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REPORT ON THE

LOWER BHAVANI PROJECT

(1946 SCHEME)

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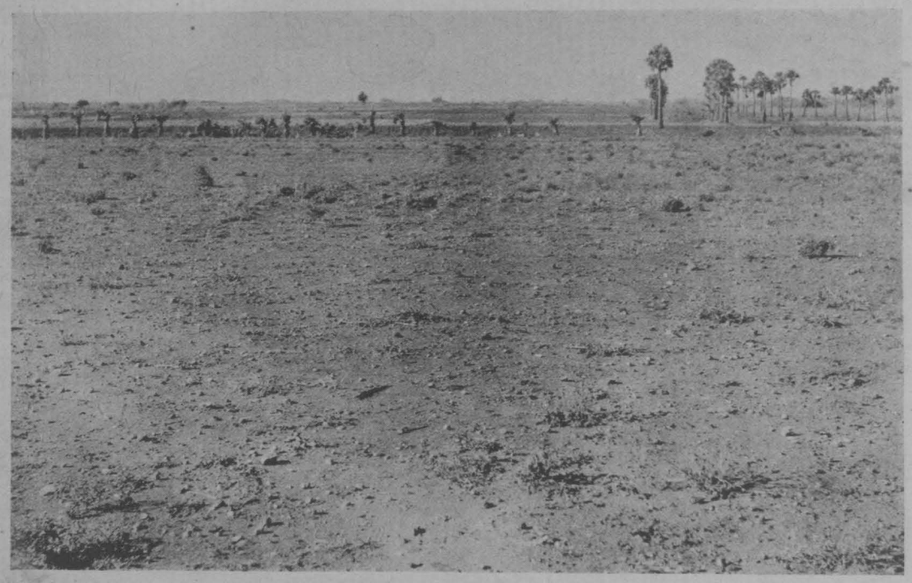

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REPORT ON THE LOWER BHAVANI PROJECT

(1946 SCHEME)

SECTION I.

PREVIOUS HISTORY.

The idea of utilizing the surplus waters of the Bhavani for extension of irrigation is as old as the days of Sir Arthur Cotton. Writing in 1834, Sir Arthur (then Captain) Cotton refers to the construction of reservoirs in the Nilgiris. Again in 1856, Government in discussing the question of the construction of an anicut at Nerinjipet, with channels taking off from it, came to the conclusion that extension of irrigation could not be permitted without storage. In the same year Mr. Fraser who was appointed to carry out an examination of the Cauvery and Bhavani basins sent in his preliminary report about the construction of storage reservoirs in the Nilgiris. In G.O. No. 1932, dated 21st October 1856, Colonel Faber in recommending the sanction of Mr. Fraser's investigations referred to the necessity for irrigation in Coimbatore. Owing to the Sepoy Mutiny in 1857 and the subsequent reduction of grants, Mr. Fraser's investigations were left in an incomplete state. In G.O. No. 597, dated 20th February 1866, Mr. Fraser was directed to report the stage at which he left his investigations in 1857 and in G.O. No. 2043, dated 28th June 1866, Government agreed to the desirability of completing Mr. Fraser's investigations. In 1869, Capt. C. J. Smith, R.E., was appointed to continue and complete Mr. Fraser's investigations for storage reservoirs on the Bhavani. Owing to illness, however, Captain Smith was unable to finish his work; but as a result of inspections and investigations made by him he recommended the construction of a reservoir at what is called the A.B. site about 4 miles above Satyamangalam (vide index map). In 1880 the matter was again taken up and Major P. Montgomerie sent up a preliminary report for the construction of a reservoir on the Lower Bhavani river advocating strongly the claims of Coimbatore to participate in the work of irrigation and to its special claim to the surplus water of the Bhavani. In 1833 Captain Romilly, R.E., was deputed to complete the investigation recommended by Major Montgomerie. Captain Romilly sent up alternative estimates for constructing reservoirs at sites A.B. and C.D., the reservoir at the former site holding 16,000 m.c.ft. and costing 44·5 lakhs of rupees including channels, the corresponding figures for the latter being 8,000 m.c.ft. and 33·5 lakhs of rupees respectively. The matter was subsequently taken up by Messrs. Larmine and Malet, the former recommending the C.D. site and the latter the G.H. site. The question of storage for Tanjore was in the meantime occupying the attention of Government and in 1897 Mr. Hughes, the then Chief Engineer for Irrigation, sent in his report in which he advocated the construction of a reservoir at the G.H. site for improving the old and providing for new irrigation in Tanjore and recommending definitely that the idea of extending irrigation in Coimbatore from the Bhavani should be given up. Mr. Larmine and Colonel Smart raised strong objections to this proposal and in 1901 the papers were laid before the Inspector-General of Irrigation who decided that the reservoir for Tanjore should be on the main Cauvery. On this, Government in G.O. No. 352 I., dated 19th March 1902, sanctioned the further investigation of the Cauvery and the Bhavani schemes. In passing these orders the officer in charge was instructed to report on the question of protecting the existing irrigation in the Tanjore delta and extending irrigation there as well as to suggest the best means of utilizing the Bhavani surplus for extending irrigation in the Coimbatore district. Mr. Moss reported that while the discharge of the Upper Bhavani amounted to 36,000 m.c.ft. per year, the quantity that could safely be utilized could not be more than 5,000 millions. Owing to this adverse report the further investigation of the project was abandoned. In 1905 the papers were transferred to the Salem–Coimbatore Investigation Party. The question of the available Bhavani surplus with reference to the requirements of existing irrigation under the Cauvery and of the new irrigation proposed under the Nerinjipet scheme, were then carefully gone into and the results, which proved the existence of a much larger volume of surplus than was reported by Mr. Moss and which appeared to justify the construction of a large storage scheme, were reported to the Government. In G.O. No. 1234 I., dated 14th December 1905, detailed investigation was sanctioned.

2. An investigation party with Mr. R. N. Arogyaswami Mudaliyar, as Executive Engineer in charge, was accordingly formed and the reports and estimates prepared by him were for two alternative projects, viz., one for a storage reservoir on the Upper Bhavani for a dry scheme and the other for a storage reservoir on the Lower Bhavani for a wet scheme. In 1906, Mr. (now Sir Charles) Innes, was appointed as the Special Revenue Officer, to investigate the revenue aspects of the proposals, and his report, together with the Proceedings of the Board of Revenue, No. 140, dated 6th May 1907, will be found printed in G.O. No. 1341 I., dated 25th September 1926. These proposals were subsequently discussed in 1908 by the Chief Engineer for Irrigation and the Inspector-General of Irrigation and it was then decided to proceed with the investigation of the Lower Bhavani project with an extended area of wet irrigation in preference to the dry project on the Upper Bhavani. Subsequently the project was ordered to lie over until the result of the Cauvery project which was also then under consideration was known since the question whether a reservoir on the Bhavani can be constructed without prejudice to the Cauvery project, required further examination.

3. The accurate gaugings which have been taken over a long term of years in connexion with the Cauvery–Mysore case proved that there is ample supply for a storage reservoir on the Bhavani in addition to the one at Mettur on the Cauvery. The original proposals for the Upper Bhavani dry project and the Lower Bhavani wet project were therefore re-examined in 1925, and revised estimate were submitted to Government. In G.O. No. 1341 I., dated 25th September 1926, the Government appointed a Special Officer to investigate in detail the revenue and cognate aspects of the proposed Upper Bhavani dry project, to decide as to which of the two projects was to be taken up. As a result of the report of the Special Officer, the Government in G.O. No. 47 I., dated 7th January 1928, ordered that the Upper Bhavani Project should be dropped in favour of the Lower. Later on, in G.O. No. 3080 I., dated 7th December 1928, the Lower Bhavani Project was also ordered to be postponed pending the result of the experiments to be made regarding the absorption, seepage, etc., in the channels in Coimbatore district. Later on, in Official Memorandum No. 6799-D/30-1, dated 4th June 1930, the Government however proposed to proceed with the investigation of the Lower Bhavani Project and called for a report from the Chief Engineer for Irrigation, whether the project should be for a wet or dry scheme and on the other points pertaining to the same. The Chief Engineer, the Director of Agriculture and the Collector of Coimbatore considered that the scheme should be for the irrigation of dry crops only, and this was also agreed to, by the Irrigation Development Board. In Official Memorandum No. 6799-D/30-6, P.W. and L., dated 29th April 1932, printed in G.O. No. 1157 I., dated 30th May 1932, the Government accepted the above proposal and ordered that plans and estimates relating to the project be revised suitably as a scheme for the irrigation of dry crops.

4. Accordingly an estimate amounting to Rs. 223 lakhs (including direct and indirect charges) and providing for the construction of a reservoir having an effective capacity of 17,740 m.c.ft. across the Bhavani (just below its junction with the Moyyar and 10 miles above Satyamangalam) together with a line of main canal and distributaries, for the irrigation of 207,000 acres of dry crops in the taluks of Gobichettipalayam, Bhavani and Erode was prepared in 1932 and submitted to Government. After the scheme was fully considered by the Board of Revenue and the Irrigation Development Board the Government in G.O. No. 959 I., dated 1st May 1933, sanctioned the complete investigation of the scheme on the lines recommended by the Irrigation Development Board, and also wanted the Chief Engineer for Irrigation to obtain the views of Mr. Hart, the then Engineer-in-Chief, Mettur Project, on certain technical portions of the estimate. The further investigation ordered was in progress for 3 years with a special staff in the concerned departments. All the points raised by the Government were examined and the estimates suitably revised. The general scope of the scheme as proposed in 1932 was not materially altered by the revision. It contemplated a reservoir of 17,740 m.c.ft. for serving an area of 207,000 acres in 2 zones, the first crop zone comprising 1·17 lakhs of acres to be supplied with water from June to September for cultivating millets and the second crop zone comprising 90,000 acres to be supplied with water from October to February for cultivating cotton. As some objection in respect of zones and crops to be grown were raised, the Chief Engineer in his letter No. 987/37–B–5, dated 20th September 1937, suggested an alteration in the scope of the scheme, viz., to irrigate the entire area of 207,000 acres in the second crop season from October to February and to abandon altogether both the division into zones and supply of water during the first crop season. The main advantage of this was that it would allow the ryots over the entire area to grow cotton if they wished to do so and enable them to pay the requisite water-rate. By this change in the

scope, the main alterations required from engineering point of view were increase in capacity of Reservoir from 17,740 m.c.ft. to 20,720 m.c.ft. and in the capacity of canal in the reach from head to M. 57/0 from 1,310 cusecs to 2,500 cusecs. The cost of the scheme as per these modifications was roughly worked out as Rs. 267 lakhs. This was accepted by Government in G.O. No. 2202 I., dated 13th October 1936. Subsequently based on the experience of flow irrigation experiments at Kugalur, the Agricultural department suggested that the season for supply of water to all-cotton scheme must be November to March instead of October to February. Working tables revealed that this would require an enlarged reservoir with a capacity of 27,460 m.c.ft. with F.R.L. 915. The rough cost of this was worked out as 280 ;93 lakhs for works or 312 ;00 lakhs, including all charges. The Director of Agriculture in examining the agriculture aspects of the scheme (vide his letter No. D. 3269/44, dated 2nd June 1945) suggested that to have good variety of cotton, the period of supply should be from early in September to middle of March but cutting of supply in the north-east monsoon for 1½ months from middle of October to end of November was also mentioned by him. It is expected that these may not need increase in capacity.

SECTION II.

SOIL SURVEY OF THE LOWER BHAVANI PROJECT AREA.

5. *Physical geography and geology of the tract.*—The area to be brought under the project canal is a strip of country lying along and to the south of the river Bhavani from the site of the proposed dam near Kothamangalam up to Bhavani town, where the river joins the Cauvery and along and to the west of the Cauvery from Bhavani town down to Kodumudi. The width of this strip is about 5 miles at Satyamangalam increasing to about 10 near Bhavani and Erode. The course of the proposed channel lies along the southern and western boundary of this area down to Perundurai near which place the channel bifurcates, one branch making down to Arachalur and the other to Unjalur towards the south-east. The general slope of the country is towards the rivers Bhavani and Cauvery, but the land is very undulating with numerous elevations and depressions and cut up at intervals by water courses. The soil, with very few exceptions, is lateretic throughout, red in colour, sometimes loamy but more often sandy or gravelly and largely admixed with fragments of quartz which may often be seen thickly covering large areas, presenting a characteristic feature. These are often gathered up into heaps or laid along the bunds of cultivation areas serving to demarcate the blocks. Where they are left on the field they would appear to serve a useful purpose in reducing erosion to which the soil is very susceptible owing to the undulating nature of the country. The soil is generally shallow varying in depth from 9 to 27 inches, 17 inches being the average of the rainfed areas. In gardens under well irrigation which are often situated in hollows, the soil is deeper and finer in texture. In no case, however, was it found to extend to below four feet. The parent rock which is usually struck before this depth is reached is gneiss, sometimes massive and granitic in character, especially at lower depths and at other times stratified in layers which may be horizontal or inclined or compressed in folds. Between the strata of gneiss, sometimes, occur one or more of quartz. Imbeded in these strata of gneiss and quartz are often seen large blocks of crystalline felspar.

Area commanded by the project and the proposed ayacut.—As a preliminary to the localization of the area that can be brought under irrigation a special Public Works Department staff consisting of an Executive Engineer with two Assistant Engineers and necessary supervisors was employed for taking levels at close intervals (in view of the steep slope of the country) for preparing the necessary block maps and ayacut registers and determining the lines of distributaries and field channels, the positions of the various sluices, etc. After the block maps and preliminary ayacut registers were prepared, a Special Deputy Collector with necessary Revenue staff was appointed for the purpose of visiting in company with the Public Works Department staff all the villages in the project area to explain to the concerned ryots the details of the proposed scheme of irrigation and its benefits and then to obtain their consent for the inclusion of their lands in the project area. The total area thus localized worked out to only 198,400 acres in the length of 73 miles 2 furlongs and 610 feet of the main canal as designed in 1932. In order to make up the deficit of about 9,000 acres it was proposed to extend the main canal on a contour by another 14 miles right up to the Novil. The extent of land available in the project area exclusive of existing wet irrigation is 292,555 acres, of which 207,475 acres are now proposed

for inclusion in the ayacut. The statement given below gives the details of the total extent, the exclusions and the net area proposed for irrigation, under the project :—

Taluk.	Exclusion.				Net area.			
	Total extent in the Project area exclusive of existing wet irrigation.	Assessed and unassessed and poramboke, unfit for cultivation.	Reserved for communal purposes.	Unwillingness of ryots.	Isolated land and land that will be occupied by distributaries and channels and lands outside the main canal.	Uncommanded.	Total exclusions.	Single crop.
	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
Gobichettipalaiyam ..	67,949	7,224	1,211	6,326	3,772	2,456	20,989	46,960
Bhavani	24,004	3,090	317	..	614	1,441	5,462	18,542
Erode	200,602	34,679	2,236	8,844	4,643	8,227	58,629	141,973
Total ..	292,555						85,080	207,475 or 207,500

Note.—The area of 207,500 acres represents about 70 per cent of the total area coming under the scope of the project.

The reasons for the individual exclusions under the several headings in the above statement will be found in the detail villagewar ayacut registers prepared after localization.

6. *Soils.*—Except for a few pockets and a narrow fringe near the river, the soil of which differs from the remainder only in that it is deeper, slightly heavier and freer from stones, the soil of this project area is suitably described as a shallow light gravelly loam. Laboratory analysis of certain samples of soils in the project area were also conducted by the Agricultural Chemist, who concluded that no elaborate soil survey of the project area was necessary. The Director of Agriculture in his report to the Irrigation Development Board endorsed this view and the latter body at its meeting held on 6th December 1934 accepted the above view. However, an Assistant Director of Agriculture was deputed to work along with the Special (Localization) Revenue Officer in order to examine and certify the suitability of the ayacut for the irrigation of dry crops. This officer also accordingly inspected the villages along with the revenue staff and has added necessary certificates in the village registers. The depth of soil where rock does not protrude above the surface varies from a few inches to about 5 feet but is commonly about 2 feet. Throughout the area, the soil is underlain by rock which dips at an angle and is usually decayed for a depth of 10 feet or so. In consequence drainage will be excellent and will render the soil most suitable for growing irrigated dry crops without producing waterlogging.

7. *Rainfall.*—There are three rainfall-recording stations in the area commanded by the project, viz. (1) Satyamangalam, (2) Gobichettipalaiyam and (3) Erode. The average annual rainfall at these stations is given below :—

Stations.	South-west monsoon June-September.	North-east monsoon October November.	Other months.	Total.
	IN.	IN.	IN.	IN.
Satyamangalam	8·63	12·65	6·94	28·22
Gobichettipalaiyam	10·37	12·15	7·34	29·86
Erode	10·96	11·52	6·57	29·05

8. *Existing crop and crop seasons in the district.*—The crop seasons in Coimbatore are roughly three, the first or Kar season extending from March to June, the second or the south-west monsoon season extending from June-July to September and the third or the north-east monsoon season extending from October-November to February. The sowing time for the first crop is March and April, and the reaping time June and July; for the second crop the sowing months are June and July, while the harvest time extends from September to October. The sowing season for the last dry crop extends from September to November while the harvest goes on from December to February. For paddy cultivation (wet) the sowing time is July and August, while the harvest is in December and January.

IRRIGATED DRY CROPS UNDER WELLS IN THE PROJECT AREA

RICE CULTIVATION UNDER BHAVANI CHANNELS (ARAKANKOTTAH CHANNEL SLUICE NO. 3)

SECTION III.

AVAILABILITY OF SUPPLY.

9. *Quantity available for storage.*—There are three channels now taking off from the Bhavani river below the site of the proposed reservoir, supply to which will be intercepted by its construction. These are the Tadapalli and the Arakkankottai channels taking off from above the Kodiveri anicut and the Kalingarayan channel taking off from above an anicut (of the same name) lower down. The supply of water required for these channels will be let down through vents in the body of the proposed dam and will be picked up at the respective anicuts and utilized for irrigation as hitherto. Figures of daily surplus of the Bhavani over the Kodiveri anicut, 16 miles below the site of the reservoir, are available for a sufficiently long number of years. The daily surplus less the requirements of the Kalingarayan channel (referred to above) is taken as the quantity available for impounding in the reservoir.

As detailed in paragraph 12 below, for purposes of the working tables only the actual discharge at Kodiveri anicut that obtained in the past years have been taken into account. However, when the reservoir comes into operation, the supply let down for the existing Bhavani channels will be based on the average drawn by them during each half month during a period of, say, 10 years. There may, however, be some apprehension on the part of the Trichinopoly ryots that their summer supply would be reduced by impounding in the Bhavani Reservoir. From the actual flow in the Bhavani channels for a period of 5 years (1927–32) it is seen that the quantities drawn are on an average 1,000 cusecs in the first half of February, 500 cusecs in the second half and 300 cusecs in March, April and May. It may therefore be taken that during the first half of February all flows in the river up to 1,000 cusecs will be passed down for existing irrigation and only any excess over 1,000 cusecs will be impounded in the reservoir. Similarly, during other periods, only excess over the limits fixed above will be impounded. The normal flow in the Bhavani up to these limits, which will be allowed to flow down, along with the 1,000 cusecs let down from the Stanley Reservoir should satisfy the requirements of the summer crops under the Cauvery channels.

10. *Duty.*—In the 1936 proposals, the area proposed to be irrigated was divided into two zones to be cultivated alternatively with cereals and cotton in two different seasons. After a great deal of discussion and examination it has since been decided to have only one season of cultivation for the whole area between September and March. Half the total area will be cultivated with cotton and the other half with dry irrigated crops in any one year. This is exclusive of 10,000 acres of very low lying lands which would not be suitable for dry crops and on which paddy will be grown every year. Supply to the irrigated cotton and dry crops will be issued from the reservoir except for one and a half months in the north-east monsoon period. It has been found by actual experiments conducted at Kugalur that the cotton crop requires about 28·8 inches of water inclusive of rainfall in the season October to February. The Director of Agriculture has since stated that cotton crops may be given water from September to middle of March supply being cut off during north-east monsoon rains in October and November. Making allowance for these alterations the depth of water for irrigated cotton is taken as 30 inches. The requirements of dry crops will be about 20 inches. But as this dry crop will be intermixed with cotton and an extent of 10,000 acres is also proposed to be cultivated with paddy no reduction is made in the quantity required for dry crops. This assumption being on the safe side will leave a very desirable margin for a greater variety of dry crops and also for other uncertain and unknown factors.

11. *Evaporation and transmission losses.*—Over and above the supply mentioned above, additional provision has been allowed for evaporation and transmission losses in the main and branch canals and distributaries on the following basis. The soil through which the canal runs is mostly red loam, gravel or mooram and 8 cusecs per million square feet of wetted border as suggested in standard publications have been allowed for the losses therein. Actual experiments were also conducted in selected reaches of the Tadappalli and the Arakkankottai channels in February and March 1934 and it was found that the average loss in transmission was only 5·5 cusecs per million square feet of wetted border (against 8 cusecs provided for). The results were discussed fully by the Irrigation Development Board in one of its meetings and the provision made in the project estimates was accepted as adequate. Observations were also taken of the transmission losses in distributaries and field channels at the two experimental stations. As a result an allowance of 5 per cent of the supply on fields has been made for losses in distsibutaries and field bothies. Transmission losses on all channels irrigating more than 5,000 acres are worked out on the basis

of 8 cusecs. The total loss on the above basis in branch channels inclusive of distributaries taking off from them and in the field bothies, works out to 10 per cent of the field supplies while that in distributaries and field channels works out to 5 per cent on the field supplies. The total transmission losses on the above basis work out under full supply conditions to 33⅓ and 30 per cent of the field supplies.

12. *Working tables.*—It is proposed to work both the Mettur and Bhavani reservoirs jointly. The working tables have been prepared accordingly on the following basis :—

I. *Stanley or Mettur Reservoir.*—The basis is the same as that adopted in 1936 report and working tables with slight modifications.

(1) *Inflow.*—The impoundable flows are based on the flows at Cauvery dam limited to limit flows minus the surplus over the Kodiveri anicut.

(2) *Crop period.*—The irrigation season is from 1st June to 31st January. If a storage of 40,000 m.c.ft. is not available the commencement of the season will be postponed but to a date not later than 1st July.

(3) *Issues for irrigation.*—This is based on the scales of supply proposed in 1942, but with season commencing on 1st June. For the period after 15th October, the scales of supply as per Cauvery Reservoir Project report are adopted as the rules for regulation do not specify the quantities for the period and the issues are left to the discretion of the Superintending Engineer.

(4) *Reduction of supply during scarcity periods.*—These are the same as in 1936 tables.

(i) Rules printed in Volume IV of Cauvery Reservoir Project report have been followed for the period from 31st July to 15th of October. For the period 16th to 31st July also a 10 per cent cut has been proposed if the storage falls below 60 t.m.c.ft.

(ii) Cuts of 10 per cent in the supply to old area and 40 per cent in the supply to the new area will be adopted for a fortnight only so long as storage in the Bhavani reservoir is available. Beyond this period 10 per cent cut for the whole area will be enforced and the deficits in the Cauvery flows to make up the quantity required with a cut of 10 per cent will be drawn from the Bhavani reservoir.

(5) *Power issues.*—A minimum storage of 9,000 m.c.ft. has been proposed to be maintained at all times in the Stanley reservoir to assure a working head of power development though special issues are not allowed for power during irrigation season. During the summer, i.e., February to May, the natural flows are issued for power subject to a limit of 1,000 cusecs.

II. *Bhavani Reservoir.*—The area proposed is 207,000 acres.

(1) Impounding is based on the tabulated surplus over the Kodiveri anicut less the actual draw off through the Kalingarayan channel from day to day.

(2) *Crop period.*—The area proposed is 207,000 acres comprising 10,000 acres paddy and the remaining area divided equally between cotton and other dry irrigated crops. However for purposes of working tables the whole area is taken as equivalent to cotton, as explained in paragraph 10 above.

(3) *Issues for irrigation.*—The supply is based on 6 inches per month including rainfall, i.e., a quantity of 195 m.c.ft. per day including rainfall and loss in transmission. The supply is suitably reduced whenever there is rainfall in the irrigated area.

Issues for Cauvery irrigation will be from stored supply including natural flow to the extent already indicated.

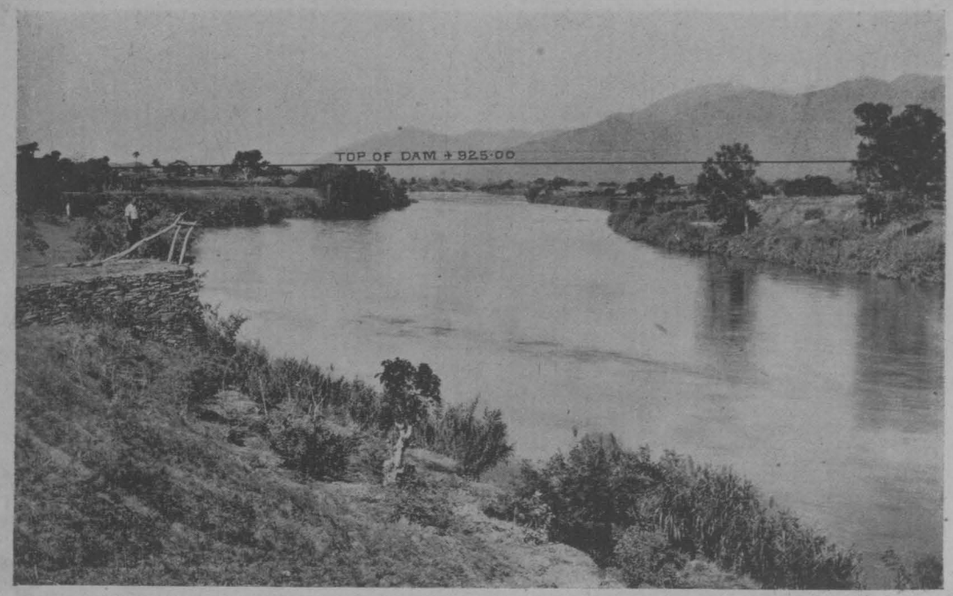
From the working table so prepared for the 27 years 1916 to 1942 it is seen that full area under Bhavani project is irrigable in 16 years.

SECTION IV.

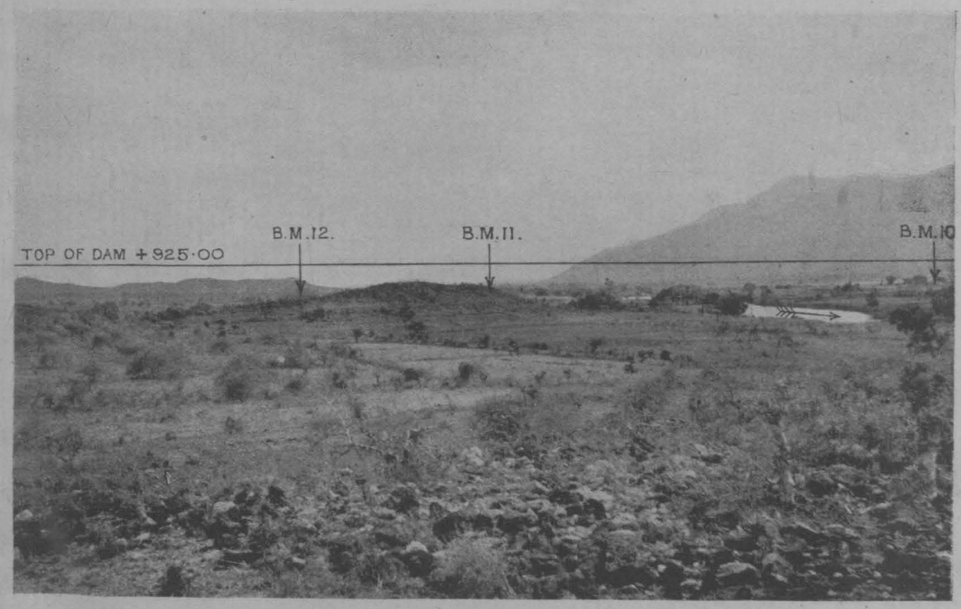
LOCATION AND DESIGN OF WORKS.

A. Headworks.

13. *Location.*—Three sites referred to below as sites A.B., G.H., and C.D., 4, 6 and 10 miles respectively above Satyamangalam were recommended by different officers at different times. A Committee consisting of three engineers and Mr. Holland of the Geological Survey Department was formed in 1899 for examination of the sites. In his report Mr. Holland has dealt with all the three sites. He has condemned the site A.B.



VIEW OF THE BHAVANI RIVER AT THE SITE OF THE PROPOSED DAM (FROM A POINT 300′ DOWN STREAM OF THE DAM)



VIEW OF DAM SITE FROM B.M. 12 TOWARDS THE BHAVANI RIVER

d considered both C.D. and G.H. as suitable, for construction of dams but preferred e site G.H. The C.D. site has now been selected for the following reasons :—

(1) The river bed at this site is 30 feet higher than the one at G.H. and therefore sures the maximum extent of irrigation in Coimbatore district.

(2) It is much less expensive than G.H. on account of the line of low hills which esent facilities for economical construction and easy disposal of surplus.

(3) At this site there are large quantities of earth available for an earthen bund.

(4) The following opinion of Mr. Holland, the Director of Geological Survey, quoted from his report in G.O. No. 811, dated 24th January 1900, shows that the site C.D. is geologically suitable: "From the geological standpoint therefore I will give a vote in favour of G.H. but it is only fair to state that had C.D. been the only site available, I should not consider the change from biotite gneiss to amphibolite sufficiently important to justify a protest against its selection. At the same time, when another good site is available without any apparent drawbacks, I should, as a matter of principle, decide in favour of the latter."

Mr. Fox, Superintendent of Geological Survey of India, also inspected the site in November 1933 and he was of opinion that though the site appeared suitable it was necessary to have some systematic borings taken along the alignment to ascertain the nature and depth of solid rock in the deep portion of the river (between B.M. Nos. 9 and 11). An estimate for Rs. 35,000 was sanctioned for the purpose and calyx drill borings were first put down along the line B.M. No. 9 to B.M. No. 11. These showed that although the results obtained at both the flanks were not bad, those in the river crossing at the proposed site were unsatisfactory inasmuch as the level at which hard rock was met with was very low, and the Chief Engineer for Irrigation after inspecting these ordered the putting down of a second line of boring 200 feet downstream of the original line at the river crossing. These showed hard rock at much higher levels and it has therefore been decided to shift the centre line of the dam from B.M. No. 9 to a point 200 feet below the original line at the river crossing and thence to B.M. No. 11. The results of these borings are exhibited on plans L.B.P. Nos. 7 and 7-A/1934. Mr. Crookshank, Superintendent, Geological Survey, who came down to Mettur in May 1936 in connexion with the survey of the Salem Ore 'Iron' Deposits, also inspected the dam site and examined the ores taken out and has pronounced the site as quite suitable preferring the lower alignment (200 feet below in the deep portion of the river) for the dam. He also considered that the dam can be founded on a much higher level than allowed for in the present estimate. This however can best be decided during execution when the foundation trenches along the alignment are actually opened out. If this is found feasible there will be appreciable savings in the estimate.

