after passing the crest, so that the short distance of only half a mile between the anicut and the bridge might be insufficient to allow the flood to accommodate itself to the change of direction. The flood waters impinging on this back and forced suddenly to change their course would naturally produce the strong back currents, eddies and swirls which were seen by the officers on the spot. Mr. Upcott remarks that the contraction of the water-way would, by checking the velocity, prevent these eddies, but the eddies are not a consequence of the high velocities, if uniform, but of the changes and interruptions of velocity resulting from the blocking of the left side of the channel. No doubt eddies are caused by the meeting of the waters passing through the undersluices and over the weir, but these have always existed, and will be no greater on the left than on the right bank when the conditions in this respect are identical. I see no reason, therefore, for doubting the assertion of the very competent observers on the spot that, over and above these ordinary eddies, a great back-swirl was set up by the obstruction caused by the left embankment, which might, if continued long enough, or if frequently repeated, endanger the safety of the left end of the anicut and undersluices. The existence of such a swirl is clearly indicated by the levels given in para. 4, which shew that the water on left bank below anicut stood 1·3 feet higher than on right bank. There is of course nothing extraordinary in the level on one bank of a river being slightly higher or lower than that on the other during a high flood, according to the position and volumes of the main currents, but in this case the levels upstream of the anicut were identical (in 1882 there was a difference of 0·66 feet) so that the discharge was as nearly as possible evenly distributed over the whole length of the anicut. The great difference in the levels immediately downstream shews, however, how the water must have piled up above the left embankment, and is a measure of the violent eddies and swirls which must have occurred between the anicut and bridge. The remedy proposed by the Superintending Engineer to remove the embankment and lengthen the bridge on the north end by three spans would, no doubt, reduce this action, but it is my

opinion only on this account, and not because the water-way at the bridge as in itself insufficient, that the lengthening of the bridge can be recommended. The same object might be almost as effectively attained by removing two or three spans from the south and adding them to the north end, though this would be open to obvious objections on other grounds.

10. There is little doubt that this left embankment tends to set in motion new forces during the flood season which must be reckoned with by those responsible for the safety of the canal head-works, but the question is whether the difficulties cannot be met by some less heroic and expensive measure than that of lengthening the bridge by three spans, which would probably cost something between 7 and 8 lakhs of rupees. It is however first necessary to consider what damage has actually occurred which may be wholly or partially attributed to any change in conditions since the bridge was constructed. Major Baddeley refers only to a hole 50 feet deep which was scoured in 1895 below the apron near the Bezvada undersluices. It may here be noted that the anicut is protected on the downstream side by an apron of loose stone which extends for an average distance of 170 feet beyond the retaining wall at the foot of the talus. Ever since the construction of the anicut scour holes have been formed annually downstream of this apron, more especially on the right and left flanks or near the lines of the undersluices. The normal reduced level of the bed beyond this apron is 26·25, and the depths of scour are measured downwards from this datum. Plans and sections shewing the positions and depths of these scour holes since January 1891 were examined by me. The hole referred to by Major Baddeley when measured in January 1896 had a length in a direction square to the line of anicut of 330 feet, and a width in a direction parallel with anicut of 400, the maximum depth being 50·3 feet at about the centre of figure, or 160 feet beyond the end of apron, and 200 feet from the dividing wall of the undersluices. In November 1896 the position and dimensions were about the same, but a sounding of 56 feet was recorded. The plans for January 1891 to 1894 shew large holes below the flanks only of the weirs. On the right side these holes varied in depth from 50 to 60 feet. On the Bezvada side the scour was much less, being nil in January 1893, and never exceeding 35 feet in other years. The exact changes that have since taken place would be conveniently shewn by super-imposing on one sheet the plans of successive years, but the conclusion that I derived from an examination of them was that since the construction of the bridge the scour holes on the left flank have increased both in extent and maximum depth (the soundings having increased from 35 to 55 feet), that there are frequent scour holes below the central portion of the anicut of which there were but traces before, and that the depths of scour or right flank have decreased from between 50 and 60 to 40 feet. It is the increased scour on the left flank more particularly that has caused the Superintending Engineer's apprehension, but although it is only right that this matter should be carefully watched the depths recorded on this side after the great flood of 1896 were less than occurred regularly on right side before the bridge was constructed. Moreover although the downstream eddies no doubt tend to produce these holes the severe action on the weir itself, due to the raising of the crest already referred to, has probably been a far more important factor, and until this has been eliminated, by cutting down the crest as proposed in para. 5 above, it cannot be said to what extent the action is due to the bridge training works. Finally it may be said that these holes, which occur below all anicuts in sandy beds, are of no importance, however great the depth, provided that they are kept at a sufficient distance from the retaining wall of the *talus*, and are not allowed to cut back. I understand that the practice has been to fill them up with sand only every cold weather to a surface sloping down from the 26·25 feet level. If the apron were extended over this filling for a distance of 30 feet, or to 200 feet beyond the retaining wall, by means of concrete or masonry blocks, 4 feet × 4 feet × 2 feet, built *in situ* and laid to a slope of about 1 in 5, these scour holes would, in my opinion, cease to be a danger to the work. This would take seven rows blocks, costing about Rs. 50 only per run of 4 feet, or Rs. 12·5 per foot run, so that the whole length of anicut could be protected at a cost of not more than Rs. 50,000, which might be expended gradually. This system has

been found very successful in Northern India. If preferred, loose stone might be employed, large stones, such as these in the present apron, being laid over a stratum of small stuff, but in this case the apron should be extended at least 50 feet, and the blocks will, I think, be found more satisfactory.

11. I should mention here that a very nasty hole was scoured in the talus of the anicut, the general dimensions being 75 feet in line of anicut and 45 feet transversely, the depth varying from 1 to 12 feet, and the edge of the hole being only 18 feet from the left undersluices and 15 feet from the wall of the anicut. This hole cannot, however, be attributed to the contraction below the anicut. It did not occur during the high flood when the effects of that contraction would be most marked, but was first observed on the 3rd July when the levels at the upstream and downstream gauges were 55·90 and 0·45, respectively, *i.e.*, when the depth over the anicut was nearly 12 feet less than on August 6th. It was probably due to the displacement of stones by floating timber; an accident to which all weirs are liable. It has been thoroughly repaired, and was filled up with small stone, overlaid with stones 2 feet deep, which were topped with Portland cement concrete 2 feet thick on upstream side tapering down to 2 feet on the downstream.

12. In regard to the penultimate paragraph of Mr. Upcott's report, I understand that Major Baddeley recommended the strengthening of the right embankment because it will be absolutely necessary to maintain it intact unless or until the bridge is lengthened, when it would of course be dismantled. Even if it were decided to lengthen the bridge the work could not be completed before next floods, and in the meanwhile the embankment must be maintained to the height and section that may be advised by the responsible Irrigation Officers.

13. My general conclusion therefore is that there has been no contraction of the water-way at the Bezvada bridge such as would affect appreciably the levels above the anicut. By lengthening the bridge the violent action which now occurs below the left end of the anicut would probably be materially reduced, but there is no evidence that this action has hitherto caused any serious damage, though it may do so in time and must undoubtedly be guarded against. I consider however that the safety of the anicut and undersluices will be far more securely assured by cutting down the upper 2 feet of the present crest and strengthening the works in the manner proposed in para. 10 above, than by lengthening the railway bridge, and this at less than one-tenth the cost, but the left training embankment should be made secure against over-topping by the highest flood and against the violent action that takes place along its water face.

