Public Works (1883) Department

Misc ORDINARY.

G.O. No. 1102 W

DATED 13-4-1883

[Despatch Abstract.]

BACK PAPERS.

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

FURTHER PAPERS.

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

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

5th April 1880, No. 856 W.

Buildings and Roads.
Civil Works.

No. 12. Read the following paper :—

MEMORANDUM BY CHIEF ENGINEER, PUBLIC WORKS DEPT.

As the Department will soon it is to be hoped settle down after its last re-organisation, it appears desirable that steps should be taken to try and place such projects as may be considered to be specially suited for famine purposes in such a forward condition that they may be sanctioned for execution whenever the necessity arises.

2. There are several projects of a more or less promising character which if now taken up with this view could be completed and passed within a reasonable time—well it may be hoped in advance of any actual necessity arising from famine. Some of these may also prove to be so remunerative, or so thoroughly protective in character, as to admit of their being taken in hand even before such a contingency arises, under the sanction of the Government of India, whose policy in regard to the Famine Insurance Fund has all along been so distinctly proclaimed.

3. Among such works in this Presidency few apparently have commanded so much attention as the Periyár project, which forms the subject of the annexed note by Major Pennycuick, and the history of which is so well known that I need not say anything on the subject here.

4. All that need here be said about it is, that notwithstanding its remunerative character and its special suitability as a work for famine protection, the project is not now in a condition to admit of Government sanctioning its execution were famine to occur.

1*st*. The Travancore Government make the extraordinarily heavy demand of Rs. 75,000 per annum as rent for the reservoir site; and,

2*nd*. Some of the most important points connected with the constructive features of the design remain unsettled.

5. The last official communications on the subject of this project left all in a state of abeyance. This Government* recommended the deputation of Major Pennycuick to obtain special information regarding dams carried out under exceptional conditions in Europe and America, but the proposal was negatived† as "full and reliable data for the project" were not then available, and as this Government was not in a position to undertake it.

* Despatch to the Secretary of State, No. 1 of 1877, dated 23rd January.

† Despatch from the Secretary of State, No. 4 of 1877, dated 29th March.

6. Judging from the tenor of this correspondence it may be inferred that further investigations connected with the project were considered indispensable, but it is doubtful whether Her Majesty's Secretary of State thought the deputation of an officer necessary. It seems clear also from a previous reply‡ by the Government of India, that they were averse to any reference being made to experienced authorities outside of India.

‡ Letter from the Government of India, No. 560 A, dated 28th March 1876.

7. Major Pennycuick, it appears, submitted a memorandum to the Chief Engineer for Irrigation in connection with this work on 16th May§ 1878, but as this was never disposed of he has again brought up the subject in an office note, dated 5th March 1880, (herewith).

§ Letter from District Engineer, Salem, No. 19 S. L.

8. The reasons for not taking any action on the memorandum of the 16th May 1878 are not recorded, but whatever they may have been, these two communications should, I think, now be considered by Colonel Mullins.

9. It is needless for me at this stage to enter on any professional criticism of the project in its present condition, though I may at once say I entirely share the adverse views in regard to an earthen embankment already expressed by General Walker,* supported as they are by the opinion of Major Tulloch† in his Bombay Water-supply Report, and by my own experience in India and Australia. Indeed, there is nothing in the correspondence to show that Colonel Mullins would not himself thoroughly approve of Major Pennycuick's proposed substitution of a simple concrete bund by which he hopes on the whole to save‡ some $4\frac{1}{2}$ or 5 lakhs of rupees.

* Paragraph 5 of his note printed with G.O., 30th April 1875, No. 1,193.

† Chapter III of his Report of 1872.

‡ The late Mr. Smith's estimate was ... ... Rs. 26,43,000 (for head works).
Major Pennycuick's present rough estimate ... ... 22,00,000 on which Rs. 40,000 more might be saved if water transport were used from mouth of cutting to site of main dam.

10. Should the Government approve of the suggestions made above, I would therefore urge the desirability of the Chief Engineer for Irrigation being requested to state—

1*st.* What are the projects in his branch now sufficiently matured for sanction to allow of their being at once put in hand on the occurrence of famine.

2*nd.* Those which being now in various stages of advancement can be completed for sanction, and the arrangements he would propose with this object.

3*rd.* What he would now propose to do in reference to Major Pennycuick's two memoranda on the subject of the Periyár project.

(Signed) R. H. SANKEY, Colonel, R.E.,
Chief Engineer, P.W.D.

P.S.—The present time would appear very suitable for initiating and carrying through such negociations as may be required in regard to the unwarrantably heavy demand made by Travancore for the use of the site, which might be pressed greatly to the disadvantage of this Government if at any time they were compelled by the near approach of famine to enter hurriedly on the undertaking.

MEMORANDUM.

AT a time when the prevention and mitigation of famines in India is occupying so much attention as at present, it may be considered as not out of place to draw attention to a work which gives promise of being highly remunerative in ordinary years, and of being of immense benefit to a large and important district, while as a protection against famine it may safely be said to be unrivalled by any work constructed or proposed in the Madras Presidency since the execution of the great delta systems of irrigation.

2. I allude of course to the Periyár Project.

3. What gives this work its great superiority as a preventive of famine over ordinary irrigation works, is that its water-supply is drawn from a country under different climatic conditions from that which it is to irrigate, and that the former will be unaffected by the drought of the latter. Ordinary irrigation works which merely store and utilise local supplies are affected by the same causes which affect the tracts which they supply, and consequently may fail at the time they are most needed. The larger the area from which the supply is drawn, the less of course is the latter affected by local conditions; but in all cases, except those of the great rivers, whose number is unfortunately limited, there is risk of failure, partial or total, at the time water is most wanted.

4. No competent judge would allow this one defect, or rather imperfection, to weigh against the numerous benefits derived from irrigation works even of the smallest class, but it does exist, and its absence in the case of any particular work stamps that work as one of a limited class of the very highest excellence.

5. The water-supply of the Periyár is drawn from a tract not merely distant from the plains of Madura where it is to be used, but different in its climatic condition; the former may be parched and dry from failure of successive monsoons, but no one has ever heard of the hills of the Western Ghats being deprived of rain, or of the streams which flow through Travancore being dried up. If these works had been in operation during the last two years, they would have produced food to the value of more than two millions of rupees, and it is difficult to overestimate the difference they would have made in the condition of the Madura district.

6. How valuable soever a work may be as a protection against famine, it may not be desirable to undertake it unless it is in ordinary years at least sufficiently remunerative to ensure the State against loss from its construction. The particular work in question is estimated to produce a revenue, after providing for the monstrous payment of Rs. 75,000 annually (a capital of fifteen lakhs of rupees for some twelve square miles of uncultivated jungle) to the Travancore Government, of not less than eight per cent. on its cost, and if this could be ensured, it is hardly conceivable that there should be any hesitation as to carrying it out.

7. The question of revenue has been so carefully and thoroughly examined that there is hardly room for doubt concerning it; indeed I am not aware that any has ever been expressed, and the only point on which any doubt exists is, whether the works can be constructed for the sum at which they are estimated.

8. As regards a considerable portion of the estimated cost, all, that is, which relates to the works of distribution, there is not, nor can be, any doubt; these works are of an ordinary character, their cost is susceptible of accurate calculation, and they have been planned in detail, probably in fuller detail than any previous work of a similar kind, by one of the most careful and experienced officers in the department, the late Mr. Smith.

9. The only doubt is with reference to the head-works, and with regard to these it will probably be admitted that the only serious doubt has reference to the construction of the main dam; it is with special reference to this point that this memorandum is written.

10. The project was first seriously taken up by the late Major Ryves, and he satisfied himself that the cost of a masonry dam so far exceeded that of an earthen one as to be prohibitory of the former; an opinion, it may be added, which, if the work were carried out as originally proposed by him, would be unquestionably correct.

11. All the officers who have subsequently dealt with the project have worked more or less on Major Ryves' lines, and though the difference between the project in its latest form and that originally drawn up by him is considerable, the deviations have been gradual, and the great earthen dam has always remained part of the scheme.

12. As finally worked out by Mr. Smith and submitted to Government in 1875, the project included a dam a hundred and seventy feet in height, to sustain a maximum depth of water of a hundred and fifty-five feet; this dam was to be constructed by means of the silting process introduced by the late Mr. McIvor, which not only greatly reduces the cost of earthwork, but also improves its quality, to an extent which, in the opinion of two successive Chief Engineers for Irrigation as well as of Mr. Smith himself, removed the objection which might otherwise have been felt to the construction of an earthen dam of the unprecedented height above mentioned.

13. The late Chief Engineer, Major-General Walker, took a different view, and while admitting the generally valuable qualities of earthwork executed by the silting process, considered that sufficient experience had not been gained concerning it to justify our trusting to it for a work of such magnitude as the one in question, so that the Periyár dam would really be a gigantic experiment carried out under somewhat unfavorable conditions.*

* Something was also said about the difficulty of closing the tunnel, but General Walker would probably have been the first to acknowledge, if he had had occasion to consider the point practically, that this difficulty had been very much over-estimated, and was in reality a very small matter.

14. Holding these views, General Walker declined to recommend the project for execution, and his opinion was adopted by the Madras Government; there has I believe been some slight further correspondence and discussion on the subject, but nothing practical has come of it.

15. It is not proposed here to discuss the question regarding which this difference of opinion has arisen; personally (*a*) I agree with those officers who think that the dam could be safely constructed in the manner proposed by Mr. Smith (whether his estimate is sufficient is another question), but no one in his senses will deny that there is an element of risk and uncertainty in the matter, and if that element can be entirely removed by the adoption of a different mode of construction without involving any expense above the estimate already made, the only cause which justifies the postponement of the work will be removed at the same time.

16. It has already been stated that Major Ryves' opinion as to the excessive cost of a masonry dam as compared with an earthen one would be perfectly correct if the work had been carried out as originally contemplated by him.

(*a.*) Since I wrote this I have seen reason to doubt whether it would be safe to trust to an earthen dam 170 feet high, even if executed by the silting process; but a masonry dam of this height, or near it, is at least in two instances an accomplished fact. (Intld.) J. P.

5th March 1880.

17. Subsequent inquiry showed that this was not possible, and various subsidiary arrangements had to be made, notably as regards provision for the discharge of water during the construction of the work, which added so much to the cost of the earthwork as to render it doubtful whether a masonry dam would not be actually cheaper than of earth.

18. This point was never so far as I know seriously considered until 1875, when I submitted a note on the subject containing a rough estimate of the cost of a dam partly of masonry and partly of concrete, a construction which was (rightly) objected to on the score of risk of unequal settlement. Since that time I have studied the subject, and others connected with it, more deeply, and am now prepared to assert positively and with perfect confidence that a dam of rubble masonry with Portland cement (locally made of course) can be constructed at a cost certainly less than that allowed by Mr. Smith for an earthen dam,* all subsidiary works included. With ordinary surki mortar it could be constructed for a still smaller sum.

* It may be worth while to note here that I think both Colonel Mullins and Mr. Smith were mistaken in their expectation that a great reduction in the cost of tunnelling would be made by the use of machinery. The benefit of rock boring machinery is in the saving of time; tunnelling by its use is distinctly more costly than tunnelling by hand even when the cheapest possible motor, water with a great head, is available. I have gone into this subject with some care, and believe that Mr. Smith's rate of ten rupees per cubic yard, though it was rather a guess, will very fairly represent the actual cost of such work for the large tunnel.

19. A dam entirely of concrete, which for many reasons I consider a still better arrangement, will be somewhat cheaper than one of masonry. The objection of unequal settlement, the force of which I quite admit as against a combination of masonry and concrete, does not apply to a structure entirely of concrete, and there is good reason to believe that well-made concrete is actually stronger than rubble masonry of the same materials.

20. To prevent misunderstanding I think it as well to note that I am not now contemplating the execution of the masonry by the process, a rough sketch of which was shown by me to the Chief Engineer for Irrigation in 1875. I believe that a considerable reduction in cost might be made by the adoption of this process, but the statement in paragraph 18 refers to masonry constructed in the ordinary manner "with stones not too large to be conveniently handled" and with no special reduction in the amount of labor on account of the convenience of working on a large mass, or the careful and incessant supervision that will be available.

21. It is not now proposed to go in detail into the proof of the correctness of the above statement; to do this would involve a careful and minute examination into many distinct questions and would lengthen out this paper and occupy my own time to an extent which would not be desirable unless I knew that there was a prospect of some practical result therefrom. For the present it is enough to say that the conclusion at which I have arrived is the result of a most careful and thorough consideration of the subject from every point of view, and of every detail connected therewith, and that I am confident of being able, if called upon to do so, to establish it to the satisfaction of any competent authority.

SALEM,
16th May 1878.

(Signed) J. PENNYCUICK, Major, R.E.,
District Engineer, Salem.

No. 13. ORDER THEREON, 5th April 1880, No. 856 W.

THE above memorandum with the papers accompanying it will be communicated to the Chief Engineer for Irrigation, who will be requested to report as soon as possible upon the three points, and especially the third, mentioned in paragraph 10.

2. The memorandum will also be communicated to the Political Department, with reference to the remarks contained in the postscript.

(True Extract.)

(Signed) R. H. SANKEY, Colonel, R.E.,
Secretary to Govt., P.W.D.

To the Chief Engineer for Irrigation.
" Political Department.
" Chief Engineer, Public Works Department.
To Major John Pennycuick, R.E.

Exd. S. T. Austin.
Spare Copies

BUILDINGS AND ROADS.
CIVIL WORKS.

Govt. of {1880} Madras.

PUBLIC WORKS.

To

THE CHIEF ENGINEER FOR IRRIGATION,

&c., &c., &c.

Dated April, 5th.

Issued

Recd. *Encl.*

G. O., 5th April 1880, No. 856 W.

APRIL.

Nos. 12-13.

Projects specially suited for famine purposes.—Memorandum by the Chief Engineer, Public Works Department, recommending the advisability of placing such — including the Periyar project, in such a forward condition as will admit of them being sanctioned for execution whenever the necessity arises, communicated to the Chief Engineer for Irrigation for report.

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

3rd March 1881, No. 563 W.

Buildings and Roads.
Civil Works.

Read again—

No. 7. Proceedings of the Madras Government in the Public Works Department, dated 23rd November 1880, No. 2,690 W.

Read also—

No. 7-A. From the Consulting Engineer for Railways, dated Madras, 10th December 1880, No. 319.

NOTE.

ADVERTING to the Proceedings of Government, under date 23rd November 1880, No. 2,690 W., the undersigned has the honor to append a list of the various projects for railways within this Presidency, which have been under discussion during the last few years; classed so far as possible under the heads *Productive* and *Protective*. Owing to want of establishment, these projects (with one or two exceptions) have not been worked out in detail sufficient to ascertain the return which may be expected from each work.

PRODUCTIVE WORKS.

(1). *Bellary to Hospet and Hubli.*—This was begun as a famine work during 1877-78, and this Government has urged that it should be completed by the Madras Railway Company and worked by them. In despatch, dated 28th September 1880, No. 134 R., the Government of India recommended to the Secretary of State that the line from Bellary to Gudaq, or under certain contingencies from Bellary to New Hubli, should be added to the undertaking of the Madras Railway Company and built by them under their contract.

With reference to paragraph 2 of the letter from the Government of India, dated 16th October 1880, no further action regarding this line appears necessary.

(2). *Shoranur to Cochin.*—"The Cochin and Travancore Railway Company, Limited," have undertaken the construction of this line upon certain conditions.

The proposal was laid in full detail before the Government of India with letter, dated 21st October 1880, No. 617 R., to which no reply has yet been received.

The length of the proposed line is $59\frac{1}{4}$ miles, and the Company's capital is taken at £550,000 or Rs. 66,00,000.

No further action regarding this line is at present necessary.

(3). *Mettupálaiyam and Coonoor.*—The construction of this line has also been undertaken by a private Company, styled "The Nilgiri Regi Railway Company, Limited."

The proposal was laid before the Government of India in letter, dated 21st July 1880, No. 417 R., and a general approval was accorded in their reply, dated 20th November 1880, No. 680.

The length of the proposed line is 12 miles, and the Company's capital is taken at Rs. 15,00,000.

Further action is delayed pending receipt of information respecting the raising of the necessary capital.

(4). *Máyavaram and Tranquebar.*—The construction of this short line was proposed by the Tanjore Local Funds Board, and in their Proceedings, dated 21st October 1879, No. 2,006, and 16th January 1880, No. 105, Government expressed themselves in favor of the proposal.

The length of the proposed line is 18 miles.

What action has been taken by the Local Funds Board is not known.

(5). *Pálghat and Dindigul.*—In Proceedings, dated 8th August 1878, No. 750 R., Government expressed the opinion that this line "is evidently one of great local importance," but that the question of its construction must stand over for the present.

Nothing has been done in the matter of getting up this project.

(6). *Beypore to Mysore.*—The construction of this line has been urged by the Wynaad planters, but in their letter to the Government of India, dated 3rd July 1880, No. 1,558 W., this Government stated that they attached less importance to its construction than to that of several other lines within the Presidency.

The length of the proposed line is about 150 miles.

(7). *Vizagapatam to the interior.*—The construction of a line from Bimlipatam in the direction of Raipur was mooted on several occasions by the late Maharajah of Vizianagrum, and it is understood that the proposal has recently been again brought forward by the present Maharajah.

So far as is known no survey or estimate has been made.

(8). *From the South Indian Railway south of the Pálár to Pondicherry.*—The construction of this line was proposed during 1878 to be undertaken by a private Company.

The length of line is about 48 miles, and the principal object was to develope the manufacture of salt by providing easy means of transport.

The present position of the scheme will be seen from the under-mentioned Proceedings of Government:—

7th June	1878, No. 528 R.	
1st March	1879,	„ 246 R.
4th November	„	„ 867 R.

Information respecting the raising of the necessary capital is awaited.

PROTECTIVE WORKS.

(1). *Madura to Pámban.*—During the famine of 1877-78 this line was partially surveyed and estimated. In the *forecast* submitted to the Government of India on 25th November 1878 with letter No. 1,173 R., a sum of £360,000 was entered as the approximate cost, and it is not improbable that this rough estimate will prove tolerably accurate.

Much additional work is however necessary before the project can be satisfactorily dealt with. Mr. Jenkinson, by whom part of the line was surveyed, was removed when the famine pressure became lighter, and no officer has since been available for the completion of the project.

The object of the proposed line is to bring Madura into communication with the Pámban harbour, which is understood to be capable of great improvement at moderate cost, and so to provide another means of throwing food supplies into the interior in times of scarcity.

The length of the proposed line is about 94 miles.

(2). *Cuddapah and Nellore.*—Part of this line was examined during 1878.—*Vide* Proceedings of Government, dated 4th September 1878, No. 1,896 F.R. In the forecast submitted to the Government of India on 25th November 1878, the approximate cost was set down at £761,000.

No part of the line has, however, been properly surveyed and estimated for a railway.

The length of the proposed line may be taken at about 94 miles.

The object is to bring the great northern deltas into more direct communication, by means of the Buckingham Canal, with Cuddapah, Bellary, and Kurnool, and so to provide a much-wanted means of supplying those districts with grain in time of scarcity.

(3). *Adóni to Kurnool.*—The construction of this line was proposed during 1877-78, but nothing has been done towards surveying it or estimating its cost. In the forecast submitted to the Government of India in November 1878, the approximate cost was set down at £360,000, and that is probably an outside figure.

The length of the proposed line is about 55 miles.

MADRAS, 6th December 1880.

(Signed) J. SHAW-STEWART, Col., R.E., Consulting Engineer for Railways.

	India.	Madras.	Percentage borne by Madras to India.
Population	190 millions ...	31⅓ millions ...	17·5
Area	897,000 sq. miles ...	139,000 sq. miles.	15·5
Revenue from Land	£21⅓ millions ...	£4½ millions ..	...
Do. Salt	£6½ do. ...	£1¼ do. ...	...
Do. Customs	£2½ do. ...	£ ⅓ do. ...	...
Do. Stamps	£2¾ do. ...	£ ½ do. ...	...
Total Revenue excluding Opium ...	£40 do. ...	£8 do. ...	20·0
Length of Guaranteed Railways ...	6,096 miles ...	1,512 miles ...	...
Do. Imperial State Railways ...	1,604 do. ...	...	...
Total length of Railways, Guaranteed and Imperial	7,700 do. ...	1,512 miles ...	19·6
Expenditure on Guaranteed Railways...	£97¼ millions ..	£14¾ millions ...	...
Do. Imperial State Railways	£18¾ do. ...	...	...
Total Expenditure on Railways, Guaranteed and Imperial	£116 do. ...	£14¾ millions ...	12·5

(Signed) J. SHAW-STEWART, Col., R.E., Consulting Engineer for Railways.

SUBMITTED to Government, in compliance with their Order, dated 23rd November 1880, No. 2,690 W.

2. In paragraph 33 of General Fraser's Minute, which accompanied the letter from the Government of India, dated 16th October 1880, the statement is made that "Madras has been singularly lucky in the extent of railway it has had constructed under a guarantee." I am by no means prepared to admit the accuracy of that statement, and the submission of this note has been delayed in the hope of obtaining figures illustrative of the point. This I have not been able to do, but there is every reason to believe that the amount of Imperial funds which have been spent on railways within this Presidency is much smaller, in proportion to its area, population, and revenue, than in other provinces of the empire.

No. 4 W.

No. 7-B. IRRIGATION MEMORANDUM.

THE following information is submitted with reference to G.O., No. 2,690 W., of the 23rd November 1880.

2. *Productive Public Works.*—There is no present probability of any Irrigation systems other than those already classed as Productive Public Works being brought under this head, with perhaps the one exception of the Sungum project. The five

systems so classed are shown below, together with the estimates sanctioned and the probable further outlay required.

No.	Systems.	Works and Tools and Plant.		Establishment.		Probable further sanction required. Direct charges.	Remarks on entries in Column 7.
		Current sanction.	Outlay to end of 1879-80.	Sanction.	Debit to end of 1879-80.		
1	2	3	4	5	6	7	8
		Rs.	Rs.	Rs.	Rs.	Rs.	
1	Godâvari Delta	28,24,953	22,26,844	..	7,93,688	*15,00,000	10 lakhs, Central Delta. 5 do. unforeseen works or further improvements.
2	Kistna Delta	9,08,129	8,70,859	..	3,19,054	*90,12,000	....
3	Pennér Anicut	5,94,810	6,06,092	..	1,63,353	* 1,00,000	Excess on revised estimate and unforeseen works.
4	Cauvery Delta	..	..	..	..	* 15 to 20 lakhs.	Regulation of Cauvery and minor rivers and improvements to water-supply of distribu taries.
5	Srivaikuntham Anicut System.	9,71,614	9,44,599	1,81,413	2,68,714	2,80,000	Additional in revised estimate *plus* 1 lakh for unforeseen works.

* Column 7 does not include establishment sanction required to cover charges connected with current sanction for works.

As for some of the above systems the establishment charges have not been covered by sanctions, it has been necessary to divide the items as shown, otherwise the true balance of sanction for *works* would not appear.

The estimate† for the Sungum project amounts to Rs. 25,83,800, and though the Government of India have hitherto declined to consider it to be sufficiently remunerative to be classed as a Productive Public Work, its claims are considerable to be so treated. It provides for the better irrigation of a triangular tract of country on the north side of the Pennér, the apex of the triangle being about 28 miles from the sea, and the northern point on the coast about 16 miles from the river.

† All direct charges.

3. Of the above five systems all but the last have been highly remunerative, as will be seen from the subjoined statement—

Systems.	Total Capital debited up to dates named.	Revenue due to Irrigation.	Public Works Receipts.	Total gross Revenue.	Maintenance charges.	Net Revenue.	Remarks :—The years named are the latest for which complete particulars are available.
1	2	3	4	5	6	7	8
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	
Godávari Delta	79,08,308	17,73,080	61,115	18,34,195	2,58,990	15,75,205	1877-78
Kistna Delta	48,30,306	8,57,888	21,306	8,79,194	1,81,764	6,97,430	1877-78
Pennér Anicut	14,10,995	1,38,806	37	1,38,843	22,166	1,16,677	1877-78
Cauvery Delta	‡ 14,04,389	8,47,722	4,857	8,52,579	1,00,352	7,52,227	1878-79
Srivaikuntham Anicut ..	11,82,765	51,283	447	51,730	68,165	—16,375	1878-79

‡ Approximate.

4. It is necessary to note that for one component work, the Commamur Canal, of the Kistna Delta there is a current sanction§ for Navigation Works which has not been included in the above statements, as it has been ordered to be otherwise classed.

§ Rs. 3,55,550.

5. There are many small works of local value and importance, such as extensions of existing river channels or construction of new ones, adjustment of storage capacity of tanks to the requirements of the land irrigated, concentration of storage by the abolition of tanks which were unwisely constructed many years ago, and are not only not wanted but are a source of danger and expense. Such works as these will not be

classed either as Productive or Protective, but they will want money and 5 lakhs a year will be none too much to assign.

6. *Protective Works.*—The chief of these which has been either completely investigated or otherwise brought to notice are shown in the annexed table. Some were started as relief works during the late famine and the outlay (normal value of work done) on such is shown, while in the case of those on which expenditure has been subsequently incurred, the amount so spent up to the end of 1879-80 is separately entered. The expenditure entries are all on *works* only. In compiling this table only such works as may be properly considered to be protective have been entered, while some, such as the schemes for irrigation from the Tungabhadra in the Bellary District, which were investigated by the Madras Irrigation and Canal Company, but have been handed over to Government have been omitted, because their cost has been considered to be out of proportion to the benefits they would confer, and from the nature of the soil it is more than doubtful whether in ordinary seasons the water-supply would be made use of.

PUDUGUDY,
15th January 1881.

(Signed) JOHN MULLINS, Col., R.E.,
Chief Engineer for Irrigation.

To the Secretary to Government, Public Works Department.

	District.	No.	Name of Project.	Estimate. Works.	Establishment.	Tools and Plant.	Total.	Outlay to end of 1879-80. Famine.	Subsequent.	Total.	Remarks.
				Rs.	Rs.	Rs.	Rs	Rs.	Rs.	Rs.	
5	Ganjam ..	1	Rushikulya	19,67,414	5,41,039	89,247	25,97,700	..	..	..	Proceedings of Madras Government, No. 1,293, dated 23rd May 1876. Intended to irrigate 120,000 acres. Estimated net return on cost including interest 4 per cent. Country has suffered severely from famine.
X	Nellore ..	2	Sungum project ..	22,60,980	2,73,000 / 1,69,570	49,820	27,53,370	..	..	..	Estimate complete. If not treated as a Productive Public Work it should be considered a Protective Work. Proceedings of Madras Government, No. 1,818, dated 28th July 1870. Under Establishment an addition has been made for direction and account.
12	Kurnool ..	3	Mamidivaram reservoir ..	About 22½ lakhs.	6,18,750	1,31,250	About 30,00,000	..	..	..	Only a preliminary investigation made. Probable capacity, 54,000 millions of cubic feet. Land lies in Kistna District. Complete investigation of dam and weir sites desirable; if these work out well the project should be completely investigated, the site being apparently remarkably favorable, the land which would be submerged being mostly waste and the villages few. Proceedings of Madras Government, No. 1,095, dated 19th April 1875. Do. famine relief No. 3,004, dated 3rd December 1877.
X	North Arcot ..	4	Pálár anicut system, north section improvements.	3,10,178	41,722	5,970	3,57,870	1,64,445	1,454	1,65,899	An estimate of Rs. 2,82,000 sanctioned in G.O., No. 715 I., of 10th September 1878. The famine outlay includes Rs. 857 for Tools and Plant. Revised estimate ready. Establishment shown for work remaining to be done.
7	..	5	Do. do., south section improvements.	About 1,92,300	52,882	4,818	About 2,50,000	..	..	..	Field work nearly complete. The project will provide for turning the supply of water to the best account. Many tanks are now supplied from the anicut.
10	South Arcot ..	6	Atúr anicut on Guddelem.	About 40,000	12,500	1,500	About 54,000	..	..	..	The estimate has to be revised and was returned for that purpose in 1873. The water-supply is good.
8	..	7	Lower Coleroon anicut, Vadavar and Viranum tank improvements.	About 5 lakhs.	1,37,500	12,500	About 6,50,000	..	..	..	Already an extremely valuable field of irrigation and capable of much improvement.
3	Salem ..	8	Marandahulle	About 3,00,000	82,500	7,500	About 3,90,000	62,092	3,437	65,529	The project includes (1) an anicut, (2) a supply channel, (3) the enlargement of two reservoirs, and (4) distributaries. (2) is far advanced, and a good deal of work has been done to (3). The leading features of the scheme have been settled and the estimate should shortly be ready.
2	Do. ..	9	Baroor	2,35,500	64,625	5,875	3,06,000	67,185	4,644	71,829	Includes (1) an anicut, (2) a supply channel, (3) the enlargement of a reservoir, (4) distributaries, and (5) some miscellaneous works. (2) and (3) are considerably advanced. The estimate is ready and the report of the Revenue Officers is awaited.
11	Salem ..	10	Krishnagiri reservoir ..	About 6 lakhs.	1,65,000	15,000	About 7,80,000	..	..	..	Partly investigated. A promising site, if good foundations in the bed of the river for a masonry dam can be found, but the investigations of water-supply for Baroor project indicate that there is not water enough for a reservoir of the great capacity originally contemplated. Proceedings of Madras Government, famine relief No. 883, of 9th April 1878. Do. Public Works Department, No. 92 I., of 11th Feb. 1879.
4	Do. ..	11	Vanniár reservoir ..	6,54,000	1,79,850	17,150	8,51,000	The work done is of no value.			Was commenced as a relief work at the wrong site. The proper site afterwards investigated; water-supply good.
6	Coimbatore ..	12	Púgalur channel improvements.	3,08,400	58,668	2,932	3,70,000	91,700	3,357	95,057	The estimate is ready and provides for extending the channel which is supplied by the Cauvery. The ryots of the villages concerned are much interested in the scheme which promises well.
9	Do. ..	13	Bhaváni reservoir above Satyamangalam.	30,40,000	8,36,000	76,000	39,52,000	..	..	..	A preliminary investigation has been made and report submitted by Major Montgomerie. The water-supply is excellent, and if the scheme prove feasible a very large extent of country will be fully protected.
1	Madura ..	14	Periyár	53,13,000	14,61,075	1,32,925	69,07,000	..	..	..	The details of the main dam across the Periyár have not yet been finally settled, but the project has otherwise been completely worked out and estimated for. The terms on which the site for the head works and permission to divert water will be granted by the Travancore Government likewise remain to be settled. The area to be irrigated is 93,172 acres.
13	..	15	Gullapuram reservoir ..	7,70,847	2,11,983	44,970	10,27,800	..	..	..	This project will be unnecessary if the Periyár project be carried out. It was investigated for famine relief purposes in 1878, but was not completed in time to be of use then. Proceedings of Madras Government, No. 491 I., dated 14th June 1878.

SUMMARY.

Projects the Estimates of which are ready.

Ganjam ..	1	Rushikulya	19,67,414	5,41,039	89,247	25,97,700	..	..	..	To irrigate 120,000 acres.
Nellore ..	2	Sungum	22,60,980	4,42,570	49,820	27,53,370	..	..	..	Do. 94,000 do.
North Arcot ..	4	Pálár anicut system, North section.	3,10,178	41,722	5,970	3,57,870	1,64,445	1,454	1,65,899	Do. 39,468 do.
Salem ..	9	Baroor	2,35,500	64,625	5,875	3,06,000	67,185	4,644	71,829	Do. 7,500 do.
..	11	Vanniár reservoir ..	6,54,000	1,79,850	17,150	8,51,000	..	..	..	Do. ~~2,000~~ do. 10000
Coimbatore ..	12	Púgalur channel ..	3,08,400	58,668	2,932	3,70,000	91,700	3,357	95,057	Do. 5,100 do.
Madura ..	14	Periyár	53,13,000	14,61,075	1,32,925	69,07,000	..	..	..	Do. 93,172 do.
			1,10,49,472	27,89,549	3,03,919	1,41,42,940	3,23,330	9,455	3,32,785	362,240

Projects the Estimates of which are not ready and the amounts given are approximate.

Kurnool ..	3	Mamidivaram reservoir ..	22,50,000	6,18,750	1,31,250	30,00,000	..	..	..
North Arcot ..	5	Pálár anicut system, South section.	1,92,300	52,882	4,818	2,50,000	..	..	..
South Arcot ..	6	Atúr anicut	40,000	12,500	1,500	54,000	..	..	..
Do. ..	7	Lower Coleroon anicut, Vadavar and Viranum tank.	5,00,000	1,37,500	12,500	6,50,000	..	..	..
Salem ..	8	Marandahulle	3,00,000	82,500	7,500	3,90,000	62,092	3,437	65,529
Do. ..	10	Krishnagiri reservoir ..	6,00,000	1,65,000	15,000	7,80,000	..	..	..
Coimbatore ..	13	Bhavani reservoir ..	30,40,000	8,36,000	76,000	39,52,000	..	..	..
Madura ..	15	Gullapuram do. ..	7,70,847	2,11,983	44,970	10,27,800	..	..	..
			76,93,147	21,17,115	2,93,538	1,01,03,800	62,092	3,437	65,529

PUDUGUDY,
15th January 1881.

(Signed) JOHN MULLINS, Col., R.E.,
Chief Engineer for Irrigation.

No. 7-C. From Major-General, J. S. TREVOR, R.E., Deputy Secretary to the Government of India, Public Works Department, (Railway Construction,) to the Secretary to the Government of Madras, Public Works Department, Railway, dated Fort William, 26th January 1881, No. 47 R.C.

REFERRING to Government of India Public Works Department No. 754 R.C., of the 16th October 1880, I am directed to forward, for information of His Excellency the Governor in Council, copy of despatch addressed to Secretary of State, No. 3 R., of the 12th January 1881, giving an outline of Railway works proposed to be carried out in 1881-82 and following years, and to draw special attention to paragraph 14 thereof.

2. It has been suggested to the Government of India that a line connecting Bezváda at the head of the Kistna canals to Hyderabad in the Deccan would be a useful Protective Public Works, as it would place the Bombay Presidency in direct communication with the irrigated delta of the Godávari and Kistna rivers. But I am to add that the selection of a line for construction is left entirely to the Governor in Council at Madras.

Despatch from the Government of India, Public Works Department, Railway Construction, to the Right Honorable the Secretary of State for India, dated Fort William, 12th January 1881, No. 3 R.

In continuation of our despatch No. 128 R., of the 7th September 1880, and in reference to your Lordship's Financial despatch No. 299 of the 2nd September 1880, we have now the honor to report the further measures we have taken for giving effect to the proposals made in General Fraser's Minute of the 6th May 1880.

2. In Burma, we have asked for your Lordship's permission to take in hand, as a Productive Public Work, the railway from Rangoon to Tounghoo, and we have set aside a sum of 30 lakhs from the assignment for such works in 1881-82, in anticipation of your Lordship's sanction, in the hope of ensuring rapid progress. The great financial success of the Rangoon-Prome Railway—a success almost unprecedented in railway construction in India—has demonstrated that railways in Burma will, on account of the enterprising character of the people, and the great undeveloped wealth of the country, not only give large indirect returns in land, customs and forest revenue, but will pay, within a very short period after being opened to traffic, a fair percentage of net income on their capital cost. Apart from its remunerative character the line from Rangoon to Tounghoo has special recommendations, as connecting an important military station on an exposed frontier with the capital of the Province. At present, under the most favorable circumstances, the journey from Rangoon to Tounghoo cannot be accomplished under a fortnight.

3. So impressed is the present Chief Commissioner with the value of railways in his Province, that it is not improbable he will proceed, out of Provincial funds, to extend the Rangoon-Prome Railway to the frontier at Allanmyo, opposite to the European military station of Thayetmyo.* The cost of this extension of 42 miles, which has been surveyed and carefully laid out, is estimated at Rs. 37¾ lakhs, and we have to ask your Lordship's sanction to the work being carried out as a provincial undertaking.

* *Vide* enclosure No. 1, Government of India, P.W.D. Pros. R C., Nov. 1879, Nos. 48—59, Part A.

4. The Company projected to construct in Upper Assam a railway from Dibroogurh to Sudya, with branches to a coal mine at Makum, and to some tea gardens, and about which there has been some correspondence, closing with our despatch No. 184 R., of the 22nd December 1880, has not yet, we believe, been able to raise sufficient capital to commence operations; but strong hopes are entertained of ultimate success. The line will be of great use to owners of plantations in Upper Assam, a Province said to be more suitable for the growth of a high priced class of tea than any other part of India.

5. Your Lordship—in your railway despatch No. 64 of the 8th July 1880—authorised the prolongation of the two branches of the Tirhoot State Railway for distances of 24 and 78 miles respectively. Tenders for the construction of these extensions are being invited, and we have intimated to the Lieutenant-Governor of Bengal that a sum of 25 lakhs out of the Productive Public Works assignment for 1881-82 is at his disposal for expenditure on the undertaking. In conveying this information, it has been necessary to explain that with the sum now applied, under your Lordship's predecessor's instructions, to the construction of Productive Public Works, it is impossible for us to allot for expenditure, in any one Province, a larger sum than 25 or 30 lakhs, and that even this small sum cannot be given continuously for a long number of years. But in consideration of the population and extent of Bengal, we have promised to place the

same sum that has been given this year regularly at the disposal of the Bengal Government, until the completion of another set of lines stretching from Dacca in the south, in two branches, to a point opposite Goalundo, the terminus of the Eastern Bengal Railway, on the Ganges, and to the town of Mymensing, on the Brahmaputra River. The length of these two lines is 128 miles, and their estimated cost 125 lakhs.* Plans and estimates for the work have been submitted to us for sanction, with a statement of the financial position of the Government of Bengal, and an undertaking to meet the charges for interest on the capital to be invested. These statements being in all respects satisfactory, and the importance of the line being indisputable—numerous petitions having been sent in to us urging its early construction on account of the gradual silting up of the former navigable Mymensing channel of the Brahmaputra river—we have the honor to solicit your Lordship's permission to allow the work to be taken in hand by the Government of Bengal as soon as funds can be released for the purpose, from the Tirhoot Railway extensions, that is, in 1882-83. We ought to add that the extension of the Dacca-Mymensing branch towards Assam on the left bank of the Brahmaputra river is probably the best railway that can be constructed for opening out Lower Assam. It is our intention to instruct Bengal to finish this branch before it commences the other more expensive branch to Aircha opposite Goalundo.

* METRE GAUGE.

	Length MILES.	Estimated cost. LAKHS.
(1)—Aircha opposite Goalundo to Dacca	43	65(*a*)
(2)—Hajeegunge through Dacca to Mymensing	85	60
Total ..	128	125

	RS.
Estimated gross traffic	12,75,000
Working charges, 75 per cent. ..	7,25,000
Net income, equal to 4·4 per cent. per annum	5,50,000

(*a*) Includes cost of ferry steamers.

Vide enclosure No. 2.—Letter No. 852 S. R. of the 26th October 1880, from the Government of Bengal.