14. *Drainage area and capacity.*—The total drainage area of the river at the site is 1,621·5 square miles. The F.R.L. has been fixed at 915·00 with an effective capacity of about 27,460 m.c.ft. The statement below gives the capacity and waterspread of the reservoir at the various levels :—

Statement showing the capacity of the Lower Bhavani Reservoir.

Contour level.	Submerged area in acres.	Area submerged in square feet.	Mean area in square feet.	Depth in feet.	Capacity between contours.	Total capacity in cubic feet of reservoir at each level above 820·00.	Total capacity in cubic feet of reservoir at each level above 840·00.	Remarks.
820·00	34·2	1,489,752	..	..	..	..	..	
830·00	434·1	18,909,396	10,199,574	10	101,995,740	101,995,740	..	
840·00	1,608·3	70,057,548	44,483,472	10	444,834,720	546,830,460	..	Sill level of head sluice 840·00 M.S.L.
850·00	2,978·1	129,726,036	99,891,792	10	998,917,920	1,545,748,380	998,917,920	
860·00	4,462·6	194,390,856	162,058,446	10	1,620,584,460	3,166,332,840	2,619,502,380	
870·00	6,586·6	286,912,296	240,651,576	10	2,406,515,760	5,572,848,600	5,026,018,140	
880·00	8,594·8	374,359,488	330,655,892	10	3,306,558,920	8,879,357,520	8,333,527,060	
889·00	10,776·0	469,402,560	421,896,024	10	4,218,960,240	13,098,317,760	12,551,487,300	
900·00	13,031·7	567,660,852	518,531,706	10	5,185,317,060	18,283,634,820	17,736,804,360	
905·00	14,391·7	626,902,452	597,281,652	5	2,986,408,260	21,270,043,080	20,723,212,620	
910·00	15,426·7	671,987,052	649,444,752	5	3,247,223,760	24,517,266,840	23,970,436,380	
915·00	16,605·3	723,326,868	697,656,960	5	3,488,284,800	28,005,551,640	27,458,721,180	F.R.L. + 915·00. M.W.L. + 920·66.

15. *Waterspread.*—The waterspread consists of a large extent of forest lands. Six villages will also be submerged with an extent of more than 4,000 acres of cultivated lands. The old temples and Fort of Dananayakan Kottai will also be submerged. (For further details—vide Appendix II of Mr. Innes's report in G.O. No. 1341 I., dated 25th September 1926.)

16. *Design.*—The design originally adopted for an F.R.L. of 900 was a composite dam consisting of a masonry section at the river crossing for a length of 8,368 feet and earthen sections at the two flanks 4,200 feet on left and 5,630 feet on the right. Near the left end a surplus weir 3,540 feet long was located. The dam proposed was of gravity type to be built of small rubble masonry in cement mortar in river sections and in surki mortar in shallower portions.

The section of the dam (plan L.B.P. 7/1935) was designed to admit of a further raising of the F.R.L. by 10 feet, i.e., 910, by simply adding a block of masonry over the top. It provided a F.B. of 4 feet over the M.W.L. a foot more than that adopted in 1932 to make allowance for strong winds during south-west monsoon period. This design provided for an impervious face varying in thickness with the depth below F.R.L. to ensure water tightness. Expansion joints and the usual precautions to prevent cracks developing due to the heat developed by the initial set of cement were proposed. No allowance was made for uplift on the assumption that the grouting the foundation rock through calyx holes would form an impervious curtain and efficiently cut off all seepage and prevent uplift. A drainage gallery was also proposed in the deep river section to be connected to the foundations by a series of staggered drainage shafts to lead any water under pressure in the foundations away to the gallery where it would escape through the outlets to the downstream face of the dam. The provision of cement masonry had been based on a main mortar mix of 1 : 4 the impervious face mortar being 1 : $2\frac{3}{4}$. The mix of 1 : 4 was proposed to be used in the lower portions of the dam and in the higher portions where the water pressure would be less a mix of 1 : 5 was proposed, the front face being continued with a mix of 1 : $2\frac{3}{4}$ throughout. The top 3 feet of the masonry was proposed to be built with the richer mix of cement mortar 1 : $2\frac{3}{4}$ in order to resist deterioration by weathering and to withstand greater wear and tear due to traffic.

The F.R.L. has now been raised to 915 increasing the capacity from 17,000 m.c.ft. to 27,460 m.c.ft. The Hydraulic particulars for this reservoir will be as follows :—

F.R.L.	+915
M.W.L.	+920
Top of dam	+925 tentative.
Top of parapet	+928·5 tentative.
Mean level of river bed	+797·0
Waterspread	25·94 sq. miles.
Sill level of high level sluices	+840·0

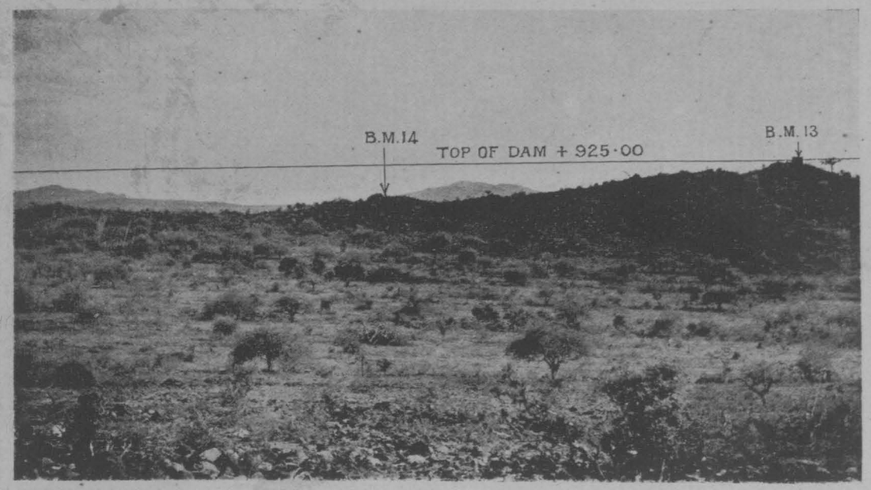
The question of revising this design to a spillway dam to follow the more modern designs is under consideration. Model experiments on the suitability and other details are being conducted at the Poondi Hydraulic Research Station. Based on the results of these experiments, the dam design will be finalized. Maximum height of dam will be 166 feet above the bottom of foundations. The top width of the dam will be 20 feet, allowing for a clear roadway of 16 feet with two parapets 2 feet thick and $3\frac{1}{2}$ feet high. The other details of construction will be generally similar to those originally proposed.

17. *Earthen bund.*—This is, as proposed in 1936 report, at the two flanks. The bund will be constructed of good soil for hearting with a casing of gravel and soft rock. Particulars of bund sections will be as noted below :—

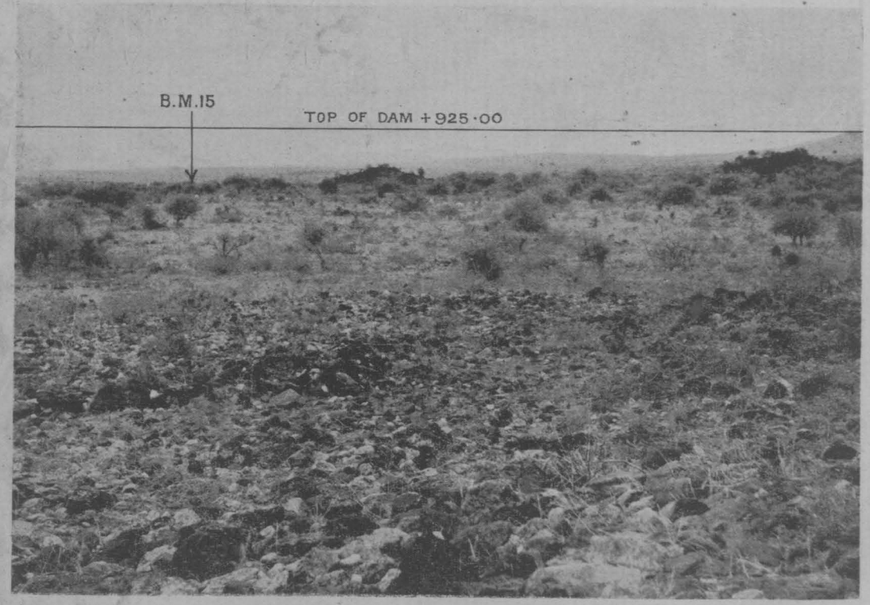
F.R.L.	+915
M.W.L.	+920
T.B.L.	+927 tentative.
Top width of bund	20 feet (exclusive of parapet) tentative.
Casing front slope	2 : 1 tentative.
Rear slope	$1\frac{1}{2}$: 1 at top to get greater top width and below 2 : 1 modified to suit a hydraulic gradient of 1 : 4 tentative.
Top level of hearting	+920 or 921.
Front slope of hearting	$1\frac{1}{2}$ to 1
Rear slope of hearting	1 : 1

A puddle trench will be provided at the centre of the bund with a bottom width of 10 feet and side slopes to suit the soil, the depth of trench at any section being $\frac{1}{2}$ a foot for every foot depth of water in the reservoir at the section. The bund will be revetted right up to the top with a parapet wherever the depth of water exceeds 15 feet and to 3 feet above M.W.L. at other places. During the last investigation, the soils in five or six villages in the vicinity were gone over for selecting soil suitable for hearting. That in two villages alone, viz., Denacundapalayam and Dottampalayam about 6 furlongs at left flank and at two miles at the right respectively of the dam site was found to be satisfactory and available in sufficient quantity. The suitability of the soil was tested by experimental tanks formed of the selected soils.

The length of the bund will now be greater than in the original design due to increased F.R.L. of the reservoir. The masonry sections may have to be similarly longer so as to limit the height of the earthen flank bunds to the same depth as in the original estimates. These points will be looked into during the investigation now in progress.



VIEW OF DAM SITE FRM OB.M. 14 TOWARDS B.M. 13



VIEW OF DAM SITE FROM B.M. 15 TOWARDS B.M. 14

18. *Connexion between earth and masonry dams.*—The earthen dam at the left flank abuts hills at both ends while that on the right flank abuts the hill at its right end and joins the masonry. At this junction the masonry dam will be taken sufficiently into the earthen bund to have a proper connexion and the earthwork at the junction will be protected by suitable revetment.

To facilitate construction and location of points on the dam, a method of defining any point by co-ordinates with suitable lettering is proposed to be developed. This is illustrated in the sketch, Plate No. VII.

19. *Sluices—Facilities for irrigation and surplussing.*—Two sets of irrigation sluices, one high level (sill at 840·00) and the other low level (sill about 800·00 are required. The high-level sluices which will serve the new area to be irrigated in Coimbatore district are designed to discharge 2,500 cusecs at lake level (850·00) to allow also for probable future extension. The low-level sluices which will serve the existing wet irrigation in Coimbatore district, lower down the river will also be utilized to supplement the supply from Mettur reservoir for Tanjore irrigation. It may be desirable to have the sill of the sluice at 810·00 or even higher instead of at 800·00 but this will be examined during execution. Three vents have been provided capable of discharging 13,200 cusecs. Gates of the same size 7 feet by 13 feet (approximately) are proposed for both high and low level sluices, the idea being that one emergency gate will suffice for the two sets. The high-level gates must be designed to operate against a head of 75 feet and the low-level gates may have to operate against a head of 115 feet for the F.R.L. of 915·00.

In considering the stability and limiting pressures on the piers of the culvert, all masonry up stream of the groves on which the sluice roller paths are bedded, is neglected. This method is recognized as being conservative. The spacing of the gates will be fixed to suit the manufacturer's requirements but this detail must be left for final decision until work is actually in progress. For estimating purposes 25 feet piers have been allowed.

20. *Location of the irrigation sluices.*—The high level sluices will be fixed about L.S. 24,717. They will discharge into the main canal; provision has been made in the estimate for a stilling chamber to break the force of the water issuing from the lake under high heads.

The low-level sluices will be located in the river section but their exact position must be left for decision until the soundest rock has been proved by further exploration, during execution.

An extra sluice gate has been provided to guard against the contingency of one gate being out of action at any time.

21. *Surplussing arrangements.*—The highest maximum flood at the Kodiveri anicut occurred in October 1939 and has been computed to be nearly 1,22,000 cusecs. A weir 3,540 feet long was proposed to discharge the above floods with a depth of 5 feet. Details of this weir are given in the next paragraph. In view of the fact that the moderating effect on the floods due to the reservoir has not been taken into account and that the Kodiveri anicut receives in addition the drainage from an area of about 300 square miles below the site of dam, the provision made for the surplus is considered sufficient.

22. *Method of surplussing and location of surplus.*—The surplus weir will be located at the left flank. Along with the borings taken in the deep portion of the river, a few borings were also put down in the above length of the surplus weir portion. These reveal the existence of hard rock at a reasonable depth—vide plan No. L.B.P. 7-B/1934. The weir section was designed to take the overflow and to admit of installing 10 feet shutters if and when the F.R.L. is increased later on. The surplus weir will be of random rubble in surki or cement mortar. Suitable provision has been made for plastering the top and rear faces, for forming an Ogee curve for easy flow of water and for the necessary aprons and retaining walls in rear. Provision for wings and returns at its junction with the earthen bund has also been made. The overflow has an easy run off to a stream some 2,500 feet downstream of the dam with a fall of about 60 feet and this stream joins the main river 6,000 feet below the dam. A few borings were also put down along the surplus course and soft rock is met with at a depth of 2 feet to 3 feet below the surface. Since the above proposals were made, the question of providing an Ogee type of overflow dam in the river portion is under examination on models and the spillway design of the dam will be on the basis of this study.

23. *General method of construction.*—It was originally proposed to utilize practically the whole of the tools and plant available at Mettur except the heavy machinery such as the concrete placing towers and stone crushers, but since the 1936 report was

prepared, the Tungabhadra project was started in 1945 and nearly all the available machinery has been transferred to that project. No old machinery is therefore available for this project. New machinery has to be obtained.

The conditions of work have also altered very considerably. Labour of all forms has become costly and difficult to obtain, while in the old conditions manual labour was yet cheap and easy and in the present day conditions work done by machinery is found to be generally cheaper and also comparatively quicker. Increased provision for Special Tools and Plant is therefore necessary and has been made reducing the unit rates for work. The amount is however tentative and liable to revision after a full study of the mechanical methods of planning and equipment. It is proposed to appoint one or more Special Executive Engineers and if necessary also a Superintending Engineer separately for machinery, with a view to finalize the requirements and selection of necessary tools and plants. A visit to the United Kingdom and the United States of America by these officers may be also necessary both for study and for obtaining the required machinery which is in short supply at present.

The idea in using machinery is not to displace labour but to supplement the available labour with a view to keep down cost and facilitate speedy execution of the work.

24. *Works preparatory to building the dam.*—It is proposed, should the project be sanctioned, to spend the greater part of the first two years of construction in preparatory works and installing machinery and plant. The preparatory works to be finished in these two years other than those forming a necessary part of the construction of the main dam are—

(1) Constructing a light railway frim the most convenient point of the main railway line to the dam site. Probable length is 20 miles.

(2) Erecting a power line to join up the dam site with the Pykara main. Probable length—18 miles.

(3) Constructing a bridge over the Bhavani immediately below the dam.

(4) Constructing roads, laying tram lines, etc., as required at the headworks.

(5) Further exploration with power drills required to establish definitely the best sites for quarries, most suitable location or locations for the surplus, etc.

(6) Construction of quarters for the staff to be engaged on the work.

(7) Erection of power house, cement sheds, etc.

(8) Installation of a piped and filtered water-supply throughout the lines and works.

(9) Installation of a drainage system.

(10) Building hospital, police station, treasury office, etc.

(11) Collection of stocks of stone, sand, etc., for starting the actual work.

(12) All other works necessary for the construction of the dam and canals, including fixing gauges at site of dam and recording flows during investigation and execution.

In addition, works in the river bed will be undertaken during the preparatory period, when the rock at the river crossing has been proved. Diversion works in the river, of a nature to suit the excavation required, can be pushed through. This will be dealt with further later on.

25. *Preliminary operations.*—The first year will be spent by a special staff appointed for the purpose in elaborating working plans, preparing fresh plans, and making all arrangements to begin work, building up camps, buildings and all other works required before commencing the dam proper.

26. *Programme of construction.*—Actual construction must be preceded by one year's preliminary work in which more detailed surveys will be done, further exploration with power drills will be done, estimates will be prepared and plans drawn. In addition, during this year the light railway will be started to connect with the main railway line and the high-tension transmission line erected. This year is not included in the period allotted to construction.

The first two years of construction will be devoted to preparatory works as described in paragraph 24. Though every effort will be made to begin masonry on the dam proper before the end of the second year, it is considered advisable to base the estimate of the time required for completion on the assumption that masonry except in the main section cannot be started earlier. This is the least optimistic view; it prolongs the period for which the works will be in progress and delays the incidence of revenue from the irrigated area and therefore represents the financial aspect of the project in the worst light possible. Hence this assumption has been followed for estimating purposes. Work in the river section must be commenced in the beginning of the second year as

is necessary to ensure completion in the five-year period, and if progress in the river-bed section can be accelerated, the time required for completing the whole dam will be reduced and the financial aspect materially improved.

The total quantity of masonry in the dam for a reservoir of 900·00 F.R.L. was estimated as 22·4 m.c.ft. or 1,400,000 tons (specific gravity of masonry 2¼ or 140 lbs.) consisting of 17·4 m.c.ft. of cement masonry and 5 m.c.ft. of surki masonry. The contents of masonry in the main river-bed section was worked out as 5·9 m.c.ft. It is in this section where work is most concentrated and the working season limited, that the greatest difficulty will occur in the supply of material and the time taken to complete this section will determine the time required to finish the dam. Speaking generally, no major trouble or difficulty is anticipated in dealing with the flanks; actual construction on either flank may commence even in the first year but there is no point in incurring expenditure and thereby increasing interest charges, on doing earlier than necessary, the work that can be postponed with safety till later. The quantities given above will be greater for the dam to suit the higher F.R.L. of 915·00.

27. *Basis of calculation of rate of progress and method of construction.*—As explained previously, the time required for completion is determined by the time taken to raise the dam in the river section. The working season in the river is limited to 168 days and to ensure this, arrangements must be made to discharge 25,000 cusecs during the working season. The site is near the hills and the river is liable to sudden and probably heavy freshes, the peak of which is flattened out considerably before being measured at Kodiveri anicut, which is 16 miles downstream. It is essential to prevent dislocation of the work during the dry season. Experience at Mettur has shown that the interruptions caused by unexpected heavy freshes are costly in time and money and that it pays to take all reasonable precautions to avoid them

No difficulty is anticipated in getting sufficient skilled and unskilled labour to ensure the output.

All machinery will be worked as far as possible electrically. The power house now at Mettur will be taken down and rebuilt at dam site if possible. If not, a new house will be erected In it will be placed the air compressors, transformers and main switchboards. From the power house, the distribution lines and the compressed air pipes will radiate. The probable maximum load will be 850 K.W. and though this will be far higher than the average, it has been assumed for estimating purposes that the maximum load will be required for four years. The cost of energy has been fixed in consultation with the Chief Engineer, Electricity.

All useful machinery, tools and plant, stores, etc., were originally intended to be taken from Mettur. As most of these have now been transferred elsewhere, new purchases have to be made. A provision of Rs. 50 lakhs is made for the purchase and erection of all tools and plant for headworks. This will include all kinds of earth moving, concreting and construction machinery and also transport machinery like tram-lines and trucks, lorries, wagons and staff cars for transport of labour and technical personnel. Provision is also made for motor trolley, motor boats and boats for crossing the river. All these will be required for execution of work and proper supervision of construction operations. A suitably equipped workshop with modern machine tools will be provided as also mobile repair units.

28. *Buildings.*—A sum of Rs. 30 lakhs has been provided in the estimate. The provisions are on the model of the arrangements adopted by the T.V.A. in America which represents the latest practice for large-scale departmental execution of work. The provisions noted below will be made and they include among others :—

(*a*) Employee housing for the various classes of employees. These include officers' quarters, subordinates' quarters of the family type and non-family or dormitory type, cafeteria, hotel and community buildings including club and entertainment facilities.

(*b*) Civic group of buildings such as school, hospital, first-aid centres, police station, fire station, post and telegraph office, market, provision, grocery and drug stores, dairy, barbers' shops and other similar classes of buildings.

(*c*) Storesheds, workshops, power house, transport vehicle and machinery stores and depots, laboratories of different kinds and similar buildings.

(*d*) Administration buildings; office blocks of different kinds, propaganda and information office and similar buildings.

(*e*) Circuit houses, inspection bungalows, rest and tourists' sheds.

(*f*) Workmen's quarters and labour colony including all amenities necessary and usually provided for labour.

Provision will be made for a good layout plan with streets, public grounds, etc. good water-supply, sewerage and electrical systems and necessary health and sanitary services will be also separately provided under civil miscellaneous. The buildings will be more or less of semi-permanent type consistent with low first cost and comparatively small cost of maintenance as these houses will have value even after the construction of the project. The area will be well served with water and electricity from Pykara and Moyar and as the climate is equable, the area is likely to develop into a town of moderate size. In view of these possible developments, it is desirable also to acquire a belt of publicly owned land round the colony to prevent haphazard development of the town.

The entire control and management of the township amenities will be in charge of the senior local Public Works Department officer in charge of the project and he will be invested with powers of the appropriate departmental officers under the District Board and Public Health Acts, for the purpose of efficient administration. This is necessary to ensure effective and unified control in all matters as in military cantonments.

Proper planning, control and provision of essential modern amenities are absolutely necessary to keep the staff and labour contented and make them co-operate fully in the speedy execution of the project. A State Bus service should be also run to provide connexion to the nearest railway station and other important centres.

29. *Sanitary and medical staff, police, etc.*—The estimate provides for the medical and health staff required for the medical and sanitary arrangements of camps and works and for the necessary police staff. There is no reason to apprehend that the site of the headworks will prove feverridden or otherwise unhealthy, but it is considered essential to take all reasonable precautions to avoid epidemics such as cholera and hence provision has been made in the estimate for installing a complete system of filtered and pipe water-supply to all lines, camps and residences as well as on the work itself. The estimate also provides for the installation of a drainage system. These arrangements will be also under the administrative control of the senior local Public Works Department officer in charge of the project.

30. *Land compensation.*—As already referred to in paragraph 15, the details of the land compensation for the waterspread area given in Appendix 11 of Mr. Innes's report in G.O. No. 1341 I., dated 25th September 1926, were suitably revised in 1932 by the Collector according to the then prevailing rates. Exclusive of forest reserves the amount came to Rs. 5·9 lakhs. An additional 7 per cent of this sum had also been provided for land acquisition staff. The Special Deputy Collector appointed for the localization enquiry—vide paragraph 5 supra—has suggested that the amount of land compensation can be reduced by giving lands in exchange in the near vicinity of individual villages. He also mentioned that an extent of about 600 acres of panchayat forest area lying in the head reaches of the main canal, which if disafforested can well be brought under irrigation can be made available for the purpose. The matter was referred by the Board to the Chief Conservator of Forests who was however of opinion that the Panchayat forest area should not be disafforested as even the areas now existing in the district are not sufficient for the grazing of cattle and other purposes for which they are intended. To cover present high rates, the provision has been increased to Rs. 18·9 lakhs.

B. Main Canal.

31. *Design.*—The main canal starts from the reservoir and is aligned throughout on a falling contour. The length of the main canal as first investigated was fixed at 73 miles, 2 furlongs, for an extent of 207,000 acres proposed for irrigation. As already referred to in paragraph 5 supra this extent could not be localized in the above length and hence during the subsequent investigation the main canal was proposed to be extended by another 14 miles, 6 furlongs, making the total length about 88 miles.

The alignment of the canal is the same as that proposed for the wet scheme in 1905 but its design has been throughout recast with reference to the proposed scheme of dry crop irrigation. In 1936, the total extent was proposed to be divided into two distinct blocks—one with an extent of about 113,800 acres to be supplied in the first crop season and the other with an extent of 93,700 acres to be supplied in the second crop season. The latter block was to be in the upper reaches down to 56 miles, 6 furlongs, of the main canal, and the former, in the lower reaches, i.e., below 56 miles, 6 furlongs. Each of the two blocks was to be further subdivided into four sub-blocks and supply arranged on a rotational basis, i.e., the first and the third sub-blocks forming the area for one rotation (of five days) and the second and the fourth for the other rotation (of five days). Suitable regulators were to be provided along the course of main canal to

at the above rotation and for maintaining the required command. Based on the periments conducted at Kugalur and Chennasamudram, the supply on fields allowed r both the first and second crop seasons was to be 2 inches depth in 10 days which rks out to a duty of 120. The canal discharges required at head inclusive of transmission sses in each crop season were worked out as under—

First crop. 113,800 acres at 120 duty plus 1/3 of the same for transmission losses $949 + \frac{949}{3} = 1{,}265$ **cusecs.**

Second crop. 93,700 acres at 120 duty plus 30 per cent of the same for transmission losses $781 + \frac{781 \times 3}{10} = 1{,}015$ **cusecs.**

The experiments carried out for two years show that taking the average of groundnut and cereal in the first crop season there is a reasonable margin of profit after deducting cultivation expenses and water rate; while taking the average of cotton and cereal in the second crop season the profit is more. Since the above proposals were made, the division of the ayacut area into two separate zones for cultivation during I and II crop seasons has been given up. The whole area is proposed to be treated as one zone the cultivation season being from September to middle of March. In any year 50 per cent of the area will be cultivated with cotton and the remaining with irrigated dry rotation crops. This will permit of designing the canals and distributaries for continuous flow. The canal and the auxiliary works in the first reach up to M. 56 F. 6 will have to be redesigned on this basis.

32. *Hydraulic details.*—Except at deep cuttings the general bed fall up to 51st mile is 0·415 foot per mile. The fall beyond varies from 0·415 foot to 0·40 foot per mile. The bed width of the canal and depth as originally designed varied from 60 feet and 8 feet at the head to 50 feet and 7·5 feet at the 74th mile where there is a big off-take for 46,738 acres. The main canal below was to have a section varying from 20 feet by 4·25 feet to 5 feet by 1·7 feet for the irrigation of 9,119 acres—vide hydraulic particulars at pages 13–16. These will now be altered to suit continuous flow and single zone.

In deep cuttings the reduction of section from the normal one above cuttings to the diminished section through the cuttings is effected gradually by means of bell mouths with bed and surface falls to suit the loss of head due to the increase in velocity.

The same principle has to be observed in increasing the canal section from the reduced one in the cutting to the normal one beyond. In fixing the bed and surface falls, credit has been taken of the recovery of level, due to the increase in the velocity.

At each of these cuttings, alternative proposals for a contour canal had already been worked out in 1905 and given up either on account of its greater cost or because it was found to be impossible on account of the short and sharp curves necessitated and the difficult nature of the country traversed.

Hydraulic particulars of the Lower Bhavani Main Canal.

I Crop—113,800 acres.

	Reach.	Distance.	Area.	I Rotation. Requirements including transmission losses in branches and distributaries.	I Rotation. Transmission losses in main canal.	Total discharge.	Area.	II Rotation. Requirements including transmission losses in branches and distributaries.	II Rotation. Transmission losses in main canal.	Total discharge.	Area.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
		M. F. FT.	ACS.	CUSECS.	CUSECS.	CUSECS.	ACS.	CUSECS.	CUSECS.	CUSECS.	ACS.
I crop II crop zone.	I ..	0 0 0	56,834	1,040	225	1,265	57,001	1,026	239	1,265	46,954
	..	29 4 0	56,834	1,040	137	1,177	57,001	1,026	151	1,177	23,824
	II ..	38 6 0	56,834	1,040	110	1,150	57,001	1,026	124	1,150	23,824
	III ..	53 1 330	56,834	1,040	65	1,105	57,001	1,026	79	1,105	..
	IV ..	56 6 0	56,834	1,040	56	1,096	57,001	1,026	70	1,096	..
	V ..	60 3 600	48,222	883	45	928	57,001	1,026	59	1,085	..
	VI ..	72 6 600	48,222	883	8	891	9,119	160	18	178	..
	VII ..	74 5 395	..	..	..	..	9,119	160	10	170	..
	VIII ..	88 0 215	..	..	..	..	..	..	..	..	..

II Crop—93,700 acres.

Reach.	I. Rotation. Requirements including transmission losses in branches and distributaries.	I. Rotation. Transmission losses in main canal.	I. Rotation. Total discharge.	Area.	II. Rotation. Requirements including transmission losses.	II. Rotation. Transmission losses in main canal.	II. Rotation. Total discharge.	Main canal as designed. Bed width.	Depth.	Calculated discharge.	Remark.
	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
	CUSECS.	CUSECS.	CUSECS.	ACS.	CUSECS.	CUSECS.	CUSECS.	FEET.	FEET.	CUSECS.	
I ..	840	160	1,000	46,729	847	168	1,015	60	8	1,322	
..	434	72	506	46,729	847	80	927	57	8	1,232	These statements were prepared for the old proposal of two zones.
II ..	434	45	479	23,752	434	53	487	57	8	1,232	
III ..	..	..	..	23,752	434	9	443	57	7·75	1,148	
IV ..	..	..	..	..	..	..	..	57	7·75	1,148	These will be altered suitably to the new proposals for a single zone canal.
V ..	..	..	..	..	..	..	..	57	7·5	1,105	
VI ..	..	..	..	..	..	..	..	50	7·5	967	
VII ..	..	..	..	..	..	..	..	20	4·25	171	
VIII ..	..	..	..	..	..	..	..	5	1·7	..	

N.B.—(1) The rotation under each crop area will be as shown in the annexure.

ANNEXURE.

	Second crop. ACS.		First crop. ACS.
I. 0/0 to 29/4	23,130	V. 56/6 to 60/3/600	8,612
II. 29/4 to 38/6	22,977	VI. 60/3/600 to 72/6/600	47,882
III. 38/6 to 53/1½	23,824	VII. 72/6/600 to 74/5/395	48,222
IV. 53/1½ to 56/6	23,752	VIII. 74/5/395 to 88/0	9,119
I and III (first rotation)	46,954	V and VII (first rotation) ..	56,834
II and IV (second rotation) ..	46,729	VI and VIII (second rotation) ..	57,001

(2) The figures in columns (4), (8), (12) and (16) are the total of the requirements in the branches and distributaries in the respective rotation including transmission losses at 10 per cent and 5 per cent respectively. These figures were got from the sluicewar statement.