14. It remains to consider what other works are required to ensure the safety of the head works during an extraordinary flood, and which must be undertaken whether the bridge is lengthened or not. The weak points are the head sluices or regulators on each bank. As regards those on the Sitanagram side or Western Delta Canal, it appears that owing to apprehensions felt as to their safety, a second regulator was commenced in 1895 a chain or two below the existing work so as to take its place in the event of failure. The chamber referred to in para. 4 of the Superintending Engineer's No. 1244 K., dated 13th August 1896, is the length of canal lying between the two regulators, and the construction of the retaining walls proposed was in progress during my visit. This lower regulator was only partially completed when the flood occurred, but it was of considerable service, as by the insertion of planks water was held up 2·65 feet in the chamber. The head on the upper regulator was 13·85 feet, which is almost as much as it can stand with safety, and if it had not been for the lower regulator, it would have been necessary either to increase this head or to have increased the canal supply from 11·20 to 13·85 feet, which would have increased the number of breaches, and also have brought into the canal a very large quantity of silt. If the lower regulator had been completed, the canal might have been closed altogether or the supply reduced to the minimum required. The work is, however, in active progress and should be completed before next flood season. The other works in the Western Delta head sluice referred to in para. 7 of the Superintending Engineer's letter No. 1244 K., dated 13th August 1896, were also in hand.

15. On the Bezvada or Eastern Delta side there is no second or ancillary regulator, and in order to avoid subjecting the existing regulator to an excessive head the depth of water admitted into the canal as measured on the rear gauge was 12· feet, and this has resulted in a very heavy silt deposit in the upper reach of the canal. A second regulator is very necessary on this side, but to construct it on the ordinary pattern with small vents would lead to a great loss of head, which cannot be spared in view of the extensions of irrigation which are contemplated in the Eastern Delta. The Superintending Engineer, therefore, proposes to build two piers, in the line of the piers of the existing bridge below the head sluices, with suitable flank walls, and to have three large sluice gates of 40 feet span, constructed in accordance with Stoney's patent. This will be more costly than sluices of the ordinary type, but under the conditions that obtain at the site will be the most suitable form of regulator. Unless something of the kind is made, there will always be a danger of the head regulator failing in such a flood as occurred in August last, so that apart from the advantage of being able to control the amount of flood water passed into the canal the matter may be regarded as one of great urgency, and the necessary plans and estimates should be prepared at once. If preferred, the sluices might be constructed on the principle proposed by Colonel Smart referred to in para. *infra*, which is said to be less expensive than Stoney's system, and in the situation proposed could certainly be worked without any risk of failure, but this is a detail to be considered when the plans are under preparation.

16. The works required at Bezvada are therefore—

(*a*) Substitution of falling shutters for the upper 2 feet of anicut.

(*b*) Extension of the apron downstream of the anicut and undersluices.

(*c*) Raising and strengthening the left training embankment between anicut and bridge.

(*d*) Completion of the lower regulator and connected works in the Sitanagram side.

(*e*) Construction of a lower regulator on the Bezvada side, consisting of three 40-feet sluices.

Of these (*a*), (*a*) and (*e*) may fairly be charged to the Capital account of the canal, and (*b*) might also be so charged, unless the Local Government prefers to charge it to Revenue. (*c*) should apparently be carried out at the cost of the railway, as part of the bridge works.

I understand that no estimate has yet been sanctioned by the Government of India for the work now in progress in the Sitanagram side, and that the outlay already incurred is held under objection. It appears to have been thought that under the orders conveyed in Government of India letter No. 95 I., dated 18th May 1896, estimates for new works for which no provision was available from the current sanction for the Kistna Canals could not be considered or sanctioned until the construction estimate had been formally closed on 31st March 1898. This is, however, a misapprehension. In the letter referred to the Government of India declined to sanction an addition of Rs. 8,00,000 in a lump sum to the existing sanction for the Kistna Canals to provide generally for unforeseen contingencies, but there is nothing in those orders to prevent the submission of specific estimates even before the closing of the construction estimate for works that may be urgently required. Such estimates will be considered on their merits, and if the safety of the canal works is involved, no time should be lost in submitting them for the orders of the Government of India.

Kurnool Cuddapah Canal.

17. The Kurnool-Cuddapah Canal was constructed under a 5 per cent. guarantee by the Madras Irrigation Company, which was incorporated under an Act of Parliament in 1858. The work was commenced in 1859, and virtually completed in 1871. As explained at length in the monograph forwarded by the Government of Madras with their No. 456 I., dated 10th June 1882, the undertaking was a financial failure, and difficulties arose which resulted in the acquisition by the Secretary of State of the Companies' rights and interests

in the canal. This was effected in 1882, the sum paid on account of purchase of the canal amounting to £1,742,246. The Capital outlay standing to the debit of the canal at end of the year 1887-88 amounted to Rs. 2,16,44,795 and to Rs. 2,17,00,550 at the end of 1895-96. In the former year the working expenses exceeded the gross revenue by Rs. 79,424, and the Government of India in their Resolution No. 33 I., dated 26th February 1889, remarked that it might be economical to close the canal as an irrigating system, merely keeping it in repair so as to be ready to be put in working order again if a season of drought should create a sudden demand for water. The Government of Madras was asked to "consider the question and formulate such proposals as may seem to them expedient with a view to putting a stop to the constant drain on the Treasury which the maintenance of the canal on its present footing entails." In their reply, letter No. 236 I., dated 15th May 1889, the Government of Madras strongly deprecated closing the canal, but promised to reduce the cost of the Navigation Establishment by Rs. 3,000, and to effect other petty economies, especially by abandoning the Telegraph line along the canal. They remarked that the principal way by which the working expenses might be reduced was by the entire abandonment of navigation, and that this would be recommended were it not that the Guntakal-Bezvada Railway, then approaching completion, crosses the canal at about the middle of its course, and it was "considered advisable to wait and see the effect of the complete opening of the line on the navigation, which may possibly then develope so as to avoid the loss now accruing on that account." This view was accepted by the Government of India, and no further communications on the subject have been received within the seven years and more that have since elapsed.

18. I struck the canal at the railway crossing (Nandyal) and travelled down it to the tail at Cuddapah, a distance of 88 miles, accompanied by Mr. Hughes and the Superintending Engineer, Mr. DeWinton. It is unnecessary to describe the works in detail, but it was obvious that the earthwork and masonry, as originally constructed, was of a very inferior class for canal work, and an extraordinary amount of leakage occurs, both through the banks and lock walls. The canal is maintained in very fair order, considering the small sum that can be spared for its maintenance, and I infer from a perusal of previous Inspection Reports by the Chief Engineer, Madras Irrigation Works, that matters are gradually improving, and that the banks and works are now in a much better condition than they were when first taken over in 1882.