6. Besides the railways in Eastern Bengal, His Honor the Lieutenant Governor of Bengal is anxious to have built a set of lines in the part of Lower Bengal confined between the Hooghly and the Ganges. About these lines a despatch will be addressed to Your Lordship in connection with the offer of Messrs. Rothschild to make the line from Calcutta *viâ* Jessore to Kulna. The details of the terms on which an agreement might be concluded with those gentlemen are now under our consideration. It would be a desirable arrangement if all the lines between the Hooghly and the Ganges projected and built—a little under 500 miles in length—could be worked under the same management. In any agreement provision will have to be made for doubling the line from the new Hooghly Bridge (sanctioned for construction by your Lordship as part of the East Indian Railway) to Sealdah and for the enlargement of the Sealdah Railway Station to accommodate the additional traffic to be expected on the establishment of communication with the East Indian Railway.

7. His Honor the Lieutenant Governor of Bengal has commenced the construction, out of Provincial funds, of a short branch, 14 miles long, from the Sonarpur Station of the Calcutta and South-Eastern Railway to the large village of Mugrah, about half-way on the road to Diamond Harbour. The work is being executed by contract, and will be finished by 1881-82. Its cost is under 12 lakhs of rupees.

(1) *Vide* enclosure No. 3.—Letter No. C 93 R of the 24th August 1880, from the Government of the North-Western Provinces and Oudh.
(2) *Vide* enclosure No. 4.—Letter No. C 145 R of 17th September 1880, from North-Western Provinces and Oudh.

		RS.
* *Kalpi Railway*—		
Estimated gross receipts..		1,75,521
Less working charges—		
Per-centage on receipts as on East Indian Railway ..	32 per cent.	
Add for use of East Indian Railway stock	10 „ „	
Total ..	42 „ „ =	73,718
Net receipts		1,01,803
which is 6 per cent. on the capital cost (16½ lakhs) of the line.		
Pilibhit Railway—		RS.
Estimated gross earnings		1,83,612
Working charges, 60 per cent.		1,10,167
Net receipts		73,445
or 4·2 per cent. on a capital outlay of 17½ lakhs.		

8. In the North-Western Provinces two projects have been submitted to us for sanction as Productive Public Works on provincial responsibility—one (1) for a railway from Bhowpore, 14 miles north-west of Cawnpore, to Kalpi, 33 miles in length, at an estimated cost, on the broad gauge, without rolling stock, of 16½ lakhs, the other (2) for a line from Bareilly to Pilibhit, on the metre gauge, 33 miles long, at an outlay of 17½ lakhs.

The expected net* revenue to be derived from these lines has been calculated on the basis of the existing traffic on the public road, and is in one case found to be sufficient to yield 6, and in the other about 4½ per cent. on estimated cost. In the enquiries made about the branch to Kalpi, it has been ascertained that the cost of a broad gauge road from Bhowpore to be worked with the stock of the East Indian Railway is about 3½ lakhs less than the cost of a metre gauge line from Cawnpore, inclusive of a small

provision for rolling-stock, and that even after giving the East Indian Railway Company 10 per cent. of the gross earnings for hire of their stock—a rate most remunerative to the Company—the returns on invested Capital will, if the line is built on the broad gauge, be 6 per cent. against 3½ on the metre, while, as regards public convenience, there can be no comparison between a broad gauge road, worked as part of the East Indian Railway System, and a metre gauge line on which nearly all goods will have to break bulk, and on which, in consequence, goods traffic will never, from shortness of transit, attain its true development.

On the Pilibhit Railway Mr. Molesworth's note* shows that a broad gauge road without stock and worked as part of the Rohilkhund Railway could be built for the same sum as a metre gauge line with a separate stock. After the experience we have had of the expense and hindrance to traffic attendant on break of gauge, we are strongly of opinion that such breaks should not be sanctioned without adequate cause, *i.e.*, only in cases where a large pecuniary saving may be expected by building on the metre gauge. In the present instance, if it had been intended to terminate the branch finally at Pilibhit, we should have asked your Lordship to allow it to be constructed on the broad gauge, and to be worked as part of the Oudh and Rohilkhund Railway. But the intention is that the branch should form part of a system that will in time be prolonged through Kheri and Sitapoor to Lucknow, and also be extended to the foot of the Himalayas near Naini Tal. The length of line that may thus eventually be carried out, on the Pilibhit Branch as a base, is probably sufficient to justify a change of gauge, and in accordance, therefore, with the wish of the Local Government,† we request your Lordship's sanction to the construction of the branch on the metre gauge, at an estimated cost of 17½ lakhs. The Local Government accept full financial responsibility for both the Kalpi and Pilibhit Branch Railways, and if their execution is approved by your Lordship, we purpose putting them in hand in 1882-83 when funds will be available from the Productive Public Works grant.

* *Vide* enclosure No. 5.

† *Vide* enclosure No. 6.—Letter No. 1,822 R., of the 3rd December 1880, from the Government of the North-Western Provinces and Oudh.

9. The Punjab Government have solicited sanction to build a line on the broad gauge from‡ Amritsar to Pathankot, a distance of 65 miles, at an estimated cost of Rs. 45 lakhs. It is proposed to work the railway through the agency of the Sind, Punjab and Delhi Railway Company. The gross traffic is estimated at Rs. 7,19,006, and the net income at Rs. 2,51,654, or over 5 per cent. on capital cost. We think the estimate of income too sanguine as regards passenger traffic, but the Local Government, with a full knowledge of the possibility of having to make good for two or three years about a lakh of rupees per annum for interest, undertakes all financial responsibilities for the enterprise. The line will be a most valuable feeder to our railway system, and will, besides giving access to the Kangra Valley, open out a well-populated district, the seat of numerous well attended fairs, and irrigated, as well as provided with water power, now being turned to useful account by the Baree Doab Canal; we therefore strongly recommend the projected railway for sanction as a Productive Public Work for commencement in 1882-83. No extension of this branch is possible, nor will it be cheaper to build it on the metre gauge with an equipment of stock and with interchange platforms and sidings, than to construct it on the broad gauge and work it as an integral part of the Sind, Punjab and Delhi Railway. As there will be no saving of capital expenditure by the adoption of the metre gauge, and as there will be considerable inconvenience to the public by a break of gauge, we are of opinion that, on this branch, the metre gauge is on all grounds inadmissible.

‡ *Vide* enclosure No. 7.—Letter No. 5,265 of the 19th October 1880, from the Government of the Punjab.

PARA. 1. I have had before me in Council your Excellency's letter No. 266 of 18th October last, regarding the regulation of expenditure on State Railways, and I desire to give my cordial assent to the sound principles laid down in the first eight paragraphs of that letter.

2. According to these principles, the criterion of the remunerative prospect of a State Railway project will not be its promise to pay at once full interest on an estimate of Capital expenditure sufficient to meet the wants of a traffic which it may take years perhaps to develop, but that it shall afford reasonable ground for the expectation that it will, after a moderate interval, more than pay the interst on the first direct outlay, and that there shall be some available resource, such as the surplus Provincial revenues, from which to meet any deficiency for annual interest or otherwise arising, before equilibrium shall have been established.

In connection with the railways above referred to, for construction out of the Productive Public Works grant, we beg to quote, for easy reference, in the margin, the principles laid down by Lord Cranbrook in his despatch No. 13 of 5th February 1880, for regulating expenditure from that grant on railways.

10. There is another line that we should wish to see taken in hand in the Punjab, viz., an extension on the metre gauge of the Rajputna Railway, in the direction of Forezepore from Delhi. But the construction of this line will have to be deferred for want of funds, till other more urgent works are brought to completion.

11. In the Central Provinces it is proposed to continue the line now under construction from Nagpur to Dongargarh, for a further distance of 135 miles to Bilaspur. The plans and estimates are in course of preparation, and will be submitted to your Lordship in due course. In the meanwhile, it is our intention, with your Lordship's permission, to make a grant of 20 lakhs annually towards the construction of this extension of the Nagpur branch of the Great Indian Peninsula Railway, into Chota Nagpur. A glance at any map of India will show the large area of the empire, that is, in this neighbourhood, unprotected by railways, and we are anxious that regular steps should be taken to open it out. We do not advocate any large sudden expenditure, as the country beyond the rich grain-producing district of Chattisgurh, though abounding in coal, iron and other sources of undeveloped future wealth, is scantily populated and covered with forest, and time is required to make railways productive in such regions. But the necessity of the line is sufficiently obvious to render detailed explanation unnecessary. All that need be said at present is, that the line as far as Bilaspur will satisfy the conditions laid down for the expenditure of money on Productive Public Works, and that we propose to proceed with its construction in short sections, finishing off one section before putting others further distant from Nagpur in hand. The next section to be commenced extends from Dongargarh* to Nandgaon, and will require—to prevent intermission of work—to be taken up for construction by the end of 1881-82. The length of this section is 19 miles, and its estimated cost 8½ lakhs. The Chief Commissioner, Central Provinces, is urging us to let him commence this section on the ground that the great eastern road runs through Nandgaon, but does not approach Dongargarh, the present terminus of the railway; and that if the railway be at once extended to the former place the expense of a connecting road will be saved, and the trade from the south and east of Chattisgurh will be attracted to the railway, as well as the trade from the north and west which would alone flow to the terminus now under construction. We have not decided as yet to accede to the application to the Chief Commissioner of the Central Provinces, but we shall probably have before long to permit him to proceed with the proposed work in anticipation of sanction to the complete project to Bilaspore.

* *Vide* enclosure No. 8, Proceedings R.C., September 1880, Nos. 28—33 A.

12. The funds at our command for expenditure on Productive Public† Works in 1882-83, will, it is presumed, be similar in amount to the sums granted in 1880-81 and 1881-82, viz., for Railways 180 lakhs, and this sum will, according to the preceding proposals, be distributed in 1882-83 as follows:—

† Productive Public Works grant—

	Lakhs.
Railways	180
Irrigation	63
Madras Harbour	7
	250

	Lakhs.
Burma	30
Bengal	25
North Western Provinces and Oudh	20
Punjab	25
Central Provinces	20
Total	120

The balance of 60 lakhs is not more than it is necessary to keep in reserve for the completion of the Rajputana-Malwa Railway system, and for the gradual development of the stations, workshops and rolling-stock equipment, of nominally completed undertakings.

13. In your Lordship's Financial despatch No. 299 of the 2nd September 1880, allusion is made to a probable additional allotment on Protective Public Works of about 75 lakhs annually, as soon as our finances can bear the charge. In the event of the instructions from Her Majesty's Government on the subject of the expenditure of the funds raised by the special taxation imposed in 1878 rendering this sum available for outlay in 1882-83, or in a subsequent year, the works which we consider demand early attention are, *first*, the line from Hootgi *viâ* Bijapur to Bagalkot, in the Bombay Presidency, that has already been partially built for famine relief purposes, and, *secondly*, a line to open out Bundelkhund. The difficulty in improving the communications of Bundlekhund is the Jumna crossing on the east, and the Nerbudda river and Vindhya range on the south. The Jumna river could not be bridged much under a cost of 30 or 35 lakhs of rupees, nor could the Nerbudda crossing and ghaut ascent be surmounted at much less cost. We do not think it would be prudent to incur this expenditure at present. The best plan appears to be to extend the Gwalior Railway *viâ* Jahnsi to Mau-Ranipore, the great trade centre of Bundelkhund. There are two large rivers on this line—the Sinde and the Betwah, but both streams have rocky beds, and the bridges will not, in consequence, be expensive. A survey is in progress, and we hope to be able to submit plans and estimates for your Lordship's sanction in time, if funds be available, for the commencement of operations in 1882-83. If at some future date, this railway could be extended to join, *viâ* Banda, the Jubbulpore Branch of the East Indian Railway at Manickpore or Markundu, the whole province of Bundelkhund would be brought within easy reach of the ports of Calcutta and Bombay, and would secure both a market for its produce, as well as immunity against famine in seasons of severe drought.

In regard to the line, in the south-east of the Presidency of Bombay, surveys, more or less complete, have been already made, and the cost of a fair-weather broad gauge railway from Hootgi *viâ* Bijapur to Bagalkot, 106 miles, is put down at 53 lakhs.*

* *Vide* enclosure No. 9.—Letter No. 2,523 of the 12th October 1880, from the Government of Bombay.

14. Besides these two lines a third ought to be undertaken in Madras, if the whole sum proposed to be alloted for Protective Public Works can be devoted to railway construction. The position of this line will have to be left for selection to the Madras Government, whose attention will be drawn to the desirability for preparing a project in due detail for submission to your Lordship.

15. Besides State lines, we have already recommended to your Lordship that the agency of Guaranteed Companies should be called in to build the following branches and new railways :—

East Indian Railway Company.	Hooghly Bridge at Hooghly.
†Madras Railway Company.	—Bellary to New Hubli.
†Stafford House Committee —new Company.	Karwar to New Hubli, with extensions to open out Southern Mahratta country.
Sind, Punjab and Delhi Railway Company.	Raiwind to right bank of Sutlej, opposite Ferozepore.
Bombay, Baroda and Central India Railway Company.	Extension of Dakor Branch to Godra.

† Orders have been received since this despatch was written on our recommendations in favor of these lines in your Lordship's despatch No. 127 Railway of 9th December 1880, to which we shall reply in another communication.

16. The only addition as far as we can yet accurately judge that it may hereafter be desirable to make to these recommendations will be in favor of the completion, by the Oudh and Rohilkhund Railway Company, of the connecting* link between their system and that of the Sind, Punjab and Delhi Railway, from Moradabad to Saharunpore, with a branch to Hurdwar, that formed the subject of our despatch No. 180 Railway of the 10th July 1879.

* Broad-gauge—

Length inclusive of branch to Hurdwar ..	134 miles.
Estimated cost	148 lakhs.

Besides the value of this link as a military line of communication, on which point we beg to refer your Lordship to the report of the late Indian Army Commission, to Lord Napier of Magdala, Sir Henry Norman and others—who have held high positions in the army in India, as well as to Sir W. Muir, formerly Lieutenant Governor of the North-Western Provinces, it is obvious that we shall not derive full benefit without its construction, from the large expenditure now being incurred on the bridge over the Ganges at Benares. One of the great objects of that important work is to relieve the strain on the single track of the East Indian Railway, west of Mogul Serai. Your Lordship in despatch No. 113 Railway of the 11th November 1880 has permitted the double line, that now stretches from Howrah to Buxar, to be continued to Mogul Serai, and it is to be expected that a further extension will be necessary before long unless we can provide a second channel for the traffic. This channel can best be obtained by making the Oudh and Rohilkhund Railway part of the through system from Calcutta to the Punjab. It is scarcely necessary to remark that a second line which opens out new country and developes new traffic is a more useful investment of capital than doubling the track on an existing road. Double tracks should not, in our opinion, be laid, except as a last resort, when no other means are available for carrying off the traffic. In a railway point of view also it is highly desirable that all lines, where practicable, should lead into one another at both ends, instead of being stopped short at a town however large or important. Railways thus terminated are deprived of a considerable share of traffic that would otherwise pass over them. As a strong illustration of the weight attached to the connection together of railways, even when leading to the largest of cities, we can point to the enormous sums spent of late years in London and Paris on building lines over most expensive land, in order to establish inter-communication between the various railways, of which those cities are, or rather were, the termini. But in the present state of our finances, it is, as stated in our despatch No. 180 Railway of 18th July 1879, not prudent for us to add to our liabilities by borrowing the million and half sterling that will probably have to be expended in carrying this work to completion. Our object in drawing attention again to the great importance of the line is in the hope that in the existing state of the money market it may be possible to revive with success the project put forward in our previous despatch on the subject of getting the line built by private enterprize on terms that would not impose an onerous burden on our exchequer.

18. The specific recommendations to which we have to ask your Lordship's sanction, independent of recommendation already made in other despatches, are—

1st.—Permission to allow the Chief Commissioner of British Burma to build by degrees,

* Length .. .. 42 miles.
Estimated cost .. .. 37½ lakhs.
Gauge .. .. Metre.

as he can spare the means, out of provincial revenues, the extension of the Rangoon-Prome* Railway to the frontier at Allanmyo.

2nd.—Authority to construct, as Productive Public Works, on the financial responsibility of the Local Governments, the undermentioned railways :—

On the metre gauge—

(*a.*) From the port of Dacca to Mymensing, with a branch to Aircha, opposite Goalundo, the terminus of the Eastern Bengal Railway, to be worked by the Local Administration—Bengal Government.

a Length .. .. 128 miles
Estimated cost .. .. .. 125 lakhs.
Expected dividend .. .. .. 4·4 per cent.
Gauge .. .. .. Metre.

(*b.*) From Bareilly on the Oudh and Rohilkhund Railway to Pilibhit, to be worked by the Local Administration—North-Western Provinces Government.

b Length .. .. 33 miles.
Estimated cost .. .. .. 17½ lakhs.
Expected dividend on cost .. .. 4·2 per cent.
Gauge .. .. Metre.

On the broad gauge—

(*a.*) From Bhowpore to Kalpi, to be worked as a branch of the East Indian Railway—North-Western Provinces Government.

a Length .. .. 31 miles.
Estimated cost .. .. .. 16½ lakhs.
Expected dividend on cost .. .. 6 per cent.
Gauge .. .. 5′ 6″.

(*b.*) From Amritsur to Pathankot, to be worked as a branch of the Sindh, Punjab and Delhi Railway—Punjab Government.

b Length .. .. 65 miles.
Estimated cost .. .. .. 45 lakhs.
Expected dividend on cost .. .. 5½ per cent.
Gauge .. .. 5′ 6″.

3rd.—And finally sanction to carry out as Protective Works, when funds are available—

(*a.*) The completion of the fair-weather railway from Hootgi, near Sholapur, to Bagalkot, to be worked as a branch of the Great Indian Peninsula Railway.

a Length .. .. 106 miles.
Estimated cost .. .. .. 53 lakhs.
Gauge .. .. .. 5′ 6″.

(*b.*) The railway into Bundelkhund from Gwalior, after preparation and sanction of the estimate by your Lordship, to be worked as an extension of the Sindia Railway by the East Indian Railway Company.

b Length .. .. .. about 100 miles.
Probable cost .. .. .. about 100 lakhs.
Gauge .. .. .. 5′ 6″.

19. In the distribution of the Productive Public Works assignment, our object has been to give sufficient money to a Local Government to enable it to construct from 30 to 40 miles of railway in each year. Smaller grants than those that have been assigned would be of little use in the development of the railway communications of the large provinces of our empire. But even with the very limited grants it has been in our power to allot, it will be perceived, after making the necessary reservation for the improvement and better equipment of nominally completed lines, that no money is available for the presidencies of Madras and Bombay, or for the Commissionership of Assam. If no increase is possible in the annual grants for railway construction, it will be incumbent on us, as soon as the Rangoon-Tounghoo Railway in Burma and the lines to which sanction is now asked in the Punjab and North-Western Provinces are completed, to stop further railway construction in these provinces, and to take up work in parts of India that are now to be left without assignments. But it is our earnest hope that the grants may be supplemented by private enterprise if we are successful in getting the Messrs. Rothschild and Co. to make a commencement in this direction in Central Bengal, and your Lordship will understand that in requesting sanction to the above-named works, we are not debarred from handing them over to a private Company should it appear subsequently desirable to adopt such a proceeding.

No. 8. ORDER THEREON, 3rd March 1881, No. 563 W.

ORDERED that the following letter be sent.

(Here enter No. 564 W., dated 3rd March 1881.)

(True Extract.)

Major, R.E.,
Under Secy. to Govt., P.W.D.

To the Chief Engineer for Irrigation, } with copy of letters.
„ Consulting Engineer for Railways, }

Exd. S. T. Austin.

8 Spare Copies

Irrn Cag.

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Rae 166

CHIEF ENGINEER FOR IRRIGATION
12 MAR
1881

BUILDINGS AND ROADS.
CIVIL WORKS.

Govt. of (1881) Madras.

PUBLIC WORKS.

To

THE CHIEF ENGINEER FOR IRRIGATION,

&c., &c., &c.

Dated March, 3rd.

Issued

Recd. Encl. 1.
only one copy of letter sent
12/3

G. O., 3rd March 1881, No. 563 W.

MARCH.
Nos. 7-8.

Recd
Cent
16-3-81

Smith
12-3-81

Productive Public Works in the Madras Presidency.—Ordered that the Government of India be addressed on the subject of the —.

PUBLIC WORKS DEPARTMENT.

Buildings and Roads.
Civil Works.

No. 564 W.

No. 9.

FROM

THE SECRETARY TO THE GOVERNMENT OF MADRAS,

Public Works Department,

To

THE SECRETARY TO THE GOVERNMENT OF INDIA,

Public Works Department.

SIR,—In reply to your letter, No. 754 R. C., dated 16th October 1880, and to another to same purport in the Irrigation Department, I am directed to submit, for the information of the Government of India, the memorandums of the Chief Engineers for Irrigation* and Railways† as marginally noted, which deal with the subjects adverted to in Major-General Fraser's minute of the 6th May 1880, forwarded with the above communication.

* No. 4 W., dated 15th January 1881.
† Dated 6th December 1880.

2. The memorandum of the Irrigation Branch now sent up is not so complete as could be wished, as it fails to show precisely the present condition of the projects, as also the increased acreage under irrigation and the probable returns which may fairly be looked for as the result of the expenditure to be undertaken under "Productive." It is, moreover, believed that the Sungum Project has already been accepted as belonging to this class by the Government of India.

3. In addition to the various large projects forming Colonel Mullin's first table, the Periyár, Baroor, and Rushikulya, and perhaps some of the other projects enumerated, should, in the opinion of this Government, be removed from the list of merely "Protective" works to that of "Productive."

4. On the first named work for instance the ultimate returns are calculated to be over 7 per cent., and there would appear no room to doubt that in this, as also in regard to the Baroor work, they will be well in excess of the $4\frac{1}{2}$ per cent. required to be shown on the indirect as well as direct outlay.

5. Incomplete however as the lists are, they will, it is thought, sufficiently meet the object of the Government of India in making the present inquiry; and should there be any need for it Colonel Mullins on return from tour will no doubt be enabled to supplement in great measure the deficiencies noted.

6. As regards Railways, the information under the head Probable Cost is even less complete, but of the lines referred to in Colonel Shaw-Stewart's memorandum the following are, in the opinion of the Right Honorable the Governor in Council, of special importance.

7. The proposed line from Bimlipatam on the East Coast *viâ* Vizianagram to Raigurh, with eventual extension to either Raepore or Sumbulpore on the prolongation of the railway which it is understood has been already pushed forward from Nagpore towards Raepore and may eventually be extended to Calcutta, is specially deserving of consideration.

8. The Famine Commission have dwelt strongly on the fact of this tract of country being specially marked out for the establishment of "Protective" lines of railway, and in paragraph 11 of Railway despatch No. 3 of 12th January 1881, to Her Majesty's Secretary of State, the Government of India draw attention to the "large area of the empire that is in this neighbourhood unprotected by railways."

9. The Right Honorable the Governor in Council attaches also great political importance to the construction of this line, which will form the first link of communication from the East Coast with the interior, and will open up for the passage of troops a wild and frequently disturbed district, which is at present without any means of communication either by road or railway. The subject of this line has lately, moreover, been prominently brought under notice by the Rajah of Vizianagram, as will be observed from G.O., No. 149—151 R., dated 15th February 1881, forwarded to the Government of India, who is prepared to advance its construction to the utmost of his power and means. Much local interest is credibly stated to be manifested in the project by local large proprietors.

10. The projected lines from (1) Bellary to Hospet, (2) Shoranur to Cochin, and (3) Madura to Pámban, are all likewise, in the view of this Government, deserving of serious attention.

11. As regards the line from Bezváda to Hyderabad, which is referred to in Major-General Fraser's letter No. 47 R., of 26th January 1881, I am to observe that, while doubtless of value for the purpose therein specified, this Government are not sufficiently in possession of the facts to enable them to express a decided opinion.

12. Lastly, the proposed extension of the Bangalore-Mysore Railway through the Wynaad to either Mangalore or Beypore, as mainly based in late communications on the impression that one or other of these ports could be made into first-class harbours, must, it is held, be in future discussed from other points of view, as a late joint inspection of these places by the Chief Engineer and the Master Attendant has satisfied this Government that all attempts to do more than facilitate the present system of landing and lading the cargoes of ships in the offing by boats must be finally abandoned as altogether impracticable.

13. While regretting the incomplete manner in which they have been enabled to meet the call of the Government of India in regard to both Irrigation Works and Railways needed for the proper development of this Presidency, as also for its protection against famine, this Government can only point as the direct reason for this to the wholly inadequate strength of the Public Works Establishments, to which the very serious attention of the Government of India has been drawn in correspondence ending with my letter No. 337 W., dated 8th February 1881, and which the Right Honorable the Governor in Council feels that he cannot too often and too seriously bring under the notice of the Government of India.

14. It is only necessary here to remark that the refusal to grant the strength of Establishment which is, in the opinion of the Right Honorable the Governor in Council, essential for the proper administration of the department must unavoidably prevent the completion of the detailed estimates required for the above objects.

15. With reference to Railway works, it is shown in the attached figured statement, compiled by Colonel Shaw-Stewart, that whereas the proportion which Madras bears to the rest of British India is 17·5 per cent. as regards area, 15·5 per cent. as regards population, and 20 per cent. as regards revenue: its total expenditure on railway construction has been only 12·5 per cent., and its total length of line 19·6 per cent., which can hardly be said to bear out the opinion expressed by Major-General Fraser in paragraph 33 of his minute that Madras has been "singularly lucky in this respect."

16. In connection with the remark in paragraph 3 of the letter under reply, that not more than 20 or 25 lakhs could be allotted in any one year, I am directed to submit that this sum is only one-tenth of the total sum proposed to be set aside for the construction of Productive Public Works in the whole of India,—whereas the proportion indicated by the figures given in the last paragraph would be one-fifth or one-sixth. Further, as during the three years ending with 1879-80 the total

expenditure on Productive Works in Madras has been only Rs. 7,20,335 against Rs. 2,15,45,075 in the four provinces of Bombay, Bengal, North-West Provinces and Punjab, it would, in the opinion of the Right Honorable the Governor in Council, be but just and reasonable to assign to Madras in future years more rather than less than its normal proportion of the grant for the whole country.

17. In addition to the special Irrigation and Railway Works, which alone are dealt with in General Fraser's minute, equal consideration should, in the opinion of the Right Honorable the Governor in Council, be given to ordinary communications, in the shape of roads and navigable canals, for the proper development of which the means at the disposal of the Government under "Provincial" and of Local Fund Boards are wholly inadequate.

18. The entire tract north of the Godávari, comprising Rampa, (the disturbances in which have lately caused so much anxiety and expense) Jeypore, and the country beyond in the Central Provinces, are at present devoid of a single mile of road suitable for cart traffic. The coast from Ganjam southward has no navigable canal, though so much needing one, and the Buckingham Canal, on which so large an amount has been laid out, is quite unfinished, though already recognized as a very valuable work.

19. The extension of this last work south of Mercanam, and the construction of a line of West Coast Canal in completion of the work so well finished lately at great expense by the Travancore Government, are all works of importance, to say nothing of the demands in the way of communications which are already making themselves felt in connection with the gold fields of Wynaad, for adequately meeting which there are no sufficient local resources.

20. Looking to the great interests at stake in this Presidency, the devastation and misery occasioned by the late famine, and the present inability of the Public Works Department to meet a similar catastrophy should occasion require it, the Right Honorable the Governor in Council considers he would be failing in his duty if he did not point out in the clearest terms the manner in which this Public Works Department has been starved, and the necessity which now exists for placing it in a position which will enable it in some adequate manner to fulfil its highly important functions. I am therefore to express a confident hope that it will be found possible to provide whatever funds may be required for expenditure on works, the estimates for which have been duly approved, even if the sums so required should considerably exceed the twenty-five lakhs named by the Government of India.

21. In conclusion I am directed to express the entire concurrence of the Right Honorable the Governor in Council in the views expressed in paragraphs 91 to 94 of General Fraser's minute, and his hope that these views will be urged upon the consideration of the Secretary of State.

I have the honor to be,

Sir,

Your most obedient servant,

(Signed) R. H. SANKEY, Colonel, R.E.,
Secretary to Govt., P.W.D.

Fort St. George,
21st February 1881.

Exd. S. T. Austin.

Spare Copies

CHIEF ENGINEER
12 MAR
1881
FOR IRRIGATION

BUILDINGS AND ROADS,
CIVIL WORKS.

Govt. of {1881} Madras.

PUBLIC WORKS

To

THE SECRETARY TO THE
GOVERNMENT OF INDIA.

Dated February 21st.

Issued

Recd. *Encl.*

G. O. 21st February 1881, *No.* 564 W.

FEBRUARY.

No. 9.

ADDRESSING on the subject of the Productive Public Works in the Madras Presidency.

Proceedings of the Madras Government, Public Works Department,
28th July 1870.

No. 441.

No. 118.

Note by the Acting Chief Engineer for Irrigation on the Sungum Project.

THIS project is for the extension of irrigation in what has been named the Northern Delta of the Pennair in the Nellore District, and it is called the Sungum Project because the off-take from the Pennair is situated close to the cusbah town of Sungum, where for many years past two native channels, the Gundaveram and the Duvur, have been in existence and have irrigated with varying efficiency upwards of 40,000 acres of land. Sungum is about 20 miles west of Nellore, which again is 108 miles north of Madras. The Pennair has a drainage basin of about 20,000 square miles; it takes its rise at Nundidroog in Mysore, and runs northwards through the eastern part of Bellary, then across the Cuddapah District from north-west to south-east, and, passing through the Nellore District from west to east, it falls into the sea a little more than 100 miles to the north of Madras.

2. At Nellore an anicut was commenced across this river about fifteen years ago, and was completed some five years later: the channels in connection with this anicut are now nearly finished, and the irrigated area, which was estimated to reach ultimately to 64,000 acres, and which is all to the south of the river, was, according to the latest returns, 57,286 acres. It is now anticipated that the area, which will be irrigated in the Southern Delta, will exceed considerably the acreage originally provided for, and accordingly, instead of allowing only 1,088 cubic feet a second for this Delta, 1,352 cubic feet will be left available, and only the supply which runs to waste after making this deduction has been taken into account in designing works for the better irrigation of the country to the north of the river.

Vide Proceedings Madras Govt., No. 260, dated 21st January 1870.

3. From the papers which accompany this note it will be seen that in October last Mr. R. Smith, the Executive Engineer, who has throughout been charged with the preparation of this project, sent in estimates amounting to 38 lacs for the irrigation of—

	Acres.
The present average area of cultivation	44,053
The area of ordinary wet land left waste for want of water.	19,613
Additional land	19,954
Total...	83,620

and, from the latter part of the report which accompanied those estimates, it will be noticed that the expected net returns from the outlay amounted to 6·36 per cent.

4. An examination of the project so prepared showed that the smallness of the returns likely to be obtained, which returns, I may add, did not appear to me to be sufficient to warrant so large an outlay from Loan Funds, was due to two causes—

1*st*.—The works had been designed upon the data furnished by the register of the Pennair for the year 1863, which was the most unfavourable of the series of eight years, 1861 to 1868, for which reliable records were forthcoming at the time.

2*ndly*.—Some parts of the scheme were found to be much less remunerative than others, and on going into this part of the question I considered it advisable to omit the northern channel, the bank channel, and the auxiliary feeder from the north flank of the Nellore Anicut.

5. In another respect also the arrangements proposed by Mr. Smith appeared to me capable of improvement. It was intended by that officer, for the reasons detailed in the sixth and following paragraphs of his first report, to do without an anicut across the river, and to place the floor of the head-sluice 3 feet below the ordinary deep bed of the river, but 3 feet above the deep bed of a pool which has been maintained at this point owing to certain peculiarities of the site; while, in order to obtain the great discharge, 7,007 cubic feet a second, at that time contemplated, without requiring a head-sluice of corresponding dimensions, the main canal was to have had a fall for a short distance of 7 feet per mile, and a velocity of over 9 feet a second, to guard against the effects of which special arrangements were made.

Dated October 1869.

6. After discussing the subject fully with Mr. Smith it was decided what modifications of the scheme were apparently advisable, and that officer was instructed to revise the project accordingly. The principal alterations which were to be made were as follow* :—

* This office Memorandum, No. 14, dated 18th January 1869.

1*st*.—The substitution of an anicut at Sungum for the arrangement of head-works originally designed.

2*nd*.—The alteration of the main channel so as to carry as a maximum 4,800 cubic feet a second, with a velocity of about 3 feet a second.

3*rd*.—The omission of a bank channel from the main canal to the junction with the feeder from the Kanigherry Tank.

4*th*.—The reduction of the water-level of the Kanigherry Tank to three feet below the level intended in the original project.

5*th*.—The alteration of the arrangements for the supply of the Duvur Tank, so as to allow of the existing channel being utilized.

6*th*.—The omission of the northern channel, the cost of which had been found to be somewhat out of proportion to the area to be supplied.

7*th*.—The enlargement of the principal channel from the Kanigherry Tank, and the omission of the subsidiary canal from the anicut at Nellore.

Proceedings of the Madras Government, Public Works Department,
28th July 1870.

8*th*.—The carriage of the drainage of the southern part of the country affected into the Pennair, instead of the exclusion of all such drainage from that river, and its diversion to the eastward and northward.

7. With these modifications which, it may be remarked, include the all-important alteration of the basis on which the works were to be designed from the water-supply of the worst year to the average of eight years, of which that worst year was one, it appeared probable that the area to be irrigated might be extended from 83,620 acres to 94,000 acres, and that the estimates might at the same time be educed from 38 to 26 lacs of rupees.

8. A few words may be said perhaps with advantage regarding the considerations which have appeared to me to make it desirable to plan the project with reference to the average, rather than the minimum, water-supply available. In the first place the choice seemed to lie between carrying out a scheme promising to be fairly successful and remunerative, and weighting the project with the extra cost of almost absolute security, which probably would have resulted in swamping it altogether. I think I am correct in saying that not one of the irrigation systems in this Presidency has been laid out so as to be completely efficient with a minimum water-supply. Not even the first-class rivers, of which there are but three, the Godavery, the Kistna, and the Cauvery, have a sufficient minimum supply for more than an insignificant fraction of the area watered by them; nevertheless, nearly 1½ millions of acres are successfully irrigated by them without the aid of tanks or reservoirs. With one or two exceptions irrigation under the other rivers is carried on with the aid of tanks, and in these cases the safest plan seems to be to ascertain what has been found possible and sufficient under certain circumstances, and to deduce from the facts thus made available what arrangements may be expected to give satisfactory results. Now, as regards the Pennair, we have some ten or twelve years experience of the character of the river, and we know that a certain quantity of water led off from the river has, with the help of the monsoon rainfall, sufficed to irrigate a certain number of acres in the Southern Delta. In preparing the revised project a similar and proportionate supply has been allowed. We know, moreover, that two small and irregular channels, having their heads at Sungum, have supplemented the supply of the tanks of the Northern Delta sufficiently to provide for the cultivation of a certain area,* and it is now proposed to give far more capacious channels in proportion to the extended area, and to ensure these channels being filled, whenever the state of the river will admit, by means of an anicut, instead of leaving them to catch such a supply as happened to find its way to the head, or was led there by temporary sand-bunds.

Gundaveram and Duvur.

* Acres 14,053 on the average.

In the second place it appeared to me that the Government cannot afford to construct irrigation works on such a scale as to carry a full supply in a year much less favourable than the average, and that it is better to run the risk, or, it may be the certainty, of having the successfully cultivated area variable, rather than

design works which in average years could carry all the water wanted in less than half the time available for the performance of this duty.

9. From the register of 1863 it was found that only fifteen days were to be had for passing down the Sungum Main Canal the whole of the water needed for 83,620 acres. On the other hand, the average supply of the eight years admits of thirty-three days being used for carrying the proper quantity for 94,000 acres. The difference is very important, and I think the true bearing of the question will be the better appreciated from the following illustration. The net return on the original project was estimated at 6·36 per cent., that on the revised scheme at rather more than 50 per cent. additional. Now, supposing the people had to pay in either case sufficient to yield the higher returns to Government, they would have to be assessed at 50 per cent. more with the original, than with the revised, project. The assessment is taken to be $5\frac{1}{2}$ rupees, so that for seven years out of eight they would have to pay $2\frac{3}{4}$ rupees per annum to render secure the value of, say, half the crop in one year, and this value would be 5 or 6 rupees. The Government, too, will be better off in obtaining $(8 - \frac{1}{2}) \times 9 = 67\frac{1}{2}$ per cent. on the outlay in eight years, instead of $8 \times 6 = 48$ per cent. in the same time.

10. On the average, then, it is supposed that for thirty-three days in each year there will be enough water in the Pennair to supply all existing cultivation below Sungum and to afford 4,800 cubic feet a second to the area under the proposed Sungum Anicut, and the works have been designed accordingly. The data on which this conclusion has been come to will be found in Appendices B. and C. attached to Mr. Smith's first report. As, moreover, the rice-crop requires water from September until January, it is not enough to provide for the total supply required being drawn off from the river in thirty-three days, but the quantity not consumed in that time in the fields must be stored in readiness for use when the discharge in the main canal is below the average quantity required. 94,000 acres would, at the usual rate of two cubic yards per acre per hour, consume 1,410 cubic feet out of the 4,800 cubic feet a second to be carried by the main canal; the rest will be stored chiefly in the Duvur and Kanigherry reservoirs, the capacity of the latter of which it is intended to raise from 77·44 millions of cubic yards to 237·74 millions, and partly in the numerous tanks, some of which, and especially the two near Alluru, are of considerable size. The total storage capacity provided in the revised project is for 320·59 millions of cubic yards, which is equivalent to more than half the total quantity, 506·88 millions, which is to be brought from the river. The existing storage amounts to 152·50 millions, and this has sufficed for 44,053 acres, and 94,000 acres would at the same rate require 325·4 millions to be stored, a quantity to which 320·59 millions approximates sufficiently closely when the much more complete arrangements intended to be introduced are taken into account.

11. It has been assumed that 8,000 cubic yards of water will be required for each acre of cultivation, this being the usual allowance in the Eastern Coast districts near Madras. Of this total, 6,000 cubic yards will, it is expected, have to be derived from the river, leaving 2,000 to be obtained from rainfall. Also of the 6,000 cubic yards 5,392 will be carried during the time* the main canal will, it is anticipated, carry a full supply, while the difference, 618 yards, will be made up when

* Thirty-three days.

the river is comparatively low but nevertheless discharging more water than is needed lower down. Altogether the registers show that on the average the canal will run full for $33\frac{1}{3}$ days and will obtain about one-fourth of the maximum supply on $9\frac{7}{8}$ days, and this will more than suffice.

12. As regards the returns to be derived from the proposed outlay, it will be seen that, of the 94,000 acres to be irrigated, 6,056 acres are Inam lands, from which probably no additional revenue will be derived. Mr. Smith, after consultation with the Collector of Nellore and the Officers of the Settlement Department, who are at work in the district, has taken $5\frac{1}{2}$ rupees as the assessment of all the Government lands to be irrigated. The correctness of this rate will, I think, require confirmation in the Revenue Department before the sanction of the Government of India is asked to the execution of the project from Loan Funds, but it may be remarked here that the evidence is strongly in favour of the conclusion that at the approaching revision of the assessment a lower average rate will not be fixed. The gross returns would then be—

Vide Appendix C. to the Memorandum on the revised scheme.