(3) The figures in columns (5), (9), (13) and (17) represent transmission losses in main canal alone below the respective reaches.

(4) During execution slight alteration necessary in the design of the canal will be made.

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Statement showing the hydraulic particulars of the Main Canal, Lower Bhavani Project.

Serial number.	Distance. From (2) M. F. FT.	Distance. To (3) M. F. FT.	Ayacut in acres. (4)	Required discharge in cusecs. (5)	Bed level. At start. (6)	Bed level. At end. (7)	Fall in feet per mile. (8)	Bed width in feet. At start. (9)	Bed width in feet. At end. (10)	Depth in feet. (11)	Side slopes. (12)	Velocity. At start. (13)	Velocity. At end. (14)	Calculated discharge. At start. (15)	Calculated discharge. At end. (16)	Balancing depth. (17)	Remarks. (18)
1	..	0 1 585	58,565	1,310	840·00	838·56	6·03	27	27	8	½ : 1	5·67	5·67	1,315	1,315	..	Cutting.
2	0 1 585	0 2 90	58,565	1,300	838·56	838·87	..	60	59	..	1 : 1	2·43	2·38	1,322	1,276	..	Bell mouth.
3	0 2 90	6 3 140	58,565	1,288	838·87	836·22	0·415	..	..	8	..	..	..	..	..	4·12 and 4·18	
4	6 3 140	6 3 280	58,565	1,288	836·22	835·87	..	..	31	..	½ : 1	4·97	4·97	1,312	1,312	..	Bell mouth.
5	6 3 280	6 4 480	58,565	1,287	835·87	835·15	4·43	..	59	..	..	..	..	..	..	..	Cutting.
6	6 4 480	6 4 620	58,565	1,287	835·15	835·38	..	59	59	8	1 : 1	2·34	2·34	1,254	1,254	4·18	Bell mouth.
7	6 4 620	9 5 245	58 565	1,278	835·38	834·11	0·40	..	..	..	..	..	..	..	..	..	Cutting.
8	9 5 245	9 5 410	58 565	1,278	834·11	833·62	..	26	26	8	½ : 1	5·75	5·75	1,288	1,288	..	Bell mouth.
9	9 5 410	9 6 405	58,565	1,277	833·62	832·83	6·40	..	..	..	..	..	..	..	..	..	Cutting.
10	9 6 405	9 6 570	58,565	1,277	832·83	833·16	..	59	58	8	1 : 1	2·38	2·37	1,276	1,251	4·18 and 4·20	Bell mouth.
11	9 6 570	17 3 430	58,565	1,260	833·16	829·74	0·415	..	..	..	..	..	..	..	..	..	Cutting.
12	17 3 430	17 3 555	58,565	1,250	829·74	829·47	..	33	33	8	½ : 1	4·44	4·44	1,244	1,244	..	Bell mouth.
13	17 3 555	17 4 290	58,565	1,250	829·47	829·21	3·45	..	..	..	..	..	..	..	..	..	Cutting.
14	17 4 290	17 4 415	58,565	1,250	829·21	829·39	..	58	58	8	1 : 1	2·37	2·37	1,251	1,251	4·20	Bell mouth.
15	17 4 415	20 4 540	58,565	1,240	829·39	828·14	0·415	..	..	..	..	..	..	..	..	..	Cutting.
16	20 4 540	20 4 620	58,565	1,240	828·14	828·02	..	42	42	8	½ : 1	3·53	3·53	1,242	1,242	..	Bell mouth.
17	20 4 620	20 5 325	58,565	1,240	828·02	827·88	1·98	..	..	..	..	..	..	..	..	..	Cutting.
18	20 5 325	20 5 405	58,565	1,240	827·88	827·96	..	58	57	8	1 : 1	2·37	2·37	1,251	1,232	4·20 and 4·22	Bell mouth.
19	20 5 405	22 4 570	58,565	1,233	827·96	827·14	0·415	..	..	..	..	..	..	..	..	..	Cutting.
20	22 4 570	22 5 50	58,565	1,233	827·14	826·80	..	29	29	8	½ : 1	5·00	5·00	1,240	1,240	..	Bell mouth.
21	22 5 50	22 5 560	58,565	1,233	826·80	826·36	4·55	..	..	..	..	..	..	..	..	..	Cutting.
22	22 5 560	22 6 40	58,565	1,233	826·36	826·59	..	57	57	8	1 : 1	2·37	2·37	1,232	1,232	4·22	Bell mouth.
23	22 6 40	24 1 165	58,565	1,229	826·59	826·05	0·415	57	57	8	1 : 1	2·37	2·37	1,232	1,232	4·22	
24	24 1 165	27 6 585	58,565	1,217	826·05	824·42	0·415	..	..	..	..	..	..	..	..	..	Cutting.
25	27 6 585	27 7 70	58,565	1,217	824·42	824·07	..	28	28	8	½ : 1	5·05	5·05	1,213	1,213	..	Bell mouth.
26	27 7 70	27 7 600	58,565	1,217	824·07	823·59	4·78	..	..	..	..	..	..	..	..	..	Cutting.
27	27 7 600	28 0 85	58,565	1,217	823·59	823·83	..	57	57	8	1 : 1	2·33	2·33	1,212	1,212	4·22	Bell mouth.
28	28 0 85	29 3 430	58,565	1,212	823·83	823·25	0·40	..	..	..	..	..	..	..	..	..	Cutting.
29	29 3 430	29 3 560	58,565	1,212	823·25	822·95	..	31	31	8	½ : 1	4·66	4·66	1,230	1,230	4·22	Bell mouth.
30	29 3 560	29 4 100	58,565	1,212	822·95	822·80	3·00	..	..	..	..	..	..	..	..	..	Cutting.
31	29 4 100	29 4 230	58,565	1,212	822·80	823·00	..	57	57	8	1 : 1	2·37	2·37	1,232	1,232	4·22	Bell mouth.
32	29 4 230	33 4 395	58,565	1,198	823·00	821·26	0·415	..	..	..	..	..	..	..	..	..	Cutting.
33	33 4 395	33 4 530	58,565	1,198	821·26	820·96	..	30	30	8	½ : 1	4·75	4·75	1,216	1,216	4·22	Bell mouth.
34	33 4 530	33 6 60	58,565	1,197	820·96	820·30	4·11	..	..	..	..	..	..	..	..	..	Cutting.
35	33 6 60	33 6 195	58,565	1,197	820·30	820·50	..	57	57	8	1 : 1	2·37	2·37	1,232	1,232	4·22	Bell mouth.
36	33 6 195	40 3 210	58,565	1,175	820·50	817·63	0·415	..	..	..	..	..	..	..	..	..	Cutting.
37	40 3 210	40 3 370	58,565	1,175	817·63	817·20	..	25	25	8	½ : 1	5·67	5·57	1,204	1,204	..	Bell mouth.
38	40 3 370	40 4 100	58,565	1,175	817·20	816·74	6·10	..	..	..	..	..	..	..	..	..	Cutting.
39	40 4 100	40 4 260	58,565	1,175	816·74	817·04	..	57	57	8	1 : 1	2·37	2·37	1,232	1,232	4·22	Bell mouth.
40	40 4 260	41 7 205	58,565	1,174	817·04	816·46	0·415	..	..	..	..	..	..	..	..	..	Cutting.
41	41 7 205	41 7 330	58,565	1,174	816·46	816·22	..	32	32	8	½ : 1	4·39	4·39	1,195	1,195	..	Bell mouth.
42	41 7 330	42 0 540	58,565	1,174	816·22	815·65	3·42	..	..	..	..	..	..	..	..	..	Cutting.
43	42 0 540	42 1 5	58,565	1,174	815·65	815·82	..	..	..	..	..	..	..	..	..	..	Bell mouth.

Statement showing the hydraulic particulars of the Main Canal, Lower Bhavani Project—*cont.*

Serial number.	Distance. From	Distance. To	Bed width in feet. At start.	Bed width in feet. At end.	Depth in feet.	Side slopes.	Velocity. At start.	Velocity. At end.	Calculated discharge. At start.	Calculated discharge. At end.	Balancing depth.	Remarks.
	M. F. FT.	M. F. FT.										
(1)	(2)	(3)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
44	42 1 5	46 5 237	57	57	7·75	1 : 1	2·33	2·33	1,169	1,169	4·12	
45	46 5 237	46 5 332	38	38	7·75	1½ : 1	3·80	3·80	1,177	1,177	..	Bell mouth. Cutting.
46	46 5 332	46 5 482	..	..	..	..	..	..	..	..	..	Bell mouth.
47	46 5 482	46 5 577	57	57	7·75	1 : 1	2·33	2·33	1,169	1,169	4·12	
48	46 5 577	47 5 547	..	..	..	..	..	..	..	..	..	Bell mouth.
49	47 5 547	47 5 597	47	47	7·75	1½ : 1	3·03	3·03	1,150	1,150	..	Cutting.
50	47 5 597	47 6 87	..	..	..	..	..	..	..	..	..	Bell mouth.
51	47 6 87	47 6 137	57	57	7·75	1 : 1	2·33	2·33	1,169	1,169	4·12	
52	47 6 137	48 6 585	..	..	..	..	..	..	..	..	..	Bell mouth.
53	48 6 585	48 7 70	28	28	7·75	1½ : 1	5·09	5·09	1,182	1,182	..	Cutting.
54	48 7 70	49 2 310	..	..	..	..	..	..	..	..	..	Bell mouth.
55	49 2 310	49 2 455	57	57	7·75	1 : 1	2·33	2·33	1,169	1,169	4·12	
56	49 2 455	51 3 550	..	..	..	..	..	..	..	..	..	Bell mouth.
57	51 3 550	51 4 25	30	30	7·75	1½ : 1	4·62	4·62	1,144	1,144	..	Cutting.
58	51 4 25	51 4 325	..	..	..	..	..	..	..	..	..	Bell mouth.
59	51 4 325	51 4 460	57	57	7·75	1 : 1	2·29	2·29	1,148	1,148	4·12	
60	51 4 460	56 1 230	..	..	..	..	..	..	..	..	..	Bell mouth.
61	56 1 230	60 3 280	57	57	7·75	1 : 1	2·29	2·29	1,148	1,148	4·12	
62	60 3 280	60 3 420	..	..	..	..	..	..	..	..	..	Bell mouth.
63	60 3 420	60 4 40	57	57	7·75	1½ : 1	4·64	4·64	1,112	1,112	..	Cutting.
64	60 4 40	60 4 180	..	..	..	..	..	..	..	..	..	Bell mouth.
65	60 4 180	63 0 220	57	57	7·5	1 : 1	2·28	2·28	1,105	1,105	4·00	
66	63 0 220	63 3 280	57	57	7·5	1 : 1	2·28	2·28	1,105	1,105	4·00	
67	63 3 280	63 5 90	64	64	7·0	1 : 1	2·21	2·21	1,099	1,099	3·90	
68	63 5 90	63 5 215	50	50	6·5	1 : 1	2·07	2·37	761	761	3·45	
												Bell mouth.
69	63 5 215	63 5 340	25	25	6·5	1½ : 1	4·09	4·09	708	708	..	Cutting.
70	63 5 340	64 0 55	47	47	6·5	1 : 1	2·02	2·02	703	703	3·52	Bell mouth.
71	64 0 55	64 0 165	54	49	6·0	1 : 1	1·95	1·73	702	571	3·25	
72	64 0 165	64 6 500									2·75	
			49	43	6·0	1 : 1	1·73	1·71	571	502	2·75	
73	64 6 500	67 5 0									3·43	
			43	42	6·0	1 : 1	1·71	1·70	502	490	3·43	
74	67 5 0	70 3 440									3·48	
			20	18	4·25	½ : 1	1·82	1·73	171	138	..	
75	70 3 440	74 5 395	18	15	4·00	½ : 1	1·73	1·425	138	..	..	
			15	10	3·00	½ : 1	1·425	1·23	71	36	..	
76	74 5 395	76 2 195	10	5	2·60	½ : 1	1·23	0·76	36	7	..	
77	76 2 195	79 2 295	5	..	1·70	½ : 1	0·76	..	7	..	..	
78	79 2 295	81 7 295										
79	81 7 295	85 1 295										
80	85 1 295	88 0 215										

Serial number.	Area cut in acres. (4)	Required discharge in cusecs. (5)	Red level. At start. (6)	Red level. At end. (7)
44	58,565	1,156	816·82	813·74
45	58,565	1,156	813·74	813·58
46	58,565	1,156	813·58	813·51
47	58,565	1,156	813·51	813·02
48	58,565	1,153	813·62	813·18
49	58,565	1,153	813·18	813·11
50	58,565	1,153	813·11	813·07
51	58,565	1,153	813·07	813·12
52	58,565	1,150	813·12	812·65
53	58,565	1,150	812·65	812·29
54	58,565	1,148	812·29	810·19
55	58,565	1,148	810·19	810·44
56	58,565	1,141	810·44	809·47
57	58,565	1,141	809·47	809·18
58	58,565	1,141	809·18	808·95
59	58,565	1,141	808·95	809·14
60	58,565	1,124	809·14	807·10
61	58,565	1,111	807·10	805·40
62	58,565	1,111	805·40	805·10
63	58,565	1,111	805·10	804·89
64	58,565	1,111	804·89	805·08
65	58,565	1,102	805·08	803·99
66	58,565	1,100	803·99	803·76
67	58,565	1,099	803·76	803·72
68	58,565	1,099	..	..
	38,826	701	803·71	803·47
69	38,826	701	803·47	802·19
70	38,826	700	802·19	802·35
71	38,826	700	802·35	802·02
72	38,826	698	..	..
	31,805	575	802·02	800·91
73	31,805	575	..	..
	28,407	511	800·91	799·56
74	28,407	511	..	..
75	28,407	511	799·56	797·38
76	9,119	152	797·38	795·66
77	7,234	121	795·66	792·50
78	3,794	63	792·50	789·68
79	1,923	32	789·68	786·27
80	355	6	786·27	783·24

These statements were prepared for the old proposal of two zones.
These will be altered to suit the new proposals.

33. *High embankments.*—Owing to the numerous streams crossed and the undulations of the country traversed the channel is in moderately high embankments in several places—vide statement below :—

Statement showing height of banks and height of canal bed above bed of streams along Lower Bhavani Main Canal.

Serial number.	Mileage. M.	Mileage. F.	Mileage. FT.	Canal bed above stream bed.	Total height of bank above stream bed.	Serial number.	Mileage. M.	Mileage. F.	Mileage. FT.	Canal bed above stream bed.	Total height of bank above stream bed.
(1)	(2)			(3)	(4)	(1)	(2)			(3)	(4)
1	0	6	330	7·03	18·03	39	39	0	330	7·38	18·38
2	1	2	330	11·75	22·75	40	40	1	330	6·89	17·89
3	2	2	165	8·62	19·62	41	41	2	0	7·74	18·74
4	3	5	0	16·28	27·28	42	43	0	330	9·24	20·24
5	3	6	0	15·75	26·75	43	44	0	330	10·56	21·56
6	4	2	165	16·28	27·28	44	44	7	0	6·32	17·32
7	4	6	495	14·54	25·54	45	46	0	330	14·42	25·42
8	5	2	0	4·3	15·3	46	46	3	330	6·08	16·83
9	6	1	0	9·36	20·36	47	47	2	330	5·57	16·32
10	7	1	330	13·04	24·04	48	47	4	0	13·02	23·77
11	7	2	330	11·33	22·33	49	47	7	0	9·08	19·83
12	7	6	330	7·85	18·85	50	48	2	330	11·20	21·95
13	9	0	0	17·94	28·94	51	48	5	0	12·30	23·05
14	9	7	330	11·91	22·91	52	50	2	0	10·29	21·04
15	10	1	0	7·27	18·27	53	50	6	330	9·83	20·58
16	11	2	330	10·48	21·48	54	51	1	0	17·25	28·00
17	12	6	313	19·67	30·67	55	51	7	330	9·85	20·60
18	13	2	0	7·67	18·67	56	52	3	330	5·94	16·69
19	14	5	0	9·97	20·97	57	52	7	330	9·54	20·29
20	15	7	330	18·07	29·07	58	53	5	0	16·41	27·16
21	16	7	0	6·37	17·37	59	54	2	330	8·50	19·25
22	18	7	330	11·18	22·18	60	55	1	330	5·54	16·29
23	19	7	0	8·45	19·45	61	56	0	0	12·67	23·42
24	21	2	330	11·00	22·00	62	56	4	330	9·94	20·69
25	23	2	0	7·35	18·35	63	59	3	330	8·72	19·49
26	24	4	330	9·41	20·41	64	60	5	0	6·23	16·98
27	26	4	0	10·78	21·78	65	61	4	0	17·35	27·85
28	27	1	330	8·57	19·57	66	62	0	330	9·51	20·01
29	28	4	0	13·47	24·47	67	62	2	0	10·28	20·78
30	30	0	0	4·07	15·07	68	62	4	0	11·71	22·21
31	31	3	330	7·78	18·78	69	63	3	330	5·05	15·05
32	33	3	1	6·66	17·66	70	66	4	330	5·01	14·01
33	33	7	330	4·36	15·36	71	68	2	330	8·85	17·85
34	34	2	330	9·02	20·02	72	69	6	0	5·69	14·69
35	35	0	0	9·46	20·46	73	70	2	330	5·42	14·42
36	36	2	330	11·92	22·92	74	71	5	330	8·93	17·93
37	37	4	330	12·03	23·03	75	72	2	0	5·87	14·87
38	38	2	330	8·58	19·58	76	72	3	330	5·65	14·65

NOTE.—These will slightly vary to suit new proposals for a single zone.

34. *Walling.*—Due to the paucity of suitable earth for forming the high embankments and the need for acquisition of unusually large widths of land on both sides of the canal, it has been rendered necessary to substitute masonry walling in place of high embankments. It is proposed generally to have the walling in places where the height of bank exceeds 20 feet above ground level to such lengths as would make the provision of walling suitable and advantageous. A statement showing the mileages and lengths, where such walling is proposed is appended below :—

Serial number.	Mileage of depression. From M.	F.	FT.		To M.	F.	FT.	Height of walling above G.L. 21′	22′	23′	24′	25′	26′	27′
1	3	4	419	to	3	5	590	100	391	45	109	..	..	..
2	4	6	363	to	4	7	66	13	60	..	170	..	80	40
3	7	1	119	to	7	1	377	108	50	100	..	..	..	..
4	8	7	491	to	8	7	488	4	27	50	..	35	..	95
5	12	5	630	to	12	6	530	55	149	44	..	..	..	..
6	15	7	350	to	18	0	144	4	..	23	27	..	..	..
7	24	4	130	to	24	4	390	145	..	65	..	..	..	..
8	28	3	403	to	28	4	130	257	100	30	..	..	..	..
9	46	0	35	to	46	0	361	26	..	..	..	..	..	..
10	47	3	622	to	47	4	282	100	50	170	..	..	..	..
11	50	1	265	to	50	1	527	262	..	..	..	..	..	..
12	51	0	55	to	51	1	294	92	8	18	..	..	..	..
13	53	4	434	to	53	5	83	84	..	50	..	..	..	..
14	55	7	411	to	56	0	284	138	128	19	..	50	102	23
15	56	4	183	to	56	4	348	165	..	..	..	..	..	..
16	61	3	594	to	61	4	289	79	19	..	25	..	..	..
17	62	3	401	to	62	4	2	141	..	120	..	..	..	..
							al ..	1,773	982	734	331	85	182	158

Remarks.—The mileage of the reaches noted includes the length of the aqueduct portions also.

35. The following are the principal details concerning standards of banks on th main canal :—

Top width in reaches where the discharge exceeds	1,000 cusecs, 9 feet.
Top width in reaches where the discharge is below	1,000 cusecs, 6 feet.
Side slopes of cuttings	1 to 1.
Side slopes of embankments	1½ to 1 in front and varying slopes to suit H.G. in rear.
Top level of bank	3 feet above F.S.L.
Maximum height of spoil bank	14 feet above ground level.
Berm	4 plus D/2.
Land outside toe of bank	18 feet.

In constructing these banks, selected earth consisting of loam and clay will be placed in the centre of the bank as a core and gravel and mooram laid as a casing overall. A lump sum provision has been made in the estimate for revetment one foot thick wherever necessary, i.e., at curves, etc.

36. *Regulators.*—It was already stated that regulators would be constructed wherever necessary to effect rotational supply and for securing necessary command. Taking the second crop area which was to extend as far as 56–6–0 of the main canal regulators were proposed at the end of third and fourth sub-blocks, i.e., at 53–1–330 and 56–6–0 for cutting off supplies during the respective rotation periods. Another regulator was also proposed at the end of second sub-block at 38–6–0 or at a suitable place for the big off-take for 12,657 acres at 33–7–0. Taking the first crop area of 113,800 acres below 56–6–0 a regulator was proposed in the second sub-block, i.e., 63–4–600 the head of the Unjalur distributary with an ayacut of 34,968 acres. There was also a reduction in the bed width and F.S.L. of the canal at this place. Another regulator was proposed at 74–5–395 feet and also for the sake of the big off-take for 46,738 acres at this point to cut off the supplies at the end of the third block during rotational periods. The position and number of regulators will now be modified to suit the single crop throughout the area now proposed.

37. *Cross-drainage works.*—The main canal having been aligned throughout on a falling contour, intercepts all the drainages entering the Bhavani. Most of these drainages are proposed to be disposed off by means of aqueducts or syphons without being taken into the canal. Minor drainages, having small catchments less than 0·1 square mile will be diverted into the next big stream. Flood discharges have been calculated for a runoff of 12 inches in 24 hours for all catchments of less than three square miles. Discharges for catchments of above three square miles have been calculated using Ryve's formula with 500 for the co-efficient. These allowances are, it is considered, safe for the rainfall conditions obtaining in this part of the district. The M.F.Ls. at the several sites of the crossings have been arrived at, by calculating the level at which the above flood discharges will be disposed of for the bed fall obtaining in the stream. The ventways have been allowed for a maximum velocity of 8 feet per second which the soil at the site is able to withstand, the minimum ventway allowed being 4 feet by 3 feet to secure convenience of clearance, etc. Where the existing velocity itself is greater than 8 feet per second the existing velocity has been allowed.

The hydraulic particulars concerning the various cross-drainage works are noted in the accompanying statement.

Statement showing the particulars of cross drainage works in the Main Canal, Lower Bhavani Project.

Serial number.	Nature of work.	Particulars of stream. Mileage.	Catchment area.	Discharge from catchment.	Ventway allowed.	Velocity in vent in feet.	Calculated discharge through vents.	Particulars of canal. Required discharge.	Bed width in feet.	F.S.L. depth in feet.	Bed level.	Trough width.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
		M. F. FT.	SQ.M.	CUSECS.			CUSECS.	CUSECS.				FT. IN.
1	Aq. ..	0 6 330	2·73	881	2 of 15′	8	955	1,309	60	8	838·62	30 6
2	D.C. ..	1 2 330	0·99	320	1 of 10′	8	320	1,309	60	8	838·39	..
3	D.C. ..	2 2 190	0·38	123	1 of 6′	8	192	1,309	60	8	837·99	..
4	Aq. ..	3 5 540	3·20	1,086	2 of 20′	8	1,136	1,309	60	8	837·35	30
5	D.C. ..	4 2 190	1·90	613	1 of 20′	9	612	1,309	60	8	837·10	..
6	D.C. ..	4 6 185	0·26	84	1 of 4′	8	96	1,309	60	8	836·87	..
7	D.C. ..	6 0 415	0·20	65	Do.	8	96	1,309	60	8	836·36	..
8	D.C. ..	7 1 280	0·99	320	1 of 15′	8	329	1,287	59	8	835·16	..
9	Aq.	7 6 310	2·08	671	3 of 10′	8	751	1,287	59	8	834·87	30

Serial number.	Nature of work.	Particulars of stream. Mileage.	Catchment area.	Discharge from catchment.	Ventway allowed.	Velocity in vent in feet.	Calculated discharge through vents.	Particulars of canal. Required discharge.	Bed width in feet.	F.S.L. depth in feet.	Bed level.	Trough width.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
		M. F. FT.	SQ.M.	CUSECS.			CUSECS.	CUSECS.				FT. IN.
10	D.C. ..	8 7 595	0·84	271	1 of 10′	8	320	1,287	59	8	834·39	..
11	D.C. ..	9 7 385	0·20	65	1 of 4′	8	96	1,277	59	8	833·15	..
12	D.C. ..	11 2 406	1·37	442	1 of 15′	8	458	1,277	59	8	832·58	..
13	D.C. ..	11 5 550	0·96	310	1 of 10′	8	320	1,277	59	8	832·41	..
14	Aq. ..	12 6 230	37·90	5,640	3 of 20′	10·2	5,551	1,277	59	8	831·93	29 6
15	Aq. ..	13 1 475	42·69	6,100	11 of 15′	8	5,953	1,277	59	8	831·64	30 0
15A	..	13 4 200	Crossing of the channel for the ayacut of Ukkaram tank on the left side of the canal.									
16	D.C. ..	14 4 501	0·62	200	1 of 6′	8	192	1,277	59	8	831·04	..
17	Aq. ..	15 7 542	46·10	6,426	7 of 20′	9·5	6,783	1,277	59	8	830·40	29 6
18	D.C. ..	16 6 495	0·20	64·5	1 of 4′	8	96	1,277	59	8	829·99	..
19	D.C. ..	17 6 500	0·73	236	1 of 10′	8	320	1,250	58	8	829·29	..
20	D.C. ..	18 7 362	0·22	71	1 of 4′	8	96	1,250	58	8	828·83	..
21	S.A. ..	19 6 517	27·30	4,530	3 of 15′	12·0	4,536	1,250	58	8	828·45	..
21A	..	20 1 100	Crossing of the channel for the ayacut of Elathur tank on the left side of the canal.									
22	D.C. ..	21 2 230	0·60	194	1 of 6′	8	192	1,240	58	8	827·72	..
23	D.C. ..	21 6 186	0·35	113	1 of 6′	8	192	1,240	58	8	827·51	..
24	D.C. ..	23 2 160	0·23	74	1 of 4′	8	96	1,233	57	8	826·37	..
25	D.C. ..	24 4 255	0·85	274	1 of 10′	8	320	1,233	57	8	825·85	..
26	Aq. ..	26 4 155	6·10	1,668	4 of 10′	8	2,004	1,229	57	8	824·99	28 6
27	D.C. ..	27 1 198	0·85	274	1 of 10′	8	320	1,229	57	8	824·71	..
28	D.C. ..	28 4 30	1·20	387	1 of 20′	8	418	1,217	57	8	823·64	..
29	S.A. ..	30 0 0	8·79	2,129	3 of 15′	12·0	2,143	1,212	57	8	822·81	..
30	Aq. ..	31 3 420	2·86	923	4 of 15′	8	970	1,212	57	8	822·18	28 6
31	D.C. ..	32 4 215	2·00	646	1 of 20′	8	640	1,212	57	8	821·70	..
32	D.C. ..	33 0 490	0·20	65	1 of 4′	8	96	1,212	57	8	821·47	..
33	D.C. ..	33 7 340	0·15	48	1 of 4′	8	96	1,197	57	8	820·42	..
34	D.C. ..	34 2 195	0·74	239	1 of 10′	8	320	1,197	57	8	820·28	..
35	D.C. ..	34 7 478	0·74	239	1 of 10′	8	216	1,197	57	8	820·00	..
36	Aq. ..	36 2 470	24·89	4,263	6 of 15′	8	4,579	1,197	57	8	819·39	27 6
37	D.C. ..	37 4 250	0·22	73	1 of 4′	8	96	1,197	57	8	818·84	..
38	S.A. ..	39 0 495	10·74	2,436	3 of 10′	12·0	2,437	1,197	57	8	818·11	..
39	D.C. ..	40 1 390	0·77	249	1 of 10′	8	320	1,197	57	8	817·73	..
40	D.C. ..	41 2 50	0·20	65	1 of 4′	8	96	1,175	57	8	816·74	..
41	D.C. ..	41 5 78	1·82	587	1 of 15′	8	608	1,175	57	8	816·58	..
42	D.C. ..	42 2 470	0·15	39	1 of 4′	8	96	1,174	57	7·75	815·73	..
43	D.C. ..	43 0 250	1·25	403	1 of 15′	8	416	1,174	57	7·75	815·43	..
44	Aq. ..	44 0 200	22·51	3,980	7 of 15′	8	4,401	1,174	57	7·75	814·96	28 6
45	D.C. ..	44 3 280	1·10	355	1 of 15′	8	480	1,174	57	7·75	814·74	..
46	D.C. ..	44 7 25	1·00	323	1 of 20′	8	344	1,174	57	7·75	814·55	..
47	Aq. ..	46 0 200	13·83	2,879	5 of 15′	8	3,066	1,158	57	7·75	814·04	28 6
48	D.C. ..	46 3 370	0·73	236	1 of 10′	8	320	1,158	57	7·75	813·83	..
49	D.C. ..	47 4 40	1·05	339	1 of 10′	8	320	1,156	57	7·75	813·28	..
50	D.C. ..	49 5 60	0·38	116	1 of 6′	8	192	1,148	57	7·75	810·31	..
51	D.C. ..	50 1 450	0·84	271	1 of 10′	8	320	1,148	57	7·75	810·08	..
52	D.C. ..	50 6 200	0·66	213	1 of 15′	8	200	1,148	57	7·75	809·83	..
53	Aq. ..	51 1 60	4·46	1,357	2 of 20′	8	1,376	1,142	57	7·75	809·65	28 0
54	Aq. ..	51 7 400	1·20	387	2 of 15′	8	370	1,141	57	7·75	808·98	27 6
55	D.C. ..	52 3 270	0·16	52	1 of 4′	8	96	1,141	57	7·75	808·74	..
56	D.C. ..	53 5 0	0·43	139	1 of 6′	8	192	1,141	57	7·75	808·25	..
57	Aq. ..	55 1 165	0·41	132	3 of 10′	8	154	1,127	57	7·75	807·61	27 6
58	Aq. ..	56 0 0	1·43	461	4 of 10′	8	426	1,125	57	7·75	807·22	27 0
59	D.C. ..	57 3 520	0·15	48	1 of 4′	8	96	1,124	57	7·75	806·58	..
60	D.C. ..	58 2 120	0·25	81	1 of 4′	8	96	1,124	57	7·75	806·27	..
61	D.C. ..	58 5 450	0·30	97	1 of 4′	8	96	1,124	57	7·75	806·09	..
62	D.C. ..	59 0 600	0·15	48	1 of 4′	8	96	1,114	57	7·75	805·92	..
63	S.A. ..	59 3 540	2·50	807	1 of 10′	12	804	1,114	57	7·75	805·78	..
64	D.C. ..	60 2 480	0·65	210	1 of 10′	8	320	1,111	57	7·75	805·44	..
65	D.C. ..	60 5 70	0·61	197	1 of 6′	8	192	1,111	57	7·5	805·05	..
66	Aq. ..	61 4 200	5·50	1,560	3 of 15′	8	1,620	1,108	57	7·5	804·64	28 0
67	D.C. ..	62 0 160	0·27	87	1 of 4′	8	96	1,106	57	7·5	804·41	..
68	D.C. ..	62 2 0	1·30	420	1 of 15′	8	418	1,105	57	7·5	804·32	..
69	D.C. ..	63 2 280	0·43	139	1 of 6′	8	192	1,101	57	7·5	803·87	..
70	Canal syphon.	64 6 500	21·64	3,875	1 of 80′	12	3,876	700	47	6·5	802·02	2 of 10′
									54	6·0		
70A	..	65 4 0	Crossing for supply channel from Sinnakulam tank.									
71	S.A. ..	66 4 260	3·43	1,137	3 of 10′	12	1,118	698	47	6·5	801·34	..
									54	6·00		
72	Aq. ..	68 2 450	2·20	710	4 of 10′	8	848	575	49	6·00	800·60	27 0
73	D.C. ..	68 6 440	0·15	48	1 of 4′	8	96	575	49	6·00	800·34	..
74	Aq. ..	69 6 0	1·78	574	5 of 10′	8	580	575	49	6·00	799·90	27 0
75	D.C. ..	70 7 600	0·24	77	1 of 4′	8	96	511	43	6·00	799·35	..
76	Aq. ..	71 5 150	1·64	529	3 of 15′	8	536	511	43	6·00	799 91	22 6
77	D.C. ..	72 1 580	0·15	48	1 of 4′	8	96	511	43	6·00	798 75	..
78	D.C. ..	72 3 480	0·13	42	1 of 4′	8	96	511	43	6·00	798·65	..
79	D.C. ..	72 5 560	0·12	42	1 of 4′	8	96	511	43	6·00	798·44	..
80	D.C. ..	72 7 500	0·24	77	1 of 4′	8	96	511	43	6·00	798·34	..
81	U.T. ..	75 3 135	0·38	..	..	..	..	..	..	..	796·64*	..
82	D.C. ..	76 1 895	0·52	168	2 of 5′	8	..	171	20	4·25	795·76	..
83	U.T. ..	76 5 335	1·21	..	..	..	..	..	..	..	795·27*	..
84	U.T. ..	78 4 395	0·21	68	1 of 3′	8	..	136	18	4·00	793·28	..
85	Aq. ..	79 4 395	9·78	3,156	40 of 10′	..	..	72	15	3·00	792·22	8 0
86	Canal syphon.	80 1 595	0·15	..	..	..	..	..	..	..	791·51*	..
87	D.C. ..	80 5 555	0·11	..	..	..	..	..	..	..	790·99*	..
88	D.C. ..	81 0 515	0·16	52	1 of 3′	8	..	72	15	3·00	790·61	..
89	Canal syphon.	81 4 595	0·09	..	..	..	..	..	..	..	790·06*	..
90	Do.	82 7 15	0·23	74	1 of 10′	..	..	37	10	2·60	788·74	1 of 31′ × 4½′.
91	Do.	83 4 475	0·36	..	..	..	..	..	..	..	787·96*	..
92	Do.	84 2 335	0·11	..	..	..	..	..	..	..	787·19*	..
93	U.T. ..	84 5 595	0·34	..	..	..	..	..	..	..	786·74*	..
94	U.T. ..	85 4 235	0·27	..	..	..	..	..	..	..	785·89*	..
95	U.T. ..	85 7 635	0·30	..	..	..	..	..	..	..	785·41*	..
96	..	86 1 475	0·29	..	..	..	..	..	..	..	785·17*	..
97	U.T. ..	87 0 395	0·84	..	..	..	..	..	..	..	784·27*	..
98	U.T. ..	87 3 135	0·11	..	..	..	..	..	..	..	783·92*	..