19. When the canal was taken over by Government in 1882, a forecast of the probable revenue receipts and charges for the six years ending 1887 was made by the Chief Engineer, and will be found in the Proceedings forwarded with Madras Government endorsement No. 185 I, dated 26th February 1883. This forecast is compared below with actuals to end of 1895-96 :—

Year.	Forecast of 1882-83.				Actuals to end of 1895-96.			
	Area irrigated during year.	Gross Revenue.	Direct working expenses.	Net Revenue.	Area irrigated during year.	Gross Revenue.	Direct working expenses.	Net Revenue.
	Acres	Rs.	Rs.	Rs.	Acres.	Rs.	Rs.	Rs.
1882-83	20,000	72,750	1,45,541	—72,791	17,834	76,023	1,33,410	—57,387
1883-84	22,000	90,000	2,38,446	—1,48,446	19,674	42,896	1,81,710	—1 38,814
1884-85	24,000	96,000	2,19,385	—1.23,385	25,261	1,32,286	2,02,520	—70,234
1885-86	26,000	1,07,000	2,16,895	—1,09,895	22,801	85,000	1.90,944	—1,05,944
1886-87	28,000	1,16,000	1.48,420	—32,420	22,676	65,964	1,84,921	—1,18,957
1887-88	29,917	1 26,000	1.48,420	—22,420	21,927	65,518	1,41,440	—75,922
Total 6 years	149,917	6,07,750	11,17,107	—5,09,357	130,173	4,67,687	10,34,945	—5,67,258
1888-89	...	...	...	...	34,999	77,727	1,43,046	—65,319
1889-90	...	...	...	...	21,851	78,959	1,19,566	—40,607
1890-91	...	...	...	...	24,848	1 23,566	1,50,439	—26,873
1891-92	...	...	...	...	73,500	1,42,722	1.23,199	+19,523
1892-93	...	...	...	...	30,766	1,48,281	1,58,105	—9,824
1893-94	...	...	...	...	31,424	1,29,440	1 32,472	—3,032
1894 95	...	...	...	...	33,540	1,13,056	1,01,081	+11,975
1895 96	...	...	...	...	32,903	1,39,731	98,824	+40,907
Total 8 years	...	...	...	...	287,831	9,53,482	10,26,732	—73,250

Unsatisfactory as have been the financial results attained, it will be seen from this table that the loss during the six years following the acquisition of the undertaking by Government was not much more than 13 per cent. in excess of that anticipated when it was taken over, and that in later years there has been a steady improvement, so that during the last five years the gross revenue has exceeded the direct working expenses by Rs. 60,279, or an average of Rs. 12,056 per annum. The indirect charges for collection of revenue and on account of leave and pension allowances have not however been included in the table above, and may be taken as averaging about Rs. 10,000 per annum, so that it may be said that during the last five years the canal has just, but barely, paid its working expenses.

20. There is no doubt that the capital account of the canal has been enormously swollen in consequence of the complications which arose in connection with the Company. The Chief Engineer for Irrigation, in a note dated 20th February 1883, estimated the intrinsic value of the canal works, which stood on the books at over Rs. 2,16,00,000, at Rs. 1,25,00,000, but details of this estimate were not given, nor has it ever been formally accepted. Apart from this, however, this canal has been very heavily weighted by the enormous capital expenditure actually incurred in providing for navigation. It may be noted that the entire supply of the Kurnool-Cuddapah canal is carried in a single channel as far as the 75th mile only, at which point the greater part of the supply is passed into a line of nallahs or rivers, which cross and recross the canal. The last 117 miles of the canal may be considered as divided into four sections of unequal length, each section being almost a still-water channel, carrying only as much water as is required for navigation and the irrigation effected from it. By means of suitable works in the nallahs or river beds, the supply is reinforced at the head of each section from these channels. The entire supply is thus divided between two channels, and the consequent loss by absorption must be very great. In these four sections there are no less than 42 locks. It is obvious that if it had not been considered necessary to provide for navigation, it would have sufficed to substitute for these 117 miles of navigable canal with their 42 locks, a few ordinary rajbahas taking off from the rivers so as to command the areas to be irrigated. Had this been done, the capital outlay would probably have been reduced by at least Rs. 25,00,000, and there would have been a great saving in the cost of maintenance and in the loss of supply due to absorption.

21. But, however much the capital account of the canal may have been swollen by these and other preventable causes, there is now little doubt that it could never pay financially, even if the capital cost were one-fiftieth of the present amount. Broadly it may be stated that the people will not irrigate more than 30,000 acres per annum, and that the revenue derived therefrom barely suffices to cover actual working expenses. I have been unable to ascertain that any estimate was made of the area that would be annually irrigated when this project was first sanctioned, but in paragraph 79 of the monograph it is stated that the arable area commanded was 321,515 acres, while distributaries had been provided for an area of 196,227 acres. Irrigation nominally commenced in 1863-64, when 18 acres were irrigated. In the great famine year of 1876-77, it amounted to 90,285 acres, and in the following year to 50,918 acres, but, excepting these two years, the irrigated area never exceeded 20,000 acres until 1884-85. In the dry year 1891-92 it amounted, as shown in paragraph 19 above, to 73,500 acres, and an area of about the same extent is anticipated in the current year, 1896-97, which has also been a year of great drought, insomuch that relief works have actually been started in the Cuddapah District. Excepting these dry years the annual average area may be taken at about 30,000 acres, for a canal that has cost over 2 crores of rupees.

22. The principal reason that has been advanced for this short irrigation is that the canal tract comes under the influence of both the south-west and north-east monsoons, and in ordinary years so large an area of dry crops can be raised without resort to canal irrigation that the people are very unwilling to turn to wet cultivation or rice-crops. The revenue management of the canal is in the hands of the District Officers. The system differs from that in force elsewhere in Madras, in that the water-rate is levied only in respect

of lands for which water has been applied for, a new application being required for each crop, while penal rates are levied when water is taken, which has not been formally applied for. This system was apparently necessary when the canal was administered by the Company, and I presume that it has been found desirable to retain it, so as to avoid all semblance of a compulsory rate in a tract where artificial irrigation is so rarely obligatory. One objection to it is the inducement that it offers to illicit irrigation, but this has been to a certain extent checked of late years by the appointment of special Deputy Collector, and it is to this that the improvement in the returns during the last five years is perhaps mainly due. In order to encourage the extension of wet cultivation, specially favourable rates are offered in the case of lands that have not been wet cultivated for 10 years, under what are called the Cowle rules, the rates being reduced by 50 per cent. for first five years, and by 25 per cent. during the succeeding five years. In the case of waste lands taken up under the "block" rules, irrigation is free for the first five years, while half rates only are charged during the next five, subject to a minimum rate of 8 annas per acre. These rates are on the areas actually irrigated, but in subsequent years the charge will be on the entire extent of the block, with a minimum of one rupee per acre. Up to the end of 1895, the area of waste lands allotted under these rules amounted to 1,331 acres, and application for 1,429 acres were under consideration.

23. The measures thus taken by the Civil Officers under the control of the Board of Revenue to encourage the extension of irrigation are no doubt appropriate, and it is sufficient to note them, but it is a matter for consideration how far the short irrigation is due to causes over which the Engineers have any control, *i.e.*, to insufficiency of the supply during periods of strong demand, or to an inadequate system of distribution. Failure of the supply at a crisis not only prevents the irrigation of considerable areas for which water is in demand, but is certain to engender a want of confidence in the canal on the part of the cultivators which may be one of the causes of their unwillingness to resort to it. I am afraid that such failures have not been infrequent. In para. 43 of the monograph already referred to, the full supply at head of the canal is stated to be 3,000 cusecs. In Statistical Statement 1 A of the Madras Irrigation Administration Reports it is given as 1,468 cusecs, but the maximum actual discharge is 945 cusecs—Administration Report, 1895-96. The maximum *average monthly* discharges have been 862 cusecs in November 1894, and 891 in November 1895, and I was informed that the canal could not possibly carry more than 1,000 cusecs. I understand that if a larger supply than this could be drawn off at the head when water is available, much of it might be stored in the large tanks which exist at the upper end of the canal, so as to maintain the supply when the river was low.