	RS.
94,000 — 6,056 = 87,944 acres at $5\frac{1}{2}$	4,83,692
Deduct the present average annual revenue on 45,131 acres of Government land	1,75,736
Increase of revenue...	3,07,956

It cannot, however, be considered that the whole of this increase of revenue will be directly due to the proposed works, though they will without doubt make it comparatively easy for the ryots to pay an enhanced rent for their lands, whether hitherto irrigated but less efficiently, or newly converted into wet lands. Paragraph 3 of the letter from the Deputy Director of Revenue Settlement given in Appendix C. shows that the dry assessment in the Nellore and Gudur talooks averages about 1 rupee, and, deducting this from $5\frac{1}{2}$ rupees, the supposed revised assessment inclusive of water-rate, $4\frac{1}{2}$ rupees remain as the amount of the latter, and this multiplied by the number of acres to be newly irrigated will give the returns due solely to the provision of the means of irrigating an additional area. That area is 87,944 — 44,053 = 43,891 acres, and these returns would accordingly be Rupees 1,97,510. At the same time improved means of irrigation directly affect the paying powers of the landholders; and, if the water-supply be made such as to warrant the imposition of an assessment of $5\frac{1}{2}$ rupees on the dry and waste lands, which may be supplied by the Sungum channels, this circumstance cannot but have much weight in determining the proper assessment to be fixed, when the revision takes place, on the heretofore irrigated lands, and thus much of, though perhaps not all, the increase of revenue from these lands also may be fairly taken into consideration, in estimating the returns from the proposed outlay. Moreover, the water-rate above referred to is an addition to a dry assessment; but where lands have not been cultivated with dry grains, and where by and as a consequence of, providing water the Government obtain the returns represented by the dry assessment, this amoun also may properly be placed to the credit of the works which make the supply of

water to these lands possible. The practice in this Presidency has been to calculate returns from irrigation works by comparing the actual revenue derived during a series of years antecedent to the construction of those works with that subsequently obtained, and this is perhaps a sufficiently accurate method. In the case of the Nellore Anicut reductions of assessment were made on much of the land watered, and that project has in consequence suffered an apparent depreciation of its remunerative results. It is now in contemplation to revise the assessment, and the Southern Delta system will then show accordingly proportionately better returns. As regards the Sungum project then, it may be considered unobjectionable to calculate the gross returns as being the difference between what has been, and what will be, derived from the lands affected.

13. The following is a general abstract of the estimates as revised by Mr. R. Smith :—

Items.	RS.
1.—Anicut and head-works	7,09,000
2.—Main feeder	3,44,000
3.—Enlarging Kanigherry reservoir	3,42,300
4.—Duvur Tank-supply channel	15,020
5.—Duvur branch channel	33,600
6.—Eastern main do.	5,59,300
7.—Feeder from Kanigherry reservoir	87,200
8.—Central channel	52,700
9.—Southern do.	2,03,500
10.—River embankment	1,32,000
11.—Tramway and rolling stock	49,820
12.—Temporary buildings and contingencies	25,185
13.—Field and office establishments	3,19,200
	28,72,825
Deduct the value of the land in the beds of tanks to be abandoned	1,72,825
	27,00,000

The works have been very carefully designed and estimated for by Mr. Smith, and the manner in which he has prepared both the original and the revised projects does him great credit. In going through the designs of the works, I have come to the conclusion that some considerable reductions of cost may be effected. I may instance the foundations of the anicut and sluices, in which the substitution of circular for square wells will be economical and will much facilitate the execution of the work. The widths of the aprons, too, will probably be found to admit of reduction, as the cross section of the anicut contains proportionately more material than that at Nellore, which has to discharge the same volume of water with a length of only 1,581 feet, while the Sungum Anicut will have an effective length of 3,960 feet. Moreover, the height of the former is some two feet greater. An examination in detail of the designs and estimates has led me to the conclusion

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that some considerable saving of cost will be found practicable when the works come to be carried out. All that I propose to do now is to make the following changes, which I have discussed with Mr. R. Smith :—

	Reduction. RS.
1.—Reduction of estimate for raising the Dorenal road from Rupees 16,500 to Rupees 2,500	14,000
2.—Do. for flood-bank on south side of the river ...	6,000
3.—Omission of the southern set of under-sluices ...	50,000
Total...	70,000

The first two items are affected by the calculated effect of the anicut in raising the maximum flood-level in the Pennair. The increase of this level was estimated by Mr. Smith at 5 feet, (*vide* paragraph 7 of his Memorandum,) but this appears to be a mistake. Some time ago I calculated the flood discharge of the river at Adimapully, some 75 miles higher up, on tolerably good data, at 50 millions of cubic yards an hour. Adimapully is below the last great affluent, and the drainages falling into the river in the 75 miles are none of them very important. I think, therefore, that an addition of 10 millions of cubic yards will be ample, thus making the flood discharge 60 millions, or 450,000 cubic feet a second. The cross section of the river at Sungum with the surface fall* give a discharge of 60⅓ millions of cubic yards,

Plan No. 137.
* Three feet a mile.

and, the drainage basin being about 20,000 square miles, the formula $D = 75{,}000\,M^{\frac{2}{3}}$ makes the discharge 55·175 millions. Altogether, then, it appears to be safe to assume that 450,000 cubic feet a second is the maximum quantity to be passed over the anicut, and, the normal flood-level being 11 feet above the crest, an increase of level to the extent of 18 inches only will take place.

But for this difference it would have been necessary to raise the roadway of the head-sluice 3½ feet, which would have added considerably to the cost of that work.

The omission of the southern set of under-sluices is advisable, because no off-take is proposed on the south bank, and, except for keeping a head-sluice clear, such works in the body of an anicut are objectionable, as being a source of expense and of weakness. It is possible, though in my opinion not very probable, that a channel may hereafter be constructed on the south side to improve the supply of the Nellore Tank; but it is not necessary, I think, to spend money now in anticipation of such an arrangement, because in the first place the present project will consume almost all the water which the river has to spare, except for very limited periods, and it may be assumed, therefore, that works on the south side would be extremely expensive in proportion to the acreage. The Northern Delta works will cost per acre about twice as much as those of the Southern Delta, and similarly any future works on the south bank would cost at least three times as much per acre as the Northern Delta, owing to the large capacity of channels and head-works required to pass the supply in about ten days, which are all that would be available.

14. The details of the field and office establishments proposed by Mr. Smith are given in paragraph 101 of the report on the original scheme. I would modify them slightly as follows:—

	Salaries and allowances.	Total	
	RS.	RS.	
1 Executive Engineer	1,050	1,050	
2 Assistant Engineers	420	840	
2 Sub-Engineers	300	600	
8 Overseers	90	720	
12 Maistries	30	360	
1 Head Clerk	60	60	Executive Engineer's office.
1 Accountant	60	60	
1 Computor	25	25	
1 Draughtsman	50	50	
2 Copyists	30 and 25	55	
2 Goomastahs	15 and 12	27	
1 Peon at 7, and 4 Lascars at 6 ...	...	31	
2 Accountants	30	60	2 Assistant Engineers' offices.
2 Clerks	20	40	
2 Goomastahs	12	24	
2 Peons at 7, and 6 Lascars at 6 ...	...	50	
2 Writers and Accountants	22	44	2 Sub-Engineers' offices.
2 Lascars at 7, and 4 at 6 rupees ...	...	38	
8 Writers and Accountants	15	120	8 Overseers' offices.
8 Lascars	6	48	
2 Dressers	50	100	
2 Toties	5	10	
		4,412	
Office contingencies		138	
Total per mensem ...		4,550	
Do. per annum ...		54,600	

This establishment would be required for five years, and the provision in the estimate should, therefore, be Rupees 2,73,000, instead of Rupees 3,19,200 as allowed by Mr. Smith. With these alterations the grand total of the estimates will become Rupees 25,83,800.

15. It is necessary, however, to say a few words on the subject of the deduction of Rupees 1,72,825 on account of the value of land in the bed of tanks to be abandoned. These tanks will not be required to hold water, and their beds will be available for wet cultivation: they are shown on the sketch map, being distinguished by cross hatching from the tanks to be retained. It is proposed to sell the right of occupation by auction; the total area is 7,488 acres, and the Deputy Director of Revenue Settlement is of opinion that these lands, which are generally rich, should fetch 25 rupees an acre. Government have recognized (G. O., R. D. No. 1,545, dated 7th September 1860) the propriety of so disposing of tanks thus circumstanced, and in this case the course suggested would seem to be unobjectionable.

Vide Appendix E.

16. In paragraph 12 above the expected increase of revenue was noted as being Rupees 3,07,956, and this would give a gross return of 11·91 per cent. on Rupees 25,83,800. Mr. Smith estimates the cost of maintenance as follows:—

	Per annum.
	RS.
Conservancy establishments	16,140
Repairs, at 2⅜ annas per acre	15,666
Do. of anicut	6,000
Total...	37,806

The Executive Engineer states that the acreage allowance has been derived from the actual expenditure per acre in the last five years in the Southern Delta, to which he has added 10 per cent. I am inclined to think that the cost of maintenance may be more safely estimated to be—

	RS.
Anicut repairs, about 2 per cent.	8,500
Head-works	1,500
Subsidiary works	35,000
Conservancy establishments	15,000
Sundries	956
Total...	60,956

the net returns will then be Rupees 2,47,000, or 9·56 per cent. on the estimated outlay.

17. Appendix A., attached to the Executive Engineer's Memorandum, gives a list of all the documents belonging to the revised project. Appendix B. shows the acreage under, and the discharge with other particulars of, each principal channel. Appendix C. contains the correspondence relating to rates of assessment; D. relates to land compensation; and E. to the value of lands in the beds of tanks no longer required for storage.

18. The rates allowed in Mr. Smith's estimates appear to me to be reasonable; and, if the project be carried out under that officer's supervision or by some other competent Executive Engineer, I have little doubt of their proving ample. As regards a work of this kind it may be said that one must know who is to carry it out before it can be determined what are likely to prove to be sufficient rates. First-rate superintendence is worth its cost over and over again.

Mr. Smith has provided in some cases not only for carrying the quantity of water required for the acreage under the channels, but also for what he calls a maximum quantity. This arrangement necessarily adds to the expense, for, to take an instance, a depth of eight feet instead of six feet in a channel increases the depths of cuttings and height of embankments. All that will be necessary and advisable in carrying out the channels will be to construct them so as to convey the water needed for the acreage, or for their share of that acreage. Should hereafter a larger acreage be found available, and should the water-supply prove better than it has been assumed to be in preparing this project, increased capacity can readily be given to the channels by partial widening, and the soil so obtained will provide earth for raising the embankments. Again some of the designs of the masonry works may be revised so as to be equally efficient and cost less, and it will be advisable to confine the use of iron in culverts, regulating sluices, etc., to positions where it is mani-

festly the most suitable material. I have not considered it necessary to make any present alteration in the designs and estimates; but I have written out a memorandum upon them, which will be made use of when the working drawings come to be prepared. I have met with no instances in which greater expense than that allowed in the estimates is likely to be incurred, and the lowering of many of the embankments two feet and of masonry works to the same extent will manifestly reduce the cost of the project.

19. I have had an index map prepared showing the whole course of the Pennair from its source near Nundidroog and indicating the area to be irrigated in connection with the Sungum Project as also that under the Nellore Anicut.

FORT SAINT GEORGE,
12th May 1870.

(Signed) J. MULLINS, Major, R. E.,
Acting Chief Engineer for Irrigation.

Memorandum on the revised scheme for the irrigation and drainage of the Northern Delta of the Pennair.

THIS project has been revised agreeably to instructions received from Major Mullins, the Acting Chief Engineer for Irrigation: it differs from the original scheme, submitted with my letter, No. 57, dated 30th October last, in several details, the principal being—

I.—An alteration in the head-works.
II.—A reduction in the capacity of the main channel from the river.
III.—Dispensing with the bank channel.
IV.—Reducing the capacity of the proposed Kanigherry reservoir.
V.—The utilization of the Duvur Tank channel.
VI.—Excluding the northern channel.
VII.—Omitting the auxiliary feeder from the northern flank of the Nellore Anicut.
VIII.—The admitting of the drainage into the Pennair instead of diverting it from that river.
IX.—The irrigation of 10,380 acres in addition to the area originally contemplated.

2. As the existing irrigation in the locality commanded by the proposed works and the uncertain river we have to deal with have been fully described in my first report, I will confine my observations to the modified scheme and the arrangements decided on for the irrigation of the country under notice at a less cost than estimated by me.

3. The principal dissimilarity in the two projects consists in one being based on the water available for the extension of irrigation in the worst season of a series of eight years; the other has been planned with reference to the supply attainable on the *average* of this series.

4. In the scheme now submitted a weir has been substituted for the river wall; it will be built near the head of the comparatively straight reach in the Pennair that extends from Sungum for some miles down the river.

Alteration in head-works.

5. The level of the crest of the anicut has been fixed at 105 feet above mean tide, or seven feet higher than the deep bed of the Pennair at the proposed site.

Proposed anicut and sluices.

In connection with the anicut one head-sluice and two under-sluices have been designed; the floors of the latter will be on the same level as the deep bed of the river. The floor of the former will also be on this level until it approaches the down-stream apron, where a drop of three feet has been planned to increase the depth of water from six to nine feet, to reduce the cost of constructing the channel between the head-sluice and the Kanigherry reservoir.

Peculiarities of head-sluice noticed.

6. The head-sluice consists of forty vents of $4\frac{1}{2}$ feet span. It has been designed to discharge 4,800 cubic feet per second when the water in the river is flush with the crest of the anicut. The rear wings and apron have been planned to correspond with the decrease of breadth due to an increase of three feet in the depth of the channel immediately in rear of the head-sluice.

7. The breadth of the Pennair at the site of the proposed anicut is 4,219 feet; this space will be occupied as follows:—

	Feet.
By body-wall of anicut	3,767
By wing-walls and sluices	452

This amount of obstruction will, I calculate, raise the surface of the water five feet immediately in front of the anicut during extraordinary floods.

Effect of anicut on extreme floods.

8. The river embankments and masonry works have, therefore, been designed to meet this contingency and to act effectively under the increased head due to the construction of the proposed structure.

9. In great floods, similar to that of 1852, a portion of the Dorenal road would be submerged; provision has accordingly been made in the estimate for raising it where necessary.

10. By referring to the drawing* of the anicut, the alignment of this work and the positions of the sluices will be clearly seen: the approaches have been planned with an inclination of 1 in 18 to admit of the whole being used as a means of communication for the local traffic between the freshes.

* Sheet No. 136.

Masonry wells have been allowed for the foundations of the anicut, head, and under-sluices; they are of different dimensions to suit the several parts they have to sustain.

The shutters of the head and under-sluices will be worked by screws, the arrangement being similar to that described in my first report for those of the main head-sluice at Sungúm.

11. According to the revised arrangements the maximum volume to be taken off from the Pennair is 4,800 cubic feet per second; this will be conveyed as annexed—

Main supply-channel and Duvur tank-feeder.

	Cubic feet.
By main channel to Kanigherry reservoir	4,576·5
By Duvur Tank supply-channel	223·5

12. The main channel has been designed to discharge the required volume with a depth of 9 feet; the water section will then be 1,535·625 square feet, and the mean velocity of the stream 2·98 feet per second.

Main channel from Sungum Anicut.

13. The level of the bed of this duct will be 95 feet above mean tide at the anicut head-sluice; from this point to the end of the channel in the Kanigherry reservoir, a distance of six miles, it will fall at the rate of 9½ inches per mile.

After deducting this slope from the difference of level that exists between the head-sluice and the bed of the reservoir, 10·05 feet remain to be disposed of by a masonry work; a drop has, therefore, been planned for erection in the fourth mile to consume this extra fall. The crest of this work will be on the same level† as the high-water mark of the Kanigherry reservoir.

† 94·45 feet above mean tide.

14. The side slopes and bed of the channel below this fall and in rear of the head-sluice will be protected by rubble pitching for a length of 440 yards.

15. At 3·275 miles from the head-sluice the main channel intersects the Dorenal road; this communication will be carried over it by a wrought-iron girder bridge of three spans of 60 feet.

16. In this scheme the bank channel has been omitted. It was included in the original plan as it seemed desirable to have the means of supplying the southern and central channels direct from the Pennair during freshes in that river.

Bank channel.

17. In the modified scheme the level of the water in the Kanigherry reservoir is to be raised 9 instead of 12 feet as originally contemplated. This alteration will save a deal of labour but not much land, as the original and proposed fall contour lines run very close to each other.

Reservoirs.

18. Judging from the supply of water available on the average of a number of seasons, the reservoirs provided in the original design are excessive and may be reduced, or they may be retained and a larger area cultivated under them. The latter alternative has been in the main adopted, as it was found on investigation to be the more advantageous of the two.

19. The number and capacities of the reservoirs will, therefore, remain unaltered with the exception of the Kanigherry Tank, the capacity of which it is proposed to reduce from 8,112,614,400 to 6,419,001,600 cubic feet; the difference (1,693,612,800 cubic feet) deducted from the aggregate capacities of the tanks* allowed in the original scheme gives 8,655,987,700 cubic feet as the provision for storage in the revised project.

* Inclusive of the Alluru large tank.

20. By referring to paragraphs 21, 25, and 91 of my first report on the scheme for the irrigation of the Northern Delta of the Pennair, it will be observed

that the volume of water to be stored in the reservoirs under the auxiliary feeder from the Nellore Anicut is 540,000,000 cubic feet; that the maximum quantity to be impounded in the Kanigherry and Duvur reservoirs in a year similar to 1863 is 7,669,388,567 cubic feet; and that the capacity of the Alluru Pedda tank or Pydaru reservoir is 528,000,000 cubic feet.

21. From the above and the details contained in the appendices to the report alluded to it will be gathered that the storage capacity actually required to secure the irrigation of 83,620 acres in the worst season of the series of eight years is 8,737,388,567 cubic feet; this capacity, it will be noticed,† is greater than that allowed for the 94,000 acres under the modified scheme.

† *Vide* paragraph 19.

22. This seeming discrepancy is the result of the different data on which the two schemes are based, and it will be found, by referring to the tabulated statements‡ showing the general state of the Pennair from 1861 to 1868 inclusive, that the volume of water available on the average during this period is so considerably in excess of the quantity attainable in a corresponding year to 1863§ as would justify the quantity to be stored for each acre under cultivation being reduced to a greater extent than proposed in the revised project.

‡ Appendix C. to first report.

§ The worst season.

23. The water to be stored in the minor reservoirs will be conveyed to them by allowing the principal channels under the Kanigherry reservoir to flow a few inches deeper than necessary to supply the direct irrigation dependent on them.

24. By taking the average state of the Pennair as the standard, the maximum volume to be supplied by this river can be drawn off for thirty-three instead of fifteen days as stated in paragraph 19 of my original report. This addition of eighteen days to the time originally calculated on for drawing off water from the Pennair has reduced the maximum quantity to be taken off from it to 4,800 cubic feet per second, which is practically the volume discharged by the Nellore Anicut with a head of one foot.

25. The synopsis* attached to my first report on this project shows that the water was one foot and upwards on the crest of the Nellore Anicut for thirty-three days on the average of eight consecutive years.

* Appendix C.

26. The present Duvur Tank will be connected with the proposed main channel from Sungum by a cut taken off at 99 feet above mean tide immediately in rear of the anicut head-sluice. This cut will have an inclination of 1 in 3,520, and will discharge 223·5 cubic feet per second.

Duvur Tank supply-channel.

27. I find the old channel from the existing head-sluice to the Duvur Tank can be arranged to discharge 223·5 cubic feet per second at a trifling outlay; I have, therefore, adopted this section as it is ample together with the Duvur branch channel to fill the Duvur tank in thirty-three days.

28. The Duvur Channel will take off from the Duvur Tank and cross the main duct from the anicut a short distance above the fall proposed for construction in the fourth mile of this branch. The first reach of the Duvur Channel has been planned to act as an auxiliary supply channel to the Duvur Tank during floods in the Pennair, and to draw off 43·5 cubic feet per second from this reservoir for the irrigation of 2,900 acres between the freshes in that river.

Duvur branch channel.

29. The Duvur Channel will discharge the maximum volume of water required for the land under it with a depth of 1½ feet. This depth has been fixed with reference to the level (92·804 feet above mean tide) of the main channel, where it is intersected by the Duvur Channel and the level (94·45 feet above mean tide) of the crest of the proposed fall in the fourth mile of the former.

30. It will be observed, by comparing the longitudinal sections of both channels, that the levels of their respective beds are the same at the intersection, and that the proximity of the fall referred to renders the construction of a syphon unnecessary. It is true the water will stand back in the main channel from the fall to nearly two miles above the crossing, and there will consequently be some loss by evaporation and absorption, but practically there is no objection that I am aware of to the arrangement.

31. The details of the irrigation under the several reaches in the Duvur Channel will be found in Appendix B. The revised longitudinal and transverse sections of this branch are given in Tracing No. 144.

Irrigable area under Duvur Tank.

32. It is proposed to water 3,700 acres from the Duvur Tank as annexed :—

	Acres.
By existing sluices	800
By Duvur Channel	2,900

33. In the original scheme the northern channel was intended to water a considerable tract of jungle land above the margin of the delta. This branch has been abandoned as it crosses the drainage of the country and is naturally an expensive line in comparison with the other channels.

Northern channel too costly.

34. As an anicut is to be substituted for the river wall at Sungum and a considerable reduction has been made in the volume of water to be drawn off per second from the Pennair during floods, the necessity for the auxiliary feeder from the Nellore Anicut no longer exists ; it has, therefore, been omitted in the modified scheme.

Reasons for omitting the auxiliary feeder.

35. Self-acting outfall sluices* to discharge the local drainage into the Pennair have been designed for construction in the river embankment near Minagallu, Zonnavada, Padugaparu, Zammipalem, and Veguru.

*Tracing No. 169.

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36. The original project provided for the irrigation of 80,000 acres under the Pennair and 3,620 acres under the Pydaru ; in the revised scheme the distribution channels and masonry works have been designed to discharge sufficient water for the irrigation of 94,000 acres.

Irrigation proposed under original and revised schemes.

Subjoined is the acreage under each source of supply :—

Duvur Tank	3,700
Eastern main channel and branches	62,300
Central channel	10,500
Southern channel	17,500

37. The eastern main channel will, according to the revised arrangement, take off from the head-sluice originally planned for the northern channel and follow the line set out for this branch for a distance of 3·625 miles, *i. e.*, until it joins its original head.

Eastern main channel.

From this point the section of the eastern main channel has been modified to correspond with the increased capacity given to the first 3·625 miles of the northern channel, which become in the revised scheme the first 3·625 miles of the eastern main channel.

38. In the original scheme the auxiliary feeder from the Pennair formed the connecting link between the eastern main channel and the Pydaru ; a separate branch must, however, be provided for this purpose in the revised scheme, as the auxiliary feeder from the Pennair does not form a part of the modified plan.

39. A feeder has accordingly been designed to discharge into the Pydaru the volume of water required for the irrigation of the 25,000 acres north of this river ; it will take off from the eastern main channel near Gundaveram and fall into the Pydaru a short distance west of Trunk Road No. VI.

40. In the revised scheme the Alluru Pedda Tank will be available for the storage of Pennair as well as Pydaru water.

This modification of the original arrangement admits of the section of the Ramannah Tank channel being reduced and the substitution of a road tunnel for the bridge allowed in the line of the Kavaragunta road.

41. In addition to the alterations referred to a few masonry works have been omitted and the designs of several have been modified to agree with the revised sections of the eastern main channel.

42. As the detailed arrangements for the irrigation and drainage of the country north of the Pydaru have been fully described in my first report, I have only to add that the tabulated statements* attached to this communication contain all necessary information regarding the different reaches of the eastern main channel and branches as now planned.

* Appendix B.

43. A list of the drawings and specifications to accompany the revised estimate for the eastern main channel and subsidiary works will be found in Appendix A.

44. In the original scheme it was intended to supply the southern and central channels during floods in the Pennair by the bank channel; as the latter has been omitted in the revised arrangements, the supply for these branches will be drawn from the Kanigherry reservoir and distributed to them by the feeder that takes off from the southern margin of this reservoir.

Feeder from Kanigherry reservoir.

45. As no water is to be drawn direct from the Pennair for the central and southern channels, I have changed the position of the head of the central channel from the Punchedu Tank to 56 chains on the line of the feeder referred to in the foregoing paragraph.

46. This modification, which reduces the section of the feeder between the head of the central and southern channels, and the construction of a regulator at 58 chains from the reservoir, are the only alterations deserving notice in the feeder under consideration.

47. Appendix A. contains a list of the drawings to accompany the revised estimate of this feeder.

48. The alteration in the head of the central channel has been noticed in paragraph 45.

Central channel.

The other modifications are —

I.—The substitution of a regulating sluice for the fall originally designed for the head of this branch.

II.—An alteration in the site and design of the fall proposed for construction in the fourth mile.

III.—The construction of a road tunnel in the line of the Dorenal road.

IV.—The omission of 2·6 miles of the Challayapalem drainage channel and all masonry works planned in connection with this outlet.

V.—The exclusion of the proposed Paturu drain and aqueduct.

VI.—An alteration in the fall originally proposed for construction in the 7th mile.

49. It will be observed that the principal change is in the disposal of the drainage. This will be allowed to follow its old course and fall into the Pennair instead of being diverted to the Moldavy as suggested by me.

50. The road tunnel is necessary in consequence of the alteration in the site of the fall adjacent to the Dorenal road.

51. The drawings relating to the modified design of the central channel are enumerated in Appendix A.

52. The details of the irrigation and distribution in each reach of the central channel are given in Appendix B.

53. The southern channel begins at the termination of the feeder from the Kanigherry reservoir. The regulator allowed for the head of this branch has been omitted in the revised scheme, as the supply of water will be received from one instead of two sources as contemplated in the original plan.

Southern channel.

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54. An outfall sluice in the river embankment has been substituted for the drainage culvert planned for construction in the first mile of the southern channel.

55. As the local drainage is to flow into the Pennair, the culvert proposed for construction in the fifth mile has been omitted in the revised scheme, and one of similar design to that provided for the first mile of the southern channel* has been substituted to admit of the surface discharge flowing towards the Pennair, into which it will ultimately fall, by the self-acting sluice proposed for erection, near Bapanapadu.

* In the original scheme.

56. In the original scheme the Kovuru Channel was intended as the outlet for this drainage, and a cut was proposed to connect it with the water-course that runs between Penahalli and Bapanapadu. This cut has, of course, been omitted in the preparation of the revised scheme.

57. The aqueduct provided in the original project for construction in the 11th mile of the southern channel will not be required as the auxiliary feeder from the Nellore Anicut has been excluded in the modified scheme.

58. To admit of the local drainage flowing off to the Pennair, aqueducts have been designed for erection in the 16th and 17th miles of the southern channel, and a culvert has been provided for a similar purpose in the 11th mile of this branch.

59. The above are the principal modifications proposed for adoption in the southern channel. The details of the several reaches as now arranged and the irrigation under each are given in Appendix B.

60. A list of the drawings to accompany the revised estimate for the southern channel is given in Appendix A.

61. Having described the general arrangements proposed in connection with the modified scheme for the irrigation of the Northern Delta of the Pennair, I will proceed to notice the probable effect the works will have on the revenue.

62. From the statement† attached to my first report it will be seen that the area of land under cultivation in that Delta is 55,366 acres, and that the average revenue derived from this area is Rupees 1,90,406 annually.

† Appendix A.

63. As the northern channel has been excluded in the revised scheme, the area of the land at present under cultivation in the locality traversed by it and the annual assessment derived therefrom have to be deducted from the above totals. The former may practically be taken at 4,179 acres, and the latter at Rupees 14,670.

64. The total area, therefore, under cultivation in the tract commanded by the revised scheme is 55,366 — 4,179 = 51,187 acres. The average annual revenue derived from this acreage equals 1,90,406 — 14,670 = 1,75,736 rupees.

Existing cultivation and revenue.

65. The modified scheme is intended to water 94,000 acres, or 42,813 acres in excess of the total area under cultivation.

Additional area to be irrigated.

66. In the country commanded by the proposed channels there are 8,028 acres of Inam land classed as "wet," of which 6,056 acres appear to be cultivated; deducting this area from the 94,000 acres to be irrigated, leaves 87,944 acres of Government land to be benefitted by the proposed system of irrigation.

67. As the assessment on the irrigable lands in this district has not been settled, the exact increase of revenue cannot be stated; but a close approximation will be attained by allowing Rupees 5½* per acre as the *average* rate of the whole Delta. This rate has been assumed with the concurrence of the Acting Collector and the Deputy Director of Revenue Settlement, as will be seen by referring to Appendix C.

* Inclusive of the dry assessment.

68. By referring to paragraph 55 it will be observed that 87,944 acres of Government and 6,056 acres of Inam land will be watered by the proposed scheme. The assessment on the former at Rupees 5½ per acre would be Rupees 4,83,692, or Rupees 3,07,956 in excess of the current revenue.

Gross profit.

69. From this gross profit the cost of the annual repairs and the Conservancy Establishment must be deducted to ascertain the net return.

70. The establishment proposed in paragraph 111 of my first report will, I consider, answer very well for the revised scheme. The estimated cost of this, it will be observed, is Rupees 16,140 per annum.

Conservancy Establishment.

71. In estimating the amount required for repairs I propose to allow, as I did on a former occasion, 10 per cent. per acre in excess of the actual expenditure on repairs in the Southern Delta of the Pennair during five consecutive years. This calculation gives 2 annas and 8 pies per acre, or Rupees 15,666 per annum, for the Northern Delta. To this sum Rupees 6,000 should, I am of opinion, be added for anicut repairs, making the total amount required for the Conservancy Establishment and repairs Rupees 37,806, say Rupees 38,000 per annum.

Estimated cost of annual repairs.

72. The rates allowed per acre for compensation for land have been fixed in accordance with the Acting Collector's valuation; † they are, as a rule, much higher than entered in the original estimate, but the total sum required to cover all expenditure under this head will be less than will be realized by selling the "right of occupation" of the land in the beds of those tanks that will not be required on the completion of the proposed works and which are to be brought under cultivation.

Compensation for land.
† *Vide* Appendix D.

73. By referring to Appendix E. it will be seen that the Deputy Director of Revenue Settlement considers this land will realize Rupees 25 per acre on the average. I should perhaps explain that this payment is merely for the right of occupation; the usual assessment will be paid by the purchaser annually, irrespective of the amount paid for obtaining possession of the land.

Value of land in beds of superfluous tanks.

74. The tanks to be abandoned are clearly indicated on the revised sketch map.* The area of land within their full contours is 6,913 acres. This area, at Rupees 25 per acre, represents Rupees 1,72,825, the amount to be deducted from the estimated cost of the project.

* Sheet No. 170.

Tanks to be brought under cultivation.

75. A similar establishment to that detailed† for the original project, but for a shorter period, will be required to superintend the works proposed for construction in the modified scheme. Rupees 3,19,200 have accordingly been allowed in the revised estimate for superintendence.

† Paragraph 101 of first report.

76. Provision has been made in the revised estimate for a tramway being laid from the Sungum Quarry to the anicut, and for a line, three miles in length, to transport the stone and gravel required for the revetment of the Kanigherry reservoir embankment.

77. I have now, in conclusion, to notice the probable return that will be realized from the proposed works.

By referring to paragraph 68 it will be observed that the gross profit is estimated at Rupees 3,07,956, and from paragraphs 70 and 71 it will be gathered that the Conservancy Establishment and repairs will cost Rupees 38,000 annually.

By deducting this sum from the former, the net profit will be found to be Rupees 2,69,956, or 9·9984 per cent. on the estimated expenditure of Rupees 27,00,000.

Probable return on proposed outlay.

(Signed) R. SMITH,
Executive Engineer on Special Duty.

NELLORE,
22nd April 1870.

REVISED SCHEME.

APPENDIX A.

List of Estimates, Drawings, Tracings, and Specifications of the Works proposed for construction in the Northern Delta of the Pennair.

Description of Plans.	Numbers noted on the plans.	Numbers noted on the estimates.	Numbers noted on the specifications.	Remarks.
Head Works.				
Plan of the anicut	136	136	136	
Cross sections of the Pennair at the site of the proposed anicut.	137	.....	.....	
Main Feeder.				
Revised section of Main Feeder ...	138	138	.....	
Survey of the Main Feeder, Duvur and Kanigherry reservoirs.	.....	7	.....	
Fall in 4th mile	139	139	139	
Girder bridge	140	140	.....	
Kanigherry Reservoir.				
Revised longitudinal and transverse sections of the Kanigherry reservoir embankment from A. to B.	141	141 & 142	141 & 142	
Do. do. from B. to C.	142			
Plan of surplus weir	12	12	.....	
Plan of anti-friction rollers in nut of screw for raising or lowering sluice shutters.	13	13	.....	
Duvur Reservoir Supply and Branch Channels.				
Revised section of Duvur Reservoir Channel.	143	143	.....	
Section of Duvur branch channel ...	144	144	.....	
General plan of regulating sluices in do.	145	145	145	
Eastern Main Channel.				
Survey, of the Northern Channel from 1st to 8th mile.	57	.....	.....	The longitudinal and transverse sections on these sheets show the profile of the channel as originally planned.
Survey of the Eastern Main Channel from 1st to 8th mile	78	.....	.....	
Do. do. from 9th mile in 1st Section to end of 6th mile in 2nd Section.	79	.....	.....	
Do. do. from 7th mile to end of section.	80	.....	.....	
Revised longitudinal and transverse sections of do. from 1st to 7th mile.	157	157		
Do. do. from 8th to end of 1st Section.	158	158 & 159	.....	
Do. do. 2nd Section	159			
Head-sluice	61	61	61	Originally designed for the head of the Northern Channel.
Drainage culvert in the 1st mile ...	62	62	62	Do. do. for the 1st mile of do.
Bridge in the 2nd mile	63	63	.....	Do. do. for the 2nd mile of do.
Drainage culvert in the 3rd mile ...	64	64	64	Do. do. for the 3rd mile of do.
Fall in the 5th mile	160	160	160	
Do. in the 6th do.	161	161	161	

Survey of the Kangiri & Duvvury reservoirs & main canal in the vicinity of proposed H.E. works. 157

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Proceedings of the Madras Government, Public Works Department, 28th July 1870.

List of Estimates, Drawings, Tracings, and Specifications etc.—(Continued.)

Description of Plans.	Numbers noted on the plans.	Numbers noted on the estimates.	Numbers noted on the specifications.	Remarks.
	26	16	9	
Eastern Main Channel—(Contd.)				
Fall in the 10th mile	162	162	162	
Do. in the 11th do.	163	163	163	
Chavakacharla Tank Supply-sluice ...	87	87	87	
Fall in the 12th mile	88	88	88	Originally designed for the 9th mile of this channel.
Regulating sluice at the head of 2nd Section.	89	89	89	
Bridge in the 2nd mile of do. ...	90	90	.....	
Vavilla Tank Supply-sluice	91	91	.....	
Bridges in the 3rd and 4th miles ...	92	92	.....	
Varini Tank Supply-sluice	93	93	.....	
Regulating sluices and occupation bridges combined in the 5th and 6th miles.	94	94	.....	
Regulating sluice at the head of the Yallayapalem Branch Channel.	95	95	.....	
Drainage culverts in the 1st and 2nd miles of do.	96	96	96	
Drop in the 2nd mile of do. ...	97	97	97	
Plan of surplus weir in the Varini Tank.	98	98	98	
Regulating sluice at the head of Varini Branch Channel.	99	99	.....	
Alluru Branch Duct from the Eastern Main Channel to Pydaru.				
Section of the Alluru Branch Duct ...	164	164	.....	
Regulating sluice at the head of do....	165	165	165	
Falls in the 1st and 2nd miles of do...	166	166	166	
Alluru Branch Channels.				
Revised section of the Alluru Branch Channel.	167	167	.....	
Revised section of Ramannah Tank Channel.	168	168	.....	
Survey of the Alluru Tank Channel and its branches.	114	.....	.....	
Survey of the Zuvoaladinne and Ulanapolla Branch Channels.	115	115	115	
Longitudinal and tranverse section of the Alluru Channel and its subsidiary branches.	116	116	.....	
Head-sluice to supply the Alluru Tank Supply-channel.	117	117	117	
Regulating sluice and bridge combined in the 5th mile of do.	118	118	118	
Regulating sluice in the Gogulapalle Branch Channel.	119	119	.....	
Do. do. at the head of Zuvoaladinne Branch Channel.	120	120	120	
Road tunnels in the 1st, 2nd, and 3rd miles of the Zuvoaladinne Branch Channel.	121	121	.....	
Tunnel in the line of Kavuraganta road over the Ulavapolla branch Channel.	124	124	.....	

Excavating the Yellayapalem Branch Channel & necessary subsidiary works. - 6 87

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List of Estimates, Drawings, Tracings, and Specifications, etc.—(Continued.)

Description of Plans.	Numbers noted on the plans.	Numbers noted on the estimates.	Numbers noted on the specifications.	Remarks.
	55	45	23	
Alluru Branch Channels—(Contd.)				
Inverted syphon in the Ulavapolla Branch Channel.	125	125	125	
Self-acting regulator in the south bank of Chippalaru near Zuvoaladinne.	126	126	126	
Feeder from Kanigherry Reservoir.				
Longitudinal and transverse sections of the feeder from Kanigherry Reservoir.	27	.....	.....	The longitudinal and transverse sections on this sheet show the profile of the channel as originally planned.
Revised longitudinal and transverse sections.	146	146	.....	
Head-sluice	28	28	28	
Bridge in the 1st mile...	29	29	.....	
Drainage culvert in the 1st mile ...	30	30	30	
Regulating sluice do. ...	147	147	147	
Drainage culvert in the 2nd mile ...	148	148	148	
Bridge in the 2nd mile	20	20	.....	Originally designed for the 1st mile of the bank channel auxiliary feeder.
Bridge over Duvur Drainage Channel.	32	32	.....	
Central Channel.				
Survey, of the Central Channel.	50	.....	.....	The longitudinal and transverse sections on this sheet show the profile of the channel as originally planned.
Revised longitudinal and transverse sections.	153	153	.....	
Regulating sluice at the head of the channel.	154	154	154	
Fall in the 4th mile	155	155	155	
Do. in the 9th mile	156	156	156	
Southern Channel.				
Survey, of the Southern Channel from 1st to 8th mile.	33	.....	.....	The longitudinal and transverse sections on these sheets show the profile of the channel as originally planned.
Do. do. from 9th to 16th mile ...	34	.....	.....	
Do. do. from 17th to the end ...	35	.....	.....	
Revised longitudinal and transverse sections from 1st to 8th mile.	149	149 & 150	.....	
Do. do. from 9th to 16th mile ...	150	&		
Do. do. from 17th to the end ...	151	151		
Occupation bridges in the 2nd and 3rd miles.	38	38	.....	
Drainage culvert in the 4th mile ...	39	39	39	
Do. in the 5th and 11th miles of do.	37	37	37	Originally designed for the 1st mile of this channel.
Fall in the 6th mile	40	40	40	
Do. in the 9th mile	41	41	41	
Aqueduct in the 9th mile	42	42	42	
Bridge in the 11th mile	43	43	.....	
Fall in the 11th mile	45	45	45	
Do. in the 14th mile	46	46	46	
Drainage culverts in the 16th and 17th miles.	152	152	152	
Regulating sluices and bridges combined in the 18th, 20th, and 22nd miles.	47	47	.....	