These will require slight modifications to suit single zone proposal.

N.B.—D.C. = Drainage culvert. U.T. = Under-tunnel. Aq. = Aqueduct. S.A. = Syphon aqueduct.

* These works have not been investigated in detail. The provision for these works is based on the estimates for which detailed estimates have been prepared. Items 15A, 21A and 70A have been omitted in the 1932 investigation. They are new included. Details regarding them will be worked out during execution. Only L.S. is provided for in the estimate.

38. *Railway syphon.*—The canal crosses the South Indian Railway line at M 63–3–280 feet by means of syphon under the railway line. A lump sum provision has been allowed in the estimate for this work and detailed plans for the same will be prepared by the railway authorities during execution.

39. *Bridges.*—The main canal in the first 85 miles crosses two trunk roads, 14 metalled roads and 47 cart-tracks. Sixty-three bridges have therefore been allowed for in this length of the canal which works out to an average of one bridge for every 1·4 miles. The width of roadway allowed for the trunk roads will be 22 feet and for other roads 12 feet. As regards the road-crossings below 80/0 where the depth of water is only about 1·5 feet and bed width also is about 5 feet ramps only have been allowed.

40. *Sluices.*—With the help of the special staff detailed levels for the whole project area have been taken and the alignment of every distributary channel and water course marked on the block maps for the preparation of the ayacut registers. The total number of sluices provided in the main canal is 122—vide details below.

Lower Bhavani Project Main Canal—Statement of sluices with area irrigated under each sluice.

Number.	Mileage.			Area irrigated in round numbers.	Discharge at 60 duty plus five per cent or ten per cent for transmission losses as the case may be.	Vent way.	
						Number.	Size.
(1)	(2)			(3)	(4)	(5)	(6)
	M.	F.	FT.	ACS.			
1	0	3	0	431	8	1	1—6 × 0—9.
2	1	1	0	132	2	1	Pipe sluice 9″ diameter.
3	1	7	0	351	6	1	1—0 × 0—9.
4	3	2	330	806	14	1	2—0 × 1—0.
5	3	7	330	119	2	1	Pipe sluice 9″ diameter.
6	4	4	330	166	3	1	Do.
7	5	0	0	70	1	1	Do.
8	5	4	330	1,312	23	1	2—0 × 1—3.
9	6	5	330	4,158	73	1	4—0 × 3—0.
10	6	7	330	65	1	1	Pipe sluice 9″ diameter.
11	7	4	330	103	2	1	Do.
12	8	0	0	386	7	1	1—0 × 0—9.
13	8	5	0	356	6	1	Do.
14	9	3	330	740	13	1	2—0 × 1—0.
15	10	1	330	2,111	37	1	3—0 × 1—6.
16	11	0	330	182	3	1	Pipe sluice 9″ diameter.
17	11	5	330	102	2	1	Do.
18	12	3	0	975	17	1	2—0 × 1—0.
19	13	1	0	63	1	1	Pipe sluice 9″ diameter.
20	14	2	330	245	4	1	Do.
21	15	1	0	1,024	18	1	2—0 × 1—0.
22	15	3	330	346	6	1	1—0 × 0—9.
23	16	5	330	369	7	1	Do.
24	17	0	330	98	2	1	Pipe sluice 9″ diameter.
25	17	3	0	891	16	1	2—0 × 1—0.
26	18	5	0	339	6	1	1—0 × 0—9.
27	19	1	330	252	4	1	Pipe sluice 9″ diameter
28	20	7	330	339	6	1	1—0 × 0—9.
29	21	4	0	98	2	1	Pipe sluice 9″ diameter.
30	22	0	330	151	3	1	Do.
31	22	4	330	880	15	1	2—0 × 1—0.
32	23	5	0	3,700	65	1	3—7½ × 2—0.
33	25	4	0	116	2	1	Pipe sluice 9″ diameter.
34	26	2	0	50	1	1	Do.
35	26	7	330	75	1	1	Do.
36	27	6	330	151	3	1	Do.
37	28	0	330	134	2	1	Do.
38	28	6	330	97	2	1	Do.
39	29	4	0	1,137	20	1	2—0 × 1—3.
40	30	2	330	411	7	1	1—0 × 0—9.
41	31	0	0	4,540	79	1	4—0 × 3—0.
42	32	0	9	153	3	1	Pipe sluice 9″ diameter.
43	32	6	0	145	3	1	Do.
44	33	2	0	252	4	1	Do.
45	33	4	0	874	15	1	2—0 × 1—0.
46	33	7	0	12,657	232	4	4—0 × 1—9.
47	34	6	330	182	3	1	Pipe sluice 9″ diameter.
48	35	4	0	280	5	1	1—0 × 0—6.
49	36	0	0	56	1	1	Pipe sluice 9″ diameter.
50	36	4	0	1,363	24	1	2—0 × 1—6.
51	37	4	0	141	3	1	Pipe sluice 9″ diameter.
52	37	6	0	554	10	1	1—6 × 0—9.
53	38	6	0	1,369	24	1	2—0 × 1—6.
54	39	4	0	153	3	1	Pipe sluice 9″ diameter.
55	40	4	330	1,227	22	1	2—0 × 1—6.
56	41	0	330	96	2	1	Pipe sluice 9″ diameter.

Number.	Mileage.			Area irrigated in round numbers.	Discharge at 60 duty plus five per cent or ten per cent for transmission losses as the case may be.	Vent way.	
						Number.	Size.
(1)	(2)			(3)	(4)	(5)	(6)
	M.	F.	FT.	ACS.			
57	41	3	330	50	1	1	Pipe sluice 9″ diameter.
58	41	6	0	7,474	137	2	5—0 × 1—9.
59	42	1	330	519	9	1	1—6 × 0—9.
60	42	6	330	379	7	1	1—0 × 0—9.
61	43	6	330	498	9	1	1—6 × 0—9.
62	44	2	0	86	2	1	Pipe sluice 9″ diameter.
63	44	4	0	105	2	1	Do.
64	45	1	0	224	4	1	Do.
65	46	5	0	84	2	1	Do.
66	47	1	0	143	3	1	Do.
67	47	5	0	144	3	1	Do.
68	48	4	0	174	3	1	Do.
69	48	6	330	1,889	33	1	3—0 × 1—6
70	49	2	330	3,139	55	1	4—0 × 1—9.
71	49	6	330	255	5	1	1—0 × 0—6.
72	50	0	0	177	3	1	Pipe sluice 9″ diameter.
73	50	4	330	109	2	1	Do.
74	51	4	0	464	8	1	1—6 × 0—9.
75	52	2	0	94	2	1	Pipe sluice 9″ diameter.
76	52	5	330	5,922	109	1	4—0 × 3—3.
77	53	0	0	210	4	1	Pipe sluice 9″ diameter.
78	53	1	330	209	4	1	Do.
79	54	1	330	22,685	416	4	4—0 × 3—3.
80	54	3	330	165	3	1	Pipe sluice 9″ diameter.
81	54	7	330	81	1	1	Do.
82	55	4	330	50	1	1	Do.
83	55	6	330	83	1	1	Do.
84	56	2	0	552	10	1	1—6 × 0—9.
85	56	6	0	136	2	1	Pipe sluice 9″ diameter.
86	57	1	0	437	8	1	1—6 × 0—9.
87	57	3	330	6,877	126	1	4—6 × 3—3.
88	57	5	600	618	11	1	1—6 × 1—0.
89	59	1	600	119	2	1	Pipe sluice 9″ diameter.
90	59	4	100	151	3	1	Do.
91	60	3	600	410	7	1	1—0 × 0—9.
92	61	2	450	4,418	77	1	4—0 × 3—0.
93	62	5	300	135	2	1	Pipe sluice 9″ diameter.
94	63	4	600	34,968	641	4	5—0 × 4—0.
95	65	1	150	206	4	1	Pipe sluice 9″ diameter.
96	66	1	300	54	1	1	Do.
97	67	0	550	385	7	1	1—0 × 0—9.
98	67	4	300	4,363	76	1	4—0 × 3—0.
99	68	0	300	245	4	1	Pipe sluice 9″ diameter.
100	69	1	150	283	5	1	1—0 × 0—6.
101	69	6	600	397	7	1	1—0 × 0—9.
102	70	4	300	1,934	34	1	3—0 × 1—6.
103	71	3	0	241	4	1	Pipe sluice 9″ diameter.
104	72	6	600	253	4	1	Do.
105	73	0	600	70	1	1	Do.
106	73	2	400	905	16	1	2—0 × 1—0.
107	74	0	250	509	9	1	1—6 × 0—9.
108	74	5	395	46,738	857	4	6—0 × 4—6.
109	75	1	555	290	5	1	1—0 × 0—6.
110	76	1	135	1,594	28	1	2—0 × 1—6.
111	77	7	475	863	15	1	2—0 × 1—0.
112	78	0	235	715	13	1	Do.
113	79	2	65	1,862	33	1	2—0 × 1—6.
114	79	6	475	578	10	1	1—6 × 0—9.
115	80	4	595	50	1	1	Pipe sluice 6″ diameter.
116	80	7	395	141	3	1	Pipe sluice 9″ diameter.
117	81	6	335	1,103	19	1	2—0 × 1—3.
118	83	7	395	290	5	1	1—0 × 0—6.
119	84	4	65	185	3	1	Pipe sluice 9″ diameter.
120	85	1	235	1,093	19	1	2—0 × 1—3.
121	86	5	475	294	5	1	1—0 × 0—6.
Tail Dam.	88	0	215	61	1	1	
Grand Total	..	..		207,520.			

Note.—Size of vents will be modified during execution, if necessary.

C. Distributaries.

41. The cost of distributaries in the estimate prepared in 1932 was worked out by estimating in detail one typical distributary, viz., the Unjalur listributary, about 19 miles long, in the first crop area. In view of the divergence in the supply conditions proposed in 1936 from those proposed in 1932, the figures of cost were worked out by estimating in complete detail two more typical distributaries, one from each crop area, namely, the Punduri distributary about 5 miles long taking off at M. 67–4–300 feet

48. *Plantations.*—A sum of Rs. 26,400 was provided for planting avenues along the 88 miles of main canal at the rate of Rs. 300 per mile and also a sum of Rs. 300 each for planting the eight inspection bungalow compounds. The provision has now been increased.

49. *Maintenance.*—A sum of Rs. 600 per mile was provided for maintaining the main canal and branches during construction up o 74 miles 6 furlongs of the main canal and Rs. 250 per mile for the portion beyond. A sum of Rs. 35,150 was allowed for the maintenance of permanent and temporary buildings. To suit current prices the provision has been increased.

50. *Special tools and plant.*—A lump sum of Rs. 18 lakhs has been allowed for.

SECTION V.

MATERIALS AND RATES.

51. *Headworks.*—Stone of suitable quality is available at the site within a reasonable distance. It has not been definitely decided to adopt open quarrying, as opposed to what may be called concentrated quarrying. Experience at Mettur has shown that the local contractor following his own crude methods can produce stone cheaper than it can be produced departmentally with deep holes drilled by compressed air. Probably the same fact will be evident at Bhavani dam site. Open quarrying involves an extensive tram line system and for Bhavani dam it has been assumed that the average lead for stone will be 5 miles and that the total length of track required to convey it to the dam will be 20 miles. The physical features at Bhavani dam site are not nearly so well marked as at Mettur and without further exploration with Calyx drills it is not possible to say which method will finally be followed. The rate allowed for stone is the same as that found workable at Mettur but an extra provision has been added to allow for opening out quarries and for further exploration. Haulage was allowed at anna 1 per ton per mile in 1936. This rate was based on Mettur experience but this needs increase with reference to current costs.

52. *Sand.*—Sand of fair quality is available in the river-bed. The intention is to collect sand direct from the shoals and convey it by light railway to central dumps on either flank or to one main dump if that is found more economical. The lead for sand is not determinable exactly but to be on the safe side, it has been assumed that 20 miles of track will be required to collect the requisite total quantity. When the masonry has risen, it will probably be necessary to restrict collection to shoals downstream of the dam; hence in the first years the upstream shoals will be worked and cleaned.

53. *Cement.*—A cement factory has been opened at Madukkarai about 6 miles from Coimbatore on an area adjoining the South Indian Railway. The cement will be conveyed by the South Indian Railway to a convenient point on the Coimbatore-Mettupalayam line where a siding and transhipping shed will be erected. From the transhipping point, a light railway or other means of transport will be provided to bring the cement to the dam. The length of this communication will be approximately 20 miles.

54. *Lime.*—Good lime is available at the dam site and it may be found economical and desirable to use it in case any trouble is experienced in the supply of cement. Unless the company offers to supply cement at concessional rates, it will be possible to build the whole of the dam except the deep river section in lime surki mortar. This will be a strong point in making terms with the cement company. For the purpose of the estimate it has been assumed that cement will be used for the whole dam; this is certainly desirable, but if the company refuses to adhere to an economic rate, it is satisfactory to know that there is a cheap and reliable substitute to fall back on.

55. The rates for the several items of works at the dam were worked out on the basis of the rates at Mettur and the following were the rates for some of the chief items :—

	Per unit. Rs. A. P.		Per unit. Rs. A. P.
Random rubble in cement 1 : 2½	33 12 0	Forming earthern bund including watering, consolidation, etc —	
Random rubble in cement 1 : 4	26 0 0	Hearting section	16 4 0
Random rubble in surki	18 8 0	Casing section	11 4 0

56. The rates provided in 1936 require complete revision now; the estimate has now been tentatively revised allowing percentage increase.

SECTION VI.

DIRECT AND INDIRECT CHARGES.

57. *Establishment.*—Provision was made in the original estimate for one Superintendent of works, four Executive Engineers and one Electrical Engineer with the requisite staff, etc., for them. This provision will require increase as the size of the reservoir and canal has now been increased and greater degree of mechanization is contemplated. An additional Superintending Engineer for civil work and machinery will be required as also one or two Executive Engineers solely for machinery with necessary mechanical staff. Provision in the total cost is made in the estimate abstract as a percentage. Provision for special allowance to the staff on the following basis is also necessary to ensure good progress on the work as proposed at the conference of Public Works Department and Chief Secretaries and Chief Engineers recently — ·

Superintending Engineers and Executive Engineers.	10 per cent.	When provided with rent-free quarters, free light and water, the rates will be 7½. 10 and 20 per cent.
Subdivisional Officers	15 ..	The travelling allowance will be 25 per cent over those for ordinary tracts. Allowances for small tracts declared by the Chief Engineer (Irrigation) as unhealthy will be paid in addition unhealthy allowances in the scale allowed to other Government servants.
Supervisors and other non-gazetted services subject to a minimum of Rs. 20.	30 per cent of their pay.	
Inferior services	30 per cent.	

58. *Tools and plant—Ordinary.*—This has been calculated at 2 per cent on the net cost of works.

59. *Receipts on capital account.*—This has been estimated at 3·20 lakhs being the probable realization on the sale of machinery, etc., on the close of the work.

60. *Abatement of land revenue.*—This is capitalized on the estimate of annual loss of land revenue at 20 years purchase and a lump sum provision of 1·75 lakhs has been allowed (·25 for head works portion and 1·50 lakhs for canal portion).

SECTION VII.

COST OF PROJECT, GROWTH OF IRRIGATION AND FINANCIAL DETAILS.

61. The following abstract shows the estimated expenditure on the Lower Bhavani Project classified according to sub-head :—

Lower Bhavani Project—Classified abstract.

Sub-head.	Name of work.	Amount of estimate for each sub-head.	Total of main head.
(1)	(2)	(3)	(4)
	1. *Headworks.*	Rs.	Rs.
A	Preliminary expenses	2,53,000	
B	Land	18,90,000	
C	Works	2,29,76,000	
K	Buildings	30,00,000	
O	Miscellaneous including water-supply (emergency and permanent), roads and other arrangements.	41,33,000	
Q	Special tools and plant including lorries and wagons for transport of materials, labour, etc.	50,00,000	
			3,72,52,000
	2. *Main canals and branches.*		
A	Preliminary expenses	2,25,000	
B	Land	8,50,000	
D	Regulators	1,22,800	
F	Cross drainage works	31,20,000	
G	Bridges	8,00,000	
K	Buildings	4,10,000	
L	Earthwork	87,00,000	
M	Plantations	64,000	
O	Miscellaneous	2,00,000	
P	Maintenance	1,80,000	
Q	Special Tools and Plant	18,00,000	
	3. Distributaries	..	1,64,71,800
	4 Drainage and Protective works	..	84,00,000
		..	4,25,000
	Total works ..		6,25,48,800

S. No.	Description of work.	Amount.
		RS.
I	Total works	6,25,48,800
II	Establishment including special and leave allowances and travelling allowances	52,00,000
III	Tools and Plant, ordinary about 2 per cent	12,64,000
IV	Pensionary charges	5,99,000
V	Audit and Accounts about 1 per cent	6,25,400
VI	Receipts on capital account	— 3,20,000
VII	Abatement of land revenue	1,75,000
	Total, direct and indirect charges ..	7,00,92,200 or Rs. 700 lakhs

62. *Construction programme and financial statement.*—Construction has been spread over a period of six years as shown below :—

	Direct capital outlay during the year.
	RS.
First year	20,00,000
Second year	50,00,000
Third year	1,50,00,000
Fourth year	2,00,00,000
Fifth year	1,50,00,000
Sixth year	1,28,25,000
	6,98,25,000 or 7,00,00,000

63. Irrigation will start from the fifth year of construction and the full extent will be reached in the ninth year of construction. The Irrigation Development Board meeting on 5th February 1936 resolved to recommend concessional water rate of half the amount in the first year, and three-fourths the amount in the second year on the area actually irrigated. From the third year onwards the full rate is to be charged on the entire area thrown open for irrigation. The Revenue receipts have been estimated on the above basis after allowing for maintenance charges at Re. 1–4–0 per acre and 5 per cent for collection charges.

64. For a return of 4 per cent on the project (as suggested by Government in Revenue Memorandum No. 490-H-47-1, dated 28th January 1947) on the sum at charge, rates of Rs. 18 per acre for cotton, Rs. 10 per acre for rice cultivation, and Rs. 7–8–0 per acre for irrigated dry crops, in addition to an inclusion fee from ryots at Rs. 100 per acre will be required, as shown in the tables (Appendix III attached). These are tentative and final decision will rest with Government, after obtaining the views of the Board of Revenue.

As stated in the concluding sub-paragraph of paragraph 12 above, the full area under the reservoir will be irrigable only in about 16 out of 27 years for which working tables were made out. In some of the remaining years, rationing will have to be resorted to while in the other years, there will be cultivation over half the area or no cultivation at all. Taking this into account, and with the rates and inclusion fees specified above, the return will get reduced to 3·4 per cent—vide letter No. 1081/44-B-55, dated 11th April 1947, in Appendix III (ii).

If water-rates, Rs. 15 for cotton, Rs. 9 for paddy and Rs. 6 for other dry crops are adopted and no inclusion fees are charged the return will be 2·04 per cent on the sum at charge, viz., 8·79 crores as per details in the Appendix III (iii).

The project has been sanctioned with a betterment tax of Rs. 100 per acre in G.O. No. 2844, Public Works, dated 19th September 1947 and the final financial forecast from the Board is awaited—Appendix III (iv).

65. The present report and estimates are based almost entirely on Mr. R. Narasimha Ayyangar's estimate of 1936—vide No. 3188/34-B.E.P., dated 14th September 1936.

A. R. VENKATACHARI,
Chief Engineer for Irrigation

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APPENDIX I.

LOWER BHAVANI PROJECT.

Estimate Form—Abstract.

HEAD WORKS—A. PRELIMINARY EXPENSES.

	LAKHS.
Cost of all investigation inclusive of all previous expenditure in original investigation.	RS. 2·53

B. LAND.

	RS.
Land acquisition inclusive of villages and temples submerged.	17,66,000
Add for land acquisition staff at 7 per cent	1,23,620
	18,89,620 or 18·90 lakhs.

C. WORKS.

Dam construction.

S. No.	Quantity	Description of work.	Rate	Per	Amount in lakhs.	
			RS.		RS	
	4,427	Benching, preparing foundations, etc.	15	Unit.	0·66	
	24,878	Random rubble in cement, 1 : 2¾	33¾	,,	8·40	
	80,662	Do. 1 : 4	26	,,	20·97	
	70,460	Do. 1 : 5	23	,,	16·21	
	43,980	Random rubble in surki mortar	18½	,,	8·14	
	586	Parapet wall with random rubble in surki mortar ..	18½	,,	0·11	
	1,239	Random rubble in cement mortar 1 : 2¾ for the top 3 feet in cement dam portion (difference between rates for 1 : 5 and 1 : 2¾ mix).	10¾	,,	0·13	
	1,364	Random rubble in surki portion (difference between rates for 1 : 2¾ and surki mortar).	15½	..	0·21	
	14,214	Up and down stream face finish	1	Unit.	0·14	
	L.S.	Cutstone archwork for construction sluices	L.S.	..	0·15	
	14,214	Pointing faces of dam with cement mortar	2	..	0·28	
	L.S.	Top of dam finish including cornice	..	..	0·57	
	6,445	Excavation in earth in loose soil	6	1,000 c.ft.	0·39	
	10,817	Excavation in soft rock	26	,,	2·81	
	24,016	Excavation in hard rock	8	100 c.ft.	1·92	
	19,664	Leading away spoil	5	,,	0·98	
	3,910	Earthwork for hearting of bund	15	1,000 c. ft.	0·59	
	6,934	Earthwork for casing of bund	10	,,	0·69	
	1,238	Excavation of puddle and bonding trenches	16	,,	0·20	
	1,238	Forming puddle and bonding trenches	19–11–0	100 c. ft.	0·24	
	6,007	Dry stone revetment for the bund	8½	,,	0·51	
	6,841	Preparing the existing surface for excavating to a depth of 1 foot for bonding the new bund with the old surface.	1	Unit.	0·07	
	10,844	Consolidating and watering the earth bund (3,910+ 6,934).	1¼	,,	0·14	
	L.S.	Connection of earthern and masonry dam	L.S.	..	0·10	
	6 Nos.	Construction of sluice shutters	10,000	Each.	0·60	
	L.S.	Cost, conveyance and erection of the low level sluices including extra masonry required as per separate details.	..	..	2·15	
		Cost, conveyance and erection of the high level sluices.	..	..	1·66	
		Diversion works at river bed	..	..	0·50	
		Work and maintenance of pumps at river bed	..	..	0·40	
		Closing construction sluices	..	..	0·10	
		Surplus arrangements over dam during construction	..	..	0·40	
		Protection for the river bed in rear of dam as may be found necessary.	..	..	0·40	
	3,000 Units	Extra mortar required for joining up the old work with the new during construction.	10	Unit.	0·30	
	L.S.	Boring and grouting operations for foundations ..	..	..	0·25	
	220,566	Extra for lifting charges	½	Unit.	1·11	
	L.S.	Expansion joints	..	..	0·50	
						72·98
		Surplus weir.				
Units.	165	Excavation in earth	6	Unit.	0·01	
	719	Excavation in soft rock	26	,,	0·19	
	847	Excavation in hard rock	8	100 c.ft.	0·07	
	425	Benching, preparing foundations, etc.	15	,,	0·06	
	7,587	Random rubble in surki mortar	18½	,,	1·40	
	690	Pointing faces with cement mortar	2	100 sq.ft.	0·01	
	690	Up and down stream face finish	1	,,	0·01	
	L.S.	Plastering the rear face and giving Ogee shape curve to the top for smooth flow.	..	..	0·10	
	L.S.	Protective works and foundations for leading channel ..	..	..	1·00	
						2·85
		Contingencies and petty supervision charges	..	..	3·77	3·77 lakhs
			Total	..		79·60

S. No.	Quantity. Units.	Description of work.	Rate Rs.	Per	Amount in lakhs. Rs.
		C. Works—*cont.*			
		Brought forward			79·60
		Increase required to suit current prices			119·40
		Increase due to raising F.R.L. to 915·00 and change of design.			55·76
		Total ..			254·76
		Approximate savings expected by use of machinery			25·00
		Total ..			229·76
		Low level supply Sluices.			Rs.
1	720 ..	Extra masonry stone in cement, mortar 1 : 5	25	Unit.	18,000
1A	650 ..	Do. 1 : 4	27	,,	17,550
2	L.S. ..	Cutstone arch work, cutstone in cement for floor, etc. ..	..	..	20,000
3	L.S. ..	Protective works in rear of channel	..	..	10,000
4	3 Nos. ..	Cost, conveyance and erection of sluice shutters, 7′ × 13′.	40,000	Each.	1,20,000
5	L.S. ..	Half cost of emergency shutters	..	..	22,000
6	L.S. ..	Contingencies and other incidental charges	..	..	7,450
		Total ..			2,15,000
		High level supply Sluices.			
1	L.S. ..	Cutstone archwork, cutstone in cement for floors, etc. ..	..	..	20,000
2	L.S. ..	Excavation of leading channel, etc.	..	..	5,000
3	3 Nos. ..	Cost, conveyance and erection of sluice shutters 7′ × 13′.	38,000	Each.	1,14,000
4	L.S. ..	Half cost of emergency shutters	..	..	22,000
5	L.S. ..	Contingencies and other incidental charges	..	..	5,000
		Total ..			1,66,000

Provision is made for 3 gates. Probably two larger gates for the high and low level gates would be cheaper. This will be decided during execution.

Note.—(1) Revised details will be worked out during execution.
(2) Quantities, etc., will be revised during execution.
(3) In arriving at the cost above, the probable increase in cost of construction due to change in design and the approximate savings due to extensive use of machinery are taken into consideration.