24. Another question of probably greater importance is that of the sufficiency of the distributaries.

As remarked in para. 21 above it was reported in 1882, that distributaries had been provided to command 196,227 acres, but I understand that many of these have been since abandoned, and that the distributaries command mainly only the wet lands. Thus when the cultivators of dry lands suddenly want water, they cannot get it, without first making more or less temporary arrangements for leading it to their fields. I was told that a complete plan of the distributary system was under preparation, but unfortunately I was not able to see it; the importance of improving the distributary system was pointed out, however, by the Chief Engineer for irrigation as long ago as 1883, and as far as I could ascertain there has since been retrogression and not progress in this matter.

25. Improvements in the direction suggested in the last two paragraphs will involve an additional charge to the Capital Account, and it is of course a question whether on a canal, like this, where the normal demand for irrigation is so small, any further expenditure would be justified. It can possibly be shown that this would only be throwing good money after bad, but the question is one that should at least be considered. The canal cannot irrigate at present anything like the area for which designed, and it is significant that the irrigated areas in 1891-1892, and the present very dry year have fallen so far short of that of 1876-77. It is probable, moreover, that if the irrigation can be made

more certain not only will the areas increase, but the Revenue Officers will be justified in enhancing the fixed assessment when the settlements are revised, on the ground of the security or insurance afforded by the canal, and such enhancement will be fairly creditable to the canal. It is at any rate my duty to point out these defects and how far the carrying and distributary capacity of the canal falls short of the original designs, though I cannot say to what extent it may be feasible or desirable to provide a remedy.

26. I now come to the question of navigation. As noted in para. 17, the Government of Madras stated as long ago as 1889, that they would recommend the abandonment of navigation were it not for the approaching completion of the Guntakal-Bezwada Railway. This railway has since been completed, but the traffic on the canal is still practically *nil*. According to Statement II D. of the Irrigation Administration Reports for 1894-95 and 1895-96, the up and down traffic in those years amounted to 1,952 and 1,727 tons respectively, or a mean of 1,840 tons per annum. That is on an average 5 tons or say 7 bullock carts per diem on a canal nearly 200 miles in length. It cannot be said that the tolls are prohibitive, for navigation is free, and no attempt is made to levy tolls. For this petty traffic 42 locks have to be maintained. They are worked very economically, only one man being kept at each lock. The pure navigation charges have, however, been returned at Rs. 10,102 in 1894-95, and Rs. 10,791 in 1895-96, and if to this be added the cost of upkeep of boats, which is charged to Tools and Plant, the total will average over Rs. 11,000 per annum. If navigation were abandoned, the cost of maintenance of the canal would probably be also reduced in many other ways, as will be understood by what has been said in para. 20 above. The Superintending Engineer is desirous of starting a Government service of boats so as to encourage traffic. I am afraid that this will only add to the working expenses, and is more likely to discourage than encourage private enterprise in the matter. I am told that Messrs. Binny and Co., who own most of the boats on the canal, and are at present using them for the transport of water-pipes to Kurnool, had some idea of starting a service for the general public, but after enquiry, gave it up. If navigation cannot be developed under the present system of exemption from all tolls, little is to be expected from a Government service. Such navigation plant as there is, is very old and will shortly require renewal if navigation is to be maintained. There may be something to be said on the other side, but I am of opinion that the Government of Madras should be invited to reconsider the question of the entire abandonment of navigation on this canal.

27. It will be seen from para. 19 that the working expenses have been considerably reduced since 1890-91, and I am of opinion that they are remarkably low for a navigable canal of such length, and can only be further reduced by the entire abandonment of navigation. The canal is no doubt of great benefit to the districts traversed as an insurance against drought, and in very dry years is of immense value, and as it now pays its working expenses, its maintenance involves no charge on the State, since the interest on the capital charge is a permanent liability that would not be lessened by abandoning the canal. But the very narrow margin by which the gross revenue exceeds the working expenses would be appreciably increased by the abandonment of navigation, and it is possible that the financial position would be somewhat improved by a moderate addition to the Capital cost, as suggested above in paras. 23 and 24, while it is certain that this would considerably increase the efficiency of the canal as a protective work. Lastly it may be said that there are indications of a gradual extension of the irrigated area which may be attributed to the appointment of a special Deputy Collector and other arrangements made by the Revenue Officers, and which warrant a hope that by careful nursing the net revenue of the canal may gradually improve, though it is hardly likely ever to exceed on an average Rs. 70,000 or Rs. 80,000 a year.

Madras.

28. On the morning of the 10th December I visited the Government workshops and saw some gearing for heavy sluice gates which has been

designed by Colonel Smart, R. E., in consultation with the Executive Engineer, Workshops Division. One large gate, 35 feet by 6 feet, was mounted and subjected to the full pressure to which it will be exposed in practice, and was easily lifted by a boy at a winch handle. The system adopted is to run the gate on large rollers attached to the gate itself, and not on rollers fixed in travelling carriage as in Stoney's patent. The rollers are mounted on disc bearings. In addition to the gate alluded to above, two pairs of rollers were placed on the bed of a lathe, and a load of 24 tons placed on them. This was moved with a pull of only 24lbs, so that the moving force was only $\frac{1}{1000}$th part of the load. I also saw a model of a sluice designed by Colonel Smart on the same principle for the Periyar outlet. It is claimed that under this system the co-efficient of friction is as low as with Stoney's patent, while the cost will be less than half. Another advantage claimed is that the rollers will travel with the gate and will not remain below it when the latter is open, and so will be less liable to injuiry by silt or drift. This may be an advantage in some situations, but as to the reduced cost, if the quality of the work is the same in both cases, there is no reason why saving in cost should be much more than the amount of the royalty due on the patent. Large sluice gates that can be easily worked are required in many situations in Madras, and particularly on the works on the Cauvery for which Colonel Smart is now preparing estimates. The mechanical details of his gearing, which differs essentially from Mr. Stoney's, have been carefully worked out, and I consider that it may fairly be given an extended trial.

29. On the morning of the 11th I was taken over the harbour by Mr. Wilson, one of the Commissioners. There is said to be about 2 feet of silt in the entrance, and Sir A. Rendel has advised that this should be cleaned by means of a suitable pump dredger, but nothing has yet been decided. It is also in contemplation to construct an unloading dock for lighters on the south side of the harbour.