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Proceedings of the Madras Government, Public Works Department,
28th July 1870.

List of Estimates, Drawings, Tracings, and Specifications, etc.—(Concluded.)

Description of Plans.	Numbers noted on the plans.	Numbers noted on the estimates.	Numbers noted on the specifications.	Remarks.
	88	61	33	
Miscellaneous.				
Survey of the Minor Reservoirs ...	127	.....	.....	
Longitudinal and transverse sections of the Pennair embankment.	128	128 & 129	128 & 129	
Do. do. do. ...	129			
Self-acting outfall sluices in the river embankment.	169	169	169	
Transverse sections of the drainage channels.	130	130	.....	
Plan and elevation of tipping waggon.	131	.....	.....	
Irrigation sluices to discharge from 1 to 8 cubic feet per second.	132	132	.....	
Do. do. from 9 to 22 do.	133	133	.....	
Do. do. from 23 to 58 do.	134	134	.....	
Revised sketch map	170	170	.....	
Estimate for tramways	171	171	.....	
General abstract estimate	.....	172	.....	

(Signed) R. SMITH,
Executive Engineer on Special Duty.

NELLORE,
22nd April 1870.

Excavating the Varino Branch channel & constructing the necessary subsidiary works
Excavating the Eastern main channel & constr. do — do

78-79
88

98- 70 - 36.

All those marked in blue & red were returned to the S. Engr 20th with reference to G.O. № 1501 - 19 June 72 - 98 plans.
70 estimates with & without specifications
168

The estimates specifications & copies of plans herewith returned were sent to the Govt of Madras

EASTERN MAIN CHANNEL.

Irrigable Area, 62,300 Acres.

Reaches	Mean Radii.	Velocities in feet per second.	Discharge in cubic feet per second.	Details of irrigation in each reach.			Remarks.
				Area to be watered in acres.	Volume of water to be supplied in cubic feet per second.	Number of distribution sluices.	
From head to 1·25 miles	5·0	2·67	934·5	1,190	17·85	1	
,, 1·25 to 2·5 ,, ...	5·0	2·67	916·65	430	6·45	1	
,, 2·5 to 3·375 ,, ...	5·0	2·67	910·2	200	3·00	1	
,, 3·375 to 3·625 ,, ...	5·0	2·67	907·2	2,587	38·805	4	Yallayapalem branch channel takes off.
,, 3·625 to 3·975 ,, ...	4·81	3·28	868·395	400	6	2	
,, 3·975 to 5·625 ,, ...	4·8	3·28	862·395	1,000	15	1	
,, 5·625 to 6·875 ,, ...	4·78	3·27	847·395	25,000	375	26	Alluru branch duct takes off.
,, 6·875 to 7·125 ,, ...	4·2	3·065	472·395	1,000	15	2	
,, 7·125 to 8·375 ,, ...	4·17	3·05	457·395	2,200	33	2	
,, 8·375 to 9·475 ,, ...	4·09	3·025	424·395	3,850	57·75	2	
,, 9·475 to 10·225 ,, ...	3·92	2·96	366·645	3,200	48	2	
,, 10·225 to 12·125 ,, ...	3·76	2·89	318·645	3,400	51	1	
,, 12·125 miles to end of 1st Section ...	3·55	2·81	267·645	3,800	57	4	
Second Section.							
From head to end of 2nd mile	3·06	3·064	210·645	3,600	54	2	
,, end of 2nd to end of 3rd mile	2·64	3·03	156·645	4,000	60	2	
,, end of 3rd to end of 4th mile	2·12	2·706	96·645	3,000	45	2	
,, end of 4th to end of 5th mile	1·91	1·95	51·645	3,000	45	7	
,, end of 5th to 7·125 miles	0·88	1·04	6·645	143	2·145	1	
,, 7·125 to end of 8th mile	0·81	0·99	4·5	200	3	1	
,, end of 8th to end of 9th mile	0·53	0·74	1·5	100	1·5	1	
	.....	.....	.....	62,300	934·5	65	

NELLORE,
22*nd April* 1870.

(Signed) R. SMITH,
Executive Engineer on Special Duty.

ALLURU BRANCH DUCT.

Irrigable Area, 25,000 Acres.

Reaches	Mean Radii.	Velocities in feet per second.	Discharge in cubic feet per second.	Details of irrigation in each reach.			Remarks.
				Area to be watered in acres.	Volume of water to be supplied in cubic feet per second.	Number of distribution sluices.	
From Eastern Main to Pydaru River	3·78	2·91	375	.....	.....	.....	
Pydaru River from end of first reach to the Alluru branch channel head-sluice.	.....	.....	375	.....	.....	.....	
From head-sluice to 3·25 miles	4·22	2·0825	375	7,000	105	7	Purini branch takes off.
,, 3·25 to 4·4 miles	3·85	1·99	270	4,500	67·5	1	Indupura branch takes off.
,, 4·4 miles to Alluru Tank	3·51	1·89	202·5	.....	.....	.....	
Under Alluru Tank and distribution channels that take off from it.	.....	.....	.....	13,500	202·5	18	
	.....	.....	.....	25,000	375·0	26	

Feeder from Kanigherry Reservoir to supply the Central and Southern Channels.

Reaches	Mean Radii.	Velocities in feet per second.	Discharge in cubic feet per second.	Details of distribution.		Remarks.
				Area to be watered in acres by the branches dependent on this feeder.	Volume of water to be supplied in cubic feet per second.	
From reservoir to head of Central Channel ...	4·45	1·93	420	10,500	157·5*	*Discharge of Central Channel.
,, head of Central Channel to head of Southern Channel.	3·94	1·81	262·5	17,500	262·5†	†Discharge of Southern Channel.

NELLORE,
22*nd April* 1870.

(Signed) R. SMITH,
Executive Engineer on Special Duty.

CENTRAL CHANNEL.

Irrigable Area, 10,500 *Acres.*

Reaches	Main Radii.	Velocities in feet per second.	Discharge in cubic feet per second.	Details of irrigation in each reach.			Remarks.
				Area to be watered in acres.	Volume of water to be supplied in cubic feet per second.	Number of distribution sluices.	
From head to ·25 mile	2·52	2·96	157·5	800	12	2	
,, ·25 to end of 1st mile	2·44	2·91	145·5	900	13·5	2	
,, end of 1st to end of 2nd mile	2·35	2·85	132·0	1,000	15	2	
,, end of 2nd to end of 3rd mile	2·22	2·77	117·0	1,400	21	2	
,, end of 3rd to 3·9375 miles	2·08	2·68	96·0	1,300	19·5	2	
,, 3·9375 to 4·3875 miles	1·88	2·55	76·5	.....	.....	.....	
,, 4·3875 to end of 5th mile	1·8	2·79	76·5	1,100	16·5	2	
,, end of 5th to end of 6th mile	1·75	2·75	60·0	1,100	16·5	2	
,, end of 6th to end of 7th mile	1·49	2·53	43·5	1,500	22·5	2	
,, end of 7th to 8·0375 miles	1·41	1·4	21·0	.....	.....	.....	
,, 8·0375 miles to end of channel	1·08	2·45	21·0	1,400	21·0	1	
	.....	.....	.....	10,500	157·5	17	

NELLORE,
22*nd Adril* 1870.

(Signed) R. SMITH,
Executive Engineer on Special Duty

SOUTHERN CHANNEL.

Irrigable Area, 17,500 *Acres.*

Reaches	Mean Radii.	Velocities in feet per second.	Discharge in cubic feet per second.	Details of irrigation in each reach.			Remarks
				Area to be watered in acres.	Volume of water to be supplied in cubic feet per second.	Number of distribution sluices.	
From head to end of 1st mile	3·25	2·93	262·5	1,200	18·0	1	
,, end of 1st to 2·2 miles	3·17	2·894	244·5	500	7·5	1	
,, 2·2 to 4·2 miles	3·13	2·876	237·0	600	9·0	1	
,, 4·2 to 5·1 miles	3·08	2·85	228·0	300	4·5	1	
,, 5·1 to 5·85 miles	3·06	2·84	223·5	400	6·0	1	
,, 5·85 to 6·75 miles...	3·03	2·83	217·5	400	6·0	1	
,, 6·75 to 7·5 miles	2·99	2·81	211·5	400	6·0	1	
,, 7·5 to 7·975 miles...	2·96	2·8	205·5	700	10·5	1	
,, 7·975 to 8·375 miles	2·89	2·762	195·0	200	3·0	1	
,, 8·375 to end of 10th mile	2·79	2·92	192·0	300	4·5	1	
,, end of 10th to 10·85 miles	2·76	2·905	187·5	3,800	57·0	1	
,, 10·85 to 11·75 miles	2·5	2·765	130·5	500	7·5	1	
,, 11·75 to 12·25 ,, ...	2·44	2·73	123·0	500	7·5	1	
,, 12·25 to 12·75 ,, ...	2·37	2·69	115·5	800	12·0	1	
,, 12·75 to 13·25 ,, ...	2·25	2·62	103·5	500	7·5	1	
,, 13·25 to 13 75 ,, ...	2·17	2·57	96·0	200	3·0	1	
,, 13·75 to 14·75 ,, ...	2·08	2·52	93·0	1,000	15·0	1	
,, 14·75 to 15·8 ,, ...	1·93	2·422	78·0	500	7·5	1	
,, 15·8 to 16·75 ,, ...	1·97	2·45	70·5	1,200	18·0	1	
,, 16·75 to 17·85 ,, ...	1·72	2·285	52·5	1,500	22·5	1	
,, 17·85 to end of 19th mile	1·41	2·06	30·0	1,200	18·0	1	
,, end of 19th to 19·75 miles	0·88	2·11	12·0	500	7·5	1	
,, 19·75 miles to end of channel	0·59	1·714	4·5	300	4·5	1	
	.....	.....	.....	17,500	262·5	23	

NELLORE,
22*nd April* 1870.

(Signed) R. SMITH,
Executive Engineer on Special Duty.

From the Officiating Collector of Nellore, to the Special Executive Engineer, Nellore, dated Camp at Krisnapatnam, 6th April 1870, No. 714.

In reply to your letter, No. 160, dated 28th ultimo, I have the honour to state that I consider the rate of 5½ rupees per acre a fair average for calculating the return from the lands commanded by the Sangum Project.

From the Deputy Director of Revenue Settlement, to the Special Executive Engineer, Nellore, dated Nellore, 5th April 1870, No. 126-45.

With reference to your letter of the 28th ultimo, No. 159, I have the honour to furnish in the annexed table details as to the average wet rates of assessment prevailing in the several talooks of the district forming the principal division. These rates have been calculated on the basis of the survey areas; and as the per-centage of increase discovered affects them more or less particulars in this respect are likewise rendered.

Talooks.		Average rate of wet assessment prevailing per acre.		Per-centage of increase by survey on wet area of villages.
		Rs.	A.	P.
Nellore	Anicut villages	3	13	25
	Other villages	4	1	
Gudur	Anicut villages	4	5	18
	Other villages*	5	...	
Rapur		5	...	18
Atmakur		4	7	21
Kavali		4	9	16
Udayagiri		4	10	13

* Exclusive of Sriharikota villages.

2. As regards the rate of Rupees 5-8-0, which you have adopted as the probable average for the whole of the area under the Sangum scheme, I subjoin details as to the wet rates of settled districts taken from the G. O. of the 23rd May 1865, No. 1,096, adding thereto the enhancement of one rupee made subsequently to the water-rate in force in the several deltas under irrigation.

Districts.		Cultivated area.			Waste area.		
		Rs.	A.	P.	Rs.	A.	P.
Godavery	Western Delta	6	5	6	5	8	11
	Eastern and Central Deltas ...	7	1	3	5	7	0
	Upland†	3	13	5	2	4	10
Kistna, Bunder portion.	Delta	4	15	11	4	4	4
	Upland	4	4	2	3	12	5

† Rates amended before being finally sanctioned by Government, and as settled are higher.¶

3. The dry rates in the deltas are arrived at by deducting Rupees 4 from the above; and as regards the Western, Central, and Eastern Deltas of the Godavery are Rupees 2-5-6 and 3-1-3, respectively, for the cultivated area and similarly for the Kistna Delta Rs. 0-15-11. The marginal Statement shows the average dry rates of assessment in the Nellore Talook, both for the villages under the anicut, and the other villages not so circumstanced, also for the fourteen anicut villagers of Gudur. These rates are likewise based on survey areas, and appertain to the area in occupation under dry.

Talooks.		Average dry rate.		
		Rs.	A.	P.
Nellore ...	Anicut villages	0	15	0
	Other villages	1	0	0
Gudur Anicut villages		1	1	0

4. From a comparison of the above it is obvious that, as regards the Nellore Talook, any re-assessment based on dry rates plus a water-rate of Rupees 4, must necessarily on the average be considerably below the results thus arrived at for the Godavery Delta. There is a material difference in the soil; it has not the admixture of alluvial deposit which renders much of the Godavery Delta so fertile. Moreover, the proportion of the soil that must be deemed as indifferent in quality is very considerable, and predominates, I find, over the better descriptions, according to the results arrived at under the classification of the occupied wet assessed area of the talook. Details are below given; and, in respect to the unoccupied wet assessed area, as might be expected, the indifferent soils form even a greater per-centage.

Items.	Nellore Talook 71 villages.		Anicut villages.				Total.	
			Nellore 33.		Gudur 14.			
	Acres.	Per-centage.	Acres.	Per-centage.	Acres.	Per-centage.	Acres.	Per-centage.
Black soil.								
Good	5,215	9	2,178	8	774	7	8,167	9
Middling ...	24,384	44	15,409	57	4,005	37	43,798	46
Indifferent ...	26,412	47	9,580	35	6,108	56	42,100	45
	56,011	.....	27,167	.....	10,887	.....	94,065	.....
Red soil.								
Good	166	3	23	4	53	3	242	3
Middling ...	1,761	37	324	52	312	21	2,397	35
Indifferent ...	2,868	60	279	44	1,135	76	4,282	62
	4,795	.....	626	.....	1,500	.....	6,921	.....
Arenaceous soil.								
Good	.....	.....	.....	.....	.....	.....	.....	.....
Middling ...	933	86	1,248	82	1,098	82	3,279	83
Indifferent ...	157	14	274	18	241	18	672	17
	1,090	.....	1,522	.....	1,339	.....	3,951	.....
Total.								
Good	5,381	9	2,201	7	827	6	8,409	8
Middling ...	27,078	44	16,981	58	5,415	39	49,474	47
Indifferent ...	29,437	47	10,133	35	7,484	55	47,054	45
	61,896	.....	29,315	.....	13,726	.....	104,937	.....

5. The area occupied as wet is far greater than that occupied under dry in the villages north of the Pennair, and besides the bulk of the heavier and better description of soil, as you are well aware, is now under irrigation. The existing average assessment above shown of one rupee for dry would not represent the dry grain value of the large area under irrigation. It needs to be considered as somewhat higher; and, as the above dry rate is manifestly low, it may be presumed that the average will increase with the new settlement when proposed, and likewise that the average as regards the irrigated area would in a corresponding degree be greater.

6. The extension of irrigation will apply to an equally large proportion of indifferent soil—probably a much larger proportion; and, therefore, I consider that the average rate that should be expected to be derived from the area under the whole scheme ought to be moderately estimated. Viewed as regards the average rate prevailing in other talooks for a less certain source of irrigation, which varies from Rupees 4-7-0 in Atmakur, and certainly is low, to Rupees 5 in Gudur and Rapur, that adopted by you, viz., Rupees 5-8-0 may be accepted as moderate, but cannot safely in my opinion be taken at any higher figure.

7. It is necessary to bear in mind that the details I now furnish refer solely to the wet

assessed area according to the existing Revenue Accounts, and do not include the dry area irrigated and paying water-rate under the Nellore Anicut.

From the Officiating Collector of Nellore, to the Special Executive Engineer, Nellore, dated Nellore, 25th March 1870, No. 627.

I HAVE the honour to acknowledge the receipt of your letter, No. 139, dated 24th February 1870, requesting my opinion as to the average rate per acre of compensation for Government and Inam lands falling within the proposed Kanigiri Reservoir, and as to the propriety or otherwise of allowing any compensation for lands which are already in the waterspread of the tank and liable to be flooded annually.

2. In the case of lands taken up under the Survapally Project, compensation, so far as it has been settled, has been paid at Rupees 30 and 12 per acre of wet and dry lands under cultivation, and at Rupees 25 and 8 per acre of uncultivated wet and dry lands respectively. As regards lands taken up under the Chennur Channel, compensation has been recommended by the Tahsildar at Rupees 28 and 12 per acre of wet and dry lands respectively; but Major Clay considers this rate of compensation heavy.

Vide letter, No. 515, dated 18th December 1869.

3. In boath these instances the land concerned happens generally to be Government land. In the case of some Inam lands compensation has been recommended by the Tahsildars at 30 rupees per acre.

4. The compensation to be paid for Government or Inam land should properly speaking be fixed with reference to the sale value thereof, which will vary with reference to the circumstances of the village in which the land is situated. To grant compensation for all the Inam lands required for the project, a very large sum would be required. As the project will bring a large extent of unoccupied land under wet cultivation, the Inamdars will probably be inclined to select fresh land as Inam, instead of seeking a money payment.

5. As the value of land is rising, it is not likely that the ryots will agree to small payments. Some years ago compensation appears to have been calculated at from five to ten years' purchase.

6. The actual amount to be paid must be settled after careful examination of the circumstances of each case. As your object in calling for the information is to make due provision in the estimate, I would suggest that compensation may be calculated at Rupees 20 and 10 per acre respectively for wet and dry Government land, and at Rupees 30 and 15 per acre of wet and dry Inam land. This provision, I should think, will enable us to settle all the claims involved, for if the provision for Government land be not sufficient, a portion of the allotment for Inam lands will be available, should fresh lands be granted in lieu.

7. As regards lands which are already liable to be inundated annually, I do not consider any compensation is justly claimable, merely because their liability is made more certain by the improvements to the tank. Having voluntarily taken up such lands with their eyes open, the ryots cannot, in my opinion, claim compensation in such cases. It is different when lands are newly submerged by the extension of the waterspread, then the claim to compensation is only reasonable.

From the Deputy Director of Revenue Settlement, to the Special Executive Engineer, Nellore, dated Nellore, 26th March 1870, No. 103-36.

IN reply to your letter of the 11th instant, No. 151, I have the honour to state that I consider the right of occupation, as regards land forming the beds of the tanks, which it is proposed to abandon as reservoirs in the North Pennair Delta under the Sangum Project, should, when sold by public auction, realize on the average Rupees 25 per acre.

2. The soil of the tanks for the most part is fair, and were it not that it is liable to be fund impregnated with Chavadu or saline properties due to the long accumulation of deposit from what may be regarded as still or standing water, it would need to be almost wholly classed as of first quality. The lower part of the bed of each will probably be uneven, and require levelling to render it fit for cultivation, or else be indifferent from lying low. All these inequalities will influence the average value obtainable, and have to be considered to ensure as reliable an estimate as practicable being framed.

No. . Read the following letter from the Superintending Engineer, 2nd Division, to the Chief Engineer for Irrigation, Madras, dated Bazoarah, 19th November 1869, No. 117.

I HAVE the honour to forward plans and estimates for the works proposed for the irrigation of the country on the north bank of the Pennair in the Nellore District, surveyed and designed by Mr. R. Smith, Executive Engineer, specially deputed to the duty.

135 Plans and Sections.
129 Estimates.
73 Specification Reports.
1 Report from Executive Engineer.

338 (already sent.)

2. His report, which I also enclose, enters so exhaustively into the details of the scheme, which has been long and fully considered by Colonels Anderson and Winscom, that I need only submit a sketch of the general design of the works.

3. The southern portion of the delta has been for some years irrigated by channels taken off from the anicut at Nellore, which are now being enlarged and improved to fill certain reservoirs at Survapully, etc.; this part of the district has therefore the first claim to the ordinary supply of the river. Taking this as all below the crown of the anicut it is found from a series of recorded freshes that at the worst we may count on sixty-nine days when the water is above this standard, and that during this period enough passed to supply the 80,000 acres lying on the north bank. This is shown in Appendix D.

4. On this part of the country exist several tanks which now command 63,052 acres, but from insufficient channels water only 43,659 acres; it is proposed to enlarge one of these reservoirs, and to cut good channels from the river near Sangam, by which they may be filled from the different passing freshes in 15 days; these channels are so designed that they will also irrigate the land direct for the remainder of the period that the river is in fresh.

5. Appendix E. shows how, in the worst year on record, the irrigation would have been carried on, either directly or from the reservoirs, in such a manner that the latter would never be required to hold at any period more than five-sixths of the quantity which they are capable of retaining.

6. Lower in the delta are other tanks, some of which will be given up to cultivation, some retained as supplementary reservoirs with capacity slightly above the largest quantity which they will be wanted to hold.

7. The channels which supply the two large tanks were long since excavated from a peculiarly favourable point in the Pennair, where it received the Beerapairoo.

8. The rocky Sangam hill immediately below their confluence causes a natural scour, and the silt being deposited below the pool thus formed serves as a dam across the river, the reservoirs themselves being fifteen feet below the level. Mr. Smith has decided on drawing from the pool, arranging his head-works in such a manner that the principal quantity of silt will still be carried along the outer face of the wall, which will form for some distance the right bank of his main channel.

9. The details are fully given in plans and report.

10. To carry the large quantity of water needed in the limited period of high freshes, the head-sluice and channel must be capable of passing 7,007 cubic feet per second; there is plenty of stone available; Mr. Smith, therefore, prefers to have a rapid fall to a large section; the bed and sides of the channel will therefore be lined with stone. The dimensions of the different sections, modified according to circumstances, are given fully in the report.

11. At a short distance from the head the supply channel to the Duvuru tank will be taken off; and a little further on the opposite side the bank channel running into the Punchedu tank, and affording direct irrigation to 28,300 acres during high freshes.

12. When the water in the Pennair falls, 3,300 acres of this will be supplied by a small high level duct from the Duvuru tank, and the remainder by a channel from the Kanigery reservoir, which is shown as falling into the Punchedu tank.

13. From this minor basin start the southern and central channels conveying the water to the area (2,500 acres) between the Pennair and Moldavy, which latter stream will receive all the surplus, and act as the principal drain of this part of the country.

14. The works for these channels, drains, etc., are fully detailed in the report; plans and estimates for the various sluices, bridges for roads, under-tunnels, falls, etc., accompany.

15. The northern and eastern main channel take off direct from the Kanigery reservoir, their courses are shown in the general sketch map; plans and estimates for head-sluice, etc., etc., are forwarded.

16. The former channel is calculated to supply water for 11,830 acres; the latter 39,870; the dimensions of each, varying in their course, are fully stated in the report.

17. The northern channel discharges itself finally into the group of tanks at Kovuragunta and Alluru, the surplus passing off to the sea by the backwater and creek at Juvaladinna.

18. This last channel will receive a further direct supply from the Pennair in high freshes, by a channel which Mr. Smith proposes to take off from the north end of the Nellore anicut; it will pass under the southern channel, and meet the eastern main channel at the same level; its supply will be admitted by an inlet sluice, and two-thirds thereof can be drawn off by an outlet sluice, for the direct irrigation of the country and the supply of the Alluru tanks by the existing channel led from above the weir across the Pydaroo. Below the weir, this stream will serve as the drain of this part of the country receiving in its course the end of thes eastern main canal and its branches, and conveying them to the sea at Juvaladinna.

19. Mr. Smith has assessed the returns from the area which will

thus be irrigated, at	Rupees	4,26,602
Deducting amount now paid	,,	1,54,785
		2,71,817

Gross profit 7·15 per cent.

He has also calculated the cost of repairs and establishment at Rupees 30,077, leaving a net profit of Rupees 2,41,740, or 6·36 per cent. on the capital expended.

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28th July 1870.

20. The difficulty of procuring labour in the district has been prudently considered, and such rates have been allowed in the estimate as will admit of a considerable use of machinery, and will probably cover the cost of introducing labour from other parts of the country.

21. In conclusion, I beg respectfully to draw the attention of Government to the skill exhibited, and time and labour consumed by Mr. Smith, in designing and elaborating this large scheme. I have mentioned Colonels Anderson and Winscom as having considered the general design, etc.; but so far as I am informed the entire credit of it is due to Mr. Smith, who has had (with the exception of one young Assistant for a short period) no assistance but that of subordinates, whom he had first to teach, and who are even now but inferior instruments, copyists, and calculators.

22. All was matured and arranged before I joined the division. I have taken great interest in the project, but have avoided any interference with the details which might delay the submission of a project, which anxiously desired by the cultivators concerned, and which is likely to prove of great benefit to the district and remunerative to the State.

23. Mr. Smith's industry and ability are well known to the Government, but I would not lose the opportunity now offered me of bringing them expressly to their notice.

24. I would urge that he be placed in charge of the work when under construction with special establishment, as I believe that no officer would be more capable of executing it, and certainly no one could take greater interest in it than the designer.

Report to accompany the project for the extension of Irrigation, and the improvement of the drainage, in the Northern Delta of the Pennair.

The area of the country commanded by the proposed works is 220 square miles. This tract is partially watered by tanks deriving their supply from the Pennair or the local drainage streams.

The bulk of the existing irrigation is under the Pennair; the water is taken off from this river by five imperfect channels * between the head of the delta at Sangam and the Nellore anicut.

* Durvuru. Kovuru.
Gandavaram. Veguru.
Punchedu.

The Gandavaram and Duvuru channels are the main branches; the others water but a comparatively small area, and are not deserving of particular notice. I may add, however, their alignment is defective, and that they cannot advantageously be retained as irrigation channels; the Kovuru branch traverses generally the lowest part of the country between its head, west of Minagolla, and the Kovuru tank; it is peculiarly adapted for a drainage outlet, and will be utilized as such in the scheme under notice.

2. The Gandavaram and Duvuru channels are supposed to feed the Kanigery and Duvuru tanks, but like the other three river-channels already referred to are very inefficient, and by no means capable of drawing off a large volume of water during a short fresh in the Pennair, which is essentially necessary to the success of all irrigation dependent on this river.

Existing main channels do not discharge the required quantity of water.

These tanks have not received their full supply for years, although in the *worst*

of seasons the volume of water that passed the Nellore anicut was more than sufficient to irrigate 20,000 acres in addition to the *whole area* under the existing works; the actual results, however, are very different, as will be observed by the statement* furnished by the late Acting Collector.

* Appendix A.

From this statement it appears the area classed as wet or rice land, under the several tanks and channels in the Nellore Talook, is 63,052 acres, of which 43,659 only were cultivated on the average of the past five years. To compare the present with the proposed results more accurately, it will be necessary to add to the above the ordinary irrigable area (614 acres) and the extent (394 acres) actually cultivated in the two villages of the Kavali Talook that will be watered by the new channels.

These additions will increase the area of the ordinary wet land to 63,666 acres, and the acreage under cultivation to 44,053 acres.

3. This project will secure a supply of water for all the land now regularly cultivated, the 19,613 acres that are deprived annually of their supply, and for an additional area of 19,954 acres.

39,567 acres will be brought under cultivation by this scheme.

4. The comparative failure of the Gandavaram channel is owing to the following causes:—

Comparative failure of present system of irrigation attributed to certain causes.

(1.) The level of the bed in the vicinity of Sangam is too high to permit a large volume being drawn off during low freshes in the Pennair.

(2.) The soil is so friable, and the fall in the bed of the channel so great ($3\frac{1}{2}$ feet per mile) that advantage cannot be taken of high floods to increase the discharge, by allowing the water to flow down with increased depth and velocity.

(3.) Insufficient waterway.

For like reasons the Duvuru channel does not discharge the required quantity of water, a greater depth, however, can be admitted with safety as the fall per mile in the bed is $1\frac{1}{2}$ feet less than that in the Gandavaram channel.

The silting at the head of the Gandavaram channel, and in the vicinity of the Duvuru channel head-sluice, also tends to reduce the discharge of these ducts; but it is not allowed to accumulate and become a permanent obstruction; the villagers constantly employ a number of labourers during the cultivating season in clearing this, and constructing temporary dams in the river on the subsidence of each fresh.

5. From what has been stated it will be observed the channels are under the existing arrangements unsatisfactory; they do not take off sufficient water to irrigate the area, which apparently the native rulers thought they would do; their construction is faulty, and a considerable charge must be made before the irrigation of this delta can be placed on a sure basis. This point will be subsequently noticed in detail, when the question of the water available for the extension of irrigation is being considered.

6. The great defect in the existing main channels is the levels of their respective beds; they are as has been noted too high; this can be remedied by building an anicut across the Pennair at Sangam, or by deepening the channels.

Main feeder proposed to be taken off at a lower level than the Duvuru and Gandavaram channels.

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To attempt to carry out the latter proposition would in most cases be a mistake; but in this particular instance I believe it is the plan that should be adopted. I will now recount my reasons for having come to this determination.

About half a mile north-west of Sangam the Beerapairoo, a tributary of the Pennair, falls into the latter river, and scours out a portion of its bed for some distance along the foot of the Sangam hill; this forms a depression, the bottom of which varies from three to six feet below the general level of the deep bed of the Pennair in that locality; this pool is also acted on by the Pennair impinging on the Sangam hill, close to the mouth of the Beerapairoo, and forming eddies which pass over the depression on their way down stream. This state of things, judging from all the information I could collect has gone on for a lengthened period; the borings made in the bed of the Pennair parallel to the Sangam hill indicate a chasm must have originally existed between the hill and the ledge of rock in the bed of the river, or that it is the result of the combined action of the Pennair and Beerapairoo during a long series of years. Since the trigonometrical survey was made no change whatever can be detected in the bank of the Pennair at the confluence of this river and the Beerapairoo; it still hugs the foot of the Sangam hill, and will, I have no doubt, continue to do so unless the configuration of the country is altered by some extraordinary convulsion of nature.

7. From the description given of the Pennair, in the immediate neighbourhood of the proposed head-works, I trust it will be conceded we have good grounds for supposing the depression referred to is a permanent one, and that a head-sluice judiciously constructed within the influence of the Beerapairoo would be kept clear of silt by the scour of this stream in the same way as it now regulates to a great extent the contour of the depression, and prevents this being raised to the same level as the adjoining deep bed.

8. In designing the head-works advantage has been taken of the local peculiarities just noticed, to save the cost of an artificial anicut; we have a natural one in the difference of level that exists between the bed of the river at the site of the proposed head-sluice, and a few hundred yards lower down; and in the Beerapairoo we possess a scouring power equal, if not superior, to many under-sluices.

Advantage taken of local peculiarities in designing works.

The site selected for the head-sluice is in the bed of the Pennair immediately below the mouth of the Beerapairoo; it will be connected with the pagoda hill at Sangam, by a masonry wall carried along the bed of the river, at a sufficient distance from the foot of the Sangam hill, to secure the required waterway for the main feeder without much cutting. The length of the wall as planned is $860\frac{3}{4}$ yards.

9. The length of the river wall might be considerably reduced, and a moderate saving effected, by turning it inland from the main head-sluice; but I cannot recommend this arrangement, as it would necessitate the channel being carried very close to the bank of the river to avoid as much heavy cutting as possible; the line would also be objectionable on account of its running partly at the foot, and

River wall.

partly along the face of the Sangam hill ; the debris from this precipitous spur would, I feel certain, prove particularly troublesome, and entail costly clearances from time to time.

By referring to the plan* of the masonry wall it will be seen the foundation is rock for a considerable length ; where this is too deep, or was not reached by the borings, it will be built on masonry wells ; in these portions the river face of the wall will have a substantial apron of large rubble to protect the wells in the event of any great deepening of the bed. I do not, however, apprehend this, as the Pennair is excessively wide in those parts, and the area reclaimed from it by the erection of the masonry wall will be so small in comparison with the section of the river that the contraction will have no appreciable effect.

* Sheet No. 3.

10. The design of the river wall now submitted is different to what I had intended. I proposed a much smaller section with openings in it above the full channel supply level to admit water during high floods, and neutralize the pressure, by having the water on the same level on both sides of the wall ; to this proposition Colonel Anderson would not consent ; he considered silt would enter by the several openings, and it that would not be prudent to build a wall in the exposed situation decided on incapable of resisting the maximum pressure due to the highest known flood. In carrying out Colonel Anderson's instructions, I have endeavoured to do so as economically as possible consistent with the required stability ; rubble abounds on the face of the Sangam hill, and can be collected and packed much cheaper and quicker than masonry could be turned out ; it has, therefore, been extensively introduced in the plan of this work. Colonel Anderson further directed the portion of the river wall abutting on the head-sluice to be of a very substantial section, as it will be exposed to the set of the same stream that impinges on the Sangam hill ; this has also been attended to, and I trust the enlarged section provided for the part under notice will be found sufficient to withstand all force likely to be exerted against it.

Design of river wall different to that originally proposed.

11. From the diagram† showing the results of the numerous borings taken along and in the immediate vicinity of the proposed river wall, it will be seen rock is available for the foundation where strength is most required ; this is a fortunate circumstance; it will lessen the cost of construction, and materially add to the stability of the structure.

Masonry wall will partly be built on rock.

† Sheet No. 2.

12. To enable Government to judge of the relative merits of a weir, or river wall at Sangam, Colonel Anderson suggested that a section, and abstract estimate of the former, should accompany the project. Sections‡ of two weirs are accordingly herewith submitted, the nine feet anicut would increase the cost of the project 2,53,000 rupees,§ the other would do so to the extent of Rupees 3,50,000.

Weir more costly than river wall.

‡ Further details regarding the relative merits of the different arrangements investigated are given in the appendix.

§ Sheet No. 14.

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13. Before entering into a detailed description of the works it will be necessary to prove—

(1.) That the Pennair is capable of supplying water, in the most unfavourable seasons, to the whole area proposed to be irrigated.

(2.) That the channels can draw off the required water during freshes.

(3.) That the reservoirs are of sufficient capacity to store the volume of water necessary to keep up the supply when the freshes subside, and this I will endeavour to do *seriatim.*

From the statements* showing the rise and fall of the Pennair during the last eight years, the description of river we have to deal with will be apparent ; in some months the freshes succeed each at intervals of a day or two, in others a few only occur, and occasionally they fail altogether ; with these statistics and the knowledge that the southern Delta has a prior claim to the northern on the Pennair, it would not, I consider, be fair to calculate on the *average* supply of a number of years ; the only safe proceeding is to take one of the most unfavourable seasons and plan the works to act efficiently in a similar adverse year, as has been done in the preparation of this project.

* Appendix B.

14. The head-sluices, the supply channels leading from the Pennair, and the reservoirs have been designed with reference to the volume of water that passed the Nellore anicut and flowed to the sea in 1863.

Works planned with reference to water available in 1863.

15. By turning to the synopsis† it will be seen the freshes in 1863 and 1867 were considerably below the average of the other six years under review ; in those seasons there was water (rejecting the days on which it fell to more than a foot below the crest of the anicut) for 69 and 86 days only. Here again there is a great difference in the total number of days, but practically there appears to have been very little dissimilarity in the volume discharged over the anicut in those years ; in 1863 the water flowed over it for 21 days ; in 1867 it discharged for 16 days only ; during the latter year, however, the freshes were higher, and compensated for the variation noticed.

Discharge of Pennair in 1863 and 1867 considerably below the average.

† Appendix C.

By referring to the statements‡ showing the volume of water that passed the Nellore anicut *daily* in the months of August, September, October, November, and December 1863, the quantity available for the extension of irrigation will be clearly seen. The quantity proposed to be utilized in a similar season, and the volume of water in excess of the requirements of the proposed scheme and the southern Delta, are given in Appendix E.

‡ Appendix D.

The volume to be taken off by the Sangam and Nellore anicut northern headsluices, for the irrigation of the northern Delta, and the daily state of the reservoirs during the cultivating season, in an unfavourable year like 1863, are detailed in the nine statements comprising Appendix F.

The sources from which the irrigation will be supplied, and the volume to be furnished daily by each feeder, are given in Appendix G.

16. The information contained in Appendices D. and E. will, I trust, be considered sufficient evidence to prove the Pennair is unmistakeably capable of irrigating 80,000 acres in the northern Delta.

Pennair can certainly water the area proposed.

17. I have now to submit the arrangements I propose for taking off the required body of water from the Pennair. This will be done at two points, namely, Sangam and the northern flank of the Nellore anicut; the former will be the main head, the latter a valuable auxiliary, capable of drawing off when water is available sufficient for the direct irrigation of 30,000 acres, and a considerable volume for storage in the minor reservoirs situated in the eastern section of the delta.

18. The main feeder from Sangam has been planned to discharge, with a depth of 9 feet, 7,007 cubic feet per second; the auxiliary feeder will take off 923 cubic feet per second when the water in the Pennair is flush with the crest of the anicut; these sections seem excessive, but they are not, as will appear subsequently.

Capacities of proposed channels not excessive.

19. The volume of water required annually for the irrigation of 80,000 acres, at the rate of $2\frac{1}{4}$ cubic yards per hour per acre for 150 days, would be 17,496,000,000 cubic feet.

Water required annually.

From Appendix E. it will be gathered the works have been planned to take off in a like year to 1863, as follows:—

	Cubic feet.
In September	6,179,549,399
,, October	8,916,135,436
,, November	348,695,464
,, December	2,051,619,705
	17,496,000,004

To do this it is manifest the channels must be of sufficient section to discharge on those days when the volume available is in excess of the ordinary supply the quantity of water necessary to make up the total volume required for the season. During similar months to the above the *ordinary* water appropriable would be 7,217,781,439 cubic feet, leaving a deficiency of 10,278,218,565 cubic feet to be drawn off on those days when the supply exceeds the demand. In 1863 this was for 15 days, viz.:—

September.	October.			November.	December.
Dates.	Dates.	Dates.	Dates.		
2nd	18th	23rd	26th	.....	6th
7th	20th	24th	27th	.....	
10th	21st	25th	28th	.....	
11th	22nd			.....	

$\frac{10,278,218,565}{15}$ = 685,214,571 cubic feet, the maximum quantity to be drawn off from the Pennair in twenty-four hours.

This volume will be taken off as annexed—

By Sangam head.... ... ...605,474,571.
By head from Nellore Anicut 79,740,000.

$\frac{605,474,571}{86,400}$ = 7007·8075 cubic feet, the maximum discharge per second of the main feeder from Sangam.

Discharge of main channels.

$\frac{79,740,000}{86,400}$ = 922·916 cubic feet the maximum discharge per second of the feeder from the Nellore Anicut.

The main feeder from Sangam has been designed to discharge the above volume when there is but $4\frac{1}{2}$ feet of water in the Pennair at Sangam.

This depth has been arrived at by comparing the state of the river at Sangam with the register kept at Nellore.

From this statement* it will be observed there was generally a considerable body of water passing the Nellore Anicut when the depth on the floor of the Gandavaram head-sluice at Sangam was more than four feet; and that with three exceptions, when this was increased to five, the discharge at the Nellore Anicut was considerably in excess of the water required for both deltas. On the 29th of October when the depth at Sangam was 4′ 5″ the volume that passed the Nellore Anicut closely approximated to the maximum quantity required for irrigation, and on the 18th, when the depth was only 2″ more, it exceeded this.