K. Buildings.

(*a*) *Employee housing for the various classes of employees (family type; non-family type or dormitory type—Numbers to be decided during construction according to requirements).*

S. No.	Quantity.	Description of work.	Rate. Rs.	Per.	Amount. Rs.
1	1 No.	Quarters for Superintending Engineer	30,000	Each.	30,000
2	5 Nos.	Quarters for three Civil Executive Engineers and two Mechanical Executive Engineers.	20,000	,,	1,00,000
3	18 ,,	Quarters for Assistant Engineers	10,000	,,	1,80,000
4	1 No.	Quarters for Electrical Engineer	20,000	,,	20,000
5	1 ,,	Quarters for Health Officer	10,000	,,	10,000
6	1 ,,	Quarters for Medical Officer	10,000	,,	10,000
7	1 ,,	Quarters for Lady Assistant Surgeon	10,000	,,	10,000
7	50 Nos.	Quarters for high grade subordinates such as Supervisors. Accountants, Head Clerk, Police officers (family type).	4,000	,,	2,00,000
8	200 ,,	Quarters (family type) "and non-family (bachelors) dormitory type" for lower grade subordinates and work establishment such as drivers, mechanics and chargemen	3,000	,,	6,00,000
9	100 ,,	Quarters for maistris	1,500	,,	1,50,000
10	100 ,,	Quarters for peons	1,000	,,	1,00,000
11	20 ,,	Quarters for scavengers	500	,,	10,000
12	L.S. ..	Buildings for Cafeteria, hotel, cinema and other miscellaneous quarters and additional quarters.	L.S.	..	3,00,000
		(*b*) *Civic group of buildings.*			
13	1 No.	Buildings for school	20,000	Each.	20,000
14	1 ,,	Hospital buildings	30,000	,,	30,000
15	4 Nos.	First aid centre	3,000	,,	12,000
16	1 No.	Police station and treasury	20,000	,,	20,000
17	1 ,,	Fire station	8,000	,,	8,000
18	1 ,,	Post and Telegraph office	10,000	,,	10,000
19	1 ,,	Market	10,000	,,	10,000
20	L.S.	Provision, crockery, drug stores, dairy and miscellaneous store, buildings, barbers shop, laundry	L.S.	..	50,000
		(*c*) *Stores and workshop buildings.*			
21	10 Nos.	Store shed of different kinds	10,000	Each.	1,00,000
22	1 No.	Workshops and power-house	1,00,000	,,	1,00,000
23	4 Nos.	Transport vehicle and machinery depots	L.S.	..	25,000
24	1 set.	Laboratories of different kinds	40,000	1 set.	40,000
25	L.S. ..	Extra for other similar buildings if necessary	L.S.	..	50,000
		(*d*) *Administration block.*			
26		(1) Office block of different kinds, Control office buildings, Field office. (2) Propaganda and Information office buildings .. (3) Other similar buildings	L.S.	..	1,00,000

No.	Quantity.	Description of work.	Rate. Rs.	Per.	Amount. Rs.
		K. Buildings.—*cont.*			
		(*e*) *Rest-house buildings.*			
27	1 No.	Circuit house	25,000	Each.	25,000
28	2 Nos.	Rest-house	15,000	,,	30,000
29	10 ,,	Rest and tourist sheds—Dormitory type	2,500	,,	25,000
		(*f*) *Workmen's quarters and labour colony.*			
30	1,000 Nos.	Coolies' huts	500	Each.	5,00,000
31	L.S. ..	Health and Sanitary units	L.S.	..	20,000
32	L.S. ..	Maintenance charges for three years	..	..	1,05,000
		Total ..			30,00,000
		O. Miscellaneous.			
1	20 miles.	Light Railway to connect with main line—Cost of embankment including light bridges, etc.	..	..	3,00,000
2	L.S. ..	Pumping stations for supplying water to locos on route.	..	..	25,000
3		Road crossings	..	..	25,000
4		Sidings at main line junction	..	..	15,000
5		Bridge over Ellerumai Pallam	..	..	60,000
6	5 years ..	Maintenance of light railway	..	..	2,00,000
7		Improvements to the road from Satyamangalam to Pungar and dam line north end.	..	..	1,00,000
8		Improvements to the road from Goddapalayam to Dam site and to Mettupalayam.	..	..	2,00,000
9		Constructing bridge across the Bhavani below Dam site (length 400 feet).	..	..	4,00,000
10		Constructing access roads within headworks	..	..	2,00,000
11		Maintenance of all roads for five years	..	..	1,00,000
12		Telephone from Mettupalayam to Dam site	..	..	37,000
13		Telephone within headworks	..	..	12,500
14		Drainage, sanitation and medical requirements ..	..	..	5,00,000
15		Water-supply, maintenance charges for 300,000 gallons per day for 5 years.	..	..	2,50,000
16		Installation of water-supply, etc., including emergency water-supply.	..	..	5,00,000
17		High tension line from Karamadi to Dam site	..	..	3,00,000
18		High tension wiring at headworks	..	..	37,500
19		Wiring bungalows, offices, etc.	..	..	25,000
20		Maintenance charges for fans, lights at 2 per cent of above items for 5 years.	..	..	10,000
21		Ice plant	..	..	25,000
22		Testing machines and equipment	..	..	50,000
23		Maintenance of tram line within headworks	..	..	1,25,000
24		Power charges for the whole period of 4 years at 24 days in the month.	..	..	5,20,000
25		Items unforeseen	..	..	1,16,000
		Total ..			41,33,000
		Special Tools and Plant.			
		1. *Automotive.*			
1	20 Nos.	Trucks commercial—Lorries and trailors, transport wagons and staffcars for materials and personnel.	10,000	Each.	2,00,000
2	10 ,,	Lorries—Heavy dump 4 to 6 cubic yards	15,000	,,	1,50,000
		Tractors and Track Trucks.			
3(*a*)	2 Nos.	D_7 Tractor			
(*b*)	2 ,,	D_8 Tractor	30,000 (average).	Each.	1,80,000
(*c*)	2 ,,	D_4 Tractor			
4	12 Nos.	Locos—Diesel	24,000	,,	2,88,000
5(*a*)	50 ,,	Wagons—3 cubic yards	700	,,	35,000
(*b*)	200 ,,	Wagons—2 cubic yards	550	,,	1,10,000
(*c*)	400 ,,	Wagons—1 cubic yard	360	,,	1,44,000
6	20 ,,	Platform wagons and bogies	600	,,	12,000
7	50 miles.	Tram line track complete	20,000	Mile.	10,00,000
		2. *Excavation equipment in rock.*			
8	3 Nos.	Air compressors—Portable—315 c.ft.	30,000	Each.	90,000
	L.S.	Accessories to Air compressors—Portable—315 c.ft.—Pneumatic tools line—wagon drills (6), rock and hammer or tripod drills (6), jack hammers (20), drill sharpener with oil furnace, quenching tank, etc., (4), Dump pumps, vibrators, tampers and other kinds of air equipment	..	,,	1,30,000
9	2 Nos.	Air compressor—Stationary 2,000 c.ft.	1,30,000	Each.	2,60,000
10	4 ,,	Disintegrators	3,500	,,	14,000
11	4 ,,	Crushers of different types and capacities—15 tons per hour (average).	25,000	,,	1,00,000
12	6 ,,	Calyx and other types of drills	30,000	,,	1,80,000
		3. *Hoisting equipment.*			
13	2 Nos.	Derricks	40,000	Each.	80,000
14	4 ,,	Cranes (Power driven)	5,000	,,	20,000
15	5 ,,	Cranes (Hand operated)	5,000	..	25,000
16	6 ,,	Overhead cranes of different capacities, 10, 5 and 3 tons.	2,500 (average)	Each.	15,000
17	6 ,,	Power hoist and winches	15,000	,,	90,000

S. No.	Quantity.	Description of work.	Rate. Rs.	Per.	Amount. Rs.
		SPECIAL TOOLS AND PLANT—*cont.*			
		4. Excavating equipment.			
18	2 Nos.	Excavators, 2½ cubic yards capacity	2,50,000	Each.	5,00,000
19	6 ,,	Bull and angle dozers for D_7, D_6 and D_4	6,000	,,	36,000
20	2 ,,	Rollers (4 to 6 tons)	15,000	,,	30,000
		5. Electrical and unwatering equipment.			
21	50 Nos.	Pumps of different sizes, 12″, 8″, 5″, 4″, 3″ and 2″ ..	L.S.	..	3,00,000
22	50 ,,	Motors A C of different sizes	5,000 (average)	Each.	2,50,000
		6. Concreting.			
23	5 Nos.	Mixers—Portable	12,000	Each.	60,000
24	5 ,,	Grouting machines, high and medium pressure ..	20,000	,,	1,00,000
25	2 ,,	Cement guns	9,000	,,	18,000
		7. Miscellaneous.			
26	..	Aerial cableway, conveyors and whirler cranes ..	L.S.	..	1,00,000
27	4 Nos.	Weighing machines	L.S.	..	6,000
28	..	Motor boats, boats with outboard motors etc. ..	L.S.	..	25,000
29	1 set.	Workshop equipment (comprising lathes, boring, milling, planing, shaping, grinding, drilling and gear cutting machines, smithy equipment moulding and welding, etc.)	L.S.	..	3,00,000
30	..	Spares for tools and plant	L.S.	..	1,52,000
				Total ..	50,00,000

Note.—Details shown in the list are liable to modification.

Estimate Form—Abstract—Classified.

Sub-head.	Name of work.	Amount of estimate for individual works.	Total of sub-heads.	Total for each canal or distributary.	Total of each main head.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	LOWER BHAVANI PROJECT.					
	I. WORKS.					
	1. Headworks.					
A	Preliminary expenses	Rs. 2,53,000	Rs. 2,53,000			
B	Land	18,90,000	18,90,000			
C	Works	229,76,000	229,76,000			
K	Buildings	30,00,000	30,00,000			
O	Miscellaneous including water-supply* and roads and other arrangements.	41,33,000	41,33,000			
Q	Special tools and plant including lorries, transport wagons, etc.	50,00,000	50,00,000			
	Total 1. Headworks ..				3,72,52,000	
	* Emergency and permanent.					
	2. Main canals and branches.					
A	Preliminary expenses—					
	Share of cost of original surveys ..	25,000				
	Surveying and tracing out the main canal and other unforeseen expenses.	2,00,000	2,25,000			
B	Land—					
	Land compensation for main canal ..	7,30,600				
	Land for inspection bungalows 8 in number.	48,000				
	Revenue establishment for the above.	71,400	8,50,000			
	M. F. FT.					
D	Regulators—					
	Regulators at 33 4 80	31,000				
	Do. 53 7 150	31,000				
	Do. 56 1 230	31,000				
	Do. 63 5 90	15,500				
	Do. 73 2 610	14,300	1,22,800			
F	Cross Drainage works—					
	Aqueduct at 0 6 330	49,500				
	Drainage culvert at .. 1 2 330	22,500				
	Do. 2 2 190	19,000				
	Aqueduct at 3 5 540	94,500				
	Drainage culvert at .. 4 2 190	52,500				
	Do. 4 6 185	5,000				
	Do. 6 0 415	9,000				
	Do. 7 1 280	10,500				
	Aqueduct at 7 6 310	50,500				

Sub-head.	Name of works.	M.	F.	FT.	Amount of estimate for individual works. Rs.	Total of sub-heads.	Total for each canal or distributary.	Total of each main head.	Remarks.
(1)	(2)				(3)	(4)	(5)		(7)
	I. WORKS.—*cont*								
	2. Main canals and branches—cont.								
F	Cross Drainage works—*cont.*								
	Drainage culvert at ..	8	7	595	7,500				
	Do.	9	7	385	9,000				
	Do.	10	2	406	33,500				
	Do.	11	5	550	22,500				
	Aqueduct at	12	6	230	1,22,000				
	Do.	13	1	475	1,15,000				
	Syphon at .. .. (for carrying Ukkaram tank water.)	13	4	200	3,000				
	Drainage culvert at ..	14	4	501	19,000				
	Aqueduct at	15	7	542	1,49,000				
	Drainage culvert at ..	16	6	495	9,000				
	Do.	17	6	500	22,500				
	Do.	18	7	362	9,000				
	Syphon aqueduct at ..	19	6	97	84,500				
	Syphon at .. .. (for carrying Elathur tank water.)	20	1	100	3,000				
	Drainage culvert at ..	21	2	230	19,000				
	Do.	21	6	186	19,000				
	Do.	23	2	160	9,000				
	Do.	24	2	255	7,000				
	Aqueduct at	26	4	155	63,000				
	Drainage culvert at ..	27	1	498	22,500				
	Do.	28	4	30	14,500				
	Syphon aqueduct at ..	30	0	0	58,000				
	Aqueduct at	31	3	420	59,000				
	Drainage culvert at ..	32	4	315	52,500				
	Do.	33	0	490	9,000				
	Do.	33	7	340	9,000				
	Do.	34	2	195	22,500				
	Do.	34	7	478	22,500				
	Aqueduct at	36	2	470	91,500				
	Drainage culvert at ..	37	4	250	9,000				
	Syphon aqueduct at ..	39	0	495	55,000				
	Drainage culvert at ..	40	1	390	24,500				
	Do.	41	2	50	9,000				
	Do.	41	5	78	14,000				
	Do.	42	2	470	9,000				
	Do.	43	0	250	33,500				
	Aqueduct at	44	0	220	84,500				
	Drainage culvert at ..	44	3	280	33,500				
	Do.	44	7	25	52,500				
	Aqueduct at	46	0	200	1,02,500				
	Drainage culvert at ..	46	3	370	22,500				
	Do.	47	4	40	6,500				
	Do.	49	5	60	19,000				
	Do.	50	1	450	7,000				
	Do.	50	6	200	33,500				
	Aqueduct at	51	1	60	96,000				
	Do.	51	7	400	58,000				
	Drainage culvert at ..	52	3	270	9,000				
	Do.	53	5	0	6,500				
	Aqueduct at	55	1	165	43,500				
	Do.	56	0	0	90,500				
	Drainage culvert at ..	57	3	520	9,000				
	Do.	58	2	120	9,000				
	Do.	58	5	450	9,000				
	Drainage culvert at ..	59	0	600	9,000				
	Syphon aqueduct at ..	59	3	540	43,000				
	Drainage culvert at ..	60	2	480	22,500				
	Do.	60	5	70	19,000				
	Aqueduct at	61	4	200	83,000				
	Drainage culvert at ..	62	0	160	9,000				
	Do.	62	2	0	33,500				
	Do.	63	2	280	19,000				
	Half cost of drainage and Railway culvert.	63	3	280	29,500				
	Canal Syphon at ..	64	6	500	55,000				
	Drainage culvert for the supply channel to Sinnakulam tank.	65	4	0	9,000				
	Syphon culvert at ..	66	4	260	34,000				
	Aqueduct at	68	2	450	54,500				
	Drainage culvert at ..	68	6	440	9,000				
	Aqueduct at	69	6	0	45,000				
	Drainage culvert at ..	70	7	660	9,000				
	Aqueduct at . ..	71	5	150	48,500				

Sub-head.	Name of work.			Amount of estimate for individual works.	Total of sub-heads.	Total for each canal or distributary.	Total of each main head.	Remarks.
(1)	(2)			(3)	(4)	(5)	(6)	(7)
				I. WORKS.—*cont*				
				2. *Main canals and cranches*—cont.				
F	Cross drainage works—*cont.*							
		M.	F. FT.	RS.		RS.		
	Drainage culvert at ..	72	1 580	9,000				
	Do.	72	3 480	9,000				
	Do.	72	5 560	9,000				
	Do.	72	7 500	9,000				
	Under tunnel at.. ..	75	3 135	2,800				
	Drainage culvert at ..	76	1 595	9,000				
	Under tunnel at ..	76	5 335	2,800				
	Do.	78	4 395	2,800				
	Aqueduct at	79	4 395	72,500				
	Syphon at	80	1 595	2,800				
	Drainage culvert at ..	80	5 555	4,000				
	Do.	81	0 515	4,000				
	Syphon	81	4 595	4,000				
	Do.	82	7 15	3,500				
	Do.	83	4 475	3,500				
	Do.	84	2 335	3,500				
	Under tunnel	84	5 595	3,500				
	Do.	85	4 235	2,000				
	Do.	85	7 635	2,000				
	Do.	86	1 475	2,000				
	Do.	87	0 395	2,000				
	Do.	87	3 135	2,000				
	Diverting minor streams			1,78,300				
	Total cost			31,20,000				
						31,20,000 *		
G	Bridges—							
	Bridge at	0	4 166	14,500				
	Do.	1	3 54	14,300				
	Do.	4	6 200	14,200				
	Do.	3	2 0	20,500				
	Do.	6	1 480	14,900				
	Do.	7	6 230	25,800				
	Do.	9	3 225	20,200				
	Do.	10	4 460	20,100				
	Do.	11	4 460	13,900				
	Do.	13	1 205	22,900				
	Do.	14	4 165	18,500				
	Do.	15	5 99	13,900				
	Do.	16	5 165	14,000				
	Do.	17	4 100	6,000				
	Do.	18	5 330	7,100				
	Do.	19	2 60	14,700				
	Do.	20	6 165	14,400				
	Do.	22	0 105	13 900				
	Do.	22	5 330	7,100				
	Do.	25	2 595	14,400				
	Do.	26	3 560	25,600				
	Do.	29	1 25	19,800				
	Do.	29	6 495	14,700				
	Do.	31	5 165	14,700				
	Do.	33	1 165	14,200				
	Do.	34	3 250	19,100				
	Do.	35	7 0	14,700				
	Do.	37	1 420	15,200				
	Do.	39	5 620	20,900				
	Do.	42	5 300	14,000				
	Do.	44	6 25	14,200				
	Do.	45	2 0	7,100				
	Do.	46	7 450	14,000				
	Do.	49	4 50	14,200				
	Do.	50	3 380	13,900				
	Do.	51	0 50	14,400				
	Do.	53	0 380	18,800				
	Do.	54	3 480	13,500				
	Do.	55	3 180	14,000				
	Do.	56	5 225	14,000				
	Do.	57	4 270	19,800				
	Do.	59	1 460	14,000				
	Do.	60	3 560	9,100				
	Do.	63	2 610	13,300				
	Half cost of drainage and Railway culvert at.	63	3 280	29,800				
	Bridge at	64	0 630	11,300				
	Do.	65	2 590	15,700				
	Do.	66	7 430	17,400				
	Do.	69	1 110	10,200				

* Revised details will be worked out during execution the amounts against individual items are subject to variatio

Sub-head.	Name of work.			Amount of estimate for individual works.	Total of sub-heads.	Total for each canal or distributary.	Total of each main head.	Remarks.
1)	(2)			(3)	(4)	(5)	(6)	(7)
				I. WORKS—*cont.*				
				2. *Main canals and bridges* - cont.				
				G. Bridges—*cont.*				
		M.	F. FT.	RS.	RS.		RS.	
	Bridge at	71	2 580	9,900				
	Do.	75	0 395	2,300				
	Do.	75	4 395	2,300				
	Do.	76	0 55	5,200				
	Do.	77	7 535	2,300				
	Do.	78	4 135	2,300				
	Do.	78	5 555	2,300				
	Do.	79	2 355	1,800				
	Do.	79	6 435	1,800				
	Do.	80	0 335	1,800				
	Do.	80	4 635	1,800				
	Do.	81	5 395	1,800				
	Do.	82	2 515	1,800				
	Do.	83	6 135	1,800				
	Do.	84	4 555	3,300				
	Ramp at	85	1 335	150				
	Do.	85	4 595	150				
	Do.	86	3 135	150				
	Do.	86	6 335	150				
				8,00,000	or 8,00,000 *			
K	Buildings—							
	Two Executive Engineers' quarters with outhouses, etc., complete.			40,000				
	Six Assistant Engineers' quarters with outhouses, etc., complete.			60,000				
	Offices of the Executive Engineers and Assistant Engineers.			20,000				
	Twenty-six subordinates' quarters ..			78,000				
	Stores and Telegraph offices			20,000				
	Hutting labour wherever necessary ..			20,000				
	Eight Inspection bungalows with out-houses.			1,20,000				
	Quarters for regulating establishment and Lascars' sheds.			52,000	4,10,000*			
L	Earthwork—							
	Excavating main canal 88 miles including widening down to 56 miles.			1,00,00,000	1,00,00,000			
M	Plantations—							
	Planting along main canal from head to M. 74–5–395.			49,000				
	Planting along main canal from M. 74–5–395 to 88–0–215.			8,500				
	Planting eight inspection bungalow compounds.			6,500	64,000			
O	Miscellaneous—							
	Fixing mile and furlong stones ..			11,000				
	Constructing sluices			1,89,000	2,00,000			
P	Maintenance—							
	Maintaining main canal up to M. 74–5–395.			97,000				
	Maintaining main canal from M. 74–5–395.			7,200				
	Maintaining temporary buildings at 5 per cent for five years.			55,000				
	Maintaining permanent buildings at 2½ per cent for five years.			20,800	1,80,000			
Q	Special Tools and Plant—							
	Special tools and plant including purchase of excavators, dozers, etc.			18,00,000	18,00,000		1,77,71,800	
	Deduct for Savings due to use of machinery.			....	13,00,000		13,00,000	
	Net Total ..			....	....		1,64,71,800	
				3. *Distributaries*..				
	Excavating distributaries for irrigating the total ayacut at 60 duty.			84,00,000	84,00,000		84,00,000	
				4. *Drainage and protective works.*				
	Drainage and protective works			4,25,000	4,25,000		4,25,000	
	Total I. Works ..						6,25,48,800	

* Revised details will be worked out during execution ; the amounts against individual items are subject to variation.

APPENDIX II—GEOLOGICAL REPORTS OF DAM SITE.

Bhavani Project.

(a) Report of Mr. Holland.

Report on the geological structure of the sites proposed for the dam.

The sites suggested for a dam across the Bhavani valley lie from 4 to 8 miles west of Satyamangalam in the Coimbatore district, and just below the junction of the Moyar with the Bhavani river.

The prevalent rocks in this particular part of the valley are biotite-gneisses of a type generally regarded to be the oldest members of the Archæan group of crystalline rocks. With the biotite-gneisses there occur bands of hornblende schist, quartzites, quartzfuchsite schists, quartz iron-ore schists and members of the charnockite series which have been considerably altered.

The gneisses and schists of the Bhavani valley being situated between two great masses of strong, homogeneous charnockites—the Nilgiris and the Bargur hills—have noticeably suffered severely from the crushing effects of earth-movements; but as all such movements ceased in South India early in palæozoic times, when these rocks were deeply buried, the cracks and faults in the gneisses have been completely healed, and their present crushed appearance, due to the preservation of the old scars, is more apparent than real; the gneisses, for all practical purposes are now as firm as they would have been if they had escaped deformation.

The principal points kept in view whilst examining the proposed sites were—

(1) The distance from the surface of the fresh unweathered rock.

(2) The probable rapidity of alteration on exposure of the fresh rock to the new conditions near the dam foundations.

(3) The direction and character of the younger joint planes which would permit percolation of water under pressure.

(4) The coincidence of junction planes between adjoining large formations with areas of high pressure under the dam, and the consequent possibility of differential settlement in the foundations.

(1) The first point had been very thoroughly investigated by the officers of the Public Works Department before the time of my visit, and the detailed report by Mr. Malet shows the depth of subærial decomposition at numerous points along each of the proposed sites. It was on account of the great thickness of the soft, weathered rock that the site A.B., first selected, was afterwards condemned. Besides the great depths to which the weathering agents have penetrated in the region of the A.B. site, the excavations made to the south of the river cut an intrusion of the peculiar decomposed dunite with magnesite which is now known in so many isolated patches in South India. Their soft, irregular nature and the readiness with which these rocks (the dunites) lend themselves to hydrous decomposition render them quite unfit for the foundations of a large dam. There is, therefore, in this discovery an additional reason for abandoning the A.B. site, and I entirely agree with the general opinion of the Engineering officers as to its unsuitability.

(2) With the exception of the dunite referred to in connection with the abandoned A.B. site, there are no rocks in the valley noticeably liable to rapid alteration on exposure to the weather or water. The second consideration needs, therefore, no further discussion.

(3) The display of the old fracture scars and the strongly marked foliation of the biotite-gneisses have given rise to ill-founded suspicions as to their stability. Microscopic sections across the fracture planes show the rocks to be completely re-cemented by crystalline material, and to be just as firm now as if they had never suffered any crushing in the past. Similar remarks apply to the foliation planes, which, at the G.H. site, strike nearly east and west, or at right angles to the alignment of the dam. It has been suggested that such a disposition of the foliation planes parallel to the river bed and across the line of the dam will facilitate the percolation of water under the dam; but it should be remembered that though the disposition of the constituent minerals, especially of the mica scales, in bunds permits an easy clearage of isolated fragments along the foliation planes, these planes are perfectly closed up in the rock mass. The tendency to easy clearage, due to the thin films of mica principally, is quite consistent with the absence of actual open fissures in the rock mass. The principal channels for percolation would be along the younger joint planes which occur as frequently across as along the foliation, and in this particular respect the biotite-gneiss is as sound as most rocks, whilst its composition is unfavourable to any form of solution in water which would tend to widen such joint planes and convert mere cracks into open fissures. I do not consider, therefore, that the direction of the foliation planes can be fairly offered as an objection to the G.H. site.

(4) The disposition of the garnetiferous basic rock (garnetiferous amphibolite) forming the small hills along the site C.D. illustrates the fourth point in which the geological features of the site are of importance. It was thought, apparently, that this garnetiferous rock (amphibolite) formed a continuous band along the central portion of the C.D. site; but excavations made at the point where the C.D. line crosses the Bhavani river reveal the ordinary biotite-gneiss on the left (N.) bank of the river, whilst the amphibolite is found to strike across at a higher point. On following the C.D. line towards C, the amphibolite is again met with,

and then continues as a ridge for over half a mile in the west-north-west direction, that is, parallel to the direction of the similar ridge on the right (S.) bank of the river, but not exactly in line with it; the two ridges are in fact arranged en echelon and the two bands of amphibolite are thus not actually continuous with one another. Either they are parts of a band dislocated by a fault plane near and parallel to the river, or, which is more likely from what we know of the habits of this peculiar rock, the two bands are separate, lens-shaped intrusions into two fissures parallel to one another and coincident with the foliation planes in the gneiss. This view is shown on the accompanying geological map.

Usually the lenticular bodies which this rock habitually forms in South India are stouter and more convex, more definitely lens-shaped in fact. But in the Bhavani Valley they have been flattened out by the same earth-movements which have so intensely foliated the associated gneisses, and this fact I did not fully appreciate until I had examined the rocks microscopically. However, the correct geological interpretation of these phenomena is of less importance for the present than the actual fact that at this point, the most critical point in the C.D. site, there is a double geological change, first from amphibolite to biotite-gneiss and, in a short distance, back again to the amphibolite band. Both the amphibolite and the biotite-gneiss would be sufficiently superior to all that will ever be required of them in this respect, that the possibility of differential settlement due to the weight of the dam need scarcely be discussed; but where the water pressure will be so great as it will be at this the deepest point in the reservoir, and where, in fact, all the enemies to its stability will act with maximum effect on the dam, I should consider it advisable, when possible, to avoid building across the junction planes of two dissimilar geological formations.

In the case of the Bhavani project the existence of an alternative site at G.H. offers a means for avoiding this form of danger. Reference to the map will show that along the G.H. line there is also a change in the geological formation, but the change is between two rock groups which, differ merely in structure, not in mineral composition; the differences between gneissose granite and a biotite-gneiss of the old type in South India, though of theoretical interest to the geologist, are of no importance from the Engineering standpoint. But in this instance, the change of formation occurs at a point in the G.H. line which is at a higher comparative level than the double and more serious change which has just been referred to in connection with the C.D. site.

From the geological standpoint, therefore, I would give a vote in favour of G.H., but it is only fair to state that had C.D. been the only site available I should not consider the change from biotite-gneiss to amphibolite sufficiently important to justify a protest against its selection. At the same time, when another good site is available without any apparent drawbacks, I should, as a matter of principle, decide in favour of the latter.

There is one point on which a brief explanation is due to the members of the committee who favoured the selection of the C.D. site. When going over the ground I noticed that the margins of the amphibolite lenses showed signs of alteration by dynamical metamorphism, but did not fully appreciate the fact that such an alteration had extended to the centre of the mass until the specimens collected had been prepared for microscopic examination. I expected, consequently that the rock of the ridges would be highly jointed until Mr. Larminie showed, by excavations made on the Pungur hill, south of the river, that the amphibolite was far more massive than I had expected. The point which I raised in committee, namely, that the jointed rock of the ridges would permit free percolation, must therefore be withdrawn. The amphibolites are, I find, slightly decomposed with formation of carbonate of lime, and they contain also considerable quantities of apatite (phosphate of lime), but the proportions of these minerals do not attain anything near a dangerous degree.

Calcutta,
1st April 1899.

(Signed) T. H. HOLLAND,
Deputy Superintendent, Geological Survey of India.

Report of Committee, dated 10th January 1900.

In accordance with G.O. No. 907, Irrigation, dated 19th November 1898, approving the appointment of a committee consisting of the Chief Engineer, Chief Engineer for Irrigation, the Superintending Engineer, and Mr. Holland, of the Geological Survey of India, to examine the proposed site for the Bhavani dam known as the G.H. site and report on the suitability of the rock as a foundation for the dam at the levels shown in the section prepared by Mr. Malet, Executive Engineer, the members of the committee have inspected the site. The undersigned members of the committee are satisfied that there is suitable rock for foundations everywhere along the line of the dam and that its level is represented in the section with sufficient correctness to allow of a reliable estimate being made of the quantities of work. Mr. Holland's report on the geological character of the rock on which it is proposed to build is appended

(Signed) W. B. deWINTON,
Chief Engineer.
(Signed) A. H. GARRETT,
Superintending Engineer.
(Signed) W. HUGHES,
Chief Engineer for Irrigation.

(b) Report by Dr. C. S. Fox, Superintendent, Geological Survey of India.

I. The question of a storage dam for an irrigation reservoir in the Bhavani valley, near the confluence of the Moyar and Bhavani rivers (about 11°–28'; 77°–6') was first brought to the notice of the Geological Survey of India on the 16th November 1898, on the receipt of the following telegram (dated 15th November) from the Irrigation Branch, Public Works Department, Madras Government:—

> "Number 39 Am directed to ask that Mr. Holland be allowed to inspect site of Bhavani reservoir in company with engineers and report on certain questions. He is willing to come December Trip will take within a week."

II Mr. T. H. Holland (now Sir Thomas Holland, K.C.S.I.), who was engaged in geological work in the Madras Presidency at the time made the necessary examination in December 1898. His report was forwarded to the Chief Engineer (Irrigation Branch), Public Works Department, Madras, on the 2nd May 1899, and was published in G.O. No. 81, I., dated 24th January 1900, by the Government of Madras (Public Works Department, Irrigation).

III. Sir Thomas Holland (Mr. Holland as he then was) gives a perfectly clear and reasoned statement of two suitable sites—CD site most favoured by the engineers from the point of view of superior command and cheapness of construction, and GH site as an alternative position favoured by Mr. Holland from a geological standpoint but known to be less attractive otherwise.

IV. Although Sir Thomas Holland while discussing the broader details of the two sites—CD and GH—carefully notes that the former alignment was fairly coincident with a band of basic (amphibolite) rocks and fairly parallel with the foliation planes of the gneisses whereas in the GH site the line of the dam would be at right angles to the gnessic foliation planes. He did not consider this any serious disadvantage for the GH site, but he was uncertain whether considerable leakage might not take place along the junction planes between the basic rocks and the gneisses in the CD alignment. He wrote—

> "From the geological standpoint, therefore, I would give a vote in favour of G.H., but it is only fair to state that had C.D. been the only site available I should not consider the change from biotite-gneiss to amphibolite sufficiently important to justify a protest against its selection. At the same time, when another good site, is available without any apparent drawbacks, I should, as a matter of principle, decide in favour of the latter."