30. A distinctive feature of the Madras irrigation works is the number of petty works (tanks and small canals with their anicuts) for which neither Capital nor Revenue accounts are maintained. Out of 6,332,482 acres irrigated in the Madras Presidency during 1895-96, no less than 3,392,165 acres were irrigated by means of these works, the total expenditure on which amounted to Rs. 17,63,317. Although no Revenue accounts are kept the amount of the land revenue dependent on these works is approximately known, and for the year under reference amounted to Rs. 91,64,415. The annual expenditure includes a sum about Rs. 5,00,000 which is regularly allotted under what is called the Tank Restoration Scheme, for the systematic examination and survey of existing works, and for the execution of such improvements, extensions, or special repairs as may then be considered necessary. The parties in charge of these surveys work in direct communication with the Chief Engineer, and during my stay in Madras I was shown the system that is being followed. There is a large scale map on which each drainage basin is indicated by a light tint as soon as it comes under survey. When the investigations are comlpeted, a record is compiled giving full particulars of each work in the basin concerned, the areas irrigable from and the land revenue dependent on them, the principal levels for anicut crests, tops of embankments, surplus works, etc., that are to be maintained, and the new works or special repairs that are recommended. The record is then printed, in book form, and copies are available for the use of the Civil and Public Works Officers concerned. A specimen copy of one of these books, for the Upper Noyil Minor Basin, accompanies this note, and will show how the record is maintained. The execution of the works proposed is subsequently carried out by the Public Works Officer in whose division the work lies, and as each record is completed, the fact is shown on the large scale map by overlaying a darker tint on the area that has been thus investigated. The map then shows at a glance the areas under investigations, those in which surveys have not commenced, and those in which investigation have been completed. The smaller works, which may be defined generally as those irrigating less than 200 acres, are managed entirely by the Civil Officers, though special works or repairs proposed in the restoration scheme are carried out by the Public Works Officers. These works under Civil Officers include no less than 25,184 tanks,

and 5,408 channels, while there are at present 2,870 tanks and 612 channels under the Public Works Officers. The systematic method in which these petty but collectively important irrigation works are now brought under observation and improvement is very satisfactory, and leaves nothing to be desired.

Cauvery Canal System.

31. With their No. 922W., dated 14th March 1896, the Government of Madras forwarded to the Government of India a copy of their Proceedings No. 150 I., dated 10th February 1896, containing a memorandum by Colonel Smart, R.E., and a note thereon by Colonel Drake-Brockman, R.E., Chief Engineer for Irrigation, on certain new works proposed in the Cauvery delta, which pointed to a possible expenditure of over Rs. 1,40,00,000, and one of the objects of my tour was to obtain some information as to the object and scope of these proposals. They may be divided into two classes, *viz.*:—

(*a*) Works not primarily intended for the extension of irrigation, but for a more effective control of the existing canal system. Colonel Smart estimated that these works would cost altogether Rs. 40,00,000.

(*b*) New irrigation works, intended for the development of new irrigation, and roughly estimated to cost Rs. 1,00,00,000.

32. Before considering proposals under class (*a*) it may be remarked that the principal channels which are comprised in the Cauvery system are not artificially constructed canals at all, but arms or branches of the Great Cauvery by which its floods are distributed over the whole of the delta. The capital expenditure hitherto incurred by the Irrigation Department has been almost entirely confined to the construction of anicuts, regulators, surplus weirs, and other works for establishing some sort of control over the distribution of the supply. Of these the Upper Anicut was the first commenced, in 1835, and the total capital outlay incurred from that time to the end of 1895-96 has amounted to Rs. 18,11,489 only, including indirect charges. The total area irrigated in 1895-96 amounted to 987,103 acres, but the average area before the commencement of these works, or of what is called "old irrigation" is taken as 778,019, so that the increase of area due to this capital outlay is estimated at 209,084 acres. The net revenue for the same year, after deducting Rs. 31,66,760, due to old irrigation, amounted to Rs. 13,81,657 equivalent to a return of 51·2 per cent. on the capital outlay. The return for the previous year, similarly calculated, amounted to 45·1 per cent. These figures are no doubt open to criticism, but whatever allowance may be necessary there is no doubt that the outlay incurred on these works has been extraordinarily remunerative.

33. The control thus obtained over the rivers of the delta is, however, by no means complete. When the supply is short there are many channels that cannot get their fair share, while in seasons of high flood great and preventable damage is done owing to imperfect control. The settlement in the Tanjore District has recently been revised, and I am told that the assessments have been enhanced by something like Rs. 12,00,000, but that when the enhancement was made it was considered that it entailed an obligation to pursue an active policy in improving the canals, and the conditions under which irrigation is now carried on, and that this is the *raisin d'être* of the proposals now under consideration. Under all the circumstances it can hardly be considered obligatory that the new expenditure proposed should be shewn to be directly remunerative. It has been possible to defer until now capital expenditure which in any new irrigation work would probably have been obligatory from the first, before a rupee of revenue could be earned, and when at length it becomes almost inevitable it is not so much as a means of creating additional revenue, but as an obligation imposed by the profits already earned. It may also be added that even if the additional outlay now proposed should be directly remunerative, so that a return of five or even ten per cent. were realized, which is quite possible, the result would nevertheless be to appreciably reduce the high percentages hitherto shewn on an exiguous capital, percentages which cannot be maintained after the capital is expanded, however directly profitable may be the new expenditure. Any improvement in the control of the Cauvery waters

will probably result in an increase of irrigation and of revenue by which the cost will be fully justified, but it is useless to insist that this should be demonstrated beforehand, and each proposal must be considered simply on its merits, as a means of controlling the supply or its distribution. If it had been necessary to shew that the works already constructed would prove remunerative, they would probably never have been sanctioned, but the results actually attained may well be held to justify further expenditure in the same direction.

34. The Aganda or Great Cauvery bifurcates into two great channels at the head of the island of Srirangam. The right branch, known as the Cauvery, may be regarded as the main line of the Cauvery canals, while the left channel, known from this point as the Coleroon river, is the natural line of escape for the flood waters. There is no irrigation on the Coleroon above what is called the Lower Coleroon Anicut, more than 60 miles below the offtake of the Cauvery, and this anicut forms no part of the Cauvery system. The first great work constructed by the British Government on this system was the Upper Anicut across the head of the Coleroon. This anicut was built with its crest five feet above the river bed, so as to force low supplies into the Cauvery, and is the sole means of regulation at this point, which may be called the head of the Cauvery canal. There is no regulator across the Cauvery channel, but simply a masonry bar at bed level. The effect of the anicut is to cause shoaling upstream, to gradually raise the bed in the Cauvery channel, and to force into the latter an undue proportion of high floods. During the great floods of July 1896, it was estimated that 50,000 cusecs passed through breaches in the left bank of the Cauvery across the island of Srirangam into the Coleroon, causing great damage. Colonel Smart's first proposal is to regulate the supply between the two channels by cutting down the anicut to bed level, and erecting large sluice or draw gates seven feet high. The Coleroon would thus be thrown entirely open in floods, whereas with a low river water could be forced into the Cauvery which now goes to waste over the anicut. In his memorandum Colonel Smart estimates the cost of fitting the existing work with Stoney's shutters at 10 lakhs. After discussing the matter with Mr. Hughes and Colonel Smart, I concluded that it would suffice to cut down the crest by 4 feet, and to use 6 foot gates, capable of being lifted 2 feet above the record flood level of July 1896. The details of the design were settled. A new bridge will be required, independent of the existing foot bridge which will be dismantled. The piers will be at 40 feet interval and will be upstream of the present line of anicut, the new upstream curtain wells will have their upstream face about 28 feet above the corresponding face of the existing curtain wells, and to be sunk to a depth of 15 feet below the level of apron or 16 feet below the new crest, while the cross wells for the piers will be sunk to the same level as existing curtain wells. The gates, which will be of 40 feet span and 6 feet in height, may be constructed on the plan proposed by Colonel Smart, and referred to in paragraph 28 of these notes. The cost has been roughly estimated at 6½ lakhs, which includes establishment and other charges. I consider that this work is very necessary, and that it should be carried out as soon as detailed plans and estimates have been sanctioned, and funds can be made available.