* Appendix H.

20. The level of the floor of the head-sluice at Sangam has been fixed at 95 feet above mean tide; *i. e.*, three feet below the deep bed of the Pennair adjacent, consequently the water would stand $7\frac{1}{2}$′ deep on the floor of the head sluice, when the depth in the river is $4\frac{1}{2}$ feet.

Floor of Sangam head sluice to be 95′ above mean tide, or 3′ above the deep bed of the pool.

As it is of great importance to have the means of diverting the full volume of water from the river during low freshes, without constructing a head sluice of corresponding dimensions, the fall in the bed of the channel, from this structure for a length of 754 feet, will be at the rate of seven feet per mile.

The velocity due to this fall and a mean radius of 6·564 feet is 9·071 feet per second; to prevent the bed, or the side slope at the foot of the Sangam hill being eroded by this current, both will be carefully pitched and grouted; at the end of this section, *i. e.*, at 754 feet from the head sluice a retaining wall will be erected at right angles to the channel, to increase the stability of the pitching, and to act as a lower weir.

The water section of this portion will be 772·5 square feet; the discharge 7,007 cubic feet per second. From this point the depth of the channel will be $1\frac{1}{2}$′ greater than that of the section just noticed, the increased depth being obtained by a drop of $1\frac{1}{2}$ feet in the bed of the channel on the lower side of the retaining wall. This retaining wall will be built on rock.

Between the retaining wall and the regulating sluice at the head of the Duvuru reservoir supply channel the main feeder will be 9′ in depth; the fall per mile in the bed 2·75 feet. The effective waterway allowed for this division is 1183·725; the mean radius will be 7·93 feet; the mean velocity 5·92 feet, and the discharge 7,007 cubic feet per second. Here also pitching is required, and it will save space

to add that this is necessary throughout the entire length of the main feeder to admit of the great difference of level that exists between the Pennair at Sangam, and the bed of the Kanigery reservoir being turned to the best advantage.

The Duvuru reservoir supply channel will draw off 792 cubic feet per second from the main feeder; the discharge of the latter below this off-let will therefore be

$$7007{\cdot}8075 - 792 = 6215{\cdot}8075 \text{ cubic feet per second.}$$

The discharge of the main feeder from the Duvuru channel regulating sluice to the bank channel head sluice will be 6215·96 cubic feet per second, the water section being 1062·558 square feet, the mean radius 7·75 feet, the mean velocity 5·85, and the fall 2·75 feet per mile.

The bank channel will take off 478 cubic feet per second, and reduce the discharge of the main feeder to 5737·8075 cubic feet per second, the volume required for the Kanigery reservoir.

As the discharge of the main feeder will be effected by the water in the Kanigery reservoir after the surface level has been raised to 86·64 feet above mean tide, the special circumstances of the case must be considered, in calculating the area of the channel requisite to discharge the full volume after the above level has been attained.

21. From Appendix F. it will be perceived the maximum quantity of water that would be stored in the Kanigery and Duvuru reservoirs in a correspondent year to 1863 would be 7,669,388,567 cubic feet. This volume would raise the surface level of the water in the Kanigery reservoir to about 95 feet above mean tide, *i. e.*, 2·45 feet below the proposed high water-mark. When the reservoir fills, the level of the water would coincide with the surface level of that of the channel at 1·68 miles from the Sangam head sluice.

As the surface level of the water in the channel from the head sluice to 1·68 miles below it will not appreciably be affected by the state of the reservoir, it may be considered as flowing parallel to the bed throughout this distance; from the latter point, however, a change must necessarily take place, as the water in the Kanigery reservoir rises and reduces the surface fall in the channel from 2·5 feet to 1 foot per mile, which would be the case when the reservoir had received the maximum supply of water necessary to meet the requirements of a year similar to 1863.

The main feeder from 1·68 miles below the head to the Kanigery reservoir has, therefore, been planned to discharge the requisite volume with a surface fall of 1 foot per mile.

The section of this portion of the channel is not regular; the bottom breadth decreases as the depth of water increases. At the commencement the bottom breadth is 173 feet; at the end of the second mile from the head sluice 159·31 feet; at the end of the third mile 125·53 feet; at the end of the fourth mile 101·3 feet; as this section is practically the same as that required to carry the full volume, with a depth of 9 feet and a fall of 2·5 feet per mile, it will be adhered to until the water tops the surface of the country, and the discharge is accelerated by the spill flowing off into the reservoir. From this point as the depth of the spill increases the bottom

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breadth of the channel decreases; at the end of the cutting it will be reduced to 20 feet.

To prevent the pitching towards the end of the channel being displaced, particularly when the water is very low in the reservoir, a retaining wall has been provided; and to protect the berms from erosion, they will be pitched for a short distance from the edge of the channel; at those parts where the action of the spill is likely to prove most injurious, the horizontal pitching will be 10 feet in breadth.

Discharge of main feeder may be largely increased during high floods.

22. I would now draw attention to the fact that, in calculating the discharge of the main feeder, the additional volume of water that could be drawn off from the Pennair during higher freshes than 4½ feet has not been considered, although provision has been made for doing so; this may be thought unnecessary and extravagant. I hope, however, it will not be altered, as some contingency may arise which would demand extraordinary measures.

By referring to the longitudinal and transverse sections* of the upper portion of this channel, it will be seen the revetment has been designed to admit of the water being raised three feet above the full supply level; this would increase the discharge from 7,007 to 10,827 cubic feet per second.

* Sheet No. 8.

Auxiliary feeder from Nellore Anicut.

23. It now remains to notice the auxiliary feeder from the Pennair. This duct has been planned to discharge 922·92 cubic feet per second, when the water is flush with the crest of the Nellore Anicut; of this volume 506·25 cubic feet are intended for the direct irrigation of 30,000 acres, and 416·67 for storage in the minor reservoirs.

Water to be stored in reservoirs commanded by auxiliary feeder.

The maximum quantity of water to be stored in the reservoirs under this branch is 540,000,000 cubic feet; this body it is proposed to take off during the fifteen days already noticed, in which the discharge of the Pennair is in excess of the maximum requirements. The discharge in feet per second for storage must therefore be $\frac{540,000,000}{15 \times 86,400} = 416{\cdot}67$.

Head sluice.

The floor of the head sluice of this channel will be 6' below the crest of the anicut. The effective waterway allowed is 306 square feet; this is divided into twelve vents 4' 3" × 6'.

Section of channel.

The water section from the head sluice to the end of the third mile has been fixed at 311·04 square feet; the mean radius being 4·83 feet; the mean velocity 2·97 feet per second, and the discharge 923·78 cubic feet per second. To reduce the cutting as much as possible through this portion a fall of 1·25 feet per mile has been allowed.

From the beginning of the fourth to the end of the sixth mile the fall in the bed will be 1 foot per mile. At the end of the fourth mile the off-let to supply the Veguru tank takes off, and will discharge 20·83 cubic feet per second.

From this sluice to the commencement of the seventh mile the water section will be 342 square feet, the mean radius 4·91 feet, the mean velocity 2·64 feet per second, and the discharge 902·88 cubic feet per second.

From the 7th mile to its intersecting the eastern main channel this feeder will be carried principally between embankments; the fall here has been reduced to six inches per mile, as it is very desirable to economize the available head when this can be done without increasing the quantity of earthwork; the mean velocity in this part will be 1·75 feet per second, the water section 525·9 square feet, and the discharge 920·3 cubic feet per second.

Inverted syphon.

At 6·9 miles this channel crosses the Moldavy by an inverted syphon, the difference of level between this stream and the auxiliary feeder being too small to admit of the construction of an aqueduct advantageously. The syphon has been planned to discharge, under a head of 1·16 feet, the maximum volume requisite for this part of the delta, *i.e.*, 902·88 cubic feet per second. This work will be more fully described hereafter when the details of the minor arrangements are being explained.

Auxiliary feeder intersects eastern main channel.

A few chains beyond this syphon, the eastern main channel crosses the auxiliary feeder; the beds of both branches are on the same level at the point of intersection.

During floods in the Pennair the auxiliary feeder will discharge into the eastern main channel 248 cubic feet per second for the direct irrigation of the 14,700 acres under the eastern main channel east of the auxiliary feeder, and 100 cubic feet per second for storage in the Chavakacherla, Vidavalura, Vavilla, and Varini reservoirs.

This decreases the discharge of the auxiliary feeder to 554·09 cubic feet per second.

The fall of six inches per mile in the bed has been continued to the end of the 8th mile; at this point a minor distribution duct takes off for the irrigation of 420 acres, and reduces the discharge of the auxiliary feeder to 547·01 cubic feet per second.

Auxiliary feeder falls into Pydaroo.

This section is maintained until the auxiliary feeder disembogues into the Pydaroo, above the dam constructed across this river, to divert water for the supply of the Alluru, Purini, and Indupuru tanks.

Alluru tank channel utilized.

On reaching the Pydaroo the auxiliary feeder terminates; from this river the supply will be taken off by the large channel that feeds the Alluru and other tanks in that neighbourhood.

24. Having given the arrangements proposed for drawing off the water required for the irrigation of 80,000 acres, it now devolves on me to prove we have the means of storing the volume necessary to keep up the full supply to this area on those days when none can be taken off from the Pennair.

25. The principal reservoirs are the Kanigery and Duvuru; the former is capable of storing 8,112,609,000 cubic feet; the latter 1,042,983,000.

These capacities have been arrived at as follows:—

Capacity of Kanigery reservoir.

The average depth of the Kanigery tank when filled to the present full contour level is five feet; this was ascertained by three sections taken across it from contour point to contour point, and, by soundings, where the depth of water precluded levelling.

* Sheet No. 7.

The levels of the bed of this reservoir are plotted with reference to mean tide on the survey:* by collating these, and rejecting all below 73' + mean tide, the level of the floors of the proposed sluices, it will be found the average level of the bed is 80·2 feet + mean tide; this subtracted from the existing high water-mark (85·45 feet) gives a mean depth of 5·25 feet; but in calculating the capacity this has been assumed at five feet only to compensate for any errors there may be in the soundings; these were taken with difficulty, and it is, I consider, advisable to deduct a few inches from the results, as there is a deal of semi-fluid matter in that part of the bed.

	Square feet.
The area of the full contour of the present tank is... ...	418,176,000
The area of the proposed, *i.e.*, with the surface level raised twelve feet will be	585,446,400
Difference between present and proposed contours... ...	167,270,400

From the above the capacity of the proposed reservoir has been deduced as follows:—

	Cubic feet.
418,176,000 × 17 =	7,108,992,000
167,270,400 × 6 =	1,003,622,400
Total volume...	8,112,614,400

Capacity of Duvuru reservoir.

The capacity of the Duvuru reservoir has been calculated in a similar manner.

† Sheet No. 7.

The average depth of this tank when filled to the full contour level is $5\frac{1}{4}$ feet; this has been gathered from five sections taken across it along the lines showing the level of the bed on the survey.†

The general level of the bed, according to these sections, is 92·76 feet + mean tide; this deducted from 98', the full tank contour, gives a mean depth of $5\frac{1}{4}$ feet.

The area of the full contour is 198,664,020 square feet; this multiplied by the mean depth shows the reservoir is capable of storing 1,042,986,100 cubic feet.

The capacity of this tank is not to be increased.

Volume to be stored under the main feeder compared with the capacities of the reservoirs.

Subjoined are the capacities of both tanks.

	Cubic feet.
Kanigery	8,112,614,400
Duvuru	1,042,986,100
	9,155,600,500
Maximum volume to be stored—*vide* Appendix F.	7,669,388,567
Difference—Excess of capacity over volume to be stored in the reservoirs under the main feeder from Sangam	1,486,211,933

26. The reservoirs under the auxiliary feeder from the Nellore anicut have to store 540,000,000 cubic feet—*vide* paragraph 23. This volume will be stored in the under mentioned tanks.

Reservoirs under auxiliary feeder.

Veguru.
Vidavaluru.
Chavakacherla.
Vavilla.
Varini.
Indupuru.
Alluru Ramannah.

The capacities of these tanks are given below—

	Cubic feet.
Veguru...	98,000,000
Vidavaluru	37,000,000
Chavakacherla	54,000,000
Vavilla...	91,000,000
Varini	36,000,000
Indupuru	44,000,000
Alluru Ramannah ...	306,000,000
Total...	666,000,000

Here also it will be observed the storage capacity is in excess of the maximum requirements.

* Sheet No. 127.

By referring to the surveys* and sections of these minor reservoirs the above calculations may readily be verified.

27. Having, I trust, satisfactorily demonstrated that the Pennair is capable of irrigating in the worst of seasons the area proposed; that the main and auxiliary feeders are capable of drawing off the requisite supply of water during freshes, and that we have ample means of storing the volume of water necessary, I will proceed to describe the several channels in detail, and the means provided for watering, draining, and protecting the northern Delta from inundation during extraordinary floods in the Pennair.

28. The site selected for the head-sluice at Sangam, and the plan of the main feeder have already been noticed; the drawing and the specification of the former afford all needful information regarding that structure, and on survey of the latter the longitudinal and transverse sections show clearly what is intended,

and I think any attempt to explain matters more fully would be unnecessary and tedious.

29. There are, however, a few details connected with the head-sluice and main feeder which should be mentioned, as they were considered in designing these works.

To facilitate the working of the shutters of the former during high floods, the sluices proposed for construction about 900 yards below the head-sluice to regulate the supply to the Duvuru and Kanigery reservoir channels have been planned to admit of the water in front of them being raised several feet above the full supply level, to reduce the pressure on the shutters of the head-sluice. The highest known flood at Sangam appears to have risen to 18 feet above the deep bed of the river there; the surface level must, therefore, have been 116 feet above mean tide; the surface level of the water in the channel when discharging the full supply will be 102½ feet above mean tide, which would give a head of 13½ feet to contend with, and require considerable power to overcome; this difficulty has, however, been removed to a great extent by the plan alluded to; the regulating sluices will convert the channel between them and the head-sluice into a chamber, the water in which can be raised to 106 feet above mean tide; this would reduce the head at the head-sluice from 13½ to 10 feet, and make the working of the shutters comparatively easy.

Capacity of head-sluice.

The capacity of the head-sluice has been fixed with reference to the large volume it will have to discharge during *low* freshes; the waterway allowed is, I consider, absolutely necessary to the success of the undertaking; to contract it so as to make any material difference in the dimensions would entail a loss of water at particular stages of the river, the value of which would be difficult to estimate.

30. In a project like this, where so much depends on the efficiency of the head-works and the main supply channel, it is very desirable to assimilate the velocity of the channel to that of the river, and prevent silt being constantly precipitated, particularly in the vicinity of the head-sluice.

31. The side slopes and bottom of the main feeder, from the head to the Kanigery reservoir, it will be remembered, are to be pitched with rubble, to admit of the difference of level that exists between the floor of the head-sluice and the bed of the reservoir being fully utilized; this plan also furnishes the means of transporting the great bulk of the silt to the reservoir, and reducing the cost of the annual clearances.

The great bulk of the silt will be deposited in the Kanigery reservoir.

The velocity of the water in the main feeder will occasionally be greater than that of the Pennair, which is about five feet per second in ordinary freshes. The velocity of the main feeder will be more than this until the water in the reservoir has risen to 86·64 feet above mean tide; from this level to 95 feet above datum it would gradually decrease to 3·41 feet per second, which may be considered the minimum velocity. The velocity of the main feeder being sometimes greater than that of the Pennair in general freshes will prove useful in stirring up and carrying on to the reservoir the deposit that

Velocity of main feeder will sometimes exceed that of the Pennair in ordinary freshes.

will necessarily take place on those days when the velocity in the channel falls below that in the Pennair.

32. Constituting the reservoir the principal receptacle for the sedimentary matter will, of course, tend to hasten its silting up, but this is of little consequence, as two or three centuries must elapse before the capacity of the reservoir would be materially impaired by the annual deposits.

Duvuru channel.

33. The Duvuru reservoir channel will take off from the main feeder at 40·5 chains below the head-sluice; it winds round the southern extremity of the Sangam hill, and traverses the country between the present channel and the Dorenal road; this line was selected to avoid the enormous spoil and silt banks that run parallel to the former for some distance from the existing head-sluice. At 61 chains east of this building the sections of these banks are so much reduced as to admit of their being removed, where necessary, at a moderate cost; the new head has, therefore, been planned to join the old channel here, as it is expedient to avoid cutting through the hard soil near the foot of the Wudderpalem hill. From this junction the latter will be enlarged and utilized, as far as the Dorenal road, where it will be abandoned for a more direct line to the deep bed of the reservoir.

Duvuru regulating sluice.

34. The regulating sluice at the head of the Duvuru channel has been designed to discharge 792 cubic feet per second when the depth of water in the main feeder is 9 feet. The level of the floor has been fixed at 91·5 feet above mean tide, *i.e.*, the level of the bed of the main feeder at the site of this work.

The difference of level between the floor of this sluice and the bed of the reservoir is 2·5 feet; this has been equally distributed throughout the three miles of channel that intervene between it and the margin of the reservoir.

From the end of the 3rd mile the channel will be prolonged until it reaches the deep bed of the tank. When this channel is discharging, with a depth of 9 feet, the mean radius will be 5·77 feet; the mean velocity due to this, and a fall of 10 inches per mile, is 2·59 feet per second, but this will vary according to the state of the Duvuru reservoir; when very low the water would approach it with considerable velocity; provision has, therefore, been made to protect the sides and bottom of the channel for some distance before the contour of the tank is reached to where the velocity will be reduced by the spill flowing freely off on both sides of the channel into the reservoir.

New bridge necessary for Dorenal road.

35. A new bridge has been designed for the Dorenal road, as the floor of the existing one is several feet above the level of the proposed Duvuru reservoir supply channel.

Local drainage to be turned into Tarunivaya tank.

36. The drainage from the eastern face of the Sangam hill, and a small area in the immediate vicinity, will be intercepted by the new head for the Duvuru channel; instead of admitting it into the channel, it will be carried parallel to the northern spoil bank by an inexpensive drain for a short distance, and then discharged into the Tarunivaya tank supply channel.

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37. The longitudinal and transverse sections of this channel are given in Sheet No. 15; the details of the regulating sluice and bridge will be found by referring to Plans Nos. 16 and 17.

38. The main irrigation lines in this scheme are the

Bank channel.
Southern channel.
Central channel.
Feeder from Kanigery reservoir.
Northern channel.
Eastern main channel.

Bank channel.

39. The Bank channel takes off from the main feeder east of Sangam, and ends at the Punchedu tank; it is intended to supply the Southern and Central channels *during freshes in the Pennair*. It has been planned to discharge 478 cubic feet per second; *i. e.*, 421·875 cubic feet for the 25,000 acres, under the Southern and Central channels, and 55·6875 for the 3,300 acres west of the Punchedu tank.

On the freshes subsiding the supply for these channels will be drawn from the Kanigery reservoir. The volume required for the 3,300 acres west of the Punchedu tank will be furnished by the Duvuru reservoir, as the land there is too high to be permanently commanded by the Kanigery reservoir.

Bank channel auxiliary feeder.

40. The channel from the Duvuru tank for the irrigation of this tract crosses the main feeder by an inverted syphon; this work was preferred to an aqueduct, as it offers no obstruction to timber, or any other floating body that may get adrift; this is very important, as the velocity here will often more resemble that of a rapid than an ordinary stream.

The Bank channel head sluice consists of 4 vents $5\frac{1}{2}' \times 9'$; it has been designed to discharge 478 cubic feet per second, with 9' of water on the floor, the level of this being 90·143 feet above mean tide. The channel from the head sluice to the first fall has an uniform inclination of one foot per mile. The full supply depth of this section is 9', the mean radius 4·69 feet, the mean velocity 2·58 feet, and the discharge 479 cubic feet per second.

Below the first fall the discharge is reduced to 422·31 feet per second; 55·69 having been drawn off above it for the 3,300 acres previously noticed. The first fall in this channel has been planned to discharge, with a head of nine feet, 422·31 cubic feet per second; no shutters have been allowed for this weir, as it will never be required to act as a regulator.

From the first fall to the end of the channel the depth will be 6'; this change is principally owing to the desire to consume as much fall as possible in the alignment of the channel, and thereby reduce the number of masonry works.

41. The foregoing arrangement is very necessary in a delta like this, where the inclination is about $3\frac{1}{2}$ feet per mile.

In the reach of the Bank channel under notice, the fall allowed per mile is 1·5 feet; the mean radius will be 3·92 feet, and the velocity 2·96 feet per second.

42. The auxiliary channel from the Duvuru reservoir will, after reaching the northern bank of the Bank channel, run parallel to it until it intersects the distribution channel that leaves the Bank channel at the fifth mile for the irrigation of 2,700 acres between that point and the Punchedu tank. The auxiliary duct has also to water 600 acres south of the Bank channel; a small inverted syphon has, therefore, been designed to convey under this branch the necessary supply to the plot referred to.

Auxiliary Bank channel feeder, continued.

Towards the end of this channel 13·5 cubic feet per second will be taken off for the irrigation of 800 acres; this will reduce the discharge to 408·81 cubic feet per second.

The survey, longitudinal, and transverse sections of the Bank channel are delineated on Sheet No. 22.

43. The Southern channel takes off from the western extremity of the Punchedu tank; the arrangements proposed for keeping up the supply to this basin have been described in paragraph 39.

Southern channel.

The surface level of the water in the Punchedu basin will vary from 80·2 to 77·5 feet above mean tide, in consequence of its deriving its supply from two sources, viz., the Bank channel and Kanigery reservoir; when the former is discharging the full volume the water would rise to the higher level, and give a head of 6' on the body wall of the proposed regulator at the head of the Southern channel; when the Kanigery reservoir is the feeder this would be reduced to 3' 4".

Punchedu tank.

The regulator just noticed will be constructed in the Punchedu tank bank, and has been designed to discharge with the above, or any intermediate heads, 246·37 cubic feet per second, the quantity of water required for the irrigation of the 14,600 acres under the Southern channel. From this regulator to the fall in the sixth mile the inclination in the bed of the channel will be 1·75 feet per mile; the mean radius 3·18 feet, the mean velocity 2·9 feet per second, and the discharge 247·95 cubic feet per second.

Regulator at head of Southern channel.

A short distance from the regulator the Southern channel crosses the Kovuru tank supply channel; this it is proposed to convert into an outlet for the drainage of the country, west of the Southern channel, and the tract lying between the Central and Southern channels.

Kovuru tank channel to act as a drain.

44. The extent of land to be drained west of the Southern and Bank channels, may be taken at six square miles; this is generally very sandy, and it will be ample to provide waterway sufficient to discharge in twenty-four hours a volume equal to three inches of rainfall running off the whole basin in that period; this would give 484 cubic feet per second

Drainage of the land between the river embankment and Southern channel.

To pass this body under the Southern channel a culvert has been designed consisting of two wrought iron pipes of 4' 10" internal diameter; these are 100 feet in length and will discharge under the available head (five feet) 486 cubic feet per scecond.

45. As the Southern channel nears the spur that extends from the left margin of the Pennair to the village of Penahalli, it makes a detour inland to avoid it, and then returns to the bank of the river on the eastern side of the spur. This alignment entails the construction of two small culverts; one on the western, the other on the eastern face of the spur for the local drainage; it is, however, more desirable than carrying the channel close to Tonnavada, as the ground adjoining that village is unfavourable; and in high floods when the Pennair is rushing through the gorge with a greatly accelerated velocity, it would be difficult to prevent the channel being injured, unless protected by a masonry wall, or some other expensive arrangement. The area to be drained by each of these culverts is three-fifths of a square mile; they must, therefore, be able to discharge 97 cubic feet per second, which represents the drainage from the extent named at the rate of six inches running off the whole basin in twenty-four hours.

46. The drainage that falls into the Pennair in the vicinity of Bapanapadu it is proposed to divert to the north by cutting a drain from near that town to the Kovuru channel; this is absolutely necessary, as the river water in high floods stands *above* the surface of the country, and stops all drainage by the present outfall for the time being.

Existing drainage imperfect.

This remark equally applies to the other parts of the delta that drain into the Pennair; any attempt to convert this into an outlet for the surface discharge would be a mistake; the drainage to be effective at all seasons must flow *from* not *towards* the river.

At present there are two exceptions to this rule, between Sangam and the mouth of the Moldavy, in addition to the one already referred to; the first in order is in the vicinity of the anicut; the second between Tammipalem and Veguru. The exception alluded to in the neighbourhood of Bapanapadu is, no doubt, due to the Penahalli spur; the section of the river is so contracted there, that in some great flood a considerable body of water must have been separated from it above the gorge, and rejoined it between Tonnavada and Bapanapadu, forming a depression which has deflected a small volume of the local drainage from its natural outfall.

47. The alteration in the direction of the drainage adjacent to the anicut is owing to the low ridge that extends from near Kovuru to east of Padanapadu, and forms two small basins, one of which discharges its surplus into the Pennair.

The third and last exception remains to be noticed; this is, I consider, to be attributed to the Pennair suddenly changing its course at Tammipalem, and running almost parallel to the natural drainage line for about 3½ miles.

48. It is proposed to improve the drainage of these localities by turning the surplus that now falls into the Pennair to the north; at Bapanapadu and Tammipalem this will be done by excavating

Means proposed to improve the present imperfect drainage.

two drains; one will discharge into the Kovuru channel, the other into the Moldavy these cuts will be rather costly, as the country falls so rapidly from the river that masonry works, to consume a portion of the excessive inclination, must be resorted to. In the Bapanapadu drain a fall of four feet is necessary, and in the Modegunta cut two falls of 5½ feet each are required.

49. The surface discharge that flows into the Pennair below the anicut will be intercepted by, and admitted into, the auxiliary feeder; the masonry works necessary to carry out this arrangement have been planned, and will be subsequently explained.

50. The Southern channel commands 1,250 acres between the regulator and the fall in the 6th mile; the quantity of water requisite for the direct irrigation of these is 21·09 cubic feet per second; this volume, deducted from that admitted at the head, reduces the discharge to 225·72 cubic feet per second. The fall in the 6th mile has been designed to discharge this volume with a head of six feet.

From this fall to that in the 9th mile the section of the channel will decrease as the minor distribution ducts draw off water for the irrigation of the land under them. The water section in this reach varies from 79·44 to 60·6 square feet, and the discharge from 225·72 to 172·56 cubic feet per second; the difference, 53·16 cubic feet, is the volume that will be taken off by the several sluices for the irrigation of the 3,150 acres dependent on this section of the channel.

Dorenal road.

With the fall in the 9th mile a bridge has been combined; the Dorenal road will cross the channel here.

After passing the Dorenal road the channel enters the small tank belonging to

Potireddipalem tank.

Potireddipalem; as this is a shrotriam village, and the owners are unwilling to relinquish their claim to the little surplus they occasionally get from the Gangavaram tank, it will be conveyed across the channel by an aqueduct and discharged into the principal part of their tank, which is on the east of the Southern channel. The supply to their tank is so scanty and precarious that I feel convinced they will convert it into wet cultivation before long; but to prevent their claiming compensation, prior to doing so, I think it prudent not to interfere with their existing interests, more than is absolutely necessary.

The fall in the 9th mile will discharge, with a head of six feet, 172·56 cubic feet per second.

Between this fall and the one in the 11th mile, the slope in the bed of the channel will be two feet per mile; the mean radius 2·66 feet; the mean velocity 2·85 feet per second; and the discharge 172·56 cubic feet per second.

At 10·8125 miles the Southern channel crosses the auxiliary feeder from the

Auxiliary feeder from Pennair.

Nellore Anicut by an iron aqueduct; at the intersection the bed of the former is 10·64 feet above the latter.

The fall in the 11th mile has been planned to discharge, with a head of six feet, 170·87 cubic feet per second; *i. e.*, 1·69 feet less than the volume discharged

The channel from the fall in the 11th mile to that in the 14th has been planned to discharge 170·87 cubic feet per second, the mean radius being 2·65 feet, and the mean velocity 2·85 feet per second.

The irrigable area to be watered by this section of the channel is 5,100 acres; 86·06 cubic feet per second must, therefore, be taken off for the direct irrigation of the above; this reduces the discharge of the main duct to 84·81 cubic feet per second.

The fall in the 14th mile will discharge this under a head of six feet.

From this fall to the regulating sluice at the end of the 19th mile the depth of the channel will be 4½ feet; the mean radius two feet; the mean velocity 2·47 feet per second; and the discharge 84·81 cubic feet per second.

The reach of channel under review commands 3,700 acres; the irrigation sluices have accordingly been planned to draw off 62·44 cubic feet per second for this acreage.

At the regulating sluice in the 19th mile the main channel may be considered to end; immediately beyond it the last plot of cultivable land is reached; this consists of 1,300 acres, and will require 21·94 cubic feet per second for its irrigation, which is practically the volume available after supplying the acreage under the several preceding reaches of the Southern channel.

51. From what has been stated regarding the configuration of the delta, and

River embankment.

by referring to the accompanying sketch map, which has the levels plotted on it, the absolute necessity of an embankment to preserve the country from inundation during high floods in the Pennair will be evident.

The embanking of the left bank of the river from Sangam to the mouth of the Moldavy necessarily forms an essential part of the present scheme, and is introduced here as it has been combined with the embankment of the Southern channel, where this could be done advantageously.

52. The Central, like the Southern channel, takes off from the Punchedu tank,

Central channel.

and will be affected in a similar manner by the fluctuations in the depth of that basin; the regulator has accordingly been designed to be capable of drawing off the full quantity of water with the variable heads alluded to in paragraph 43.

The area to be watered by this branch is 9,600 acres; and has been apportioned as follows:—

	Acres.
Under sluice above regulator..	2,800
Between regulator and fall at end of 4th mile...	2,400
Between falls in 4th and 8th miles...	2,800
Below fall in 8th mile....	1,600

The volume of water required for the direct irrigation of the above, at the rate of 2¼ cubic yards per hour per acre, will be 9,600 × ·016875 = 162 cubic feet per second. In calculating the dimensions of the regulator at the head of the Central channel, the water discharged by the sluice adjoining that work for the irrigation of 2,800 acres in the vicinity of Punchedu must be deducted from the volume allowed for the whole area. The supply necessary for this acreage will be 2,800 × ·016875 = 47·25 cubic feet per second. This subtracted from the

quantity of water requisite for the irrigation of the several plots under this channel gives the volume to be drawn off from the basin by the main duct.

The regulator and upper portion of the first reach of the channel have been planned to discharge 114·75 cubic feet per second; the section of the latter decreases from the above capacity to 74·25 cubic feet per second, as the different distribution off-lets are supplied, with the volume necessary for the irrigation of the land dependent on them.

At the end of the 4th mile the channel intersects the Dorenal road; the latter will cross by a bridge which has been planned in connection with the fall here.

This fall will discharge, with a head of 5 feet, 74·25 cubic feet per second.

The channel between this fall and the one in the 8th mile has been designed to discharge 74·25 cubic feet per second at the head, and 27 cubic feet in the immediate vicinity of the latter weir. The decrease in the capacity is gradual, and corresponds with the water taken off by the irrigation sluices for the 2,800 acres commanded by this part of the channel.

Drainage to be turned into Moldavy.

In this reach of the channel it is proposed to deflect the surplus drainage from the Kovuru tank, and discharge it into the Moldavy.

The drainage of the country between the Central channel and the Dorenal road will also be diverted to this stream by cutting through the low ridge near Challayapalem.

Irrigation and drainage have been kept as distinct as possible.

53. In maturing this scheme the advisability of keeping the irrigation distinct from the drainage has been duly considered; in two or three instances where this plan would entail an excessive outlay, and the volume of surplus to be dealt with would not justify exceptional measures, it has been admitted into the irrigation ducts; but as a rule the disposal of the drainage has been separately provided for.

54. The Kovuru channel will become under the intended arrangements the drainage outfall of 15 square miles; the surface discharge from this area, at the rate of six inches of rainfall, running off the whole basin in twenty-four hours, would practically be 2,420 cubic feet per second.

Aqueduct and regulator.

The aqueduct, in the line of the Central channel, at Patoor, has been planned to discharge this volume when necessary and also to regulate the quantity of water to be stored in the Kovuru tank.

Kovuru tank.

55. Under the improved system of irrigation proposed for the Northern Delta this tank will not be required as a reservoir; it should, however, I consider, be retained, but on a reduced scale, for the convenience of the inhabitants of the large and important town of Kovuru.

56. The fall in the 8th mile of the Central channel has been designed to discharge, with a head of 4 feet, 27 cubic feet per second. Between this weir and the auxiliary feeder from the Pennair, (the eastern boundary of the land to be watered by the Central channel,) there are 1,600 irrigable acres; the water will be

distributed to this area at a trifling cost, as the Central channel will join the existing network of channels a short distance below the weir, and supply the several ducts now dependent on the Kanigery and Kovuru tanks in that locality.

The survey, longitudinal, and transverse sections of the Central channel are plotted in Sheet No. 50.

Feeder from Kanigery reservoir.

57. The feeder to supply the Southern and Central channels, when the freshes in the Pennair subside, takes off from the Kanigery reservoir at the site of the present main sluice, and joins the heads of those channels within the limits of the Punchedu tank.

This duct and head sluice have been planned to discharge 421·875 cubic feet per second, the volume required for the direct irrigation of the 25,000 acres under the Southern and Central channels, and Punchedu tank.

Punchedu basin feeder head sluice.

58. The level of the deep bed of the Kanigery reservoir varies from 69 to 77 feet above mean tide; the mean of these has been selected for the floor of the head sluice, as 73 feet above datum agrees better with the levels of the channels dependent on this reservoir, than a lower level would do; and if a higher were assumed the vents would not begin to draw off so soon, or admit of so large a proportion of the water being utilized.

The head sluice as designed will discharge the requisite volume when the surface of the water in the reservoir has risen to 79½ feet mean tide, *i. e.*, 2½ feet above what may be termed the level of the deep bed of the southern division of this basin.

59. The feeder from the Kanigery reservoir unavoidably intercepts the drainage of six square miles; this will be conveyed under the channel by two culverts; one will discharge the drainage of two square miles, the other that of four. The smaller will be constructed in the depression that runs near and almost parallel to the Dorenal road; the larger in the valley adjacent to Punchedu; they will discharge 323 and 646 cubic feet per second, respectively; the volume equivalent to a rainfall of six inches flowing off the whole area in twenty-four hours.

In connection with this feeder two bridges are necessary in the line of the Dorenal road, one will consist of two arches of 18 feet span, the other of one arch of 15 feet span; the former is intended for construction over the feeder, the latter across the proposed drain from the first culvert to the Moldavy.

The survey, longitudinal and transverse sections of this branch are drawn on Sheets Nos. 50 and 27.

The detailed plans of the different works will be seen by turning to Sheets Nos. 28, 29, 30, 31, and 32.

Northern channel.

60. The Northern channel takes off from the Kanigery reservoir close to the village of Vavveru, and after clearing the latter traverses the high ground north of Buchireddipalem, until the plateau opposite Parlapalle is reached; at this break the channel crosses the watershed with a maximum cutting of 11 feet, and becomes two branches; one follows the contour of the country, and is carried on the highest possible level with a moderate fall per mile to about 15 miles north of the Nellore Anicut.

The other branch runs eastward, and will water that portion of the delta bounded by the Pydara and the Moldavy.

61. Before entering into the detailed description of the Northern channel, I would observe three lines have been suggested for the first mile of this branch, *viz.*:

(1.) Through the village of Vavveru.

(2.) Along the Munalapoody valley.

(3.) East of Vavveru.

The first and third of these the villagers object to; in the one instance numbers would lose their houses; in the other a few individuals would be deprived of a small area of their wet cultivation.

The line along the Munalapoody valley is the popular one with them; it would neither interfere with their houses, nor their valuable land; but I cannot recommend its adoption as it would cost Rupees 37,500 more than the line east of Vavveru, which is, in my opinion, the most eligible of the three.

The line through the village is the most economical arrangement, but it is not, I consider, a desirable one, as it would entail the removal of several houses, and be considered an oppressive measure. To enable a correct decision being formed as to the advisability, or otherwise, of selecting this alignment, I annex an extract showing the probable cost of constructing the first mile of the rival lines:—

	RS.
East of Vavveru	32,300
Through this village	28,000
Difference in favour of line through Vavveru...	4,300

In the event of the latter being approved of Rupees 4,300 will have to be deducted from the estimate, as it provides for the more expensive plan.

62. Having noticed the three lines available for the head of the Northern channel, I purpose proceeding with the descriptive sketch of the alignment of the whole.

Northern channel head sluice.

The head sluice has been designed to discharge the volume of water necessary for this branch, under the same head and conditions as the sluice, at the source of the feeder to supply the Southern and Central channels, has been planned to do, the particulars of which are given in paragraph 58.

From the head sluice to $1\frac{1}{4}$ miles the channel has been designed to discharge 872·437 cubic feet per second, the volume requisite for the irrigation of the 51,700 acres under this main head, when no water can be drawn from the Pennair for the Northern Delta.

At $1\frac{1}{4}$ miles 8·943 cubic feet per second are taken off to water 530 acres; this reduces the discharge of the channel to 863·494 cubic feet per second.

Advantage has been taken of the low ground east of Vavveru to economize the available fall; the slope in the first mile will be 6 inches only; the mean radius being 5·21 feet; the mean velocity 1·84 feet per second; and the discharge 872·16 cubic feet per second.

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A culvert has been provided to allow the drainage from the eastern face of the Vavveru spur to pass under the channel; it has been planned to discharge with a head of 4 feet 161 cubic feet per second, which is equivalent to one inch of rainfall, running off the gathering ground per hour. It would not, I think, be safe to reduce the waterway, as the basin is very small (one-fourth of a square mile) and rocky.

From $1\frac{1}{4}$ to $2\frac{3}{8}$ miles the channel will discharge, with a depth of 6 feet, 863·494 cubic feet per second, the mean radius being 4·99 feet, and the mean velocity 2·67 feet per second.

In this reach of the channel a culvert is necessary, and has been provided to discharge the drainage from three-fourths of a square mile, at the rate of one inch running off the whole gathering ground per hour, which is equal to 484 cubic feet per second.

The channel crosses the local road from Buchireddipalem to Chennuru near the end of the second mile; an occupation bridge has been allowed for this communication.

At $2\frac{3}{8}$ miles a distribution duct takes off 8·437 cubic feet per second to water 500 acres; the discharge of the channel beyond this point will, therefore, be 863·494 — 8·437 = 855·057 cubic feet per second.

Between $2\frac{3}{8}$ and $3\frac{3}{8}$ miles, the channel has been planned to discharge this volume with a depth of 6 feet, the mean radius being 4·98 feet, and the mean velocity 2·66 feet per second.

At $3\frac{3}{8}$ miles, 3·375 cubic feet per second will be drawn off for the irrigation of 200 acres; this will reduce the discharge of the channel in the subsequent reach to 851·682 cubic feet per second.

From $3\frac{3}{8}$ miles to where the eastern main branch leaves the Northern channel the latter will discharge, when flowing 6 feet deep, 851·682 cubic feet per second.