V. After the above report was received the committee of the day accepted the G.H. site as final for the Bhavani Project as it stood in 1900. However, the scheme appears to have been shelved since for nearly 30 years, but has been actively revived by the Government of Madras, Public Works and Labour Department, in a letter (No. 2554-D/33-1, dated 5th July 1933) to the Government of India, Department of Industries and Labour, Simla, asking for a re-examination of the CD site as the Chief Engineer for Irrigation, Madras, prefers it.

VI. I was deputed in October 1933, to make the necessary re-examination of the CD site, and made my investigation on the 2nd November. The exact alignment of the proposed dam is seen in the plans. Pits and trenches had been made to reveal the rock junctions between the amphibolite and the gneisses mentioned in Mr. Holland's report. Accompanied by Mr. C. T. D'Silva, Subdivisional Officer, Siruvani Dam Works, I examined the site, the pits and trenches, and the belt of rocks below the line of dam about Pungar (11°28; 77°7).

VII. I found that the amphibolite (and garnetiferous amphibolite) occurs in several places in a belt a mile wide. There are distinct bands, evidently ancient basic intrusions in the biotite-gneisses, but they are now truly a part of the gneisses. They have largely resisted foliation but are nevertheless of an age so early that they have been thoroughly incorporated in the gneisses and are partially foliated. Furthermore, lenticles of quartz and veins of pegmatitic material obliquely traverse both the gneisses and the amphibolite bands. These veins etc., are free of any trace of foliation and are consequently much younger than the rocks in which they occur. These observations and the fact that open fissures do not appear to extend downwards to any great depths show that geologically, the site CD is quite satisfactory from the evidence available.

VIII. The most important part of the site, at the Bhavani river and to the north of it for some distance, between B.M. 9 and B.M. 11 is obscured by alluvium. Rock is known to be present at relatively shallow depths but I was not able to see any except at one point just upstream of the alignment. I think this section of the alignment, between B.M. 9 and B.M 11, should be examined by drilling both along and across the alignment within the limits of the foundations of the dam. I have seen no evidence to show that open fault planes may be encountered. This matter had already been dismissed in Sir Thomas Holland's report. Nevertheless systematic core drilling should be done on this river and alluvial section of the dam to ascertain the nature and depth of the solid rock.

IX. The fact that the foliation planes are nearly coincident with the greater part of the alignment CD and that there is no reason to suspect less water-tightness along these planes than elsewhere renders this site quite satisfactory in this respect. Added to this advantage the foliation planes are steeply inclined southward, i.e., with high dips upstream, so that the structural features of the site are good. And with the evidence now available from the

numerous pits and trenches which have been made to clear up those points raised in Sir Thomas Holland's valuable report, I would choose site OD in preference to any other in this part of the Bhavani valley.

X. I understand that a large part of the dam is to be an embankment of earthwork. It is therefore necessary to say that I saw no suitable clayey material which would do for this purpose. It will be difficult to find such clayey material in this part of the country, and for this reason I think the idea of earthwork embankment anywhere between B.M. 4 and B.M. 16 will prove unreliable and porous. Stone is abundant and a masonry dam will be satisfactory in every way though more costly perhaps than an earthwork dam if the clay were available.

XI. In my opinion the foundations between B.M. 15 and B.M. 16 should be carried down deeper than elsewhere to secure water-tightness as the rocks are more deeply weathered in this tract of high ground. But as the depth of water will be small if the reservoir level is to be at 905 feet (R.L.), the matter is not of serious importance. Still, with a masonry dam and the possible increase of height to 915 feet (R.L.) it is best to secure good foundations now. This of course applies with still greater force to the river section between B.M. 9 and B.M. 11.

XII. In conclusion I have no hesitation in saying that the CD site appears quite safe for the founding of a storage dam such as is projected for the Bhavani Irrigation Scheme if the details to which I have drawn attention are carefully dealt with and earthwork avoided. In the circumstances I did not think it necessary to re-examine the GH or any other site. I would like to add that I am greatly obliged to Mr. C. T. D'Silva for personally conducting me over the site and to Mr. E. W. P. Walsh, Superintending Engineer, Coimbatore Circle, both for the information he placed at my disposal and for his hospitality.

(c) Report on the bore cores from the proposed site of the Lower Bhavani Dam, by Mr. H. Crookshank, Superintendent, Geological Survey of India.

Dr. C. S. Fox of the Geological Survey of India visited the proposed site for the Lower Bhavani Dam in October 1933 and reported favourably on it, but recommended the sinking of bore-holes with a view to determining the depth to which the rocks of the dam site were weathered.

The borings were completed recently and I was deputed to examine them. I did this during May 1936 assisted by Mr. D'Silva, the Personal Assistant to the Superintending Engineer, Coimbatore.

Across the centre line of the dam the engineers had sunk some 45 bore-holes, some of which had been down over 100 feet below ground level. The rocks encountered had been classified as (1) top soil, (2) soft rock, (3) lime kunker, (4) fissured hard rock, (5) hard rock, and (6) talc schist.

The defect of a boring is that a good bore is only obtained where the rock is homogeneous and suitable. In crystalline rocks such as those at Bhavani this is rarely the case. Thus there are big gaps in the records of all the bore-cores. Where these occur the boring is said by the engineers to pass through soft rocks or fissured hard rocks. All such are condemned as unsuitable for foundations.

In a general way this is probably sound, but in this particular area I think it probable that many of the so-called soft and fissured rocks are quite hard and sound. The reason why no bore-core has been obtained is that the rocks are fissile in the vertical plane, and so tend to get powdered up in the course of boring. The fissility is due to the development of platey minerals, such as mica, hornblende and chloride, all of which are in reality quite harmless.

It will be easier to judge to what depth the weathered surface of the rock extends when a trench has been opened up across the dam site, but I anticipate that in practice it will prove unnecessary to sink down to the hard rock of the bore chart in cases where this is very deep.

On the whole rocks such as those occurring at the dam site should be relatively free from fissures below their weathered surface.

With the help of Mr. D'Silva, I collected specimens of the hard rock on which the engineers propose to fix their foundations at each bore-hole, and such other specimens from the bore-cores as I thought might prove of interest. The specimens collected are as follows:—

Bore number.	Depth in feet.	Nature of specimen.	Remarks.
2	10	Epidiorite	Hard rock of bore chart.
3	15	Do.	Do.
4	7	Do.	Do.
5	7	Hornblende schist	Do.
6	10	Do.	Do.
7	7	Do.	Do.
8	26	Do.	Do.
10	45	Gneiss	Do.
11	52	Hornblende schist	In fissured hard rock of bore chart.
12	6	Do.	Hard rock of bore chart.
13A	45	Gneiss	Do.
14	14	Do.	Do.
15	35	Do.	Talc schist of bore chart.
15	56	Do.	Hard rock of bore chart.
16	84	Do.	Do.
17	57	Do.	Do.
17	25	Tremolite-talc schist	Talc schist of bore chart.

Bore number.	Depth in feet.	Nature of specimen.	Remarks.
18	53	Gneiss	Hard rock of bore chart.
19A	56	Hornblende schist	Do.
20	40	Gneiss	Do.
21	66	Do.	Do.
22	78	Do.	Do.
23	62	Do.	Do.
24	75	Do.	Do.
25	62	Do.	Do.
26	45	Do.	Do.
27	30	Do.	Do.
28	63	Do.	Do.
29	77	Do.	Do.
30	65	Do.	Do.
31B	54	Do.	Do.
32	..	Tremolite-talc schist	....
33	55	Tremolite-talc schist w.th olivine.	Hard rock of bore chart.
35	35	Olivine-pyroxene rock	Do.
36	43	Tremolite-talc schist	Talc schist of bore c art.
37	19	Do.	Do.
39A	10	Hornblende schist	Hard rock of bore chart.
40	5	Do.	Do.
41	23	Do.	Do.
42	13	Do.	Do.
43	8	Do.	Fissured hard rock of bore chart.
44	27	Do.	Hard rock of bore chart.
30T	22	Gneiss	Do.
32T	46	Do.	Do.
33T	28	Do.	Fissured hard rock of bore chart.
34T	50	Do.	Hard rock of bore chart.
35T	30	Do.	Do.
36T	23	Do.	Do.
38T	24	Hornblende schist	Do.
39T	34	Do.	Do.
40T	10	Do.	Do.
42T	20	Do.	Soft rock of bore chart.
44T	36	Gneiss	Hard rock of bore chart.

It will be seen that I have included the specimens under four headings: (1) Gneiss, (2) Hornblende schist, (3) Ultra basic intrusions including talc schists and olivine-pyroxene rocks and (4) Epidiorites.

Specimens of (1) and (2) vary slightly from bore to bore but not sufficiently to make any difference from an engineering point of view. Accordingly, to avoid repetition, I am giving in the following pages one general detailed description applicable to all specimens of (1) and another for (2).

In headings (3) and (4) the variations are greater, but I am treating them in the same way as (1) and (2) except that where variations might be of engineering importance, I have described the individual specimens.

(1) *Gneiss.*—The typical gneiss is a granular aggregate of quartz and felspar (mainly plagioclase) with varying amounts of chlorite and biotite. Accessory minerals commonly present are sphene, apatite and iron-ore. As the result of metamorphism of the felspar, epidote is very common and sericite somewhat less so. Secondary calcite is sometimes present in small quantities. The chlorate is probably the result of metamorphism of original hornblende. The biotite has in part developed at the expense of the chlorite.

The gneiss seems to be a metamorphosed variety of grano-diorite.

From the table of compression tests, I see that the first crack in the gneiss may appear at any point from 0·841 to 5·73 tons per square inch. The minerals of which it is formed are all reliable and the rock will in my opinion stand up easily to any stress to which it is likely to be subjected by the projected dam.

(2) *Hornblende schist.*—The typical hornblende schist is mainly composed of lath-shaped hornblende and zoisite crystals with small grains of quartz. Sphene, garnet and iron-ore occur as accessory minerals, and there is usually some secondary calcite associated with the zoisite.

In many specimens, however, there is a good deal of granular felspar and quartz. This felspar sometimes gives rise to epidote, chlorite and sericite as well as the zoistite. The hornblende in almost all the specimens is partially altered to chlorite.

In all probability there is a gradual passage from the typical hornblende schists to the typical gneisses so that deep weathering at the contact is unlikely.

The first crack in the hornblende schists may appear at any point from 1·40 to 2·74 tons per square inch.

Though somewhat softer than the gneisses they are likely to be tougher and should prove satisfactory for foundations.

(3) *Ultrabasic intrusions.*—The ultrabasic intrusions occur in several places but notably in the bed of the river where they will be subjected to considerable stresses.

When fresh (bore-hole No. 35 at 35 feet below ground level) they consist of olivine-pyroxene rocks with a little iron ore. The pyroxene is often clinio-enstatite, a form which is only found in igneous intrusions.

More commonly these rocks are metamorphosed. They then form tremolite-talc schists with a little iron-ore, some chlorite and some calcite. In bore No. 33 at a depth of 55 feet, I got a specimen of tremolite-talc schist where the original olivine was seen in process of metamorphism to chlorite. This proves the connexion between the olivine pyroxene rock and the tremolite-talc schist.

Now the first cracks in the talc-schists appear at stresses between 0·92 and 2·96 tons per square inch. That for the olivine-pyroxene rock at 4·79 tons per square inch. Experiment, therefore, shows the ultra-basic instrusions to be reasonably strong.

They will be rather soft and slippery, but their fibrous nature should make them tough. They contain some calcite which is undesirable but I do not think there is enough of this mineral in the rocks I have seen to make any difference.

Ultra-basic rocks especially those rich in olivine tend to weather to a soft serpentinous clay. This weathering might go very deep and might not have been exposed by the borings. The edges of the ultra-basic instrusions would be peculiarly subject to deep weathering. It would seem necessary to excavate anything of this kind until solid rock was encountered.

I consider either the tremolite-talc schists or the olivine pyroxene rocks seen in the bore cores are suitable for the foundations of the dam.

(4) *Epidiorites.*—The epidiorites were only seen in bore-holes 2, 3 and 4. They consist of felspar laths, zoisite and crystals of amphibole with little cores of unaltered pyroxene.

Their general texture and mineral composition shows that they are basic dykes.

They should be quite suitable for dam foundations in a situation like the existing one where the proposed head of water will be small. As the engineers were not satisfied with the talc schists met in the bore-holes in the river-bed a further line of bore-holes was drilled 200 feet down stream from the centre line of the proposed dam.

As will be seen from the list of specimens the hard rock encountered in these borings was gneiss or hornblende schist. If the design of the dam permitted the shifting of its centre line 200 feet down stream, there is no doubt that these rocks would be more satisfactory foundations than the ultra-basic intrusions at the proposed site.

APPENDIX III (i).

Estimate of growth of irrigation and revenue receipts and charges, water rates—Cotton Rs. 18 *per acre, Rice Rs.* 10 *per acre and Dry irrigated Rs.* 7-8-0 *per acre and inclusion fees at Rs.* 100 *per acre.*

Year.	Growth of irrigation (ayacut).	Revenue realized. Rate.	Revenue realized. Amount.	Working expenses. Maintenance at Re. 1-4-0 per acre.	Working expenses. Collection charges at 5 per cent on gross revenue.	Working expenses. Total.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ACS.	RS. A. P.	RS.	Rs.	RS.	RS.
5th	30,000 Dry Irrigated ..	3 12 0	1,12,500	37,500	5,625	43,125
6th	30,000 Cotton ..	9 0 0	2,70,000	37,500	13,500	51,000
	30,000 Dry Irrigated ..	5 10 0	1,68,750	37,500	8,438	45,938
7th	5,000 Paddy	5 0 0	25,000	6,250	1,250	7,500
	50,000 Cotton	13 8 0	6,75,000	62,500	33,750	96,250
	45,000 Dry Irrigated ..	7 8 0	3,37,500	56,250	16,875	73,125
8th	10,000 Paddy ..	7 8 0	75,000	12,500	3,760	16,250
	70,000 Cotton	18 0 0	12,60,000	87,500	63,300	1,50,500
	70,000 Dry Irrigated ..	7 8 0	5,25,000	87,500	26,250	1,13,750
9th	10,000 Paddy	10 0 0	1,00,000	12,500	5,000	17,500
	100,000 Cotton	18 0 0	18,00,000	1,25,000	90,000	2,15,000
	97,000 Dry Irrigated ..	7 8 0	7,27,500	1,21,250	36,375	1,57,625
10th	10,000 Paddy	10 0 0	1,00,000	12,500	5,000	17,500
	97,000 Cotton	18 0 0	17,46,000	1,21,250	87,300	2,08,550
	100,000 Dry Irrigated ..	7 8 0	7,50,000	1,25,000	37,500	1,62,500

Year.	Growth of irrigation (ayacut.)	Net revenue.	Inclusion fees at Rs. 100 per acre.	Interest at 4 per cent on inclusion fees.	Total of net revenue plus interest on inclusion fees [cols. (8) and (10)].	
		(8)	(9)	(10)	(11)	(12)
	ACS.	RS.	RS.	RS.	RS.	RS.
5th	30,000 Dry Irrigated ..	69,375	30,00,000	1,20,000	1,89,375	
6th	30,000 Cotton ..	2,19,000	30,00,000	1,20,000	3,39,000	5,81,812
	30,000 Dry Irrigated ..	1,22,812	30,00,000	1,20,000	2,42,812	
7th	5,000 Paddy	17,500	5,00,000	20,000	37,500	
	50,000 Cotton	5,78,750	50,00,000	2,00,000	7,78,750	12,60,625
	45,000 Dry Irrigated ..	2,64,375	45,00,000	1,80,000	4,44,375	
8th	10,000 Paddy	58 750	10,00,000	40,000	98,750	
	70,000 Cotton	11,09,500	70,00,000	2,80,000	13,89,500	21,79,500
	70 000 Dry Irrigated ..	4,11,250	70,00,000	2,80,000	6,91,250	
9th	10,000 Paddy	82,500	10,00,000	40,000	1,22,500	
	100,000 Cotton	15,85,000	1,00,00,000	4,00,000	19,85,000	30,65,375
	97,000 Dry Irrigated ..	5,69,875	97,00,000	3,88,000	9,57,875	
10th	10,000 Paddy	82,500	10,00,000	40,000	1,22,500	
	97,000 Cotton	15,37,450	97,00,000	3,88,000	19,25,450	30,35,450
	100,000 Dry Irrigated ..	5,87,500	1,00,00,000	4,00,000	9,87,500	

NOTE.—Half the final rate in the first year of irrigation, three-fourth rate in the second year and full rate thereafter.

Estimate of net financial results of ten years after the probable date of completion of work.

Year of construction.	Direct capital outlay during the year.	Direct capital outlay to the end of the year.	Simple interest at 4 per cent on the capital outlay to end of previous year plus half outlay during the year.	Net revenue plus interest on inclusion fees.	Simple interest less (net revenue plus interest on inclusion fees).	Net revenue and interest on the inclusion fees less simple interest.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
1	20,00,000	20,00,000	40,000	..	40,000	..
2	50,00,000	70,00,000	1,80,000	..	1,80,000	..
3	1,50,00,000	2,20,00,000	5,80,000	..	5,80,000	..
4	2,00,00,000	4,20,00,000	12,80,000	..	12,80,000	..
5	1,50,00,000	5,70,00,000	19,80,000	1,89,375	17,90,625	..
6	1,28,25,000	6,98,25,000	25,36,500	5,81,812	19,54,688	..
7	..	..	27,93,000	12,60,625	15,32,375	..
8	..	..	27,93,000	21,79,500	6,13,500	..
9	..	..	27,93,000	30,65,375	..	2,72,375
10	..	..	27,93,000	30,35,450	..	2,42,450
11	..	..	27,93,000	30,65,375	..	2,72,375
12	..	..	27,93,000	30,35,450	..	2,42,450
13	..	..	27,93,000	30,65,375	..	2,72,375
14	..	..	27,93,000	30,35,450	..	2,42,450
15	..	..	27,93,000	30,65,375	..	2,72,375
16	..	..	27,93,000	30,35,450	..	2,42,450
					— 79,71,188	20,59,300

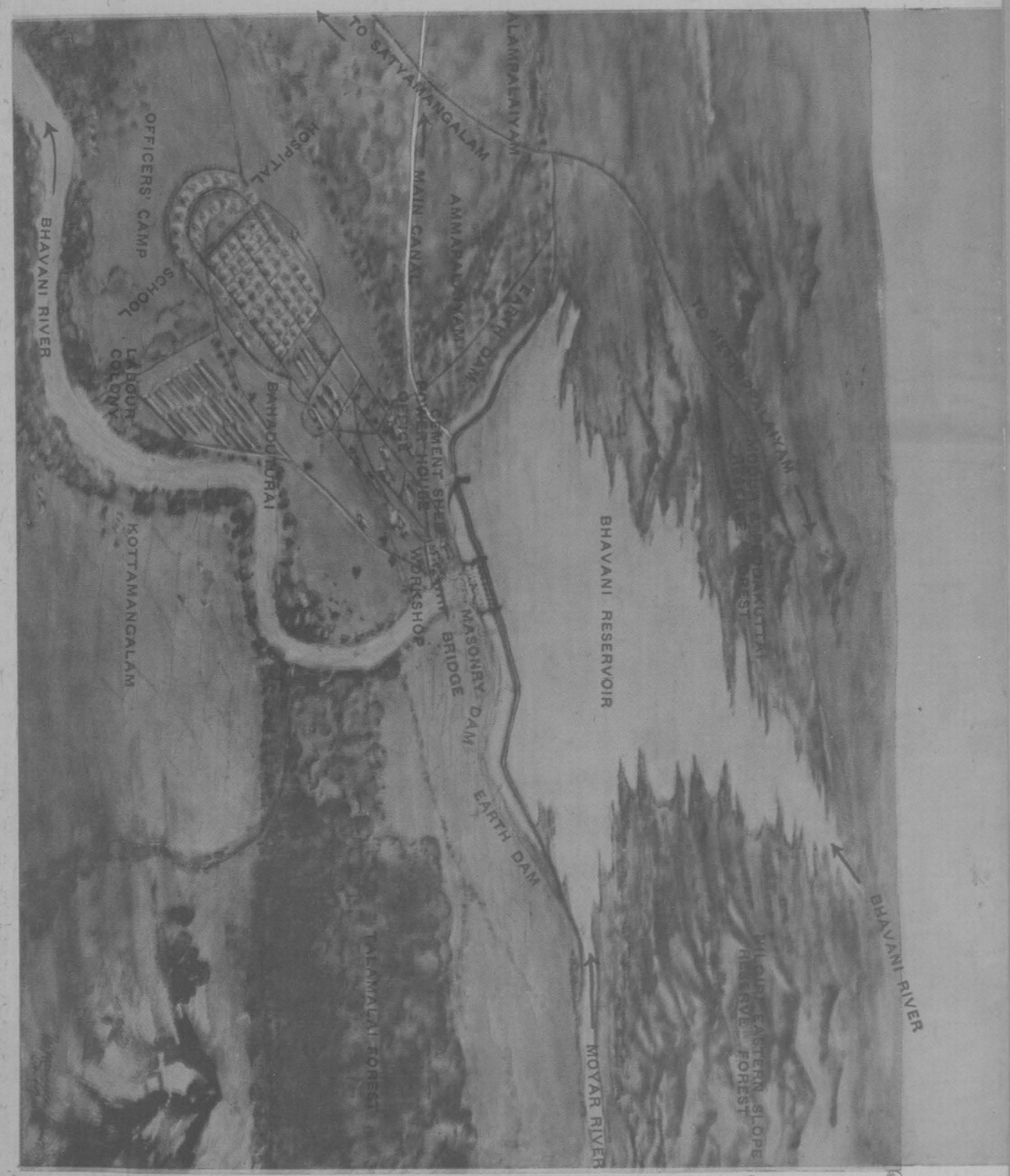
Arrears of simple interest Rs. 59,11,888.

	Rs.
Arrears of simple interest	59,11,888
Direct charges	6,98,25,000
Indirect charges	1,75,000
Total ..	7,59,11,888

Total net revenue plus interest on inclusion fees .. $\frac{30,65,375+30,35,450}{2}$ (Rs.) $= \frac{61,00,825}{2}$ (Rs.) $= 30,50,412$

Return .. $\frac{30,50,412 \times 100}{7,59,11,888} = 4{\cdot}02$ per cent.
or say 4 per cent.

LOWER BHAVANI PROJECT — AN ARTIST'S VIEW OF THE DAM AND RESERVOIR WHEN COMPLETED



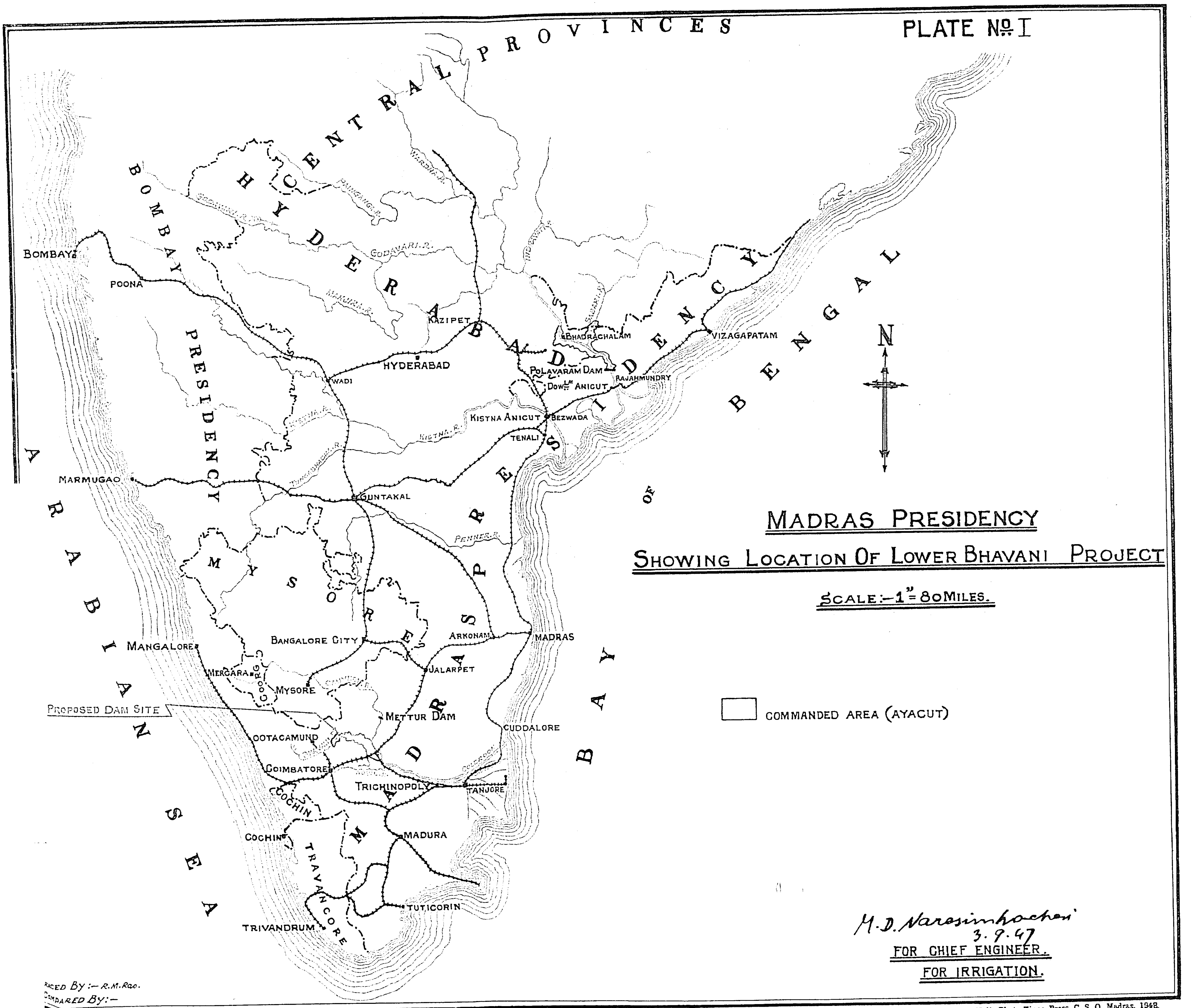


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PLATE No. II

LOWER BHAVANI PROJECT

INDEX MAP

SCALE :- 1" = 4 MILES

N

R E

TALAVADI

PROPOSED DAM SITE

G O B I C H E T T I P A L A I Y A M Tk.

B H A V A N I Tk.

SATYAMANGALAM

KOTTAMANGALAM

A.B. SITE

C.D. SITE

G.H. SITE

KODIVERI ANICUT

KUGALUR

TADPALLI CHL.

DISTRY.

GOBICHETTIPALAIYAM

MODACHCHUR

KURUMANDUR

LOWER BHAVANI MAIN CANAL

ATTANI

URACHCHIKKOTTAI

BHAVANI

TO SALEM

KAVUNDAPPADI

KALINGARAYAN ANICUT

SITTODU

METTUR DAM

AMMAPETTAI

KANJIKKOVIL

NAMBIYUR

SIRUVALUR

PUNJAI PULIYAMPATTI

SIRUMUGAI

ERODE

R.S TO MADRAS

A.B.
C.D.
G.H.
} ALTERNATIVE DAM SITES

KALINGARAYAN CHL.

A V A N A S I Tk.

KUNNATTUR

PERUNDURAI

UNJALUR DISTRIBUTARY

PUNDURAI DISTRIBUTARY

PUNDURAI

SEVUR

ANNUR

KUNAMPATTI

INGUR

AVANASHI

S.I.RY.

E R O D E Tk.

UTTUKKULI

CHENNIMALAI

TIRUPPUR

SIVAGIRI

E Tk.

SOMANUR

NOYIL R.

KODUMUDI R.S.

CHENNASAMUDRAM

CAUVERY RIVER

TO TRICHINOPOLY

SULUR

P A L L A D A M Tk.

KANGAYAM

PALLADAM

D H A R A P U R A M Tk.

K A R U R Tk.

CHETTIPALAIYAM R.S.