35. About 17 miles below the offtake above the Upper Anicut the Cauvery again bifurcates into two channels, the Vennar to the right and Cauvery to the left, while surplus water passes over the Grand Anicut on the left bank of the main channel and round the tail of the Srirangam island into the Coleroon.

The Grand Anicut is an old native work which was remodelled under the estimate for Rs. 6,88,000 sanctioned by the Government of India in their letter No. 627I., dated 17th February 1882, regulators being built under the same estimate at the heads of the Cauvery and Vennar channels. The Grand Anicut and adjacent regulators constitute together a very fine work. The crest level of the anicut is 189—45 or 5·20 feet below the cill levels of the regulators, and water is held up over this 2·5 feet by falling shutters, which however do not work satisfactorily, because in this situation there are no means of laying the anicut dry, and the shutters cannot be easily manipulated or staunched. Here, as at the Upper Anicut, greater control is required. A lower crest is desirable in floods so as to pass more water to escape, and prevent silt

deposit above the regulators, while at other times a higher crest level is required to more fully utilize the supply, especially as the Vennar channel has a tendency to silt. It is proposed therefore to lower the crest by 1 foot, and to surmount it with draw gates 5 feet high, to be worked in the same way as those proposed for the Upper Anicut. These gates have not been designed in detail, but the cost is estimated at about 1½ lakhs, including establishment, and the improvement will, I think, fully justify this expenditure, though the work is less urgent than that proposed for the Upper Anicut, which is the head of the whole system.

36. The sluices in the head regulators are worked by screws, and it was said that it was very difficult to move them under a full head of pressure. There appears to be no reason why the cills should not be raised 1·5 or 2·0 feet which would sensibly reduce the head of pressure, and would tend to keep silt out of the channel. The sluices might also at no great cost be made to run on rollers, and this might be tried on one experimentally and should result in a great reduction of the load on the screws.

37. In addition to the works proposed at the Upper and Grand Anicuts regulators are required at the heads of many of the minor channels, or open dams are required in place of immoveable anicuts. These works all have the same object, a more effective distribution of the supply and greater security from floods. It is unnecessary to consider them in detail. When the Upper and Grand Anicuts have been completed, these works, which are comparatively petty, can be taken up in order of urgency, and executed as funds may be available, and in the meanwhile a complete plan of all channels and drainages and of the areas depending on them is under preparation, so that all improvements of this kind may be undertaken systematically. It may be noted that the necessity for these surveys, with a view to the construction of additional regulating works, was recognized by the Government of India when the works at the Grand Anicut were sanctioned in 1882, but that the matter appears to have remained in abeyance, pending completion of surveys by the Revenue Survey Department (See C. W.—I., Pros., May 1883, No. 1, and September 1883, Nos. 1 and 2).

38. The Lower Coleroon Anicut is no part of the Cauvery system, and was not inspected by me. It is proposed however to treat it in much the same manner as proposed for the Upper Anicut, and for the same reason—the necessity for increasing the flood capacity of the Coleroon river. When details have been decided the cost of the alteration will be chargeable to (43) Minor Works.

39. The new irrigation works proposed or referred to in Colonel Smart's memorandum are—

(1) The Bhavani project.
(2) Pudukottai project.
(3) Udaiyarpalaiyam project.

These are all tank projects, but the tanks will be fed from the Cauvery system, and it is proposed that each should have a supply channel capable of carrying 5,000 cusecs, so that between them they would dispose of 15,000 cusecs during high floods, and to this extent relieve the system. The Bhavani will store water for the benefit of existing irrigation as well as for new irrigation, and the Puddukottai will be fed from the Vennar, and afford a relief in times of flood. Neither of these projects is in a form in which any opinion can be formed on its merits, and No. 2 only is under investigation by Colonel Smart. The Bhavani project has been proposed for years, and will involve the construction of a high masonry dam, but no definite proposals have yet been made. I formed the conclusion that however useful these works may be, they are not likely to prove highly remunerative, and if they are sanctioned as additions to the Cauvery project they will, even if absolutely remunerative, greatly lower the percentage of return on the capital outlay. The Bhavani scheme is advocated on the ground that it is required for the benefit of the people who have been lately subjected to an enhanced assessment, and is on this account more urgent than the other two, and on the submission of definite proposals the case can be considered on its merits.

40. My general conclusions on the Cauvery proposals may thus be summarized. The proposed alterations of the Upper and Grand Anicuts, estimated to cost about 7½ lakhs, should be taken in hand at once, or as soon as funds are available, and the same remark applies to the Lower Coleroon Aqueduct, but this is an independent though equally urgent work, and the outlay proposed on it will not be chargeable to Loan or Imperial Funds. A scheme for other regulating works required on the smaller channels, drainages, etc., should be drawn up by Colonel Smart during the period of his deputation under which individual works can be mentioned from time to time in order of urgency. It will not be necessary, however, at this stage to estimate for all these works in detail, and rough estimates based on typical plans will suffice to show probable future requirements for these works. The scheme for the Bhavani project (which will involve an outlay of at least Rs. 50,00,000), should also be prepared and submitted for the orders of the Government of India as soon as possible, as its execution will materially affect the distribution of the grant under (49) for some years after sanction. The Pudukottai and Udaiyarpalaiyam projects can be taken up later, unless the Bhavani is found not to be feasible, in which case the Pudukottai can be considered. It may be regarded as certain that funds will not be available for more than one of these three projects within the next seven or eight years.

Periyar Canal.

41. On my arrival at Periyar on the 18th December the lake was full, and water was lapping over the bar of the escape (R. L. 144·0). When I left on the morning of the 20th, the level had risen to 145·5, so that there was a depth of 1·5 over the escape crest. On inspecting the dam I found that there was a very slight percolation throughout the entire length, mostly through minute pinholes, so that there was a thin film of water over the whole of the downstream face. The percolation water passes through a shoot, and apparatus has been put up for gauging it, but I was unable to take an observation as it was not in gear. I was told that with a full lake it had been found that the leakage amounted to 1 cusec in July last, and that a subsequent measurement shewed only ¾ of a cusec. As far as I could judge by the eye there was more than a cusec on December 18th, but there is no reason why a daily record should not be maintained. The water should be passed continuously through a V notch, and the depth over the notch daily recorded. It is most important that the amount of percolation should be closely watched and recorded, so that it may be seen whether there is any tendency to increase.