63. The irrigable area commanded by the eastern main channel is 39,870 acres; the water required for the direct irrigation of this acreage will be 39,870 ×·016875 = 672·806 cubic feet per second. The discharge of the Northern channel below this off-let will consequently be diminished to 851·682 — 672·806 = 178·876 cubic feet per second.

Acreage under eastern main channel.

64. At the bifurcation of the Northern channel two head sluices have been allowed to regulate the supply of water to both branches.

65. The sluice for the northern duct has been designed to discharge 178·875 cubic feet per second.

From this sluice to $4\frac{5}{8}$ miles the mean radius will be 3·34 feet; the mean velocity 2·17 feet per second; and the discharge 178·875 cubic feet per second.

At $4\frac{5}{8}$ miles the inclination in the bed of the channel is decreased from one foot to six inches per mile, for some distance, to secure a suitable level for crossing the Pydaru; a less slope than the former is also desirable to admit of the channel being carried above the tanks belonging to the shrotriam villages of Chavutaputtedu, Uchaguntapalem, and Racharlapadu.

Between 4⅝ and 6¼ miles the channel will continue to discharge 178·875 cubic feet per second, the mean radius being 3·81 feet, and the mean velocity 1·57 feet per second.

This velocity may be considered objectionably slow, but I must remark there is no silt to be deposited, as the channel takes off from a large reservoir, and will discharge clear water; the danger of aquatic plants growing is also very remote, particularly as the canal will be perfectly dry for seven months annually.

A drainage culvert has been designed for construction, within the limits of the 5th mile, to discharge 1,452 cubic feet per second; the volume equivalent to one inch of surplus, hourly running off the whole catchment basin, which is 2¼ square miles.

At 6¼ miles 13·5 cubic feet per second will be drawn off by one of the minor distribution channels to water 800 acres; the discharge of the main line beyond this point will, therefore, equal 178·875 — 13·5 = 165·375 cubic feet per second.

From 6¼ to 7⅜ miles the channel will discharge 165·375 cubic feet per second, the mean radius being 3·71 feet, and the mean velocity 1·55 feet per second.

Here 5·0625 cubic feet per second will be taken off for the irrigation of 300 acres, and decrease the discharge of the channel to 160·3125 cubic feet per second.

In the 7th mile a culvert has been allowed to carry off 484 cubic feet per second, the drainage from three-fourths of a square mile at the rate of one inch per hour running off the whole area.

Between 7⅜ and 8⅜ miles the discharge of the channel will be 160·3125 cubic feet per second; at the latter point 8·437 cubic feet per second will be discharged to water 500 acres; the capacity of the main duct will, therefore, be reduced to 151·875 cubic feet per second.

In the 9th mile the channel crosses the drainage of three-eighths of a square mile; a culvert capable of discharging 242 cubic feet per second has been designed for construction in this depression. The channel from 8⅜ to 9½ miles has been planned to discharge 151·875 cubic feet per second; at the end of this reach it is decreased to 142·593 by one of the minor ducts drawing off water for the irrigation of 550 acres.

Between 9·5 and 10·31 miles the channel will discharge 142·593 cubic feet per second; the mean radius being 3·54 feet, and the mean velocity 1·51 feet per second.

At 10·31 miles a distribution branch takes off to water 300 acres, and reduces the discharge of the northern line to 137·531 cubic feet per second.

A culvert has been designed to admit of the drainage intercepted by the 10th mile of the channel flowing off; it will discharge 807 cubic feet per second; the volume equal to one inch of rainfall over the whole basin (1¼ square miles) running off hourly.

From 10·31 to 11·81 miles the channel will discharge, with a depth of 6 feet, 137·531 cubic feet per second, the mean radius being 3·5 feet, and the mean velocity 1·5 feet per second.

A culvert of similar design to that proposed for the 10th mile is requisite in the 12th to discharge a correspondent volume of surplus with the same head.

At 11·81 miles an irrigation sluice will draw off water for 350 acres, and diminish the discharge of the main line to 131·625 cubic feet per second.

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This section will be continued to the 13th mile, where a minor distribution duct takes off 20·25 cubic feet per second to water 1,200 acres; the discharge of the channel beyond this off-let will, therefore, equal 131·625 — 20·25 = 111·375 cubic feet per second.

In the 13th mile a culvert has been provided to discharge 1,452 cubic feet per second, the drainage of 2¼ square miles at the rate of one inch of rainfall over the whole area running off hourly.

At the 14th mile 1·35 cubic feet per second will be taken off for the direct irrigation of 80 acres; the discharge of the channel beyond this point will consequently be reduced to 110·025 cubic feet per second.

Occupation Bridges.

66. Occupation bridges have been allowed for the local traffic in the 11th and 13th miles.

67. For 1½ miles beyond the last off-let, the channel has been planned to discharge, with a depth of 6 feet, 110·025 cubic feet per second.

Main channel crosses Pydaru.

68. Within the limits of the 15th mile the channel crosses the Pydaru by an inverted syphon, consisting of two wrought iron pipes of 5 feet diameter.

The catchment basin of the Pydaru above the intersection is 40 square miles, and supposing the surplus that flows off in twenty-four hours to be equivalent to a rainfall of 6 inches, over the whole basin, the discharge at the site of the proposed syphon would be 6,453 cubic feet per second.

This work has accordingly been designed to admit of the above volume flowing freely off when the Pydaru has risen to its high flood-mark, which is 71·85 feet above mean tide; this, it is worthy of remark, is also the maximum level of the channel water; the embankments necessary in one case will, therefore, meet all the requirements of the other, and reduce the earthwork to the minimum.

The tributary that rises near Katrayapadu, and disembogues into the Pydaru below the site of the syphon, will be turned into that river, a short distance above this work, by cutting through the low neck of land that separates both streams.

At 15½ miles 3·375 cubic feet per second will be drawn off for the irrigation of 200 acres; this will decrease the discharge of the Northern channel in the succeeding reach, to 106·65 cubic feet per second. It has accordingly been planned to discharge this volume, with a mean radius of 2·92 feet, the mean velocity being 1·73 feet per second.

Within the limits of this section 5·062 cubic feet per second will be taken off to water 300 acres; the discharge in the next will, therefore, be reduced to 106·65 — 5·0625 = 101·5875 cubic feet per second.

Between the 17th and 20·6 miles 300 acres are commanded by the channel; the water required for the irrigation of this acreage will reduce its discharge from 101·5875 to 96·525 cubic feet per second.

In the 17th, 19th, and 20th miles culverts have been designed to discharge 968 cubic feet per second, the drainage of 1½ square miles.

69. It would be tedious and, I presume, unnecessary to notice in detail the several small reaches that intervene between the last section and the end of the channel, as the same general arrangement and procedure have been followed

throughout: I purpose, however, enumerating and briefly alluding to the masonry works that have not been described.

70. Eleven culverts are necessary, and have been allowed, between the 20th and 32nd miles to discharge the drainage from eleven valleys intersected by the channel, the area of each may practically be taken at half a square mile, and the surplus to be disposed of at 323 cubic feet per second.

71. Occupation bridges are proposed for construction in the 17th, 19th, 21st, 22nd, 24th, 29th, and 30th miles; the channel will also be spanned by another, with a roadway of 18 feet in breadth, in the line of Trunk Road No. VI.

72. The channel will end at 32·225 miles from the Kanigery reservoir; the regulating sluice at the terminus has been designed to discharge water for the irrigation of 400 acres; the irrigable area between the channel and the waterspread of the Alluru Ramannah tank; it will also act as an outlet for any surplus there may be available from this branch for storage in the latter basin.

Termination of channel.

73. The channel has been planned to discharge with a depth of six feet the full volume required for the direct irrigation of the land commanded by it; all, however, has been arranged to admit of its carrying an additional two feet of water to meet any extra demand during the ploughing season, or for storage in the Puttedu and Alluru tanks, when the Kanigery reservoir escape is discharging, and it is considered expedient to secure a portion of the surplus instead of allowing the whole to run to waste.

Depth of channel can be increased to 8 feet when necessary.

The survey, longitudinal and cross sections of this branch will be found by referring to Survey Sheets Nos. 57, 58, 59, and 60.

Drawing connected with Northern channel.

The detailed plans of the works are numbered from 61 to 77 inclusive.

74. This branch, it will be remembered, leaves the Northern channel at 3·625 miles from the Kanigery reservoir, and draws off 672·806 cubic feet per second from that feeder.

Eastern main channel.

75. The minor duct for the irrigation of the land between the Yallayapalem spur and the Moldavy, and to supply the distribution channels dependent on the existing Yallayapalem branch, takes off 38·81 cubic feet per second from the eastern main immediately above the regulating sluice; the volume to be discharged by this work will, therefore, be 672·806 — 38·81 = 633·99 cubic feet per second.

76. As the country falls precipitously from the crest of the watershed four weirs are necessary within two miles of the head to absorb 20 feet of the superfluous inclination.

In the reach between the regulating sluice and the 1st weir two irrigation sluices will draw off 9·112 cubic feet per second to water 440 acres of the high land south of the channel, and 100 acres north of it.

The channel and masonry works from the 1st weir inclusive to the end of the 2nd mile have been planned to discharge, when the water is flowing six feet deep, 624·88 cubic feet per second.

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At the latter point a sluice in the north bank will take off water for the irrigation of 800 acres, the discharge beyond this will therefore equal 624·881 — 13·5 = 611·381 cubic feet per second.

As the soil is very tenacious in the upper portion of the channel, and rather stiff for some miles below the head, the mean velocity of the stream between the regulating sluice and the weir in the 7th mile will vary from 3·18 to 3·1 feet per second.

In the 3rd mile a weir with an overfall of 3 feet has been planned to consume the difference of level between the fall of the country and the slope of the channel in that section. An occupation bridge has been combined with this work.

Towards the close of the 3rd mile the channel crosses the valley that drains into the Gandavaram tank; as this reservoir is to be brought under wet cultivation, and it would be expensive to carry the surplus under the channel, it will be deflected and conveyed by a drainage cut to the depression north of Yallayapalem for ultimate discharge into the Moldavy.

In addition to this surplus channel two small catch drains are required to intercept the drainage from portions of the Yellayapalem and Gotlapalem spurs, and discharge it into the natural drainage outlets.

At 3½ miles two distribution ducts take off, one from the north, the other from the south bank; each is intended to water 900 acres; the discharge of the channel east of these sluices will consequently be reduced to 581 cubic feet per second.

This section is maintained to 4¾ miles where 18·5625 cubic feet per second are drawn off for the irrigation of 1,100 acres; the discharge of the main line from this point will, therefore, equal 581·00625 — 18·5625 = 562·44375 cubic feet per second.

Between the last off-let and the weir in the 6th mile the channel will discharge the above volume when running 6 feet deep.

This reach of the channel commands 2,580 acres, *i.e.*, 2,380 on the north, and 200 on the south of it.

At 5·925 miles the channel crosses Trunk Road No. 6, a bridge has been planned for this communication in connection with the regulating weir proposed for construction here.

This weir has been designed to discharge 518·90 cubic feet per second, *i.e.*, the available volume after supplying 43·53 cubic feet per second to the 2,580 acres previously noticed.

A bridge has also been combined with the weir in the 7th mile for the branch road to Alluru and Isakapalle.

Immediately above this fall 12·66 cubic feet per second will be taken off to water 750 acres; the body to be discharged over it will accordingly equal 518·90625 — 12·65625 = 506·25 cubic feet per second.

Between this weir and the crossing of the auxiliary feeder from the Nellore anicut, the channel has been planned to discharge 506·25 cubic feet per second, the mean radius being 4·28 feet, and the mean velocity 3·094 feet per second.

As the eastern main has to supply the portion of the delta north of the Pydaru commanded by this scheme when no water is available in the Pennair, it will discharge 258·1875 cubic feet per second into the auxiliary feeder, for the direct irrigation of the 15,300 acres dependent on this channel and its subsidiary branches.

A regulator is proposed for erection where the eastern main intersects the auxiliary feeder, from the anicut it has been designed to admit, and apportion the water discharged by the latter during freshes, and to act similarly when this source fails, and the eastern main channel becomes the supply duct.

From this regulator to the adjacent weir the channel is capable of discharging 348·0625 cubic feet per second, *i.e.*, 100 cubic feet in excess of the volume requisite for the direct irrigation of the 14,700 acres east of the auxiliary feeder; this additional section has been allowed to draw off from the latter, during floods in the Pennair, water for storage in the Chavukacherla, Vidavaluru, Vavilla, and Varini tanks.

Between the regulator and the weir under notice four sluices will take off 99·66 cubic feet per second as annexed—

For storage in the Chavukacherla tank	60
For the direct irrigation of 2,000 acres north, and 350 south of the channel	39·66

The water to be discharged over the weir will consequently equal 348·0625 — 99·65625 = 248·40625 cubic feet per second.

A short distance below this fall the channel enters the Vidavaluru tank, as the country north and south of it falls rapidly and is generally unfavourable for the line.

The alignment proposed is the most economical; it saves heavy banking on the south, and does not entail the construction of a culvert to carry off the tank surplus which would be essentially necessary if the channel passed north of that basin.

Three sluices have been allowed for the Vidavaluru tank, two will be built in the north bank, the third in the south; those in the former will draw off water for the irrigation of 3,800 acres; the one in the latter for 250; the aggregate discharge of the whole being 4,050 × ·016875 = 68·34375 cubic feet per second.

77. The first section of the eastern main channel terminates in the Yidavaluru tank; the second takes off from its eastern margin, and follows the crest of the watershed that separates the basins of the Moldavy and Pydaru in that locality.

The head-sluice and upper reach of the second section will have to discharge 248·40625 — 68·34375 = 180·0625 cubic feet per second.

The former has been planned to do so with the available head of 3 feet; the channel will discharge this volume when flowing 6 feet deep.

At the end of the 2nd mile the duct to supply the Vavilla tank at the rate of 20 cubic feet per second leaves; two distribution channels to water 1,650 acres also take off here; these three off-lets will reduce the discharge to 132·21875 cubic feet per second.

The channel from the end of the 2nd to the end of the 3rd mile has been designed to convey this quantity, the mean radius being 2·46 feet, and the mean velocity 2·92 feet per second.

The irrigable area commanded by the proposed sluices at the end of the 3rd mile is 2,000 acres; 33·75 cubic feet per second will, therefore, be required to

water these plots which are situated north and south of the main line. In the subsequent reach the discharge will be 132·21875 — 33·75 = 98·46875 cubic feet per second.

At the end of the 4th mile a sluice in the south bank will draw off 27 cubic feet per second for the irrigation of 1,600 acres, and decrease the discharge to 71·46875 cubic feet per second; this section is maintained to the end of the 5th mile, where it is reduced to 19·06875 cubic feet per second, by supplying the following ducts with the volume specified :—

	Cubic feet per second.
Varini tank channel for storage	20
Varini branch channel for the direct irrigation of 1,070 acres.	18·05625
Distribution channel from south bank to water 850 acres ...	14·34375

In addition to the masonry works provided for these ducts a regulating sluice combined with a bridge has been designed for construction here; from this structure to the regulator in the 6th mile the depth of the channel has been decreased to 4 feet, to suit the reduced capacity.

A short distance above the regulator at the end of the 6th mile two sluices will take off 7·59375 cubic feet per second for the irrigation of 300 acres on the north, and 150 on the south of the channel, the discharge in the next reach will, therefore, be 11·475 cubic feet per second.

Below this regulator a further reduction of one foot has been made in the depth of the channel; it will discharge when running 3 feet deep 11·475 cubic feet per second up to the end of the 8th mile; from this point it will be reduced to 8·775 cubic feet per second, the difference, 2·7 cubic feet, is the volume required per second for the direct irrigation of the 160 acres commanded by the 8th mile.

The last reach of the channel has been designed to discharge 8·775 cubic feet per second, the quantity required to water the 520 acres dependent on this channel, in the vicinity of the Pydaru, which forms the northern boundary of the land commanded by it.

78. By referring to the survey* of the eastern main channel it will be observed a small branch channel is proposed from the Varini tank; this is necessary to irrigate the land west of the depression that extends from the tank near Varini to the Pydaru.

* Sheet No. 80.

79. In addition to the means of communication provided at the sites of the several weirs and regulating sluices, occupation bridges will span the channel in the 2nd, 3rd, 4th, and 5th miles.

The survey and sections of this main duct, together with the plans of the various works, accompany this report, and are numbered from 78 to 99 inclusive.

80. Having described the alignment of the principal channels and the arrangements proposed for the irrigation of the land under them, I will resume the descriptive sketch of the auxiliary feeder from the Nellore anicut.

Auxiliary feeder from Pennair.

From paragraph 23 it will be observed this channel is intended to draw off water from the Pennair during floods for irrigation and storage to reduce the demand on the Kanigery reservoir for a certain number of days annually.

The general design of the channel and its capability of discharging the requisite volume of water from the head-sluice to the Pydaru have already been adverted to; there are, however, some masonry works within these limits deserving of particular notice; the disposal of the drainage and the mode of supplying the several irrigation ducts are also of importance, and will be considered in detail.

The first mile of the auxiliary feeder crosses the drainage channel that falls into the Pennair, a short distance below the anicut; the area drained by this outlet is 4 square miles, and assuming the surplus to be disposed of, to be equivalent to a rainfall of 6 inches over the whole basin in twenty-four hours, provision must be made to discharge 645 cubic feet per second at the intersection. It has been shown that the Pennair cannot absorb the drainage at all seasons; this circumstance, together with the considerable expenditure that would be necessary to carry it over or under the channel and through the river embankment, induced me to decide on admitting it into the channel; this is, in fact, the only economical plan available; to carry it to the north would entail the construction of a culvert at the crossing of the southern channel, and deep cutting in the vicinity of Padugupadu. An inlet has accordingly been designed to allow this surplus to discharge into the auxiliary feeder at the rate of 645 cubic feet per second.

An inlet has also been planned for construction in the 2nd mile to admit the drainage of 2 square miles into the channel, as it would be difficult to dispose of it otherwise. This work is capable of discharging 323 cubic feet per second.

Surplus weir.

From what has been stated it will be gathered the channel may have to convey 968 cubic feet of drainage per second; as this volume exceeds the capability of the channel, *north of the eastern main* channel, by 74 cubic feet per second, an outlet to discharge this surplus at all stages of the Moldavy has been designed for erection in the 7th mile.

The drainage of the country north of the Padugupadu ridge will flow off parallel to the auxiliary feeder and fall into the Moldavy, *via* the channel cut some years ago to supply the Parlapalle tank.

Inverted syphon.

In the 7th mile the channel crosses the Moldavy by an inverted syphon which has been planned to discharge the maximum body of water required for irrigation without impeding the discharge of the Moldavy in high floods.

The valley of this stream west of the proposed channel is 132 square miles; in this basin there are two large and several small tanks; it will, therefore, be ample to provide waterway sufficient to allow a volume of surplus equal to a rainfall of 3 inches over the whole catchment ground to flow off in twenty-four hours.

The depth of the Moldavy in extreme floods, as far as I can learn, does not exceed 12 feet; the discharge over the syphon with this depth, and a surface fall at the rate of $2\frac{1}{2}$ feet per mile, would be 10,617 cubic feet per second, which is practically the body of surplus to be disposed of.

81. To accelerate the discharge of this stream in high freshes, the weir across it in the vicinity of Parlapalle to turn the water into the Vidavaluru tank will be removed, and the portions silted up by the present system of constructing temporary dams to divert water for irrigation will be cleared out.

Vidavaluru weir to be demolished.

82. A culvert has been designed for erection near the end of the 10th mile to carry the drainage of $5\frac{1}{8}$ square miles under the channel; it will discharge, with a head of 4 feet, 862 cubic feet per second.

Drainage culvert.

An out-fall sluice capable of discharging 894 cubic feet per second will be built in the north bank of the 12th mile to discharge into the Pydaru *below the existing dam* the maximum body of the drainage proposed to be admitted into the channel by the inlets previously noticed. This arrangement is necessary as the channel could not discharge into the Pydaru *above the dam* during high floods in that river.

Out-fall sluice.

As the surface level of the Pydaru in extraordinary floods will be about 5 feet higher than the channel water, a self-acting regulator has been designed for construction, at the end of this duct, to cut off the communication between the two, as soon as the Pydaru has risen above the channel maximum water-mark.

Self-acting regulator.

83. The dam referred to stretches across the Pydaru, a little west of the village of Talamanchi, and forms the head-work of the system of irrigation carried on under this river. It consists of an embankment and two masonry escapes for the surplus; the crest of the northern one will be reduced 1·3 feet to bring it to the same level as that of the southern, as it is very desirable to allow the heavy and sudden floods this river is subject to to flow off quickly.

Existing weir across Pydaru.

The *effective* waterway of both weirs may fairly be assumed at 340 lineal feet at least; the discharge over these during extraordinary floods (when the head would be 6′) will be 13,830 cubic feet per second* which volume is equivalent to more than a rainfall of 6 inches running off the whole catchment basin† in twenty-four hours.

† 70 square miles.

The channel that takes off above this dam will, with a few improvements, answer remarkably well to turn the water discharged by the auxiliary feeder to the reservoirs and land commanded by this portion of the project.

84. At the head of this channel a regulating sluice will be built to furnish the means of shutting off the Pydaru water when necessary.

Regulating sluice.

This sluice and the upper part of the channel will discharge, during freshes in the Pennair, 546·94 cubic feet per second, as follows:—

For the direct irrigation of 14,880 acres	251·1
For storage	295·84

* In calculating this discharge the co-efficient ·518 was used, as the crests are broad and resemble shoots.

As this volume will be discharged for a few days only each season, a regulator has been designed for construction in the 5th mile below the head-sluice to preserve the surface of the channel water at the level required for the adjoining land when the auxiliary feeder is supplying water for direct irrigation only.

In the first 4 miles of the channel 62·4375 cubic feet per second will be drawn off to water 3,700 acres, and reduce the discharge to 484·5025 cubic feet per second.

Between this reach and the regulator in the 5th mile 79·59 cubic feet per second will be taken off as annexed—

For the direct irrigation of 2,000 acres	33·75
For storage in the Indupuru tank	45·84

From this regulator to the Alluru large tank the channel has been planned to discharge 404·91 cubic feet per second.

To regulate the supply of water to the Indupuru and Purini channels, the road tunnels over these, in the line of the old trunk road, will be converted into head-sluices.

Purini tank to be retained.

85. The Purini tank will be retained, as it is well situated for distributing water to the lands east and north-east of it. The minor branch duct, for the irrigation of Gogulapalle, will take off from this basin near the village of Purini.

86. The volume discharged into the Alluru large tank will be disposed of as follows :—

	Cubic feet per second.
For the direct irrigation of 7,180 acres under this tank.	121·1628
For storage in the Ramannah tank	250
For the direct irrigation of 2,000 acres under the Ramannah tank	33·75
	404·9125

Alluru large tank to continue to store Pydaru water.

87. The Alluru large tank will be retained to store water for the irrigation of the land proposed to be still cultivated under the Pydaru; the area will, however, be considerably reduced, as this stream cannot regularly water the acreage nominally commanded by it unless at a cost quite disproportionate to the results obtainable.

88. The precarious nature of the cultivation under the Pydaru will be apparent by referring to page 5 of Appendix I. This shows that 2,893 acres, or 34·51 per cent. of the occupied area under the Alluru Pedda tank (which is supplied by the Pydaru) are lying fallow.

Irrigation under Pydaru will be benefited by this scheme.

89. The area at present dependent on the Pydaru is about 10,980* acres; this project will water 7,360 of these, and materially benefit the proprietors of the remainder, by enabling them to commence their cultivation much earlier than

* *Vide* Appendix I., pages 5, 11, and 12.

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they can generally do at present. Under the improved arrangements they will be able to begin ploughing and sowing soon after the floods in the Pennair appear; the water supplied to their fields between this period and the freshes in the Pydaru will be subsequently recovered by drawing off a similar volume from the Alluru Pedda tank for the land commanded and watered by the contemplated new channels in the vicinity of this reservoir.

90. The Alluru Pedda tank will also be utilized for distributing water to the several ducts intended to irrigate the land, proposed to be brought under the influence of this project, in that part of the delta.

Tuvvaladinne branch head-sluice.

The area of this is, as has been stated, 7,180 acres; the existing sluices will discharge the body requisite to water 2,180 acres, and a head-sluice has been designed for construction in the embankment to discharge 84·375 cubic feet per second for the irrigation of the 5,000 acres commanded by the Tuvvaladinne branch channel and its subsidiary ducts.

91. As the Alluru Pedda tank is *not* to be used as a reservoir for *Pennair* water, all discharge into it from this source will be immediately drawn off for direct irrigation, or for storage in the Alluru Ramannah tank, the object being to keep it as low as possible, to secure the maximum volume of water during freshes in the Pydaru. The capacity of this reservoir is 528,000,000 cubic feet.

Alluru Ramannah tank supply channel.

92. The head-sluice to supply the Alluru Ramannah tank will be built at the western extremity of the "Pedda tank" embankment; it will discharge 344·8375 cubic feet per second, as subjoined—

	Cubic feet per second.
For storage	250
For the direct irrigation of 2,000 acres under this project.	33·75
For the direct irrigation of 3,620 acres under the Pydaru.	61·0875

The channel to connect the Alluru Pedda and the Alluru Ramannah tanks intersects the Kavaragunta road, about a mile west of the village of Singapeta; a bridge has been provided for this communication.

93. The extent of land to be irrigated by the Alluru Ramannah tank is 5,620 acres; the water will be distributed to this area by the existing sluices, and the proposed branch channel from Ulavapolla; the former will water 1,620, the latter 4,000 acres.

Ulavapolla branch channel.

This branch will take off from the Alluru Ramannah tank, near the village of Ulavapolla, and run on the western side of the sand ridge until the old irrigation channel north of Umamaheswarem is reached; it will follow this for some distance, and after clearing the ridge will become two branches, and water the country up

to the main drain. At the bifurcation a sluice will be built to regulate the supply to both ducts.

Syphon.

An inverted syphon has been designed for construction within the limits of the second mile to allow the drainage of the Bogavolu valley and adjacent country to flow into the Ulavapollu swamp. The area of this gathering ground is 25 square miles; provision has, therefore, been made to admit of 4,033 cubic feet per second being discharged at the site of the proposed syphon.

Drainage of land adjoining Alluru Ramannah tank to be improved.

94. As a considerable proportion of the land to be watered by the Alluru Ramannah tank is annually submerged and unfit for cultivation, the drainage must be improved before the available area can be irrigated to the extent contemplated. This tract is principally flooded by the drainage of the Musunuru valley flowing into and accumulating in it when the bars at the mouths of the Chippalaru are closed; it also suffers when these are open by the spill of the Pillivagu pouring into it during high floods in this stream. When the bars are open and the freshes are subsiding the pent-up drainage begins to run back to the Pillivagu, but generally this is not materially decreased until the land has been submerged for fifteen or twenty days—a period far too long for rice cultivation to remain under water uninjured.

From these observations it will be gathered the land alluded to is prejudicially affected by moderate or extreme floods in the Musunuru drainage streams; in the former instance it is submerged by the volume of drainage not being sufficient to overtop the bars, and in the latter by the Pillivagu overflowing its southern bank.

95. To remedy the existing state of things, and permanently improve the condition of this tract, I consider an embankment should be thrown up from the village of Kadanutla to the sand ridge near Zuvvaladinne; this would prevent the spill of the Pillivagu getting into it in heavy freshes, and also protect it from inundation during ordinary floods in that stream.

96. The country along the opposite bank of the Pillivagu will also be benefited by the embankment, as the water would run off it much quicker after the construction of this work than it does at present. It is true a somewhat larger area will be submerged by the floods being prevented spreading to the south, but this would be for a very short time only, as the increased height due to this contraction would soon overtop the bar and open a suitable outlet for the drainage of the whole valley.

97. The next point to be considered is the disposal of the surface discharge of the country that drains into the low tract under notice. The area of the gathering ground south and west of the embankment is 62 square miles; and assuming the drainage to run off equivalent to a rain fall of one-fourth of an inch per hour over the whole basin, the surplus to be disposed of would be 10,003 cubic feet per

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second. This volume will be discharged into the Chippalaru by the self-acting sluice planned for erection in the line of the embankment to be thrown up between Kadanatula and Zuvvaladinne. This sluice has also been designed to prevent the floods of the Pilivagu and Ubbalavagu finding their way into the land proposed to be drained and irrigated south of the embankment.

98. The Northern Delta of the Pennair is studded with tanks; the majority of these are, no doubt, necessary under the existing arrangements, as it is of vital importance to the success of the cultivators to have the means of storing a large proportion of the surface discharge. This precarious system of irrigation, together with the necessity of maintaining a host of minor reservoirs, (the area of some of which exceeds the acreage cultivated under them) will cease as soon as the proposed channels reach the different localities.

Tanks to be brought under cultivation.

By referring to the sketch map it will be observed thirty-five of these tanks are to be reclaimed and brought under wet cultivation. This will be a profitable measure; it will increase the cultivable area by 7,488 acres, and reduce the cost of the annual repairs.

99. In the foregoing descriptive sketch of the works, connected with the irrigation and drainage of the country commanded by this project, I trust I have not omitted any particular deserving of special remark, and that all will be considered explanatory and satisfactory.

100. It now remains for me to notice the following subjects which are intimately associated with the success of the undertaking:—

(1.) The available labour.

(2.) The establishment requisite to superintend the construction of the several works.

(3.) The return that may confidently be expected on the outlay.

The first in order is the labour obtainable, and this, I must confess, is the most difficult to dispose of. I do not think it likely we could secure a permanent working party of more than 3,000 from this district; as this number would take a very long time to complete the works, it must be supplemented from without if we hope to finish all within a reasonable period.

Every possible endeavour should, I consider, be made to do this, as there will be a return on the outlay as soon as the works have reached a certain stage, and from this it will increase in proportion to the rapidity of construction.

In planning this project, the scarcity of labour was considered; iron-work has been introduced, to save it, where this could be done without materially increasing the cost of the scheme.

In a work of such magnitude as this it will be true economy to take advantage of all the appliances that really husband manual labour, and facilitate operations.

By doing this, and allowing rates that would enable contractors to import labour and employ 7,500 people on the works, the whole would, in all probability, be completed in six years.

101. To insure constant and efficient supervision, the following establishment would, I consider, be necessary :—

Number.	Grade.	Salaries and allowances per mensem.	Total.	Remarks.
		RS.	RS.	
1	Executive Engineer	1,050	1,050	
2	Assistant Engineers	420	840	
2	Sub do.	340	680	
12	Overseers	110	1,320	
6	Maistries	50	300	
1	Accountant	60	60	For Executive Engineer's Office.
1	Do.	40	40	
1	Writer	30	30	
1	Draughtsman	60	60	
3	Lascars	7	21	
3	Do.	6	18	
1	Moochie	8	8	
4	Accountants	40	160	For Assistant and Sub-Engineers' Offices.
4	Writers	25	100	
12	Lascars	6	72	
12	Writers	15	180	For Overseers' Offices.
24	Lascars	6	144	
6	Writers	15	90	To be employed under the Maistries.
6	Lascars	6	36	
2	Dressers	50	100	
2	Toties	5	10	
			5,319	

say Rupees 5,320 per mensem.

102. Before entering into the question of the return that may be realized, I think it desirable to notice the great value attached to wet cultivation by the majority of the people in this district. As a very different state of things exists in other parts of the Presidency, it was suggested that agreements should be taken from the ryots to use the water as soon as it could be supplied; they were quite willing to enter into them, but Mr. Dykes, the late Collector, considered they would be useless and unnecessary documents, as the demand for wet land is so great that there are generally four or five applicants for every patch that becomes available.

When I was engaged staking out the proposed channels, numerous applications for unoccupied land were received; one was submitted by a Native gentleman holding a responsible appointment in the Madras District for 3,000 acres, but his proposal, like the others, was rejected by Mr. Dykes, as this officer is opposed to giving away the land at present. He considers the Government should not part with what will become very valuable property in a hurry, and that any attempt to monopolize the unoccupied area commanded by this project should be carefully guarded against. As Mr. Dykes has been connected with the district for many years, and thoroughly understands its capabilities and requirements, his opinion is of high value. I must add, however, that I regret Mr. Chenchalrao's application was not complied with. He was prepared to sign an agreement to take up the land at once

at the dry rates, and to pay whatever water-tax Government thought fair to levy on it from the date of our enabling him to commence wet cultivation.

The inhabitants of the villages, traversed by the proposed channels, have, no doubt, a prior claim to participate in the local improvements; but I hardly think it advisable to reserve the whole for them, and stop all competition from without.

103. The return on the probable expenditure cannot be accurately arrived at until the assessment on the irrigable lands has been definitely settled; this will, I believe, soon be done; meanwhile, by taking the low rate of Rupees $5\frac{1}{2}$* per acre for thoroughly irrigated and drained land, a close approximation to the ultimate results will be obtained.

* Inclusive of the dry assessment.

104. Under the present very precarious and imperfect system of irrigation, the average assessment on the wet land is a fraction over Rupees 4 per acre; but this does not represent the actual cost to the ryots, as a large majority of them have to furnish, from time to time, a number of labourers to re-construct the temporary dams in the Pennair, and clear out the river channels that water their respective villages. All this expenditure of labour will be saved by the proposed arrangements; the channels that now give so much trouble are to be permanently improved or abandoned, and the uncertainty that prevails every season as to whether it will be possible to irrigate such and such lands will be removed; the ryots will also be spared the risks and losses they are at present exposed to by cultivating more land than they can get water for *throughout* the season. That this is no unimportant matter will be apparent by the annexed extract from the Collector's letter† regarding the proposed works.

† No. 1,008, dated 28th May 1869.

* * * * * *

2. "In the general abstract of the Ryotwar villages you will observe the arrears under "ordinary rates are entered at 36,336 Rupees, of this sum 34,444 Rupees represent the amount "remitted last year for withered crops.

3. "Under the head of irrigation from public sources you will observe that I have been "obliged to remit a further sum of 66,514 Rupees in the current year for want of water. And "probably remissions will have to be given for withered crops to half the amount given last year."

105. This project, it will be remembered, has been planned to water in the worst of years 80,000 acres *from the Pennair*, but it appears from the statement‡ furnished by the Collector that 6,056 acres of the irrigated land comprehended in this area are Inam§ and pay no assessment; some alteration will, I presume, be made in this arrangement, as it would be manifestly unfair to allow the Inamdars a regular and ample supply of water (which they never could calculate on before) without calling on them to contribute a reasonable quota of the extra revenue they will derive by the construction of the proposed works.

‡ Appendix I., page 02.

§ Classed as favourable rates in the general abstract.

In the absence of definite information as to what per-centage will be levied on these lands, I will not reckon on any return from them in computing the profits.

106. By referring to page 02 of Appendix I., it will be seen the total area cultivated with rice, in the portion of the delta commanded by this scheme, is as follows:—

	Acres.
Government land.....	39,662
Inam do.	6,056

This acreage yields an annual revenue of Rupees 1,63,116.

107. In comparing the present with the expected results, it will be necessary to allow for the ryots converting some of their dry land into wet; the assessment on the former must, therefore, be added to that derived from the existing wet cultivation, to ascertain, as correctly as possible, the revenue of the whole area intended to be watered. It is of course impossible to state to what extent the ryots would avail themselves of the means of turning their dry cultivation into wet; but they should not, I consider, be encouraged to do this so long as there is suitable unoccupied land for the latter within the limits of their villages.

108. The subjoined table shows the present revenue, *provided no remissions are made for withered crops*, and the probable increase that will be secured by carrying out the project under consideration:—

Current Revenue.			Probable Revenue.			
Source.	Area in Acres.	Rupees.	Source.	Area in Acres.	Rate per Acre inclusive of the dry assessment.	Rupees.
Rice lands, Government	39,662	1,63,116	Rice lands, Government	39,662	5¼	2,18,141
Do. Inam	6,056	.....	Do. Inam	6,056	.....	.....
Dry lands	3,000	3,209	Dry cultivation to be converted into wet (assumed) ...	3,000	5½	16,500
Land within full contour of tanks to be abandoned...	7,488	.....	Land within full contour of tanks to be abandoned ...	7,488	5½	41,184
Fallow and unoccupied land ...	27,414	.....	Fallow and unoccupied land ...	27,414	5¼	1,50,777
	83,620	1,66,325				
Increase...	.....	2,60,277				
		4,26,602				4,26,602

109. As the irrigation under this project will amalgamate with that proposed to be still carried on from the Pydaru, and secure for it also a regular and sufficient supply of water, instead of the present uncertain and scanty one, as described in paragraph 88, the area,* the current assessment, and the additional revenue that will be realized from this tract, have been included in the above table.

* 3,620 acres.

110. From this increase of revenue a deduction of Rupees 30,077 must be made to cover the cost of the annual repairs, and to pay for the establishment necessary to superintend these, and control operations during the cultivating season.

111. The annexed statement shows the constitution of the proposed conservancy establishment, and the sum to be assigned for repairs. The latter item has been obtained by comparing the actual expenditure on repairs in the Southern Delta and on the Anicut, during five consecutive years, with the acreage irrigated in that period, and allowing a similar sum, *plus* 10 per cent. per acre on the area to be watered by this project:—

Number.	Grade.	Pay and allowances per mensem of each member.	Expenditure per annum.	Remarks.
		Rs.	Rs.	
1	Assistant Engineer or Sub-Engineer	420	5,040	
1	Accountant	50	600	To be attached to the Assistant Engineer or Sub-Engineer in charge.
1	Writer	25	300	
3	Lascars	6	216	
1	Delta Superintendent	60	720	
1	Gumastah	10	120	To be employed under Delta Superintendent.
2	Lascars	6	144	
4	Channel Maistries	20	960	
4	Head Sluice Superintendents	10	480	
80	Permanent Lascars	6	5,760	
60	Lascars for 5 months annually	6	1,800	
	Repairs	.....	13,937	
	Total...	.....	30,077	

112. In computing the return on the estimated outlay of Rupees 38,00,000, the remissions granted, from time to time, for withered crops must be considered, as the proposed works will indemnify Government against all such loss.

This is an important point, and will influence the revenue not a little, judging from the extract from the Collector's letter* embodied in paragraph 104 of this report.

* No. 1,008, dated 28th May 1869.

The quotation referred to shows that 21 per cent. of the revenue on the area cultivated was lost last season, and that the probable loss in the current year, from the same cause, will be 10½ per cent.

113. From the above details, and the information deduced from the revenue accounts of the three previous years, Rupees 11,540 may be fairly assumed as the amount Government will save annually on the item under review.

114. The probable *net* profit will, therefore, be 2,60,277×11,540—30,077= 2,41,740 rupees, which sum represents a return of 6·36 per cent. on the contemplated expenditure.

(Signed) R. SMITH,
Executive Engineer on Special duty.

Nellore,
30*th October* 1869.

APPENDIX.