TO POLLACHI

TO TRICHINOPOLY

M. D. Narasimhachari
FOR CHIEF ENGINEER 3.9.47
FOR IRRIGATION

REFERENCE

- EXISTING IRRIGATION
- AREA COMMANDED
- MAIN CANAL
- DISTRIBUTARIES
- RAILWAY LINE
- BHAVANI: TALUK HEAD QUARTER
- STATE BOUNDARY
- DISTRICT ,,
- TALUK ,,
- HYDRO-ELECTRIC POWER HOUSE
- A.B., C.D., G.H. } ALTERNATIVE DAM SITES

77° 0' 15' 30' 45' 78° 0'

11° 0' 15' 30' 45'

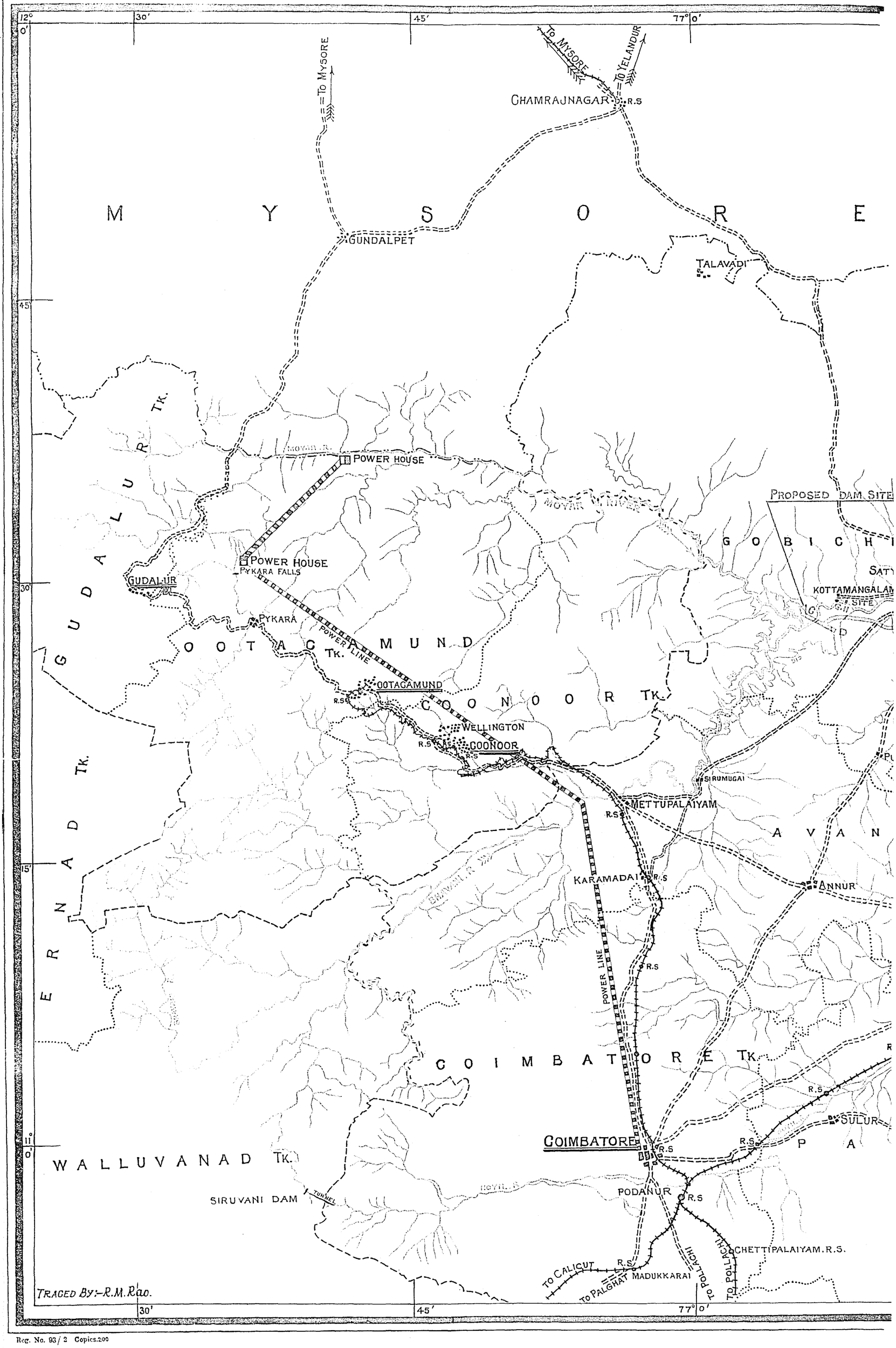

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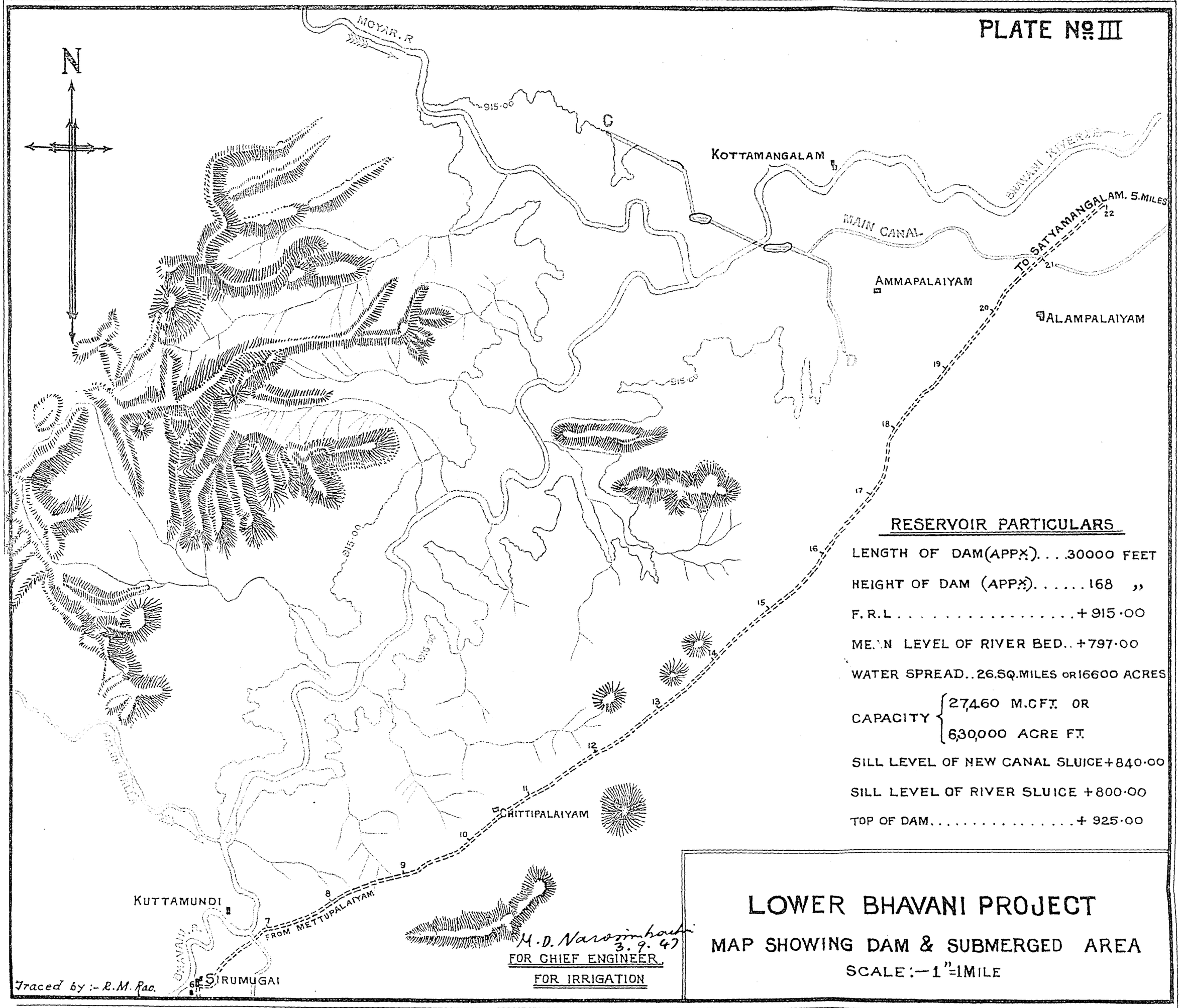
PLATE No. III



RESERVOIR PARTICULARS

LENGTH OF DAM (APPX.) . . . 30000 FEET

HEIGHT OF DAM (APPX.) . . . . . 168 ,,

F.R.L . . . . . + 915·00

MEAN LEVEL OF RIVER BED . . + 797·00

WATER SPREAD . . 26 SQ. MILES OR 16600 ACRES

CAPACITY { 27,460 M.C.FT. OR
6,30,000 ACRE FT.

SILL LEVEL OF NEW CANAL SLUICE + 840·00

SILL LEVEL OF RIVER SLUICE + 800·00

TOP OF DAM . . . . . + 925·00

LOWER BHAVANI PROJECT

MAP SHOWING DAM & SUBMERGED AREA

SCALE :— 1" = 1 MILE

M. D. Narasimhan
3. 9. 47
FOR CHIEF ENGINEER,
FOR IRRIGATION

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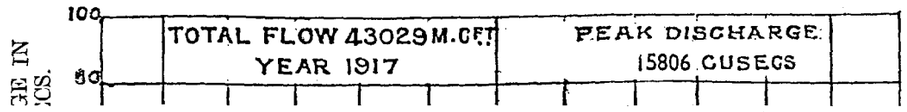
HYDROGRAPH OF THE BHAVANI RIVER AT KODIVERI PLATE V



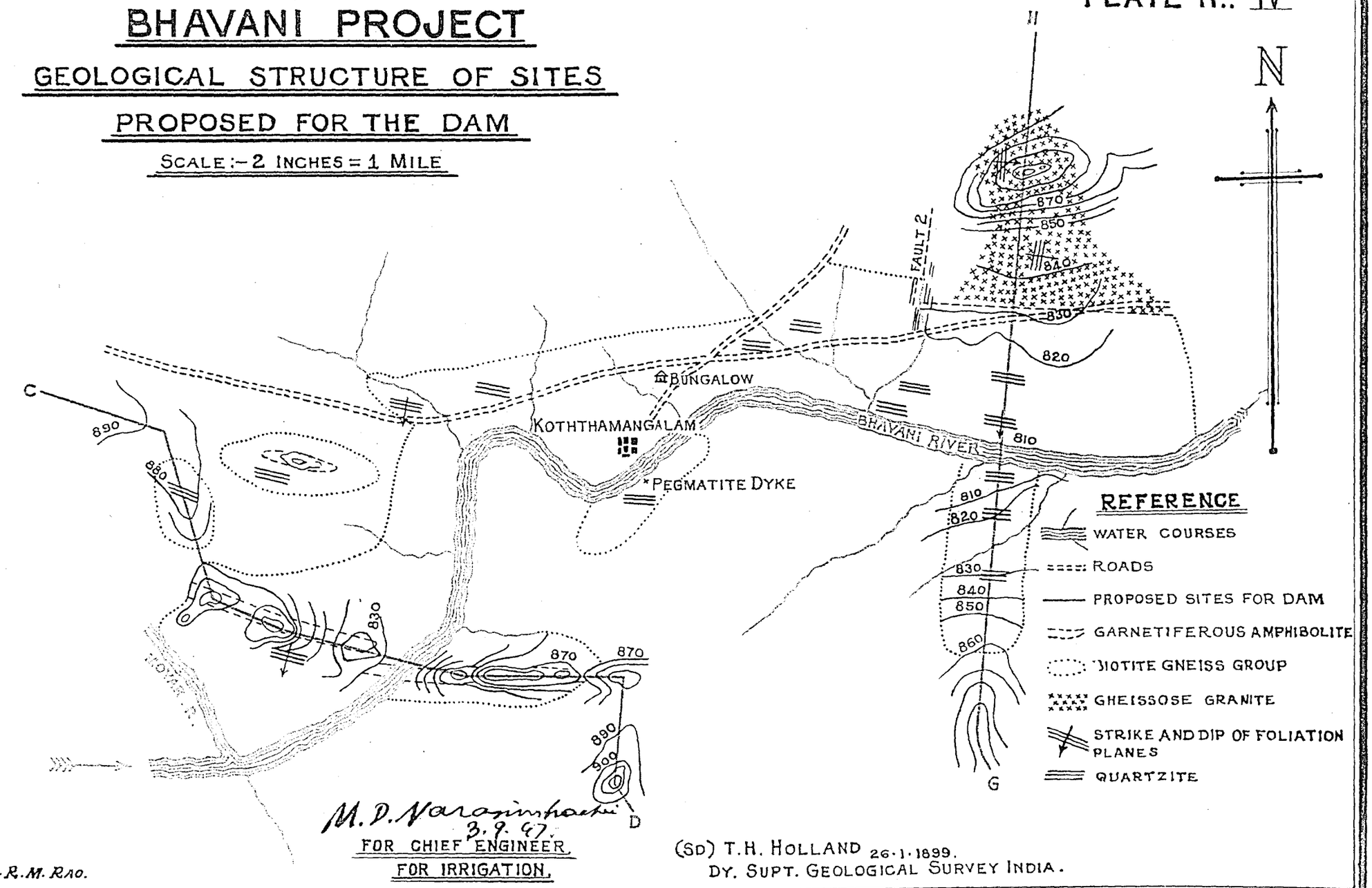
31

PLATE No. IV

BHAVANI PROJECT

GEOLOGICAL STRUCTURE OF SITES PROPOSED FOR THE DAM

SCALE :- 2 INCHES = 1 MILE



M. D. Narasimhachari 3.9.47.
FOR CHIEF ENGINEER, FOR IRRIGATION.

(SD) T. H. HOLLAND 26-1-1899.
DY. SUPT. GEOLOGICAL SURVEY INDIA.

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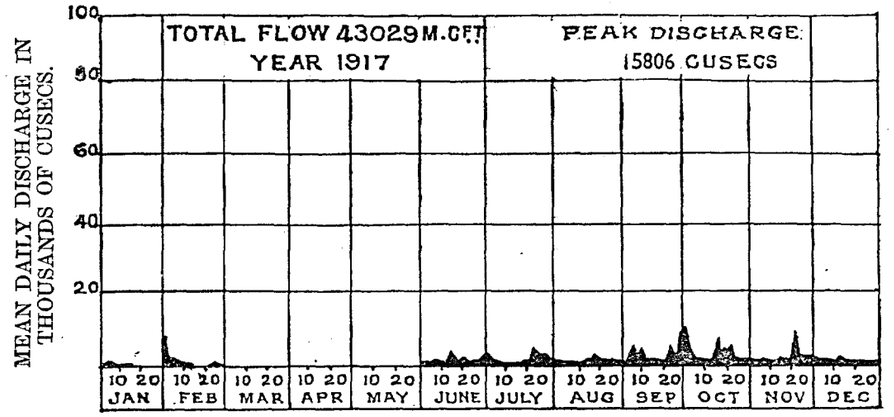
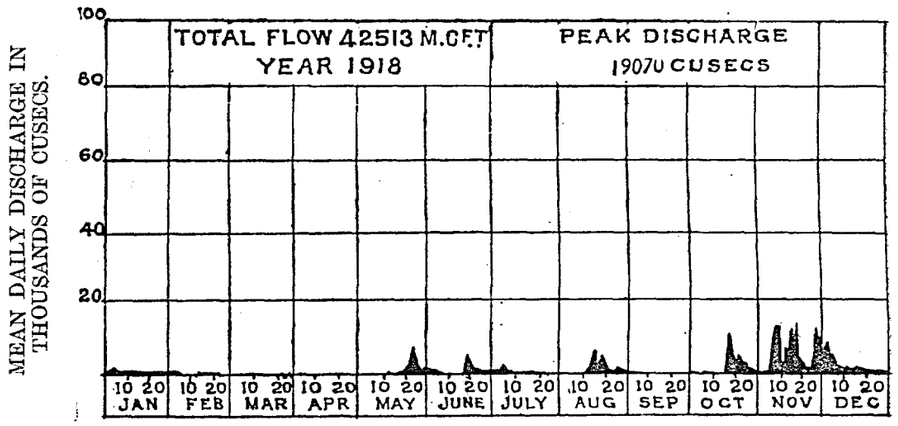
HYDROGRAPH OF THE BHAVANI RIVER AT KODIVERI PLATE V





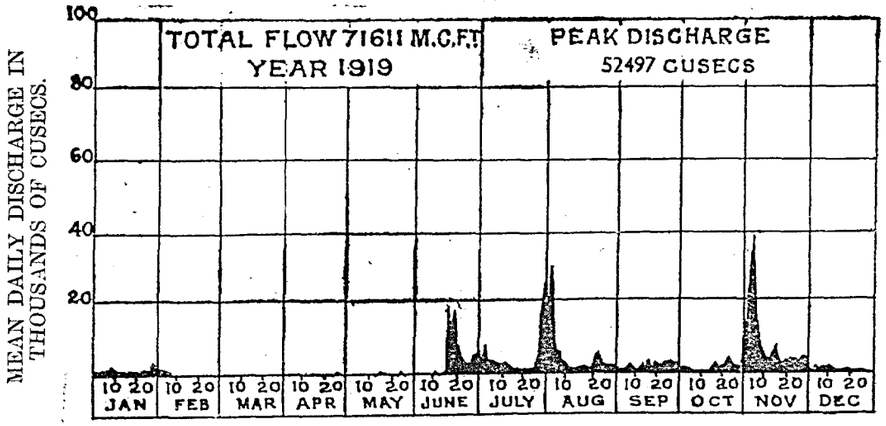
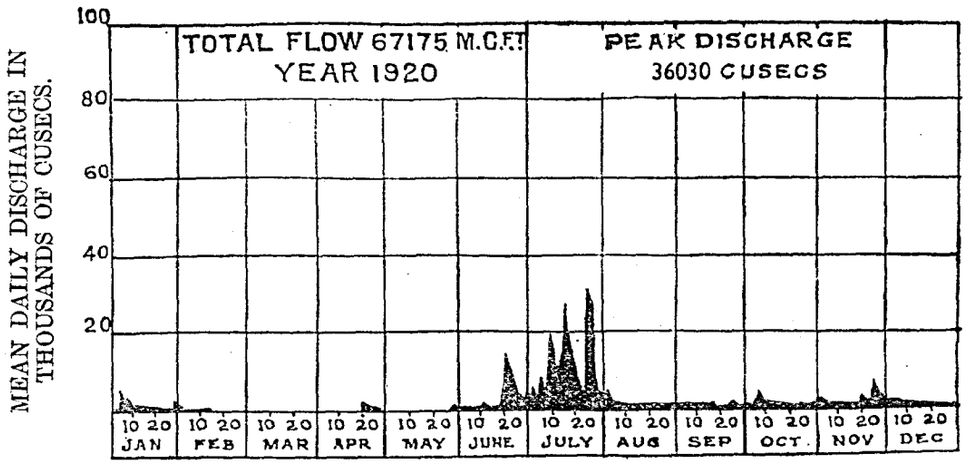
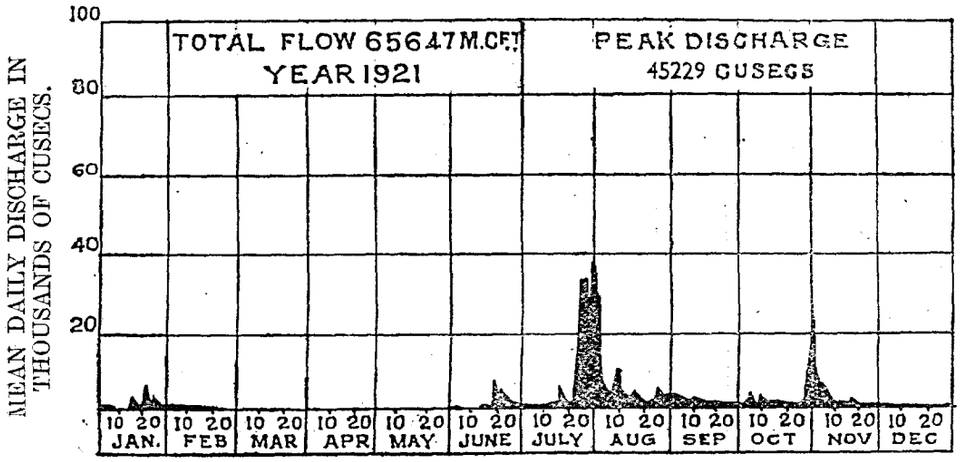
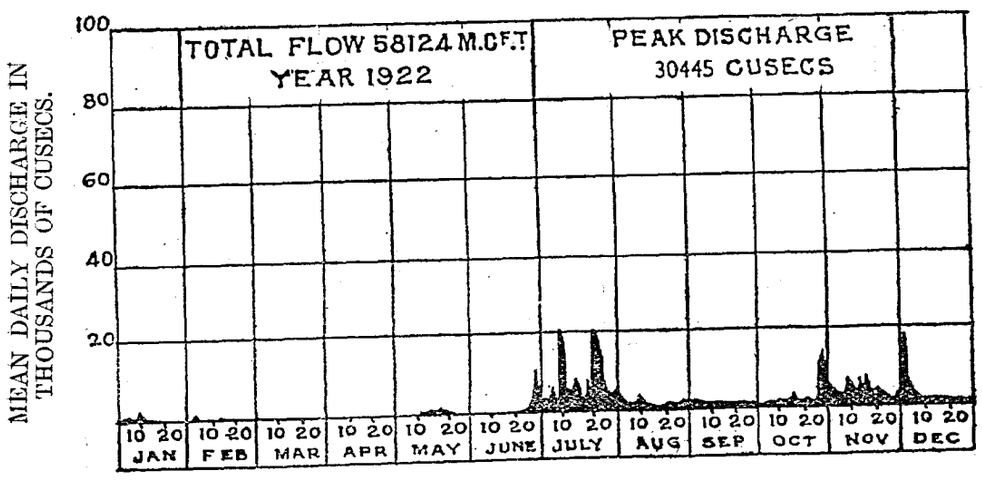