42. In the sanctioned project it was proposed to make two permanent escapes, one on the right side of the dam, 420 feet in length, and a second on the left, 500 feet in length, the reduced crest level for each being 144·00. During construction, however, it was found that owing to a landslip the proposed left bank escape would not be safe, and the line of escape was therefore permanently blocked by what is practically an extension of the main dam, so that there is no escape on this bank. The escape on the right bank was made somewhat larger than estimated, but I find that I omitted to note the exact length of crest. As far as I remember it was 488 feet, whereas the aggregate length of the two escapes as originally designed was 920 feet. In para. 135 of the report on the project estimate it was shown that with this length of escape such a flood as that of November 1869, which was the maximum then on record and of which certain data were available, would cause the water level to rise to 153·15, and the dam has been calculated for a maximum flood level of 155·0, the top of the parapet being 158·0. The details of this calculation are given in Table IV of the project report. The actual length of escape crest is however not much more than half of that then assumed, and it may also be noted that, as will be apparent from para. 43 below, the discharge through the tunnel will be less than 5 millions cubic feet per hour, instead of 6 millions as estimated in Table IV. No doubt the original estimate provided a wide margin for contingencies, and there may be later or more reliable data that have been held to justify this reduction in escape capacity, but they do not appear

to be on record, and the matter is of such importance that further enquiry appears to be called for. If found necessary to increase the escape capacity, this could be done at no very great expense by cutting down the escape crest to a level of 143·0 or 142·0, and erecting fallen shutters, which might even be made to hold up the supply to 145·0 or 146·0. The highest level yet attained in the lake was on the 31st July 1896, when the water stood at 150·5 or 6·5 feet over the escape crest.

43. The discharge through the tunnel is calculated from the readings of a gauge placed above an overfall a few chains downstream of the lower end of the tunnel. The reading had been steadily 3·1 feet from the 15th July to the time of my visit, although the surface level in lake had varied from 150·5 to 136·8. It would thus appear that above a certain level the discharge is independent of the surface level of lake, and is not affected by a difference of nearly 14 feet in the working head. From the data given to me I do not think that the increase in the discharge theoretically due to this increase of head would amount to 3 per cent., and with the rough measure of gauging at present adopted such a difference would not be detected. I understand that the discharge with a 3·1 gauge at the overfall is estimated at a little over 1,300 cusecs only, whereas the contemplated full discharge of the tunnel was 1,500 cusecs. The method of gauging is, however, so rough that the discharge is possibly under or over estimated by 10 per cent. No pains should be spared to improve this record and ascertain the actual facts. The deficiency is attributed to the rough projections from the surface of the tunnel, which was hewn out of rock. To allow for these projections the cross section of the tunnel was made larger than was thought theoretically necessary, though no one could tell me what the actual dimensions were, but anyhow the co-efficients adopted appear to have been too low, and for a unique work of this kind there was no previous experience available for guidance. In paragraph 198 of the project report it was stated that "if, as is not unlikely, the water-supply is found greater than is now anticipated, the main tunnel can be enlarged at small expense", but enlargement would really be very difficult and very costly, and cannot be contemplated for the mere purpose of rectifying a deficiency of 200 cusecs. It could only be undertaken when there is no demand for water, or no water available, and that would be during the unhealthiest season of the year, March and April, when it was found necessary to suspend all operations during the period of construction. Nor is it probable that the irrigating capacity of the canal will be reduced in the proportion of 1,500 to 1,300, supposing the maximum discharge to be no greater than now estimated. It is only during the three months, July to September, and when water is passing out at the escape that such a discharge as 1,500 cusecs could be contemplated. At other times it will be necessary to husband the supply, and it is doubtful whether at such times more than 1,300 cusecs could ever be spared even though the capacity of the tunnel were doubled. The insufficient capacity of the tunnel is nevertheless a serious matter, as it will prevent the utilization of larger supplies than 1,300 cusecs, at a time that they might be available. The immediate enlargement must, however, be considered out of the question. If it is to be enlarged at all, it should be enlarged as Colonel Pennycuick contemplated in the paragraph of the project report already quoted, so as to take all the extra supply that would be required for the extension of irrigation south of the Vigay, and this cannot be thought of for many years until a long experience has been gained of the water-supply that can be relied on as available.

44. There is, however, at present another serious difficulty. Not only is it impossible to increase the supply through the tunnel, so as to run more than 3·1 of the overfall gauge, but it is equally impossible to reduce it, as the equilibrium sluice by which the supply should be regulated cannot be lowered. It was raised to 5 feet above the cill in July last, and it has jammed in such a way that it cannot be lowered, so as to reduce the size of the opening, and with a full lake it is quite inaccessible. The design and gearing of this sluice, which remains for months out of sight under a head of 30 or 40 feet of water, was novel and experimental, and in such a position is open to serious mechanical objections, as has been proved by the event. There is

indeed a subsidiary front sluice, but this was not designed to stand the heavy head of pressure with a full lake and on this account cannot be worked. It is now proposed to rebuild the masonry connected with this front sluice, so that it may be capable of withstanding the maximum head of pressure, and to fit in it one of Stoney's gates, which should be ordered from England, and be specially designed by Mr. Stoney. Colonel Smart has already, with commendable promptitude, designed a sluice for this work, to the model for which I have already referred in paragraph 28 *supra*. The design has been very ingeniously and carefully worked out, but on discussing the matter the Chief Engineer and I agreed, that in such a situation, when so much depends on the efficiency of the sluice, which must nevertheless be inaccessible for many months in the year, it would be better to adopt Stoney's system which has now been subjected to prolonged practical tests. The only objection is that many months must elapse before the sluice and gearing can be obtained from England. But the Chief Engineer is of opinion that it will under any circumstances be almost impossible to make the necessary alterations in and additions to the masonry, and to construct and erect a gate on Colonel Smart's system, during the two or three months, March to May of current year, when an empty lake may be anticipated. This being so, there will be plenty of time to order a sluice from England, and to make all arrangements for pushing through the work when the lake is empty in 1898. It will, however, be necessary to work with the present sluice for another year. Although the design is unsuitable as a permanent arrangement, it should not be impossible as soon as the lake is empty (that is below the level of the outfall sluice) to introduce improvements in the gearing, which would render it less liable to failure in the next irrigating season. As I could not see what was wrong below, and no complete working plans were available, I am unable to say what should be done, but I would suggest that the two faces of the sluice should be very rigidly braced together, by ironframes in addition to, or in substitution for, the present tabular connections, and that the entire sluice should be lifted by means of two rack bars, firmly attached on opposite sides, which should be worked by two pinions on the same shaft so as to move simultaneously, while some improvement may possibly be made in the arrangement of the guides below. A competent mechanical expert should at any rate be sent to examine the sluice as soon as the water falls, and to make such alterations as will permit the sluice being worked until a more permanent arrangement can be carried out.

45. The Periyar works were opened on the 10th October 1895, but the dam was not finally completed until the end of March 1896. A good deal of water was therefore necessarily run to waste during the cold weather, 1895-96, but 500 cusecs, or about one-third of the estimated full supply, was passed through the tunnel during the two months ending 15th December 1895. On the 20th February the water level stood at 117·0, or 2 feet above the highest point in the bed of the water-shed cutting, though no water was taken through the tunnel after 15th December. It was anticipated that 500 cusecs might be passed from 15th March, but as a matter of fact the water remained at this low level, until about 15th June, and the sluice was not opened until the 21st June, when the water level stood at 127·0. In Table No. VIII of the project estimate, it was estimated that 9,200 millions of cubic feet would enter the lake in the five months, January to May, of which 950 millions would be lost by absorption in the lake itself, leaving 8,250 millions available for irrigation. Unless 1896 was a very exceptional year, this anticipation is not likely to be realized, and unfortunately the records of the discharge observations of the Periyar river for the previous eight years cannot be found, so that it is at present difficult to estimate what the normal conditions will be during the first five months of the year. The contents of the lake between the 144 and 117 foot contours are estimated at about 6,030 millions cubic feet, and a full discharge of 1,300 cusecs, with an addition made for absorption in the lake, would require 120 millions per diem, so that unless the supply in the tank is reinforced after it has fallen to 144·0 at the end of the north-eastern monsoon full supply could be run through the tunnel for 50 days only. In order to get over this cold weather period, it is therefore of the greatest importance to be able to regulate and even shut off altogether the supply at the sluice, while it will be necessary to utilize as much as possible all suitable tanks within the area to be commanded to store surplus water for the second crop.