As the cost and efficiency of the head works and main feeder will materially affect the success of the undertaking, I would draw particular attention to the annexed statement, showing the different arrangements that might be adopted, and the probable sum required to carry out each plan:—

Plan.	Cost of constructing Head Works and Main Feeder.	Remarks.
	Rs.	
With river wall and channel pitched throughout as estimated for in detail.	10,15,600	Recommended for adoption. To this sum Rupees 50,600 should be added, being quota of cost of tramway and rolling stock.
With river wall and channel pitched for the first half mile only.	8,94,518	
With a weir, the crest being nine feet above the deep bed of the river, and the channel pitched throughout.	12,68,981	Do. do.
With a similar weir to the above, and the channel not pitched.	11,23,692	
With a weir, the crest being six feet above the deep bed of the Pennair, and the channel pitched throughout.	13,65,929	Do. do.
With a like weir to the latter, and the channel not pitched.	12,03,782	

The cheapest design, it will be observed, is with the masonry wall and a channel requiring no revetment; but this, I consider, an objectionable plan, as the head of the channel would silt up considerably after each fresh, and advantage could not be taken of high floods to throw a large body of water into it, as the soil would not stand a higher velocity than that due to the estimated depth of 9 feet.

River embankment.

2. In the estimate for the extension of irrigation in the Northern Delta of the Pennair the embanking of the left bank of this river from Sangam to within six miles of the sea has been included, although it might fairly be considered as a separate and *indispensable* work.

It is true extreme floods are rare in the Pennair, but having occurred, we are bound to expect them again, and endeavour to prevent their inundating and injuring public and private property. A fresh similar to that of 1852 would, I am convinced, be attended with disastrous results, and should be guarded against.

Evaporation.

3. Is I omitted to notice in the Report how the loss by evaporation was to be met, I take this opportunity of stating that it will be more than compensated for by the increased volume of water the feeders have been planned to discharge during floods, and by the quantity that will be drawn off by them and stored in the reservoirs before the cultivating season begins.

Water allowed per acre.

4. As the quantity of water necessary to bring an acre of rice cultivation to maturity has not been definitely settled, I have allowed 8,100 cubic yards, which is at the rate of 2¼ cubic yards per hour, for 150 days. If this volume is ultimately proved to be excessive, the surplus could be devoted to bringing more land under wet cultivation—a measure which, it is needless to add, would make the project more remunerative than has been assumed.

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5. Had the *average* state of the Pennair been taken during the years from 1861 to 1868 inclusive, instead of the worst season in this period, in calculating the available water, the undertaking would appear *far more profitable*; but it would be attended by an amount of uncertainty which I do not think it advisable or prudent to risk.

6. The annexed Formulæ were used in calculating the discharges of the channels, culverts, and syphons:—

For Channels.

$$V = \frac{88{\cdot}51\ (r^{\frac{1}{2}} - {\cdot}03)}{(\frac{l}{s})^{\frac{1}{2}} - \text{hyp. log.}(\frac{l}{s} + 1{\cdot}6)^{\frac{1}{2}}} - {\cdot}084\ (r^{\frac{1}{2}} - {\cdot}03).$$

In the above formula
V represents the mean velocity in feet per second.
r = The mean radius in feet.

For Culverts and Syphons.

The annexed practical Formula.

$$Q = \left\{\frac{\text{hds.}}{{\cdot}0448(1+4{\cdot}2d)}\right\}^{\frac{1}{2}}$$

In this equation
Q is the discharge in cubic feet per minute.
h=Head in feet.
l=Length in feet.
d=Diameter of pipe in inches.

8. Liberal rates have been allowed for the masonry, earth work, and pitching.

9. To facilitate and expedite operations, the stone for pitching the bottom and sides of the main feeder will be carried by a tramway running along its berm. The material required for the revetment of the Kanigiri Reservoir will also be transported in a similar manner, and deposited where necessary.

10. The bulk of the rubble for these works will be brought from Sangam, as it can be quarried there at a low figure, and the carriage will cost but little, particularly as the inclination of the country is favourable for loaded waggons coming from that quarter.

(Signed) R. SMITH,
Executive Engineer on Special duty.

NELLORE,
30*th October* 1869.

Statement showing the extent of Land that can be cultivated by the Channel from Sangam, Nellore Talook, Fusly 1278 (1868.)

Number.	Names of Villages.	Extent of land that can be cultivated by the proposed channel.			Extent in acres of dry and wet land now under cultivation.	Amount of revenue raised by cultivation on dry and wet lands on pasturage and jungle on average for the last five years.	Extent under river channel and tanks in the line of the proposed channel.		Rejected Tanks.		Remarks.
		No. of acres that can be easily cultivated.	No. of acres of jungle tracts which can be cultivated at the expense of labour.	Total amount of acres.			Extent of irrigable area.	Number of acres under cultivation, or average for five years.	Number.	Extent.	
1	Padamatipalem ...	3,137	.....	3,137	774	2,064	575	614	.....	.....	
2	Liddiparam ...	1,459	.....	1,459	781	2,212	658	557	.....	.....	
3	Vengareddipalem ...	1,048	.....	1,048	481	1,549	539	421	.....	.....	
4	Davvuru	4,291	.....	4,291	1,714	6,245	2,028	1,196	.....	.....	
5	Maktaparam ...	1,207	.....	1,207	325	654	.....	302	.....	.....	
6	Annareddipalem ...	1,711	.....	1,711	977	4,496	1,312	863	1	21	
7	Minagalla	2,385	.....	2,385	582	1,581	239	420	.....	.....	
8	Penaballi	2,062	.....	2,062	983	3,804	1,046	818	.....	.....	
9	Kalayakagolla ...	605	.....	605	254	964	330	243	.....	.....	
10	Desavadadinne ...	231	.....	231	92	268	54	44	.....	.....	
11	Vavveru	1,190	2,504	3,694	1,258	5,464	1,312	1,079	1	51	
12	Pallapala	434	952	1,386	197	594	283	146	.....	.....	
13	Isakapalem ...	438	.....	438	264	857	111	204	.....	.....	
14	Rebala	1,827	1,049	2,876	611	2,760	596	549	.....	.....	
15	Pataru	2,688	.....	2,688	987	3,770	974	830	1	4	
16	Damaramaduga ...	2,678	.....	2,678	1,069	2,645	830	859	.....	.....	
17	Kovuru	4,538	.....	4,538	2,193	9,588	3,196	1,788	.....	.....	
18	Yallayapalem ...	2,677	1,140	3,817	1,699	5,981	2,185	1,311	.....	.....	
19	Gandavaram ...	2,972	2,026	4,998	1,590	3,570	2,113	946	1	644	
20	Nayadipalem ...	588	.....	588	310	718	365	232	.....	.....	
21	Bodduvaripalem ...	1,744	1,022	2,766	1,037	3,291	1,243	820	.....	.....	
22	Peda-Puttedu ...	1,813	2,135	3,948	941	2,543	788	761	.....	.....	
23	Turimerla ...	758	1,544	2,302	544	1,975	370	445	.....	.....	
24	Todakaluru ...	1,039	971	2,010	460	854	402	326	.....	.....	
25	Kavaragunta ...	460	.....	460	112	163	32	93	.....	.....	
26	Graddagunta ...	521	.....	521	246	1,474	337	280	.....	.....	
27	Amaluru	2,293	.....	2,293	576	1,964	429	479	.....	.....	
28	Talamanchi ...	1,426	932	5,358	1,136	2,780	1,314	841	1	236	
29	Alluru	17,169	.....	17,169	6,903	21,734	9,673	5,289	.....	.....	
30	Mopuru	1,026	.....	1,026	611	2,674	673	441	.....	.....	
31	Biramgunta ...	481	.....	481	233	893	219	217	.....	.....	
32	Damegunta ...	637	.....	637	421	981	409	305	.....	.....	
33	Chavukacharla ...	1,452	.....	1,452	983	3,480	1,053	793	1	511	
34	Venkarapuram ...	331	.....	331	207	628	319	122	.....	.....	
35	Basavapalem ...	567	.....	567	353	1,409	471	267	.....	.....	

Proceedings of the Madras Government, Public Works Department, 28th July 1870.

Statement showing the extent of Land that can be cultivated by the Channel from Sangam, Nellore Talook, Fusly 1278 (1868).—(Continued.)

Number.	Names of Villages.	Extent of land that can be cultivated by the proposed channel.			Extent in acres of dry and wet land now under cultivation.	Amount of revenue raised by cultivation on dry and wet lands on pasturage and jungle on average for the last five years.	Extent under river channel and tanks in the line of the proposed channel.		Rejected Tanks.		Remarks.
		No. of acres that can be easily cultivated.	No. of acres of jungle tracts which can be cultivated at the expense of labour.	Total amount of acres.			Extent of irrigable area.	Number of acres under cultivation, or average for five years.	Number.	Extent.	
36	Gundalammapalem..	505	.....	505	352	1,389	441	294	.....	.....	
37	Kodavaluru ...	1,396	.....	1,396	916	2,870	1,095	641	.....	.....	
38	Parlapalle ...	1,782	.....	1,782	995	2,802	1,229	690	1	362	
39	Vidavaluru ...	3,401	.....	3,401	2,162	7,988	2,405	1,568	1	96	
40	Alarupadu ...	267	.....	267	155	597	242	149	1	23	
41	Razupalem Talamanchi	836	.....	836	527	1,909	656	420	.....	.....	
42	Maneguntapadur ...	490	.....	490	268	1,144	469	248	.....	.....	
43	Modegunta ...	540	.....	540	491	1,994	534	391	.....	.....	
44	Vegaru	3,950	.....	3,950	2,068	8,985	2,383	1,648	.....	.....	
45	Reddipalem ...	293	.....	293	139	659	233	133	.....	.....	
46	Ramanapalem ...	635	.....	635	297	1,057	513	249	.....	.....	
47	Lyakuntapadu ...	896	.....	896	545	2,532	649	444	1	105	
48	Inamadugu ...	1,147	.....	1,147	718	3,317	810	630	1	350	
49	Isakapalle ...	2,919	.....	2,919	846	2,499	757	785	.....	.....	
50	Gogulapalle ...	4,817	.....	4,817	762	2,442	759	559	.....	.....	
51	Indupara ...	990	.....	990	702	3,755	722	596	.....	.....	
52	Purini	2,214	.....	2,214	1,342	4,272	1,562	982	.....	.....	
53	Ponnapudi ...	1,376	.....	1,376	164	542	190	131	2	76	
54	Mamidigunta ...	516	.....	516	289	585	174	179	.....	.....	
55	Varini	5,329	.....	5,329	1,427	4,268	1,654	1,134	1	45	
56	Dandigunta ...	831	.....	831	631	1,602	655	513	2	324	
57	Dampuru	1,772	.....	1,772	988	3,073	1,099	706	.....	.....	
58	Vavilla	752	.....	752	647	2,662	697	516	.....	.....	
59	Alaganipadu ...	1,123	.....	1,123	726	2,669	1,032	670	2	400	
60	Utukuru	7,129	.....	7,129	1,622	5,742	1,517	1,371	4	805	
61	Mudivarti	3,942	.....	3,942	1,622	5,895	2,067	1,333	1	544	
62	Kammipalem ...	499	.....	499	214	858	226	179	1	51	
63	Chintachelike ...	569	.....	569	173	934	507	206	.....	.....	
64	Kurru	682	.....	682	187	546	234	141	.....	.....	
65	Damegunta ...	427	.....	427	127	273	338	61	2	225	
66	Gudipalle	180	.....	180	60	465	84	78	.....	.....	
67	Dagatarti	2,019	1,516	3,535	874	2,191	368	758	.....	.....	
68	Kottapalle ...	634	3,165	3,799	426	1,263	273	355	.....	.....	
	Total ...	1,27,741	18,956	1,46,697	55,366	1,90,406	63,052	43,659	26	4,873	

Statement showing the extent of Land that can be cultivated by the Channel from Sangam, Nellore Talook, Fusly 1278 (1868).—(Concluded.)

Number.	Names of Villages.	Extent of land that can be cultivated by the proposed channel.			Extent in acres of dry and wet land now under cultivation.	Amount of revenue raised by cultivation on dry and wet lands on pasturage and jungle on average for the last five years.	Extent under river channel and tanks in the line of the proposed channel.		Rejected Tanks.		Remarks.
		No. of acres that can be easily cultivated.	No. of acres of jungle tracts which can be cultivated at the expense of labour.	Total amount of acres.			Extent of irrigable area.	Number of acres under cultivation, or average for five years.	Number.	Extent.	
	Shrotriems.										
1	Srirangarajapuram..	250	.....	250	.....	541	46	.....	.....	.....	
2	Tonnavada ...	325	.....	325	.....	204	63	.....	.....	.....	
3	Challayapalem ...	385	.....	385	.....	1,257	183	.....	.....	.....	If the contemplated Sangam Project be carried out and channels dug to irrigate all lands, high and low, the number of acres mentioned in the third column can be gradually rendered cultivable in course of years.
4	Gangavaram ...	579	.....	579	.....	1,089	404	.....	.....	.....	
5	Potireddipalem ...	998	.....	998	.....	386	89	.....	.....	.....	
6	Padugupadu ...	1,141	.....	1,141	.....	190	312	.....	.....	.....	
7	Gotlapalem ...	187	.....	187	.....	611	175	.....	.....	.....	
8	Uchaguntapalem ...	227	400	627	.....	426	159	.....	.....	.....	
9	Yalamanchipadu ...	239	300	539	.....	334	87	.....	.....	.....	
10	Ullavapolla ...	549	188	737	.....	386	53	.....	.....	.....	
11	Anantavaram ...	309	455	764	.....	415	128	.....	.....	.....	
12	Damavaram ... Narayanavaram ...	1,616	1,500	3,116	.....	488	233	.....	.....	.....	
13	Kallambatla ... Khandrika ...	136	.....	136	.....	139	45	.....	.....	.....	
		6,941	2,843	9,784	.....	6,466	1,977	.....	.....	.....	

15*th August* 1868.

(True Translation.)

(Signed) J. A. C. BOSWELL,
Acting Collector.

(True Copy.)

Nellore,
30*th October* 1869.

(Signed) R. SMITH,
Special Executive Engineer, Nellore District.

(Signed) F. J. MOBERLY, Lieut.-Colonel, R.E.,
Superintending Engineer, 2nd Division.

Statement showing the number of days, in the year 1861, *in which the Pennair rose to three feet and upwards above the crest of the Anicut, and fell to one foot below it.*

Year.	Months.	Water 3 feet and upwards on crest.	Water 2½ feet on crest.	Water 2 feet on crest.	Water 1½ feet on crest.	Water 1 foot on crest.	Water ½ foot on crest.	Water flush with crest.	Water ½ foot below crest.	Water 1 foot below crest.
1861.	January	...	...	...	...	...	...	...	...	...
	February	...	...	...	...	...	...	...	...	...
	March	...	...	...	...	...	...	...	...	...
	April	...	...	...	...	...	...	...	...	...
	May	...	...	...	...	...	...	...	...	...
	June	...	...	...	...	1	1	1	4	5
	July	...	...	...	...	...	...	2	...	4
	August	...	...	...	...	3	1	9	1	2
	September	...	...	1	2	6	1	1	1	...
	October	...	...	...	...	...	1	6	2	4
Max. 3′ 9″ ...	November	2	...	3	4	2	1	11	1	...
	December	...	...	...	...	...	...	2	1	6
	Total...	2	...	4	6	12	5	32	10	21

Nellore,
30*th October* 1869.

(Signed) R. SMITH,
Special Ex. Engr., Nellore District.

(Signed) F. J. MOBERLY, Lieutenant-Colonel, R. E.,
Superintending Engineer, 2nd Division.

Statement showing the number of days, in the year 1862, *in which the Pennair rose to three feet and upwards above the crest of the Anicut, and fell to one foot below it.*

Year.	Months.	Water 3 feet and upwards on crest.	Water 2½ feet on crest.	Water 2 feet on crest.	Water 1½ feet on crest.	Water 1 foot on crest.	Water ½ foot on crest.	Water flush with crest.	Water ½ foot below crest.	Water 1 foot below crest.
1862.	January	...	...	...	...	...	...	...	...	2
	February	...	...	...	...	...	...	...	...	...
	March	...	...	...	...	...	...	...	...	...
	April	...	...	...	...	...	...	...	...	...
	May	...	...	...	...	1	1	...	...	1
	June	...	...	...	...	...	...	1	1	1
	July	...	...	...	...	...	...	...	...	...
	August	...	...	...	...	...	...	...	...	2
Max. 5′ 2″ ...	September	5	1	7	1	1	1	10	1	...
Max. 3′ 9″ ...	October	5	1	3	4	9	...	8	...	...
	November	...	...	1	...	1	...	20	3	1
	December	...	...	...	...	...	...	1	2	4
	Total...	10	2	11	5	12	2	40	7	11

NELLORE,
30th October 1869.

(Signed) R. SMITH,
Special Ex. Engr., Nellore District.

(Signed) F. J. MOBERLY, Lieutenant-Colonel, R. E.,
Superintending Engineer, 2nd Division.

Proceedings of the Madras Government, Public Works Department, 28th July 1870.

Statement showing the number of days, in the year 1863, *in which the Pennair rose to three feet and upwards above the crest of the Anicut and fell to one foot below it.*

Year.	Months.	Water 3 feet and upwards on crest.	Water 2½ feet on crest.	Water 2 feet on crest.	Water 1½ feet on crest.	Water 1 foot on crest.	Water ½ foot on crest.	Water flush with crest.	Water ½ foot below crest.	Water 1 foot below crest.
1863.	January	...	...	...	...	...	...	...	...	...
	February	...	...	...	...	...	...	...	...	...
	March	...	...	...	...	...	...	...	1	1
	April...	...	...	...	...	...	...	...	...	...
	May	...	...	...	...	...	...	...	...	...
	June	...	...	...	...	...	...	...	...	...
	July	...	...	...	...	...	...	...	...	..
	August	...	...	...	...	...	...	2	...	...
Max. 3′ ...	September	1	...	1	1	4	...	14	...	2
	October	...	1	3	4	4	1	1	...	2
	November	...	...	...	...	...	...	...	...	11
	December	...	...	...	...	1	...	9	...	5
	Total...	1	1	4	5	9	1	26	1	21

NELLORE,
30th October 1869.

(Signed) R. SMITH,
Special Executive Engineer, Nellore District.

(Signed) F. J. MOBERLY, Lieut.-Colonel, R. E.,
Superintending Engineer, 2nd Division.

Statement showing the number of days, in the year 1864, *in which the Pennair rose to three feet and upwards above the crest of the Anicut and fell to one foot below it.*

Year.	Months.	Water 3 feet and upwards on crest.	Water 2½ feet on crest.	Water 2 feet on crest.	Water 1½ feet on crest.	Water 1 foot on crest.	Water ½ foot on crest.	Water flush with crest.	Water ½ foot below crest.	Water 1 foot below crest.
1864.	January	...	...	...	...	...	...	...	...	...
	February	...	...	...	...	...	...	...	...	...
	March	...	...	...	...	...	...	...	...	...
	April	...	...	...	...	...	...	...	...	...
	May	...	...	...	...	...	...	...	...	...
	June	...	...	...	1	...	...	...	1	1
	July	...	...	...	...	...	...	...	...	...
Max. 5′ 3″ ...	August	5	...	2	...	...	...	...	1	4
,, 4′ 3″ ...	September	3	...	1	2	2	3	5	3	7
,, 3′ 6″ ...	October	2	...	1	1	3	2	6	5	7
,, 3′ 0″ ...	November	1	1	...	...	...	...	2	2	2
	December	...	...	...	...	...	...	12	9	1
	Total...	11	1	4	4	5	5	25	21	22

NELLORE,
30th October 1869.

(Signed) R. SMITH,
Special Executive Engineer, Nellore District.

(Signed) F. J. MOBERLY, Lieut.-Colonel, R. E.,
Superintending Engineer, 2nd Division.

Statement showing the number of days, in the year 1865, *in which the Pennair rose to three feet and upwards above the crest of the Anicut and fell to one foot below it.*

Year.	Months.	Water 3 feet and upwards on crest.	Water 2½ feet on crest.	Water 2 feet on crest.	Water 1½ feet on crest.	Water 1 foot on crest.	Water ½ foot on crest.	Water flush with crest.	Water ½ foot below crest.	Water 1 foot below crest.
1865.	January	...	...	...	...	...	...	...	...	...
	February	...	...	...	...	...	...	...	...	...
	March	...	...	...	...	...	...	...	...	...
	April	...	...	...	...	...	...	1	...	...
	May	...	...	...	...	...	...	2	...	3
	June	...	2	2	1	1	...	1	2	8
	July	...	...	...	...	1	...	2	...	...
Max. 5′ 0″ ...	August	9	2	3	1	4	1	3	8	...
	September	...	...	...	...	1	...	7	5	8
	October	...	...	...	...	...	...	...	...	...
Max. 3″ 4″ ...	November	2	...	...	...	2	...	2	1	1
	December	...	1	...	2	...	1	9	5	5
	Total...	11	5	5	4	9	2	27	21	25

NELLORE,
30th October 1869.

(Signed) R. SMITH,
Special Executive Engineer, Nellore District.

(Signed) F. J. MOBERLY, Lieut.-Colonel, R. E.,
Superintending Engineer, 2nd Division.

Statement showing the number of days, in the year 1866, *in which the Pennair rose to three feet and upwards above the crest of the Anicut and fell to one foot below it.*

Year.	Months.	Water 3 feet and upwards on crest.	Water 2½ feet on crest.	Water 2 feet on crest.	Water 1½ feet on crest.	Water 1 foot on crest.	Water ½ foot on crest.	Water flush with crest.	Water ½ foot below crest.	Water 1 foot below crest.
1866.	January	...	...	...	...	...	...	...	...	...
	February	...	...	...	...	...	...	...	...	...
	March	...	...	...	...	...	...	...	...	...
	April...	...	...	...	...	...	...	...	...	...
	May	...	...	...	...	...	...	...	...	...
	June	...	...	...	...	...	...	...	...	...
	July	...	...	...	...	1	2	...	...	...
	August	...	...	...	1	7	10	2	2	1
	September	...	1	2	...	7	6	3	2	3
Max. 4' 4" ...	October	9	2	3	5	5	4	...	...	...
	November	...	...	...	...	2	4	6	7	3
,, 6' 0" ...	December	2	...	3	2	2	4	1	3	8
	Total...	11	3	8	8	24	30	12	14	15

NELLORE,
30th October 1869.

(Signed) R. SMITH,
Special Executive Engineer, Nellore District.

(Signed) F. J. MOBERLY, Lieut.-Colonel, R. E.,
Superintending Engineer, 2nd Division.

Statement showing the number of days, in the year 1867, *in which the Pennair rose to three feet and upwards above the crest of the Anicut and fell to one foot below it.*

Year.	Months.	Water 3 feet and upwards on crest.	Water 2½ feet on crest.	Water 2 feet on crest.	Water 1½ feet on crest.	Water 1 foot on crest.	Water ½ foot on crest.	Water flush with crest.	Water ½ foot below crest.	Water 1 foot below crest.
1867.	January	...	...	...	...	...	...	...	3	5
	February	...	...	...	...	...	...	...	...	...
	March	...	...	...	...	...	...	...	...	...
	April	...	...	...	...	...	...	...	...	...
	May	...	...	...	...	...	...	...	...	...
	June	...	...	...	...	...	...	4	4	1
	July	...	...	...	...	...	...	...	...	1
	August	...	...	...	...	...	...	3	...	...
Max 4' 6" ...	September	3	2	...	2	...	1	11	7	3
3' 0" ...	October	1	...	1	...	4	2	5	6	7
	November	...	...	...	...	...	...	2	5	2
	December	...	...	...	...	...	...	...	...	1
	Total...	4	2	1	2	4	3	25	25	20

NELLORE,
30th October 1869.

(Signed) F. J. MOBERLY, Lieut.-Colonel, R. E.,
Superintending Engineer, 2nd Division.

(Signed) R. SMITH,
Special Executive Engr., Nellore District.

Statement showing the number of days in the year 1868, *in which the Pennair rose to three feet and upwards above the crest of the Anicut, and fell to one foot below it.*

Year.	Months.	Water 3 feet and upwards on crest.	Water 2½ feet on crest.	Water 2 feet on crest.	Water 1½ feet on crest.	Water 1 foot on crest.	Water ½ foot on crest.	Water flush with crest.	Water ½ foot below crest.	Water 1 foot below crest.
1868.	January	...	...	...	...	...	...	...	...	...
	February	...	...	...	...	...	...	...	...	...
	March	...	...	...	...	...	...	...	...	...
	April	...	...	...	...	...	...	...	...	...
	May	...	...	...	...	...	...	...	...	...
Max 5′ 0″ ...	June	3	2	1	...	1	1	4	4	2
,, 3′ 9″ ...	July	3	1	2	2	7	2	2	1	1
,, 4′ 3″ ...	August	3	1	2	...	3	5	3	1	2
,, 4′ 3″ ...	September	3	1	1	1	3	10	4	4	1
	October	...	1	1	...	9	6	5	2	1
,, 3′ 5″ ...	November	1	...	...	...	1	4	1	5	3
	December	...	...	...	1	1	3	...	3	2
	Total...	13	6	7	4	25	31	19	20	12

NELLORE,
30th October 1869.

(Signed) F. J. MOBERLY, Lieut.-Colonel, R. E.,
Superintending Engineer, 2nd Division.

(Signed) R. SMITH,
Special Executive Engr., Nellore District.

Synopsis showing the general state of the Pennair from 1861 *to* 1868 *inclusive.*

Years.	Water 3 feet and upwards on crest of anicut.	Water 2½ feet on crest of anicut.	Water 2 feet on crest of anicut.	Water 1½ feet on crest of anicut.	Water 1 foot on crest of anicut.	Water ½ foot on crest of anicut.	Water flush with crest of anicut.	Water ½ foot below crest of anicut.	Water 1 foot below crest of anicut.
1861	2	...	4	6	12	5	32	10	21
1862	10	2	11	5	12	2	40	7	11
1863	1	1	4	5	9	1	26	1	21
1864	11	1	4	4	5	5	25	21	22
1865	11	5	5	4	9	2	27	21	25
1866	11	3	8	8	24	30	12	14	15
1867	4	2	1	2	4	3	25	25	20
1868	13	6	7	4	25	31	19	20	12
Total days...	63	20	44	38	100	79	206	119	147
Average during the eight years...	7·875	2·5	5·5	4·75	12·5	9·875	25·75	14·875	18·375

NELLORE,
30th October 1869.

(Signed) F. J. MOBERLY, Lieut.-Colonel, R. E.,
Superintending Engineer, 2nd Division.

(Signed) R. SMITH,
Special Executive Engineer, Nellore District.

Proceedings of the Madras Government, Public Works Department, 28th July 1870.

No. 442. ORDER THEREON, 28th July 1870, No. 1,818.

IRRIGATION, No. 36.

WITH his Note above recorded the Acting Chief Engineer submits the project for the irrigation of the Northern Delta of the Pennair. This, which has been conveniently termed the Sungum Project, has been worked out by Mr. R. Smith and, after careful consideration, has been brought forward in its present revised form in preference to that in which it was originally cast, in order to obtain the best results under the circumstances of the water-supply.

2. The papers contained in these proceedings give full information, not only regarding the revised project, but also as to the details of the original scheme; and the Acting Chief Engineer's Note shows in what respects the two arrangements differ, and why the one has been substituted for the other. It may be stated shortly that, while Mr. Smith's original designs were intended to ensure a full supply of water in an unusually unfavourable season, in the revised project the arrangements have been determined with reference to the average water-supply available, and the result of the alteration has been to provide for the irrigation of 94,000 acres at an estimated cost of Rupees 25,83,800, instead of for the supply of 83,620 acres by an outlay of 38 lacs.

3. His Excellency the Governor in Council considers the reasons given by the Acting Chief Engineer for the modification of the original project to be such as to make the adoption of the revised scheme advisable. In all works of this kind there is a certain limit of completeness beyond which it is not advantageous to go; and, in the case under consideration, it does not appear practicable to obtain remunerative results if, as was originally proposed, the water-supply of an unusually bad year be taken as the basis of the project. It may be added that it is the duty of the Government to make the most beneficial use of the funds which may be available for irrigation works, and in order that this result may be obtained it is necessary, while confining risk of partial failures of water-supply within definite and reasonable limits, to avoid the expense which the entire elimination of such risk would entail.

4. Assuming an assessment of 5½ Rupees an acre on the whole area to be irrigated, it appears that there will be an increase of revenue of Rupees 3,07,956, and the working or maintenance charges are estimated by Mr. Smith at Rupees 37,806, and by the Acting Chief Engineer at Rupees 60,956. Taking the latter amount, the net increase of revenue would be Rupees 2,47,000, or 9·56 per cent. on the amount, Rupees 25,83,800, of the estimates as submitted after modification in the Chief Engineer's Office.

5. The question of the assessment of the lands will be referred to the Revenue Department for final settlement; and in that department also it will be ascertained whether there is any objection to the sale of the right of occupation of the lands forming the beds of tanks proposed to be abandoned as storage works, and brought under wet cultivation. The value of these lands has been estimated at Rupees 1,72,825, and this forms a set-off against the cost of improving other tanks to serve as reservoirs.

Proceedings of the Madras Government, Public Works Department,
28th July 1870.

6. The estimates contain provision to the extent of Rupees 2,73,000 for the executive establishment required to superintend the execution of the project, which it is anticipated would occupy about five years. Whether a special separate establishment will require to be entertained, or whether the officers and subordinates needed will be obtainable from the Public Works Department Establishments, will depend upon the strength of, and the demands upon, the latter at the time. For the present it is right that the entry should appear in the estimates if only to show what the total cost of the scheme will probably be.

7. The Government notice with pleasure the favourable opinion which the Acting Chief Engineer for Irrigation has formed of the care bestowed by Mr. R. Smith on the preparation of this project; orders will be passed on the estimates so soon as the points to be settled in the Revenue Department shall have been decided.

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

To the Superintending Engineer, 2nd Division, with Memorandum.
" Chief Engineer for Irrigation.
" Revenue Department.

Exd. E. C. Shunker.

Cdr.

There is another communication subsequent to G.O. 30th March 1881 No 5-64 W, on the subject of these works which will if not in ours be in the Office of the Chief Engineer for Irrigation - Have this enquired about as soon as possible

29/ R.S.

19/5/81.

S.A.W.

This is with reference to the Requisition made yesterday re Productive Public Works - Please look up the paper.

R.S. 19/

Re Sungum Project Nellore

No. 1818 = 28th July 1870.

Govt. of {1870} Madras.

PUBLIC WORKS.

Put up with Rec^d To 30- 19 June 72 No. 1571

THE SUPERINTENDING ENGINEER, 2nd Division.

&c., &c., &c.

Dated July, 28th.

Read. Encl.

G. O., 28th July 1870, No. 1,818.

JULY.

Nos. 441-442

The Plans, Estimate & Report from the Govt. Engineer are entered in the list in this G.O.

Sungum Project, Nellore District.—Passing orders on the Note by the Acting Chief Engineer for Irrigation on the Sungum Project in the Nellore District.

No. 43. S.

Memorandum

—

Irrigation.

G.O. No. 856. W. of the 5th April 1880.

The instructions under which this office Memo No. 4. S. of the 4th January last was prepared had reference to works to be put in hand on the occurrence of Famine or, in other words, Famine relief works. It implied that Famine might at any moment recur, and it was desired to know in that event.

(1) What works were ready to be started at once.

(2) What were in various stages of advancement and what arrangements were necessary to admit of their being completed for sanction.

Two lists were accordingly prepared

prepared, the one of works either fully investigated or so far advanced as to be available at the present time for Famine relief purposes; the other of works which had at various times been brought to notice, but which required considerable further investigation before they could conveniently be started.

With regard to many of these latter it is not known whether they are likely to be good projects or not, and whether they would turn to account in the best way possible the water supply which they are intended to utilize. Supposing

(a)

that Famine were imminent it might be necessary to take up even unpromising schemes in order to provide for population needing employment; but as happily severe famines like that of 1876–78 are not of annual occurrence, it was supposed that no such necessity existed for taking up projects, which might, and would probably in many cases, be abandoned as soon as the investigations had been completed. A Course which promised the best safe guard against such waste of time and power was therefore suggested, but Government apparently

Consider

Consider that the means now or likely to be at their disposal will not admit of the adoption of the systematic treatment recommended.

2. It may be noticed that the proposals made for systematic investigation were intended in the first instance to be confined to those Districts which may be deemed more particularly liable to suffer from Famine; and it would seem to follow that, if Government cannot deal with these Districts simultaneously, the next best plan (a)

would be to confine the field of enquiry to that which can be adequately and promptly dealt with.

3. The Districts which are, judging from past experience more particularly subject to Famines more or less severe are what are called the ceded Districts, viz Bellary, Cuddapah and Kurnool. Bellary is perhaps the worst of the three, because except along the right bank of the Toongabudra, the whole District is liable to be left uncultivated for want of water. The part of the other two districts adjoining Bellary suffer similarly, but there

are

are other parts, which though they suffered severely in 1876-78, did not suffer so long or so fully as the rest.

4. Salem probably stands next in the list, then the Northern part of North Arcot District, which is nearly all zemindari; the Central part of the Coimbatore District i.e the tract between the Bhowani on the North and the Amberavati on the South.

5. There are parts of most other Districts which are liable to suffer considerably e.g. the North West of South Arcot; the North East and extreme South West of Trimevelly, perhaps two thirds of the Nellore District, the South West of the Kistna, and the greater part of Ganjam. In all these Districts however no entire cessation of agricultural operations is to be expected, and they cannot suffer in the same degree as Bellary or Salem.

6 - Government wish for information on the following points, for the projects named in this office No. 4. d. of 4th January 1881;

(1) the scope and object of the works.

(2) whether they can be classed as productive

or

or Protective.

(3) the precise stage of the projects with reference to final sanction.

(4) the general order of their importance.

7. For the works ready to be undertaken the information under (1) is given in the references quoted, but a column has been added showing the probable area of irrigation and the scope of the works is indicated by this detail. The object of all the works save one is to extend irrigation, or to make the present irrigation more secure. The one exception is the left

embankment of the Penner from Sangam to the Anicut, the object of which is to prevent floods sweeping across the country in an East and North East direction, as they did in 1874.

8. In this list there is only one project which can be classed as a Productive Public Work, viz the Sangam project, and intimation has been received since that the Secretary of State has approved of its being so classed.

9. The following works may be classed as Protective

Protective -

	Works estimate	Area to be irrigated acres	District
1. Rooshkulia -	19,67,414 ..	120,000	Ganjam
5. Palar Anicut channels North section -	3,10,178 --	39,468 -	North arcot and Chingleput
7. Baroor	2,35,500 -	7,500 -	Salem
8. Vaniar reservoir -	6,54,000 -	10,000 -	Salem
9. Marandahully -	unknown -	unknown -	— Do —
10. Pugalore Chamel extension —	3,08,400 -	5,700 -	Coimbatore
11. Perryaur	53,13,000 -	93,172 -	Madura
14 - Gullapuram reservoir -	7,70,847 -	30,000 -	— Do —

In P. W. G. № 563. W. of 3rd March 1881 is given a list of all the more important projects both complete and incomplete which may be classed as Protective. It may be as well to say however that it will depend upon the extent to which there may be a failure of rain whether these schemes will be really protective or not. The only two that would be protective in a Famine like that of 1876-78 are № 10 the Pugalore chamel and № 11 the Perryaur project.

10. Of the 14 works in the list the estimates for the following have been submitted to Government and orders passed thereon,

1. Rooshkulia project.
3. Sungum — Do —
5. Palar Anicut channels North section.
6. Badatalao project.
7. Baroor — Do —
11. Perryaur — Do —
12. Shunmuganaddi Thaliotta Manoor reservoir
13. Pulney reservoir
14. Gullapuram

Of

Of these No 3 has been sanctioned & Nos 5 & 7 have been forwarded to the Government of India for sanction, with a view to their being gone on with at once. Nos 1. 12. 13. & 14 were not disposed of, the former because the returns are not likely to admit of its being treated as a Productive work, which it is too large to be carried out as an ordinary work. The last 3 because the need of relief works had passed away. Nos 12 & 13 are not very promising projects, and No 14 will not be needed if No 11 be carried out. No 11 the Perryaur project

has been very fully discussed. At present the question as to the terms on which the site and water can be obtained from the Travancore Government is awaiting settlement.

11. With regard to the general order of importance of the works, it would seem that, if this importance has any connection with Famine relief, it must be determined with reference to the geographical position of the work, to the kind of work to be done, and to its suitability to the labour to be employed. To this end when a list of irrigation works available

for

for Famine relief was drawn up in this office in 1877, it was shown what the proportion of earth-work to other work was, and what numbers of people, for what time, could be employed on each project. A work might be a good project in itself, and well suited to Famine relief purposes; but if it were situated in, say, ~~in~~ North arcot, and the Famine were in Bellary the scheme would be for the time useless.

12. Ganjam is provided with a useful project of considerable extent

Ganjam
+Roochkulia project

(t)

Vizagapatam-

which would employ 30,000 people for about 18 months, and it is probable that, until some special emergency arises, this scheme will remain available.

13. In Vizagapatam there are only 2 Government Taluqs, and very little in the way of Irrigation project work can be done there, as the Government villages are so much mixed up with zemindari villages as to place almost insuperable difficulties in the way of carrying out improvements. Probably the best work that could be prepared against Famine

(9)

requirements

requirements for this District, and for South Ganjam, would be the extension of the Coast Canal Northwards from Samulkot or Cocanada.

Godavari & Kistna

14. In the Godavari and Kistna there can be no general famine, and the Delta works will afford employment for many years to come to any who need it.

Nellore.

15. In Nellore the Sungum project and the Penner embankment will be available for several years. On the Buckingham Canal too there is likely to be a good

deal of work, and this traverses the whole length of the District.

Ceded Districts

16. The Ceded Districts come next, and there is no work at present available. There is no probability of any Productive Irrigation Work being found, and it is very doubtful whether in Bellary and the Sub divisions of Cuddapah and Kurnool any Protective work in the proper sense can be found.

Bellary

In Bellary there is the Toongabudra, the supply in which never altogether fails

fails during the South West monsoon, forming the boundary of the District on the North. There is a strip of irrigation along its right bank and this can probably be somewhat extended. It has been demonstrated by the investigations first of Government officers and afterwards by the Madras Irrign & Canal Company that no remunerative scheme for irrigation on a large scale from this river, in Bellary is practicable On the West side of the District there

is the Huggry an extremely unsatisfactory river which falls into the Toongabudra, and on the East side there is the Penner which, there, is not good for much, and further East the Chittravati a tributary of the Penner which is much better, and already supplies by its affluents a large group of tanks, of which latter several are Considerable reservoirs. It is believed that all that can be done in Bellary is to endeavour to find a number of tank & anicut

projects

projects on a moderate scale which will be useful in ordinary seasons, and so will be worth carrying out in seasons of scarcity when the population may need the assistance which relief works would afford. If estimates for 15 or 20 lakhs under works can be thus got ready for schemes which will cover their working expenses, and pay 2 or 2½ per cent besides, it will be fortunate. Here and there perhaps a more promising project may be found which could be sanctioned without any such special object. Two schemes Nos 4 & 5 in the list of partially investigated projects are for anicuts on and channels from the Penner, neither of them promised well. The only satisfactory plan will be to see what can be done with, and in, each river basin and valley. It is considered that Bellary very specially needs complete investigation, because if it be found that irrigation projects will not afford much employment in times of scarcity, it will

(h)

be

be necessary to consider what other precautionary measures can be adopted - Wells for instance would be valuable at all times. There is a good deal possibly that may be done also in the way of enlarging and improving the more favourably situated of the old tanks.