46. The latest official estimate of the maximum irrigating capacity of the Periyar works is given in Madras Government Revenue Order No. 153, dated 15th February 1892, and is reproduced below :—

Particulars.	Area irrigated.		Irrigation revenue.		
	First crop.	Second crop.	First crop.	Second crop.	Total.
	Acres.	Acres.	Rs.	Rs.	Rs.
I. Ryotwari occupied—					
(i) Dry	27,440	13,720	1,37,201(*a*)	41,160(*b*)	1,78,361
(ii) Wet	43,446	21,723	93,919	52,428	1,43,347
II. Ryotwari unoccupied, including tank beds	33,744	29,526	2,15,048	94,355	3,09,403
III. Minor imams—					
(i) Dry	4,847	2,424	24,236(*a*)	7,271(*b*)	31,507
(ii) Wet	5,041	2,520	...	5,437	5,437
IV. Whole imam and zemindari	...	8,000	...	24,000(*b*)	24,000
Total	114,578	77,913	4,70,404	2,24,651	6,95,055

(*a*) Water-rate at Rs. 5 per acre.
(*b*) Water-rate at Rs. 3 per acre.

The irrigation revenue, when not due to water-rates, (*a*) and (*b*), is enhanced land-revenue assessment.

In the forecast accompanying the Revised Project Estimate of 1894 it was anticipated that the full area (192,431 acres) would be first irrigated in 1905-06, and that 19,262 acres would be irrigated in 1896-97 on which the indirect revenue would amount to Rs. 72,179. The revenue actually earned during 1896-97 will, however, be practically *nil*. This is due to the backward state of the arrangements for distribution, and to other difficulties connected with the introduction of enhanced Revenue assessments and water-rates for lands already occupied and with the allotment of unoccupied lands. Ever since the 21st June last there has been a fine supply in the Vaigal river, but this has either been utilized on lands that pay no additional revenue or has been running to waste. The Periyar irrigation will be effected by means of 12 branch channels, which take off from the main Periyar channel, which itself takes off from the left bank of the Vigay, above the Peranai anicut. At the commencement of the year three of these branch channels had not been commenced, and many of the others were not complete or in working order. The project estimate, moreover, provided for 102 miles of distributaries from these branch channels which had not been designed, though it is admitted that the completion of these is necessary before the people can be expected to convert dry into wet cultivation. Before these could be designed it was also necessary to decide on the best manner of dealing with existing tanks. As shown in paragraph 45 above, it is most desirable to incorporate in the Canal system all the larger and more important tanks, but on the other hand it is necessary to do away with the smaller and less efficient and to substitute direct irrigation. During the present year an Executive Engineer has been placed on special duty in connection with the completion of the distributary; elaborate and detailed survey plans have been made of all tanks, and definite proposals have now been formulated. Out of 231 tanks in the Madura taluk it is proposed to retain 80, and to abandon 151, which cover an area of 3,189 acres, of which about 2,000 will become available for cultivation, while in the Melúr taluk about 30 will be retained. It has also been decided (I think very wisely) that all minor distributaries that will serve more than 50 acres shall be constructed and controlled by Government. It is hoped that this important work may now be pushed on, so that it may be possible to utilize the supplies that will be available next May or June.

47. On the revenue side active measures are also being taken to encourage the development of irrigation. A Deputy Collector has been placed on special duty; an allotment has been made for the grant of loans, from Rs. 20 upwards, for the conversion of dry into wet lands, and applications for irrigation and for allotments of waste lands have been invited. In order to further encourage the extension of wet cultivation, it has also been notified that no charge will be made for water used in converting dry land into wet during the first year unless a crop is sown, while for the first crop raised after conversion only half rates will be charged. Arrangements have also been made for supplying water to Imam and Zemindari tanks, on application, at special rates, *viz.*, Rs. 4 per acre for first and Rs. 3 for second crops. I was not able to ascertain very clearly to what extent the people were responding to these invitations, but was told that applications were coming in pretty freely, and the fine supplies that have been run since June last will no doubt be an encouraging object lesson.

49. It is too soon yet to form an idea of the financial prospects of the Periyar Project. The conditions, both of supply and distribution, are so peculiar, and the available data so scanty, that all estimates of the irrigation and revenue that may be anticipated in future will be little better than guess work. The difficulty at present experienced in regulating or restricting the supply through the tunnel is a temporary one, and if it is remedied before irrigation is much developed, no great harm will have been done. The alleged deficiency in the discharging capacity of the tunnel is a more serious matter, as it cannot be rectified except at a great expense, and will probably reduce to some extent the efficiency of this great storage work. The experience of 1896 also indicates that the supply to the lake during the first five months of the calendar year may be much less certain than has been hitherto assumed. On the other hand, a fine supply has run without intermission from the 21st June to end of December, with a full lake at the commencement of 1897. There will no doubt be great fluctuations in the supply and in the irrigated area, which will be beyond all control, but I think it may reasonably be hoped that as soon as irrigation is fully developed, the net revenue will more than suffice to cover all interest charges, though the margin may be less than anticipated when the revised project of 1894 was submitted. There is, however, one point upon which some apprehension may be felt, *viz.*, the extent to which Periyar water may be utilized on the old irrigation above the Peranar anicut, without any adequate return to Government. The supply available above all the anicuts will be far more ample and constant than before, and although measures can no doubt be taken to prevent the extension of irrigation or the excavation of new cuts, except upon conditions to be arranged before-hand, the established irrigation will be more secure than it has ever been, and will doubtless absorb no inconsiderable portion of the extra supplies, for which, as far as I can ascertain, no allowance has been made, and on which no return can be anticipated, unless it be in an eventual enhancement of the land-revenue assessment, in consequence of the greater certainty of the irrigation.

30th January 1897.

T. HIGHAM.

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No. 128 I.

GOVERNMENT OF INDIA.

PUBLIC WORKS DEPARTMENT.

CIVIL WORKS.

Irrigation.

All communications should be addressed to the Secretary.

To

The Secretary to the Government of Madras,

Public Works Department.

Simla, the *1st May* ~~April~~ 1897.

Sir,

In continuation of Public Works Department letter No.40 I., dated the 4th February 1897, I am directed to forward, herewith, for information and for such consideration and action in the directions suggested, as His Excellency the Governor in Council may think necessary or desirable, a complete copy of a Note dated the 30th January 1897, on a tour of inspection in the Madras Presidency, during December 1896, by Mr. T. Higham, C.I.E., Inspector General of Irrigation.

I have the honour to be,

Sir,

Your most obedient servant,

N. F. Mackenzie

Under Secy. to the Govt. of India.

Document accompanying:-

One copy of the Insp. Note 3.5.97

Inspection Note referred to.

(will be sent separately in a separate packet)

G.A.