17. In Cuddapah the sub division in the South West is traversed by the Papaghi on the West side, and by two rivers, which unite and form the Cheyair, to the Eastward.

Cuddapah

The circumstances of the country are not favourable for river irrigation, but it is possible that some good tank sites may be found. There is no known good project in this part of the country. The Kodoor valley to the East of the subdivision is traversed by the Railway and is not usually liable to famine. The country to the North of Cuddapah is fairly protected by the N.S. C. Ford Canal. The North Eastern part of the Valley of the Sugglern is likely to provide a fairly good river

and

and tank project.
Mr Unwin was employed
on its investigation
shortly before the
close of the Famine,
the report thereon
was favourable,
and was reviewed
in P. W. D. No. 22. I. of
14th January 1879. It
was originally omitted
from the list of
projects the investiga-
tion of which is
incomplete, but
it has now been
added. It is supposed
that between 40 & 50
thousand acres
might be irrigated,
but this is unlikely
1st because the Penner

requires a large part of
the water for the Sungum
and Penner Anicut irriga-
tion, 2nd because the area
250 square miles, of the
basin drained and the
stated rainfall indicate
a much smaller irriga-
tional capacity. An
officer will be needed
to complete the project,
but this valley is from
a famine point of view
of much less importance
than many other localities.

Kurnool

18. Kurnool has the
M. S & C. Co's Canal traversing
a great part of it and
effectually protecting
it. To the West of the
hills i. e on the confines
of Bellary, there may be
need

need of a few works to be kept in readiness, and there are a few small streams, tributaries of the Hindry, which may be turned to account to supply moderately sized tanks, if sites for these can be found. They must not however be repetitions of the unsatisfactory Yeldurti tank.

In the Subdivision of Kurnool on the East of the Nallamullays there is the fine tank of Cumbum, and it is possible that in this part of the country, about which little is known, some favourable tank sites may be found.

It may be added that Kurnool is very badly off for roads, the only fairly good one being that from Gooty to Kurnool. There would be no difficulty in spending money to advantage on roads, should at any time relief works be required.

Chingleput

19. In this District there is not much to be done. The Cortiliar is the best river traversing it, and its water has been turned to account to supply the Chembrum-bankum, the Red Hills and Cholaveram reservoirs, the two latter being those on which Madras depends for its water supply. There is also an Anicut, the Vullur, lower

down

down the river. It is possible rather than probable that in the Northern part of the river valley some tank sites might be found. Some of the tanks in this District are supplied from the Palar Anicut and improvements are about to be carried out.

North Arcot.

20. About the Northern part of the District, which is for the most part zemindari, but little is known in this office. There are no facilities for any large project. The Poiney the Palar and the Cheyar are the principal rivers and there are

Salem

Anicuts on these, the field of irrigation under the Palar being much the more important. There is a good deal to be done in the way of improvement to existing works, but it is improbable that any new large project will be found.

21. One considerable Tank the Pennagonda-puram was restored during the Famine, and the distributaries are now being gone on with. The Baroor project partially carried out at that time will probably shortly be proceeded with as it is a fairly good scheme. The Marandahully project

is

is under investigation.
The Vaniar reservoir
has been investigated,
and is sufficiently
advanced to admit
of its being started
whenever necessary,
but it is doubtful
whether it will be
carried out except
as a relief work,
for which it would
do well.

There remain the Kistna-
-gherry reservoir project
on the Pooniar or Panar,
and the Goodamullay
reservoir scheme on
the Swethanadi to be
investigated. As the
feasibility of the former
depends upon the
circumstances of
the river bed and

these could be ascertained
fully in 2 or 3 months,
it would be desirable
to complete the informa-
-tion on this point. It
would not however
do for a relief work
as the dam will be
of masonry. The
complete investigation,
including the distribu-
-taries and the collection
of revenue information
would take the greater
part of a season.
Regarding the Goodamullay
reservoir scheme very
little is known, and
that little is recorded
in the Proceedings of
Government quoted
in the list. There may
be and probably are
some good tank sites
in this District, but

the

the projects above
referred to will occupy
any Establishments
which may be avail-
-able, for some time
to come.

Coimbatore

22. Parts of this District
are well circumstanced
as regards irrigation
works, the sources
of supply being the
Bhowani, the Noyel
and the Amravati,
tributaries of the
Cauvery, and the latter
river which forms
the Northern boundary
of the District. The
only large project
which has been or
is likely to be brought
forward is that for
a regulating reservoir
on the Bhowani over
which Major Montgomerie
has drawn up a
Preliminary report. The
scheme would be of
benefit chiefly to the
Cauvery Delta in Tanjore.
It will be desirable
to examine further
into its feasibility
as soon as the necessary
Establishment can be
made available. Some
11 or 12 years ago there
was a proposal to
construct an Anicut
across the Cauvery
near Nerinjipett to
irrigate land in Salem
on the left bank, and
in Coimbatore on the
right bank. It was
abandoned because
there is no water to spare
from

from the Cauvery Delta. Any schemes for turning to better account the water supply of the upper Cauvery and its tributaries must be for the construction of storage or regulating reservoirs to extend the duration of freshes. There is much flood water unutilized, but the regular supply is already fully made use of.

It is believed that little or nothing can be done for the benefit of the tract of country between the Bhowani and the Amhravati. The rainfall is small and the circumstances unfavourable.

To the North of the Bhowani a few tank sites may be found. One near Kongrapolliem is mentioned in the list, but no definite information has yet been obtained.

South Arcot. 23. Except in the North West part, this District is very well provided with irrigation works and the water supply is good. In the excepted tract it is believed that very little in the way of improvement is practicable. The existing works elsewhere need improvement, and should be improved. It is improbable that any large

large new projects will be found feasible.

Trichinopoly.

24. The Cauvery runs through this District, and within the limits of its influence there is a great deal of good irrigation. Elsewhere there are no facilities for large projects, but it is probable that in the valleys of the streams which fall into the Cauvery and Coleroon some good tank sites may be found.

Tanjore.

25. The fertility and prosperity of the Cauvery Delta are well known. It has the largest continuous field of irrigation in the Presidency, or any where, the irrigated area being about 800,000 acres. There is much room for improvement and it is in contemplation to take up the investigation of the requirements in an exhaustive manner. The Superintending Engineer has already been called upon to report what the arrangements should be. Tanjore has an important influence on famine in its capacity for the supply of food to less favoured Districts, but it can never

never itself suffer from Famine. Whatever may be done in the Delta will therefore be for the security and improvement of existing irrigation, there being no opening for material extension of the area of irrigation.

In the South West part of the District outside the Delta it would be very desirable to ascertain what the water supply available is, and whether any thing can be done with it. This part of the country has been always neglected.

Madura.

26. About half the District is Zemindari. In the other half there is a good deal of irrigation of a very precarious kind under very numerous shallow tanks. The one notable exception is the irrigation under the Sumulijar, the river into which it was intended to turn the diverted Periyaar water for the better supply of the Vigay, and of the lands in the valley of the latter. Much has been said at different times about the feasibility of constructing large reservoirs and so doing

doing away with to
many of the shallow
tanks. Some of the
sites brought to
notice were investiga-
-ted during the famine
and the results were
not very encouraging.
It is very doubtful
whether sites at
which water can
be cheaply stored
can be found, but
it will be desirable
to take up the river
valleys one by one
and settle this
point conclusively.

The Periyar project
is the most important
scheme that has ever
been investigated
for the benefit of this

Nos. 12, 13 & 14 in the first list in Memo: No 4-I. of 4 January 1881.

Tinnevelly.

District, and it is not im-
-probable that it will be
found impracticable to
devise better means for
irrigating efficiently an
equivalent area viz about
93,000 acres.

27. This District includes
some of the most as well
as least favourably circum-
-stanced tracts of country
in the Presidency. The valley
of the Tamiraparni is
most fertile and yields
a higher average revenue
per acre than any to be
found elsewhere. The
valley of the Chittar is
fairly well supplied,
and there is valuable
irrigation all along
the foot of the hills.
Much of the country near

the

the Eastern Coast and the South West part of the District are very badly off for water and little, if any thing, can be done to improve matters. Those streams and rivers which are supplied by the South West monsoon rains are very valuable. Those which are dependent on the North East monsoon rains are of very little value for irrigation. The freshes in them are floods of very short duration, and they do more harm than good.

There is plenty of good work for the Department to do in improving the old works and distributing the water supply, but there are no valuable

South Canara and Malabar.

water sources unutilized.

28. There are no state irrigation works, though the area of irrigation is large. Seasons vary in these Districts, but famine is unknown.

29. The above brief sketch of the circumstances of the several Districts may serve to remove the misapprehension indicated by a passage in a recent letter to the Government of India, in which it is stated that there are facilities for the creation of new, as well as for the development of existing irrigation works, which make Madras a perfectly unrivalled field for works classed as Productive. As regards new irrigation works there will be very

few

No. 337 W. of 8th Feby 1881. para 33.

(i)

few to be so classed, and with respect to the existing works some have been taken out of that category, and one more is likely to be removed.

The list including the latest addition will then comprise.

The Godavari Delta
" Kistna —do—
" Penner Anicut
" Cauvery Delta
" Sangum project.

It will be fortunate perhaps if the improvements required to the Cauvery Delta can be so classed. To admit of this it will be necessary to show not merely that the improvements will be highly beneficial, and that the expenditure is fully warranted by the great value of the irrigation, but that tangible and definite returns equivalent to a certain percentage on the outlay can be obtained as direct profits therefrom.

It is not always easy to demonstrate this, but possibly, including profits from the past outlay which has been small, a case may be made out.

30. There will, it is believed, be many projects for improvements and extensions which may be properly carried out, though their profits will not be so clearly capable of estimation as to allow of their being classed as Productive Public Works.

To

31. For Famine relief purposes any permanently useful project, which will do something more than cover its working expenses will satisfy probably the conditions which Government would think it necessary to impose, seeing that it is sometimes difficult to find relief work, which will be of permanent value when done. In the parts of the country in which relief works are likely to be more frequently needed the probability is that irrigation projects of having more pronounced merits will not be found. It is unfortunate that such should be

+ the Toongabudra

the case, but perhaps only natural that it should be so, for irrigation depends upon water, and Famines result from the want of water. If then there be not a river deriving much of its supply from country not liable to a failure of rainfall, or if, as in Bellary, there is a river, but the circumstances prevent its being turned to account, Any material permanent improvement of the circumstances, so far as they depend on rainfall and water supply, become impracticable. The District may be made better prepared to stand

stand a scarcity or a famine, and it may be more successfully supplied with food by Railways and other Communications, but the difficulties in the way of the local production of food will remain unaltered.

32. It may be useful perhaps to illustrate by means of tolerably well known irrigation projects at about what cost water for the irrigation of land must be made available in order that the project may be classed as a productive Public.

The Sungum project is the last allowed to be thus classified and this only after prolonged discussion.

The estimates are for

Works	Direct charges	Indirect charges	Total
23,13,805	3,01,231	4,09,45	34,62,176
24.61	31.93	4.90	36.83

P. W. G. no 606. I. of 14th Oct. 1879.

Area of irrigation 94,000 acres or per acre

+ old irrigation 43,659 acres
new — do — 50,341 — " —

As the extent of old irrigation is considerable this project is a guide to projects consisting in part of improvements and partly extensions.

In the Kistna Delta the extent of old irrigation is a small percentage on the total. The total area will be 470,000 acres.

The particulars are

Works	Direct charges	Indirect charges	Total
10,56,527	13,99,784	2,71,029	16,70,813
Per acre 22.47	29.57	5.90	35.47

In

In different localities the rates of assessment vary, and so therefore may the amount per acre to be spent. Experience however leads to the conclusion that the actual yield of revenue seldom exceeds 75 per cent of the full water rate, and it may be noticed that under existing rules the increase of revenue due to irrigation is, for works classed as Productive or even for those for which Capital and Revenue accounts are kept, not the difference between the revenue before and after the project is carried out, but only the water

rate or the consolidated assessment less the land assessment. Compared with the above projects the Perryaur project, which is to irrigate 93,172 acres gives the following results -

Works	Direct charges	Indirect charges	Total
53,13,000	69,07,000	96,000	78,63,000
Per acre - 57.02	74.13	10.26	84.39

3. With regard to the Establishment which may ere long be available for Famine projects, it is recommended that it be distributed as follows.

Districts	Executive Engineers	asst Engineers	Upper subordinates	Remark
Bellary with Western part of Kurnool & sub division of Cuddapah	1	3	4	
Sub division (civil) of Kurnool i.e. Cumbum and Markapur Talugs.	1	.	2	
Salem	1	1	2	
North arcot	"	1	"	
Coimbatore	1	1	2	

where

Where the officers with the necessary qualifications are to be found is not clear. It is hoped that the Irrigation Divisions will be properly officered for the care and management of existing works, and for the execution of sanctioned work, before it is attempted to take up new schemes. The requirements of the M. S & C. Jois Canal and of the Sungum project will ere long have to be considered, and several officers are at the present moment wanted in the Divisions.

(j)

Chepauk
7 April
1881.

Colonel. R.E.
Chief Engineer for Irrign.

mcL

Mr Cl 2325A

Rec 13/4/87

Mr W Hudleston
Ag Chief Secretary

For orders

The annexed memo
No 43 I of the 7th April
deals comprehensively
with with the requirements
of the Presidency in regard
to "Protective (famine)
works, and shows how
are proposed extra
Estabt of

4 Executive Engineers
6 Assistant do
10 Upper Subordinates

as provided in the
normal Estabt scale
(submitted for sanction
to be of D) can best
be utilized

Colonel Merllins's
opinion in a matter
of this kind from
his intimate acquaintance

D.S.P. 18- Cir 24/4.

with the country of the Presidency and anyone local knowledge might. I should think be unreservedly accepted. and could the G of I sanction the normal Calcutta scale as sent. also this arrangement might be finally adopted with the following provisos.

1st that we can secure the services of competent Officers

2nd that we can see our way first to framing and submitting to the G of I the various Canal projects which have so long been on hand and have not as yet reached this final stage to allow

Oct. 18. Ins 26/4.

[Initialed and dated at the end of his memo]

upon this being sanctioned by the G of I

The first of these provisos will be a real difficulty -

In my previous note I pointed out that the obtaining of qualified Officers would necessarily involve much interference with the practicability of conducting the extensive investigations at first advocated by Colonel Dunlop, and it will be observed that he is now himself so impressed with this difficulty [see (j) at end of the memo] that he allows even a doubt the practicability of securing the services of the much smaller number of Officers required under our

normal scale

When drawing up the estimates I had in view the possibility of obtaining some temporary extension of time from Simpore after the rendition of the province, but as all these are now being closed on this source has absolutely failed

The Assistant Engineers and Office Subordinates may be distributed into some trouble but as regards the Executive Engineers (4 for Special Projects + 1 for the Chadras Irrigation Canal) 5 of which ~~grades~~ cases will be needed I do not see any way clear to extend the aid of the S of I

2 out of the 5 is the most we could I take credit for in my present

distr. and the remainder would have to come from outside

The second proviso, that we should first bring into a final stage all the most important projects at present in abeyance, will present no serious difficulty if we can only obtain Mr. as above

On both points I shall ask Colonel Boustead to note his opinion at the end of this Note

C/ Ar Colonel Mullins, Memo may in dispose of the several questions that have been raised I have to be commented to the S of I it may not be out of place to remark briefly on

a few points therein contained against which I have placed letters in the margin

(a) The observation here is that it may under certain circumstances be necessary to undertake even unremunerative schemes in order to provide for protracted needing employment in famine affected Dead to modification

The great mistake in managing the last famine in Bombay was undertaking a series of unproductive irrigation schemes which were can long, which however must now be finished, and which like the Madras P.C & C rails are remain a burthen on the State

If foreign schemes cannot be found and it is essential to keep the people under exercise, it would be better to face the difficulty by placing labour camps in the healthiest spots on a line of Railway where they can be cheaply fed and let the feeble die here at one side of the camps one day to be filled up the next if necessary

This is of course a strong way of putting the case; my meaning however is that unless unproductive work can be kept within the strictest limits of the immediate requirements of the famine such should be absolutely prohibited

Unproductive work has been the curse of every past famine the last not excepted

I have provided against its use in the draft of a famine character in our P.W. Code which I hope we may be to submit for the approval of Government

(b) The General Committee have extended (as by Colonel Mullins was distinctly admitted in my note of 26/1/31 (See marked passage) and doubts of the practicability of giving effect to it were alone expressed with reference to our available means

(c) Others might surely be added to this list – I should ask Colonel Hastead to note on this point.

(d) This statement that 14 projects have been submitted to Government although true

needs qualification as from what I have seen of the projects in question the majority have by no means reached this final stage

It has formed the first of the complaints made to the G of I that this department has not hitherto had such special extra Establishment placed at its disposal as to allow of its framing projects in the manner looked for by the G of I and that as a fact we have few if any in the final state and fit to be entered on were famine to make its appearance tomorrow

The Barrow & Periyar projects are direct examples in point – The fact it is true has done all to India but visitors

are by any means complete in the Code sense

(E) The Penryn project has no doubt been very fully discussed but the Estimate is by no means fit for sanction design Penny cuits after his return could overcome if even a small Canal Estabt. be able to put it in shape in 2 or 3 months if only the Travancore Govt. accede to the last proposals submitted for its consideration

The chief necessity is to compress into reasonable compass the huge mass of undigested papers which now go to form the project

This last observation applies to nearly all the projects I have seen in the Irrigation Branch

(f) This need of the Rosshellalia project may probably be admitted but it may still be an open question as to whether it would not be politic to enter on the work before the catastrophey of a famine - The work as I understand it may nearly always sufficient returns to make it remunerative and bring it within the "Productive" Class

As shewn in the Report of the Famine Commission a work of this kind even often in a single year of famine saved more than its whole Capital outlay - I would certainly not press for its immediate commencement, but I would not on the other hand prohibit its commencement till famine had actually declared

itself

(g) The extension of the Coast canal north and of the Chilka lake Sanjam Canal south has already been suggested to the Govt. and I am now engaged in investigating the last named link

(h) It is to be regretted that Colonel Mullins did not have made some allusion to the many schemes which have from time to time engaged attention in Bellary some of which might possibly bear reconsideration as "Protective" works.

(i) I do not think that Colonel Mullins has sufficiently enlarged the bearing of the observation (in para 33 of No 337 W of 8 Feb 1887) to which

be evidently objects namely that the Presidency has unrivalled facilities for the creation of new as well as for the development of existing irrigation works

As I am I believe in a measure answerable for this expression of opinion I may be permitted to state the grounds on which I did so -

When officiating temporarily in 1878 as Director General of Irrigation in India I had the opportunity of reviewing generally the Irrigation of all the Provinces as regarded the extension of really remunerative irrigation projects, and though I found gigantic projects just favoured by enthusiasts in the Punjab, N W P, Bengal and Bombay I came

to the conclusion that
none of these presented
so good a field as
Madras - Either pe-
-culation was wanting
as in the Punjab - or
the existing rainfall
was sufficient or nearly
so as in Bengal, or
the form of the ground
& character of the
soil (black cotton)
were against remunerative
returns as in Bombay
Dep.

Now the same inexplicable reason
Colonel Mullins in
his present memo has
omitted to show
what the total
extension of irrigation
would be if the schemes
for (1) Improvements in
the Godavari delta
(2) Extra Kistna
delta

(3) Bowani reservoir
for which were actually
sanctioned & carried
out

He has also for no
sufficient reason as I
venture to think classed
Canal Projects into
-lets e.g. Barrow
Penyaur as merely
"Protective" instead of
"Productive"; and in
this way has given the
idea that there is
after all not any work
to be Executed for
the development of
irrigation

Possibly on the other
hand I may take
too sanguine a view
of the position of the
Presidency but without
going into details it
appears to me that
by adopting a classi-
-fication which is fully
justified by the facts
the total additional

area that could ever
ever be added by works
of the "Productive" Class
could not fall short
of 1 million of acres
and that the investigations
to be undertaken might
well admit enhancement
even by another half
million

Productive works such
as the Rosehearty Inlet &
other projects with such
minor improvements to
tanks & Channels to that
the country may possibly
be credited with not less
than 1 million more
or say in all 2½ millions
of acres — 50 per cent
of the existing wet land

In this case I should
still consider that
fairly flanged roadway
stands unrivalled

21/9/81

To W.

As regards the 1st of the
2 points referred to me for
opinion I am unable to
say where we are to find
officers competent for the
special work to be done.
In the late reductions
the services of one† officer
fit for the work, in my
opinion, were dispensed
with. Perhaps we might
recover one or two from
the L. F. Boards.
As to the 2nd point there
should be no difficulty
if we can get qualified
officers - the necessary
investigations cannot
be satisfactorily carried
out at present by the
officers of the Department
who, however energetic, find
current work more than
they can manage.

† Mr W. R. Morris
Exe. Engineer

Though he might
be re-employed under
a Specific engagement for
a certain work or period
I should doubt whether
looking to the facts attending
his removal in the late
reductions it would be
possible to take him
back into the regular
Dept. Estab.

I prefer below to your letters
(a) Probably the "unpromising" schemes referred to by Colonel Mullins are schemes which would give a return of 2 or 3 per cent on the outlay. If such schemes could be carried out nearly to completion by famine labour they might eventually be completed so as to pay. As I understand it, Projects that now will not show a clear profit of 4½ per cent on outlay under all heads are called 'unpromising' though they may be indirectly of considerable value by improving the circumstances of the neighbouring population.
(c) Colonel Mullins says that in a Famine like that of 1876-78 only 2 of the works mentioned in the List would be protective, but he names 8 works above which he proposes to class as "Protective". I understand him to mean that only works intended for the storage and utilization of the S.W. Monsoon rainfall would be effective as a protection against such a Famine as the last, and the 2 works referred to are those which can thus be classed.
(d) Of the 14 works in the List referred to, Estimates for 7 have been submitted to Government - of the remainder Estimates for some have been prepared & for others partly prepared but for want of officers are delayed.
(h) I am not aware that any of the schemes proposed in Bellary have been 'promising' ones. I am not personally acquainted with the District, but think it

is probable investigation may prove that some schemes are worth carrying out.

I think that Colonel Mullins has not noticed the extension of irrigation that would take place if Improvements in Godaveri and Kistna Deltas, and the Bhowany reservoirs, were carried out, for this reason. The Canals in the Godavari and Kistna Deltas have been designed to irrigate a certain extent of land. The Estimates for their completion have been, in great part, * sanctioned, but there is still a great deal to do before the full extent of land intended to be irrigated, can be supplied. After this is done, no considerable extension of irrigation

* As I understand it Major Montgomerie's Scheme for a reservoir has not only the object of regulating & securing the cultivation in the Cauvery Delta, but of supplying water for the irrigation of no less than 450,000 acres.

Attt

* To this I am unable to assent see my remarks

Attt

* Not as yet, the S.P.I. still continuing to express doubts as to which thing can be classed as "Productive"

Attt

irrigation is probable.

The Bhowani reservoirs were intended to store flood water and extend the duration of the freshes with a view to securing the Cauvery Delta cultivation - here also no considerable extension of irrigation is probable.

From my own knowledge of the Presidency I fear there is little to be done on an * extensive scale in the way of 'Productive' Works; but I believe that if the systematic investigations suggested by Colonel Mullins in his Memorandum No. 4-I of 4th January 1881 are carried out, it will be found that many minor projects may be undertaken which will ensure a considerable

addition to the area
now irrigated.

Joh
22/4/81

DLS 18. Cir 26/4.

Hon W Hudleston
His Lordship to Secretary

For orders

Colonel Mullins
have sent us a list of
14 works suitable to
execution in famine
which are supposed
to be of a purely protective nature
and 13 which are
either immature or
have not been adequately
investigated

I confess that after
a perusal and
his complete knowledge
of the works a more
complete statement
might have been looked
for showing precisely
the scope & object of the
works, whether they
can be classed as
"Productive" or merely
"Protective" the present
stage of the proposals

I concur in thinking
that the only immediate
practical steps W.P. can
can contemplate is
a detailed inquiry
by the Works specified
& extend to this
completion of the
whole as far as
be done the necessary
data about
disposal. Meanwhile
the more pressing
demand expending
sum Rs. 1 crore
available in the
Irrigation Dept. J.B.

WPA

C. 26.1.12. 281.

with reference to final sanction, and lastly the general order of this import-tance

This information can no doubt be furnished and therefore the main question concerns the Establishments which may be considered necessary

In para 4 Colonel Sullivan says he would wish to have at his disposal "one or more Special Officers in each District which may be deemed more particularly liable to suffer from Famine"

This seems to me altogether too indefinite - I have

as it stands a very large body of Officers would be needed, and what is of equal importance of Officers sufficiently trained in ~~Inspection~~ Irrigation works

The demand is not only it seems to me indefinite but impracticable as it stands

The first duty as it seems to me will be to class the works in order of importance and then state definitely the Establishments required in making the proposed investigations

In my letter to the GoI on our proposed normal Establishments of 1st October 1880

No 2277 W the
following Establ-
In investigating famine
projects was named
as:-
4 Executive Engineers
6 Assistant - do.
10 Assist Subordinates
and to the best of my
judgement this is as
large a provision as
is in the moment prac-
-ticable — Were a much
larger number demanded
it is my decided opinion
(1) that I would sanction
this entertainment or
if they did sanction
(2) we should be able
to find men of stable
adequate training
and experience

This is in fact the
weak point about
the Scheme and Famine
as to cost: if it have one

We are bound forward
as it is even now to
find a sufficiently
trained Staff for
managing our irrigation
divisions, and until
Such ~~men~~ Engineers could
hardly be trusted
with Extra Provincial
-ists

After providing
for the works of
Sufficiently known
and ascertained
value it may or
may not be feasible
to enter upon the
Comprehensive treat-
-ment of the water
Supply" Generally of
the Country which
forms the Subject
of Colonel Sullivan's
Statement -

That such are

investigation is very desirable & does admit [illegible] but as being also dependent on available means I submit it must await on the requirements which may be looked upon as of even more pressing necessity

In my note which went up to Govt originally on the normal scale I dwelt on the desirability of having a small Estabt in what I called a "Tank division" consisting of 1 Executive Engineer 3 assistt do 9 Upper Subordinates

and although his Grace objected to its inclusion in the Scheme for normal Estabt it will be observed by Clause (3) para 18 of my letter (No 2277-W) the subject was kept prominently forward and to the best of my judgment it will be desirable to revert to this when the consideration of how best to deal with the maintenance of all the Madras tanks comes up for serious consideration

Here it may perhaps suffice for me to observe that I put forward this small Estabt with practically analogous objects in some respects

to those now expressed
by Colonel Mullins

With this acceptance
of the general principle
it might perhaps
therefore be as well
if so far as concerns
the immediate response
in hand to allow
this (as I may term it)
Secondary matter to
stand over till
the whole Question
of tank maintenance
comes up for discussion

26/1/81

E.I.

For information
and such action
as the response to
the H.M's note
as may be necessary

28/2/81

Recirculated with another
Memorandum No. 43-I
of the 7 April 1881, by the Chief
Engineer for Irrigation,
thereupon letter Sec^y to Govt. P.W.D

11/4

From the W Hardinge
W.C. to Govt
Ref 21/5

For orders

I find it difficult to frame a suitable disposal of the annexed voluminous papers in which matter much that is valuable & cannot but be taken is an expression in some points of erroneous views which could call for either explanation or modification if founded to the fact

As regards the general proposals for utilizing the Canal Establishment for investigation of Inspector Colonel Chalmers views will in great measure serve as a

Minute thereupon
Note prepared for
Secretary for
Govt of India
Public Works Dept
forwarding Memorandum
Minute on Water Rates
Read in Council
Recorded for
further orders
after - MK 21/5/81

O.L.S. 18. Cir 26-4.

Guide, but as after all the first question is where the Special Views are to come from if not from outside Societies the Dept may consider it sufficient to simply "record" the views.

- Should this be so it is a position to thank absolutely the decision of the Soc I am sure professors in the normal Establishment and have assigned the Views to the usual divisions & circles

25/4/81

E. 1.

To enable me to meet the call made in Jama 8 S of 1 letter No 631 S of 5th inst: I shall feel obliged by your submitting the list of Vessels alluded to in your Branch; and with this view I forward Colonel Stubbs's memo No 43 I of 7th April 1881 on your return of the latter I shall deal with it as suggested by the Hon in his note of 2/5/81

Should your Excellency's proposals not be accepted by definitely confined to the Burrow & Penyam projects it will probably be desirable to name one or two others in order if in pursuance of the requisite Instructions, so as to shew

O.S.S. 14/5-

the P.W.D. the general system of both present and future proposals under this head

If I may here mention that in reference to the Perryaur project it is not yet known in this Office whether the Travancore Govt. are disposed to agree to the terms for carrying the Line lately made to them — As this is a vital point it would be necessary to have it settled before making definite proposals to India for forming this Irrigt. Division

Should delay be anticipated in its settlement an alternative route should be suggested for a Irrigt Division

Atty

26-5-81

No. 4-d.

Irrigation

Memorandum

—a—

In G. O. No 866. W. dated 5th April 1880, the Chief Engineer for Irrigation was directed to report on 3 points. a Note + dated 3d oct 1880. on the 3rd point, the Perryaur project, has been submitted to Government, and the other 2 points are

1st What are the projects in the Irrigation Branch now sufficiently matured for sanction to allow of their being at once put in hand on the occurrence of Famine

2nd Those which being now in various stages of advancement can be completed for sanction, and the arrangement proposed with this object.

2. The following projects have been matured or nearly

do

So.

District		Name of project	amount of Estimate for works	References	Probable area of Irrigation acres
Ganjam	1	Rooshkolia	19,67,414	P. W. G. No 1293 - 23rd May 1876	120,000
—do—	2	Mallada Tampara	30,700	Estimate ready	5,914
Nellore	3	Sungum	22,60,980	P. W. G. No 1818 - 28th July 1870 - Estimates submitted to Government of Madras.	94,000
—do—	4	Senner Embankments I. B.	1,10,000	Estimate for Earthwork only. Commenced during recent Famine. Value of work done Rs 35,788 plus part of Rs 6475 vide G. O. Nos 723 of 25th March 79 & 1159 of 26th May 1879. R. F. D.	-
North Arcot	5	Palar anicut channels north section	3,10,178	P. W. G. No 715. I - 10th Sept 1878 Partly carried out during Famine of 1876-78. The amount shown is the revised estimate.	39,468
Salem	6	Badabalao	1,13,018	P. W. G. No 417 - 6th July 1877	640
—do—	7	Baroor	2,35,500	Estimate ready. Partly carried out during Famine of 1876-78. Value of work done Rs 67,110.	7,500
—do—	8	Vaniar Reservoir	6,54,000	Revised project investigated by Mr Scott.	10,000
—do—	9	Marandahully	Unknown	Partly carried out during Famine of 1876-78. The design of much of the project is settled. The rest is now under investigation.	No information available.
Coimbatore	10	Pugalore channel Extension	3,08,400	Estimate is ready. Rupees 95,060 spent—	5,100
Madura	11	Perryaur	53,13,000	P. W. G. No 1193 - 30th April 1875. Design for main dam not finally settled or the terms of grant of site & water by the Travancore Government.	93,172

Probable area of Irrigation acres	District	Name of project	amount of Estimate for work	References
	Madura 12	Shunmuganadi Reservoir Thalaith manoor	1,20,000	Investigated by Mr D. Scott. vide P. W. G. R. D. No 601 dated 7th March 1878
2,000				
1,700	—do— 13	Pulney-do-	146,066	—do— do — No 686 d/ 14th March 1878.
30,000	—do— 14	Gullapuram Reservoir	7,70,847	Investigated by Mr Sells. P. W. G. No 491. I. 14th June 1878. will not be wanted if Perryaur project is carried out.

A project for the Unnamalunka reservoir, Rupees 8,14,000, in the Godavari has been omitted as it is improbable that relief works will ever be wanted close to that Delta.

The Madras Irrigation & Canal Company's projects for a canal from the Toongabudra to Bellary and thence to Kurnool have also been omitted because a more severe famine than the last is not very likely to occur, and they were not then deemed suitable owing to the very large amount of the estimates and to the improbability of the water being used in ordinary years, the land commanded being principally black cotton soil.

3. The following projects have either not been investigated at all or the investigations are not nearly complete.

Kurnool

District	Number	Name of project	Approximate Estimate	Remarks
Kurnool	1	Restoring Venkatareddi pollium Tank	50,000	P. Dn. G. R.D. No 2050 d/ 15th December 1876 and No 962-A. 6th March 1877
	2	Mamidivaram Reservoir.....	22½ lakhs	P. Dn. G. No 1095 d/19th April 1875 " -3004 d/3rd Dec/77. R.T.D. " " 588 d/16 Dec/77. Rvd. Reservoir site in Kurnool & lands to be irrigated in Kistna. Probable capacity 54,000 millions of cubic feet.
	3	Restoring Arvee Tank.....	25,000	Vide papers quoted against 1. nothing known as to the facts.
Bellary	4	Hindupur	2 lakhs	Have been partly investigated & the papers were returned for revision with this office No 24 B.H. dated 1st October 1877. Not considered promising
	5	Roddam	1/3 -do-	
	6	Potalakunta tank	15,000	Investigation sanctioned in G.O. No 146. S-9 July 1877 no report received since.
Chingleput	7	Vyalore channel	no information	Investigations were commenced by Mr Cecil Scott for this channel from the Thamarapak anicut on Cortiliar. No report received
South Arcot	8	Guddelum Ahtur	51,728	Has been estimated for but requires revision vide this office No 373 of 19th June 1873.
	9	Pullagacherry channel--	no information	Investigation was directed during Famine vide this office Memo No 28. SA. d/1st Oct/77 but it is believed nothing was done.
Salem	10	Kistnagherry reservoir	6 lakhs	The amount here stated is for a very much smaller project than was originally contemplated but the water supply is not likely to suffice for a very large reservoir. P. Dn. G. No 92. I. dated 11th February 1879 contains the latest information. May be feasible if rock be found in bed of river, otherwise impracticable, so this is the first point to be settled.
	11	Swethadriaddi Reservoir near Goodamullay	uncertain	Vide P. Dn. G. No 906 R.T.D. dated 15th April 1878.
Coimbatore	12	Bhowany reservoir above Sathiamangalum	No information	A very large project on which Major Montgomerie has drawn up a preliminary Report. His reservoir site is not very promising but there may be a better one - Valuable if feasible at a reasonable cost.
	13	Reservoir on Vaniputhoor stream near Kongrapollium		Investigation considered desirable vide P. Dn. G. No 971 d/23 April 1878 R.T.D.
Cuddapah	14	Sanglegherpur	unknown	vide G.O. No 22. I. 14 January 1879.

4. The undersigned is of opinion that for the purpose of matuving irrigation projects the most satisfactory arrangement will be to place at the disposal of this office one or more special officers for each District which may be deemed more particularly liable to suffer from Famine. The first duty of these officers would be to obtain a comprehensive idea of the water supply available in the several river valleys, the extent to which it is now utilized by means of channels and

tanks

tanks, the quantity of water which remains unutilized in good and in bad seasons, as regards rainfall, respectively, and the facilities which may exist from the conformation of the country for either improving the supply of existing reservoirs or for forming new ones. Having obtained a fairly complete knowledge of these circumstances, it would be practicable to decide what particular projects might properly be taken up for preliminary investigation, and thereafter which of these afforded sufficiently favorable evidence of utility to make detailed investigation desirable.

5. Hitherto no such comprehensive treatment of the water supply of the country has been attempted or has indeed been practicable. Officers whether of the Revenue or Public Works Department have from time to time when marching about the country been struck by this or that site as likely to be suitable for an Anicut or a reservoir, and in many cases investigations have been made sometimes with good, but far more frequently without any results. There was perhaps some essential condition wanting; the scheme fell through and the time spent upon it was simply wasted, that is the information obtained did not lead to a complete examination of the facts, and to the determination whether in connection with the particular valley any sound project at all whether small, moderate or large was feasible. What is therefore wanted is a systematic examination of every considerable valley or source of water supply, and a determination of the facilities, or it may be absence of facilities, to be found. Then every days' work will tend towards a settlement of the very important question whether any materially greater use than at present can be made of the water so much of which now escapes into the sea without having done the good which, if it

could

could be brought under control and applied to agriculture, it might accomplish. As regards Reservoir projects the way in which investigations should be carried out was outlined in Professional Circular No 39 of October 1877, as a guide to the officers who, it was then thought, would be employed upon work of this kind; and it is considered that only by such systematic treatment of the subject can the storage of water in the way best suited to the circumstances of each particular tract of country be secured.

Camp Salagooda
Sd 4th January 1881.

I have &c
Colonel R.E.
Chief Engineer for Irrigation

To The Jt Secy to Govt. P.W.D
Irrigation.

E.I. Circular 22 28-10-77.
~~Lib. No. 6 W. 5-4-80.~~

P. W. C. No. 330.

E. 915 8W. 30.7.79
858W 5.4.80
269W 23.11.80
563-4W 3.3.81

Rec'd. 18-1-81

Famine &
Min. Irrigation

Press papers
seen & Secretary
seen on my
table for some

P. W. Department.

Read the following :—

Memorandum by the Chief Engineer for Irrigation
No 4-I. dated 4th Jany 1881.

FOR ORDERS. through the Secretary
to Government. P.W.D.

Sd. Mackenzie Col. R.E.
Gunlundins
Joint Secretary to Govt. P.W.D.
Irrigation Branch

Sd. Mackenzie Col. R.E.
Landing remarks
as to the practical
steps to be taken
to give effect to the
Minutes suggestions
for systematic
investigations. &c
the completion of the
projects now on hand
in various stages

Agreed. This is a matter
of very great importance
not only as regards
projects in hand and
in various stages but also
as regards the systematic
investigation suggested
by Col Mullins.
If the Govt persist
the cutting down
20/1

R.C. 26-1. R. 28-1.
C. 18-1. R. 28-1.

our estate Westinvents
to a point where it is
impossible for us
to be prepared fully to
carry out them duties
& ours in case of
famine we should at
all events take care
that wastelands where
we can take care
be attended & hold
this matter of
scientific investigation
of the catchments
of the Presidency as to
its water supply and
to best use to which
it can be turned
to be one of the most
important

WPL
Jan 22/61

Public Works Dept.

FOR ORDERS.

Hon W. Hurdle Esq
The Registrar the Governor

Ch 30/04/88

Miss

No 1102 Wdy 13th April 88.

B

Recorded.

Ch

Ch.
11/4.

When given for 6-10 ____
When copied ____
When examined ____
When signed ____ } 191

READ AGAIN G.O., No. 191 . DATED

CURRENT No.

ENCLOSURES TO C. No.

ORDER OF GOVERNMENT.	A A A A A A A
LETTER OF GOVERNMENT.	
STATEMENT WITH DITTO.	
PAPERS NOT SENT UP, BEING MERELY FOR DESPATCH IN ORIGINAL.	

N.B.—
A = Copy in full.
B = Not to be copied.
P = Copy abstract only.
Q = Copy Heading only

R.C. 26-1. R 20-1.
C 18-1. R 25-1

Entd. in Rockhill Regr.