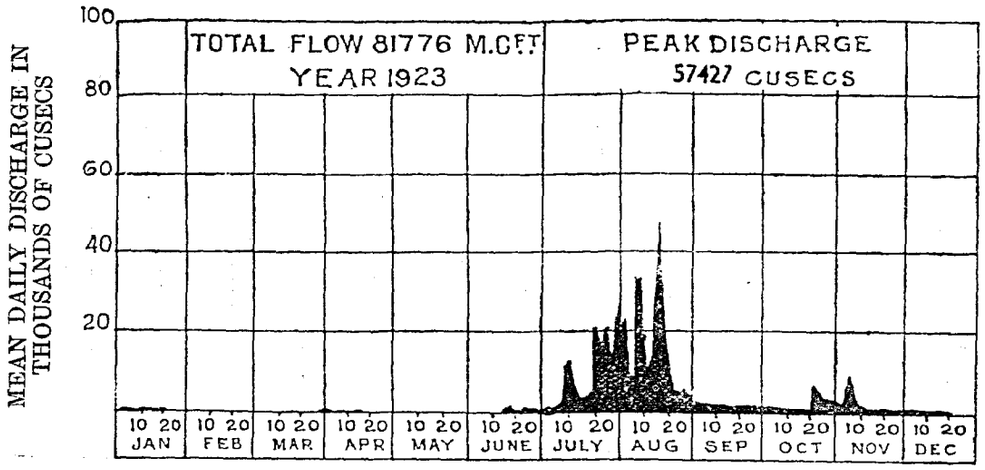
PLATE V—*cont.* HYDROGRAPHS

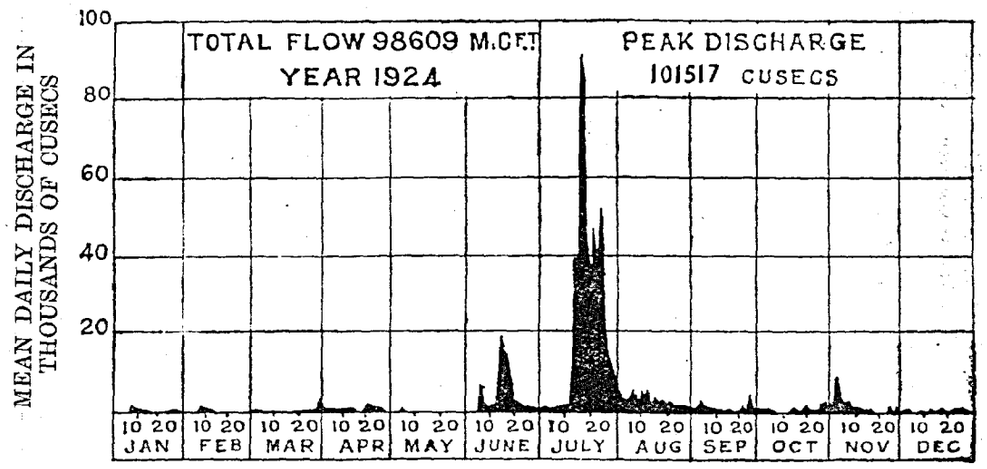


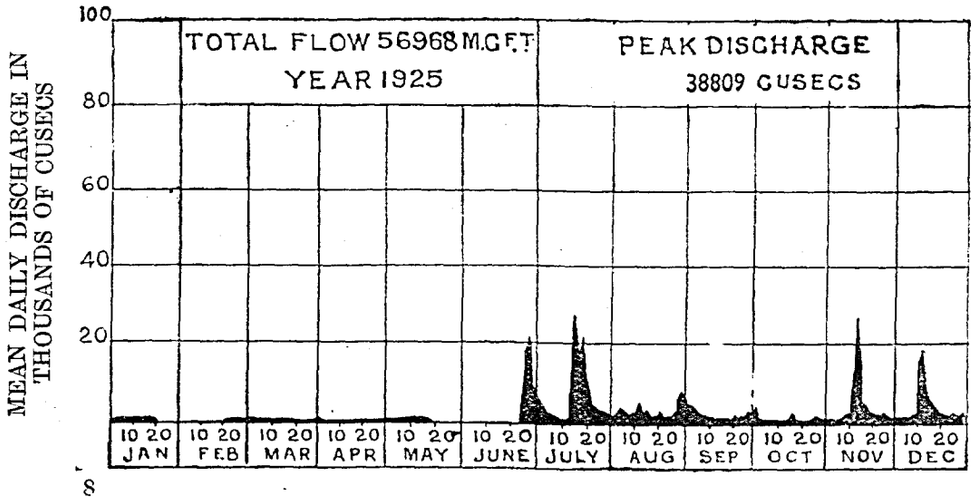




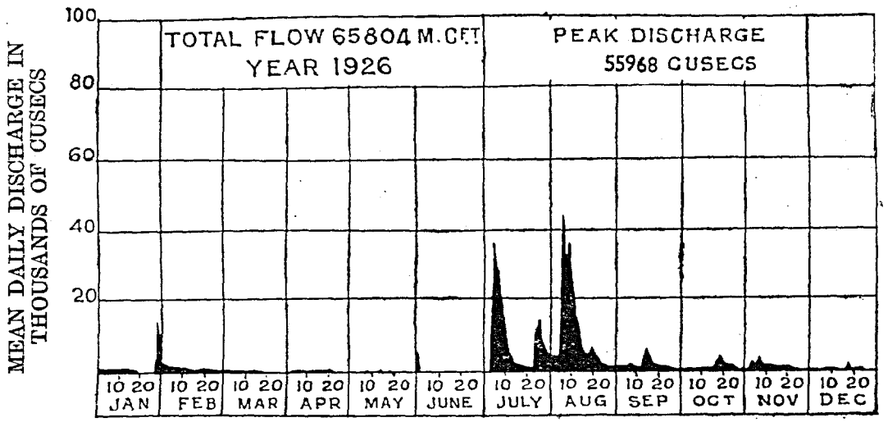
HYDROGRAPHS PLATE V—*cont.*

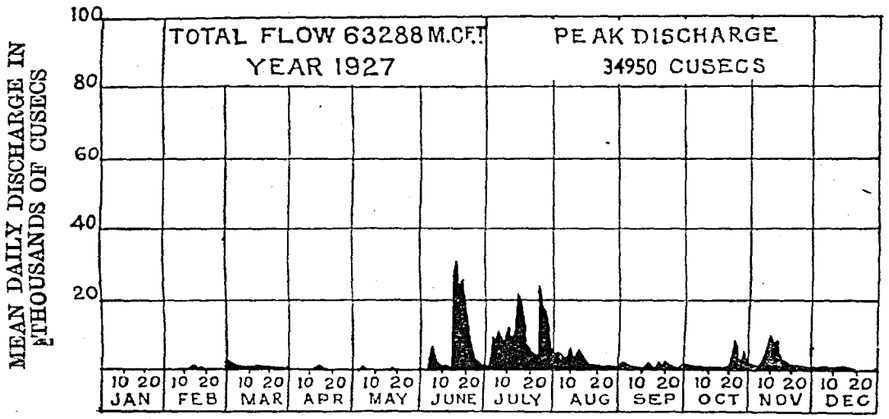


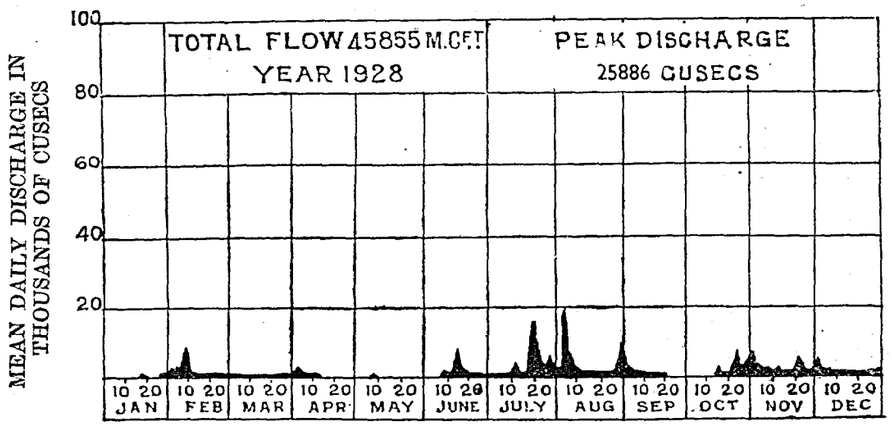


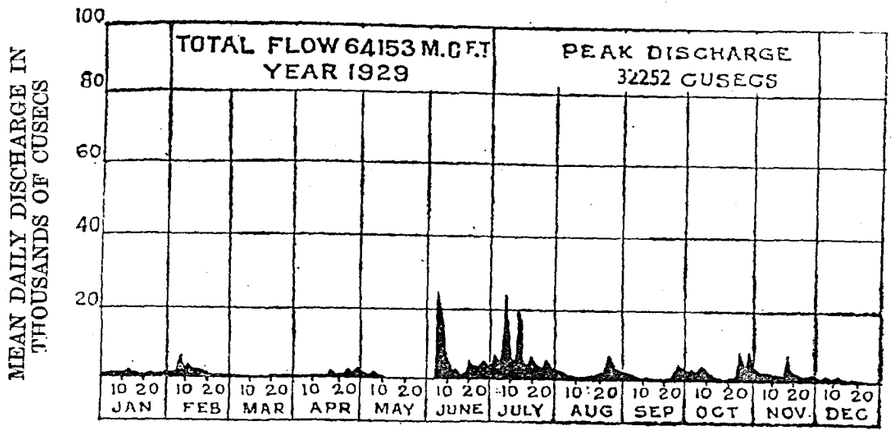


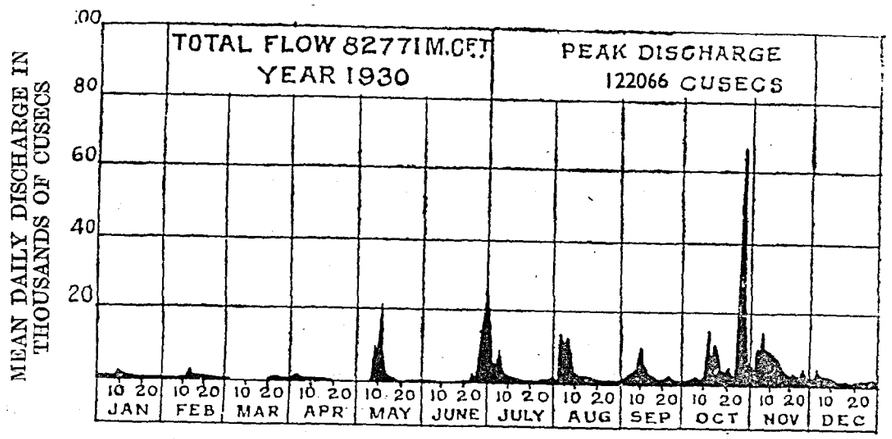
HYDROGRAPHS

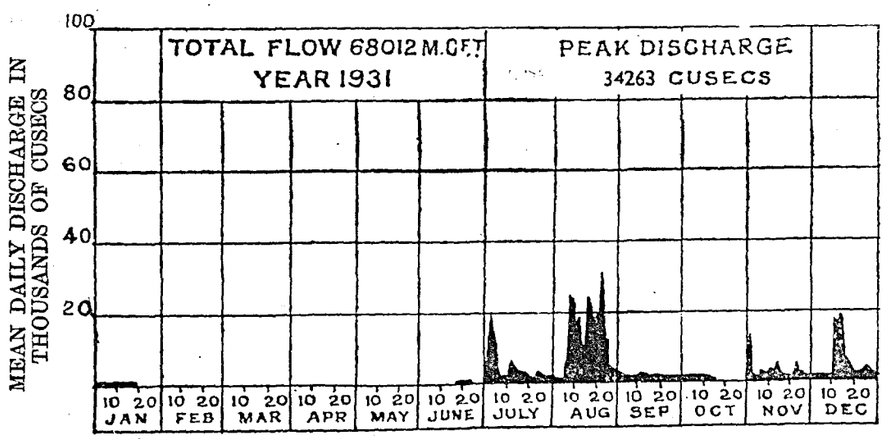


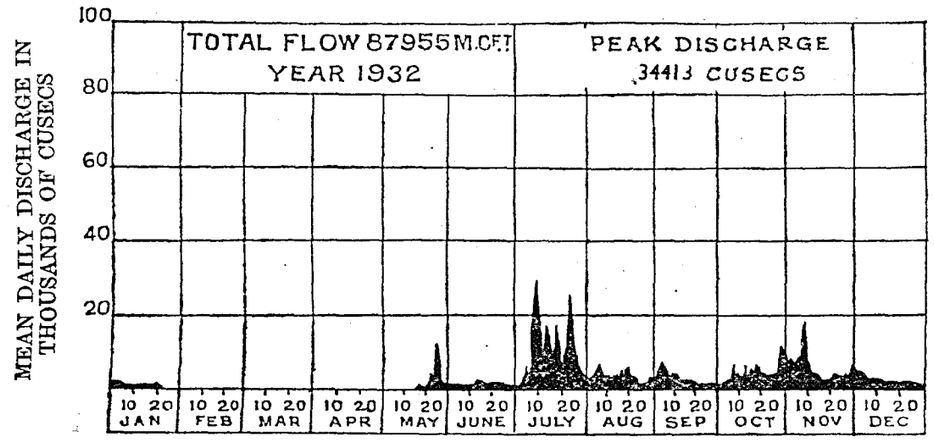


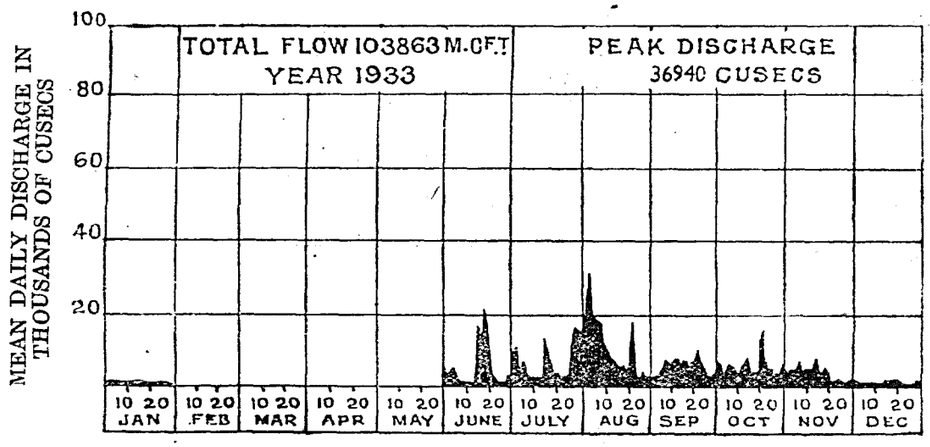


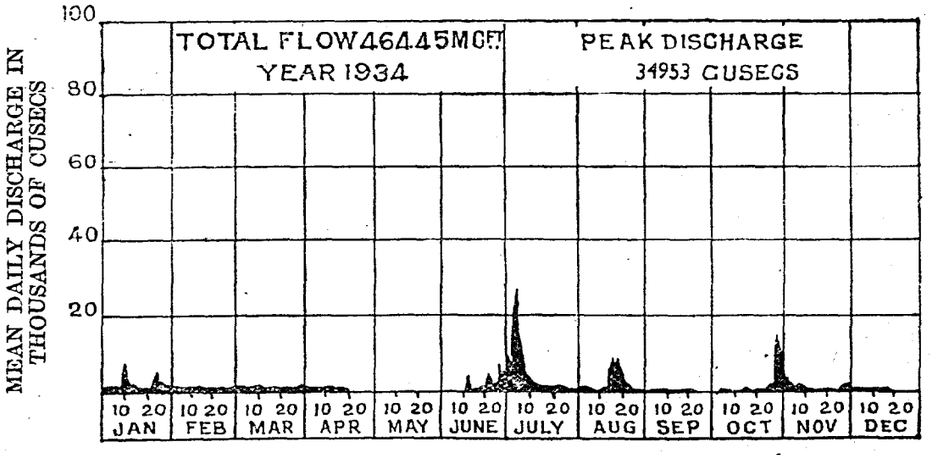


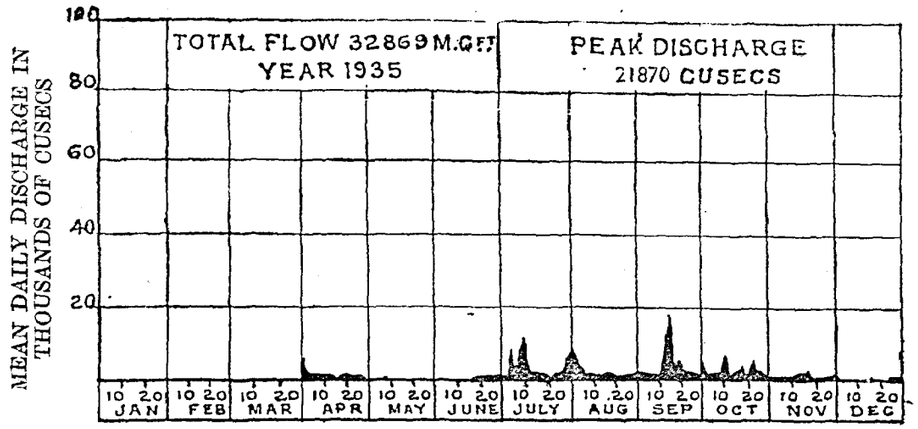


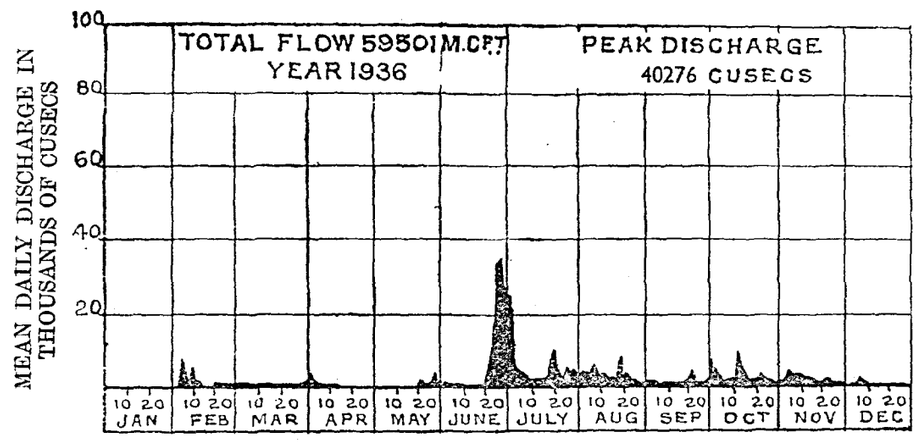


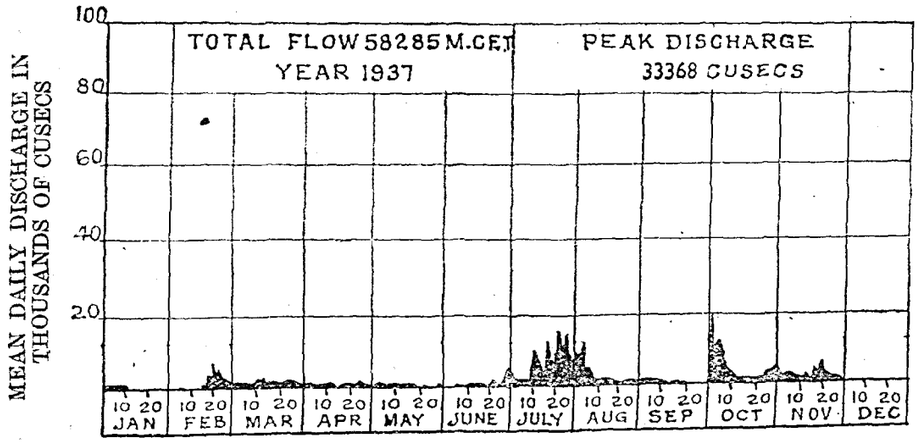

TOTAL FLOW 87955 M.CFT
YEAR 1932
PEAK DISCHARGE
34413 CUSECS
MEAN DAILY DISCHARGE IN THOUSANDS OF CUSECS
100
80
60
40
20
10 20 JAN
10 20 FEB
10 20 MAR
10 20 APR
10 20 MAY
10 20 JUNE
10 20 JULY
10 20 AUG
10 20 SEP
10 20 OCT
10 20 NOV
10 20 DEC


TOTAL FLOW 103863 M.CFT
YEAR 1933
PEAK DISCHARGE
36940 CUSECS
MEAN DAILY DISCHARGE IN THOUSANDS OF CUSECS
100
80
60
40
20
10 20 JAN
10 20 FEB
10 20 MAR
10 20 APR
10 20 MAY
10 20 JUNE
10 20 JULY
10 20 AUG
10 20 SEP
10 20 OCT
10 20 NOV
10 20 DEC

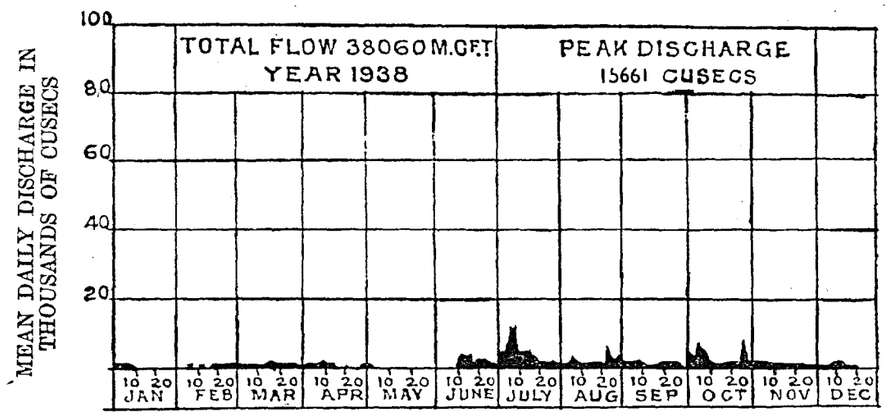

TOTAL FLOW 46445 M.CFT
YEAR 1934
PEAK DISCHARGE
34953 CUSECS
MEAN DAILY DISCHARGE IN THOUSANDS OF CUSECS
100
80
60
40
20
10 20 JAN
10 20 FEB
10 20 MAR
10 20 APR
10 20 MAY
10 20 JUNE
10 20 JULY
10 20 AUG
10 20 SEP
10 20 OCT
10 20 NOV
10 20 DEC

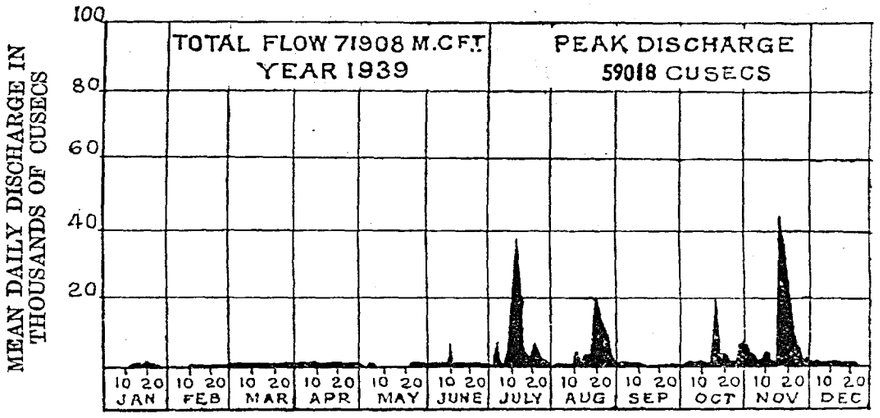

TOTAL FLOW 32869 M.CFT
YEAR 1935
PEAK DISCHARGE
21870 CUSECS
MEAN DAILY DISCHARGE IN THOUSANDS OF CUSECS
100
80
60
40
20
10 20 JAN
10 20 FEB
10 20 MAR
10 20 APR
10 20 MAY
10 20 JUNE
10 20 JULY
10 20 AUG
10 20 SEP
10 20 OCT
10 20 NOV
10 20 DEC

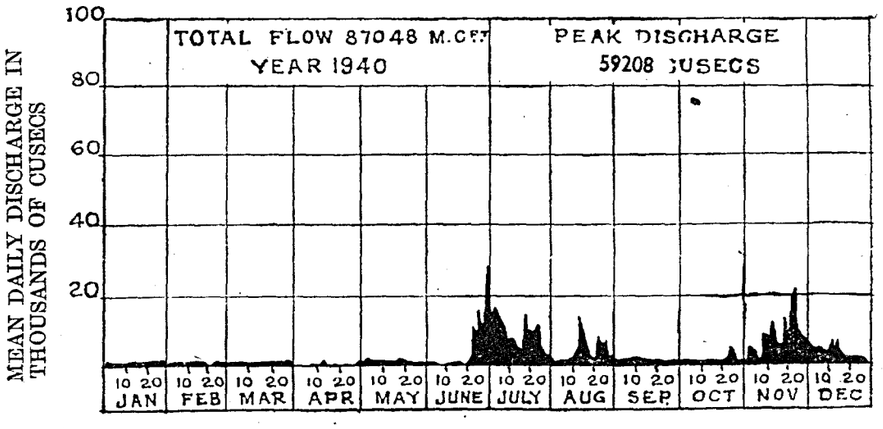

TOTAL FLOW 59501 M.CFT
YEAR 1936
PEAK DISCHARGE
40276 CUSECS
MEAN DAILY DISCHARGE IN THOUSANDS OF CUSECS
100
80
60
40
20
10 20 JAN
10 20 FEB
10 20 MAR
10 20 APR
10 20 MAY
10 20 JUNE
10 20 JULY
10 20 AUG
10 20 SEP
10 20 OCT
10 20 NOV
10 20 DEC

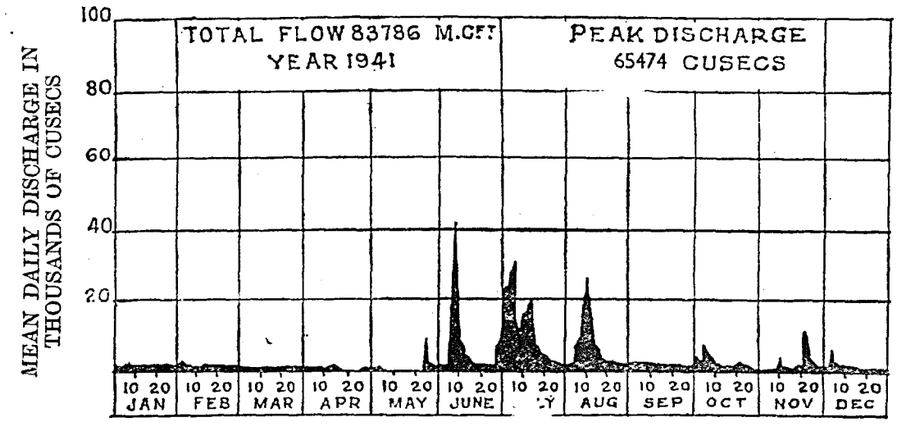

TOTAL FLOW 58285 M.CFT
YEAR 1937
PEAK DISCHARGE
33368 CUSECS
MEAN DAILY DISCHARGE IN THOUSANDS OF CUSECS
100
80
60
40
20
10 20 JAN
10 20 FEB
10 20 MAR
10 20 APR
10 20 MAY
10 20 JUNE
10 20 JULY
10 20 AUG
10 20 SEP
10 20 OCT
10 20 NOV
10 20 DEC

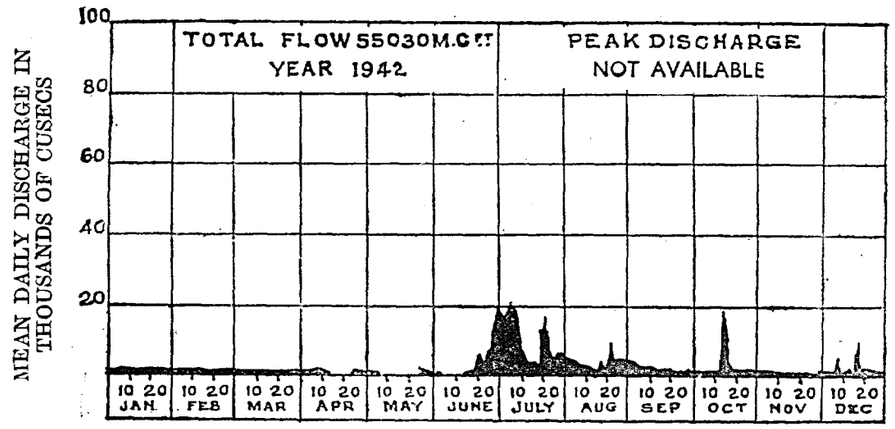
HYDROGRAPHS

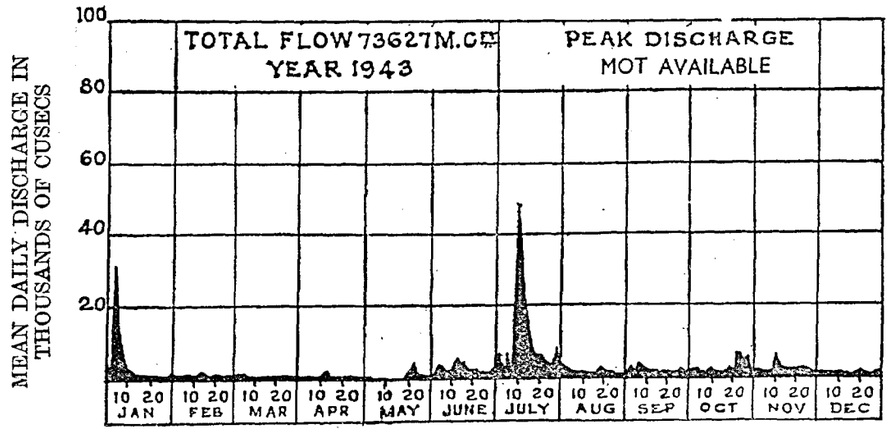












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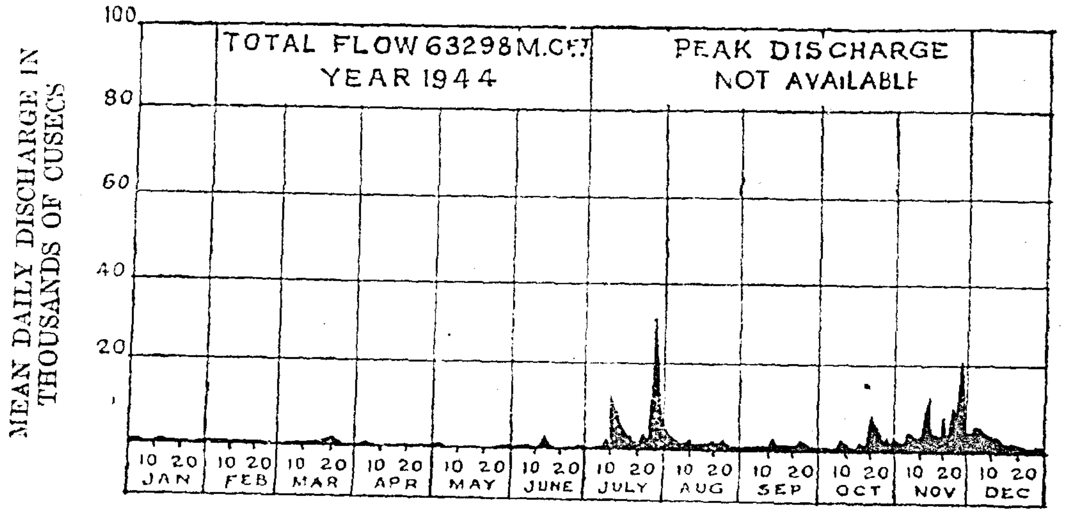

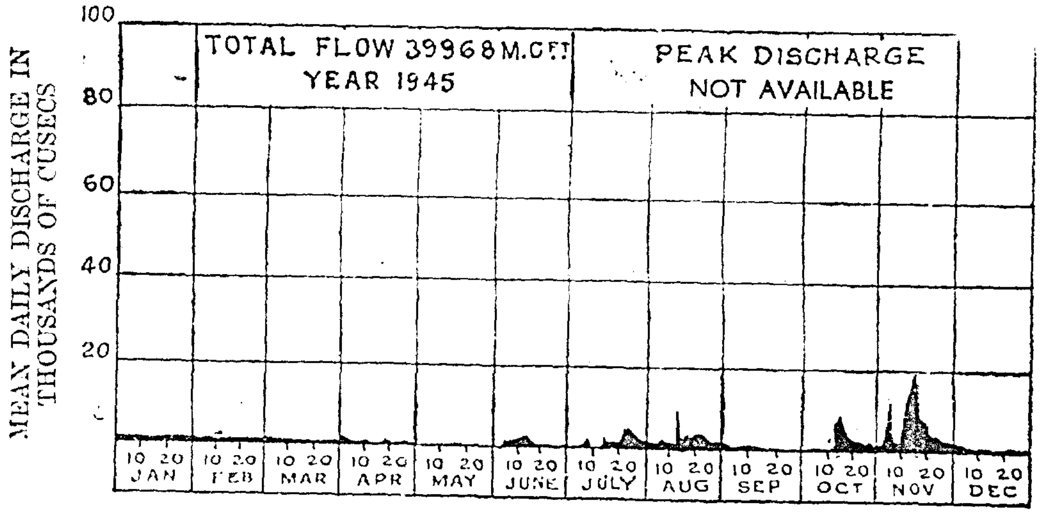

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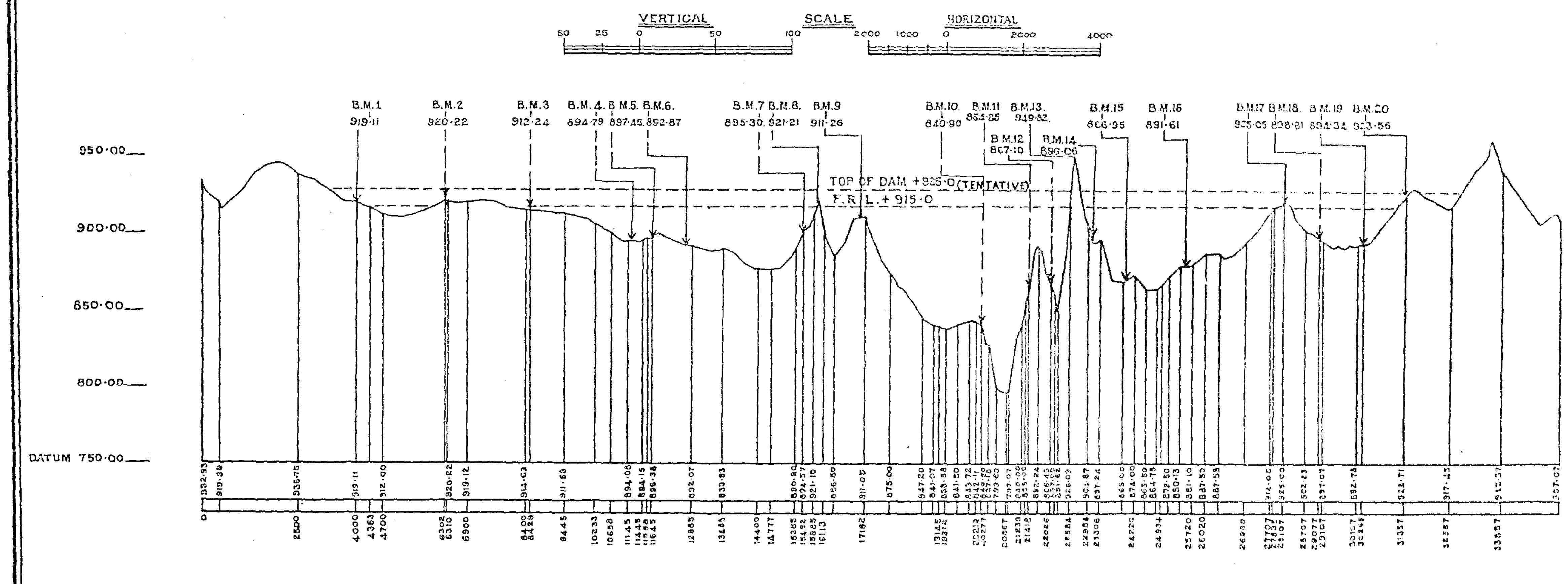
PLATE No. VI.



POSITIONS OF BENCH MARKS AS PER NEW L. S.

B.M. 1	1363′	B.M. 11	17277′
B.M. 2	3302′	B.M. 12	17867′
B.M. 3	5429′	B.M. 13	18418′
B.M. 4	7233′	B.M. 14	19026′
B.M. 5	7655′	B.M. 15	20306′
B.M. 6	8558′	B.M. 16	21934′
B.M. 7	11400′	B.M. 17	23980′
B.M. 8	11777′	B.M. 18	24895′
B.M. 9	13113′	B.M. 19	26077′
B.M. 10	16145′	B.M. 20	27265′

LOWER BHAVANI PROJECT
SECTION OF
THE BHAVANI RIVER
WITH
PROPOSED DAM
BASED ON OLD L.S.

M. P. Narasimhachari
FOR CHIEF ENGINEER
FOR IRRIGATION.

TRACED BY :- R.M. RAO.

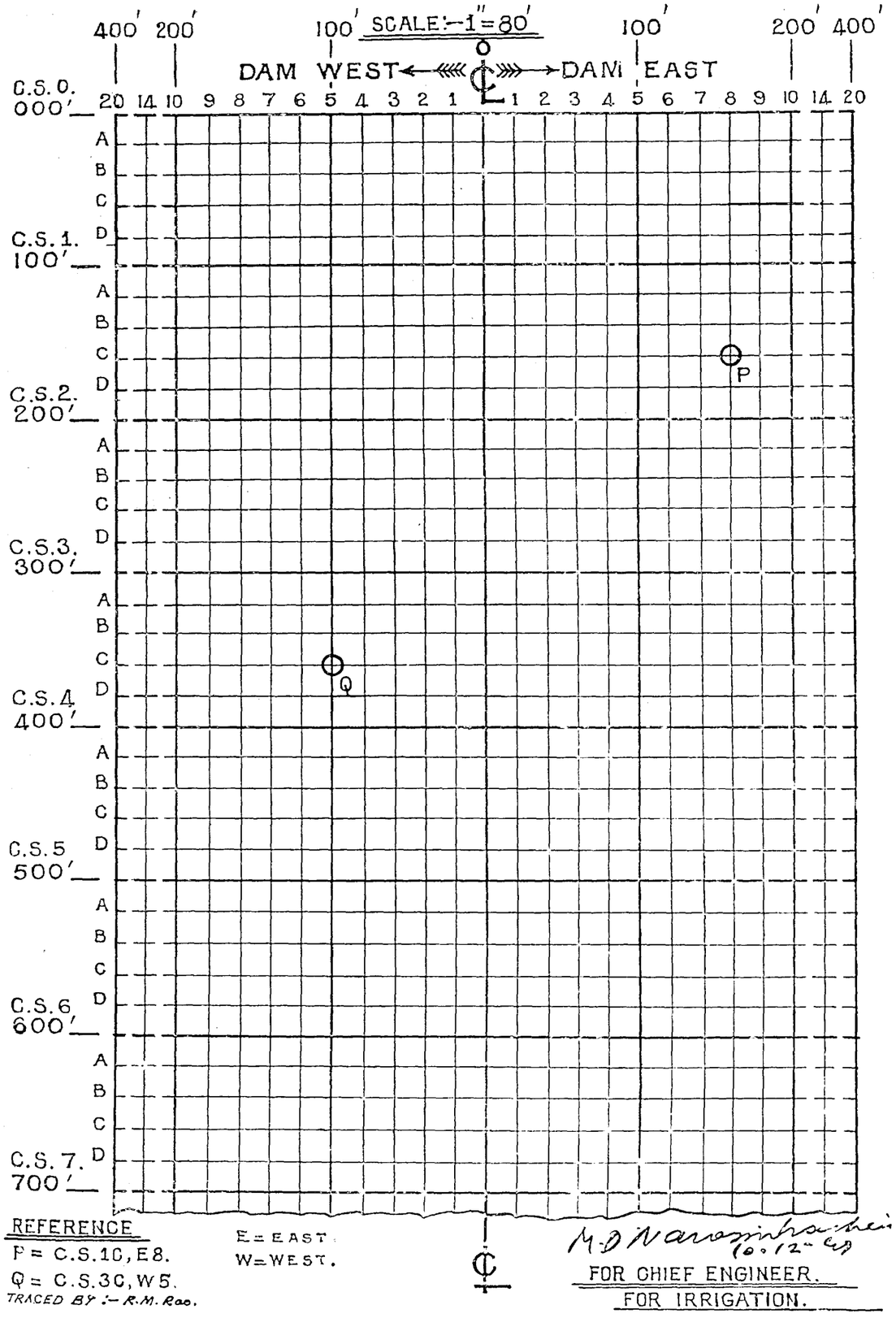
TRACED BY :- R.M. Rao.

FOR IRRIGATION.

LOWER BHAVANI PROJECT 37

ILLUSTRATIVE DIAGRAM TO LOCATE

POINTS IN THE DAM LINE BY CO-ORDINATES AT GROUND LEVEL



REFERENCE

P = C.S.10, E8.

Q = C.S.30, W5.

E = EAST

W = WEST.

TRACED BY :- R.M. Rao.

M.D Narasimharaiah 10.12.49

FOR CHIEF ENGINEER.

FOR IRRIGATION.

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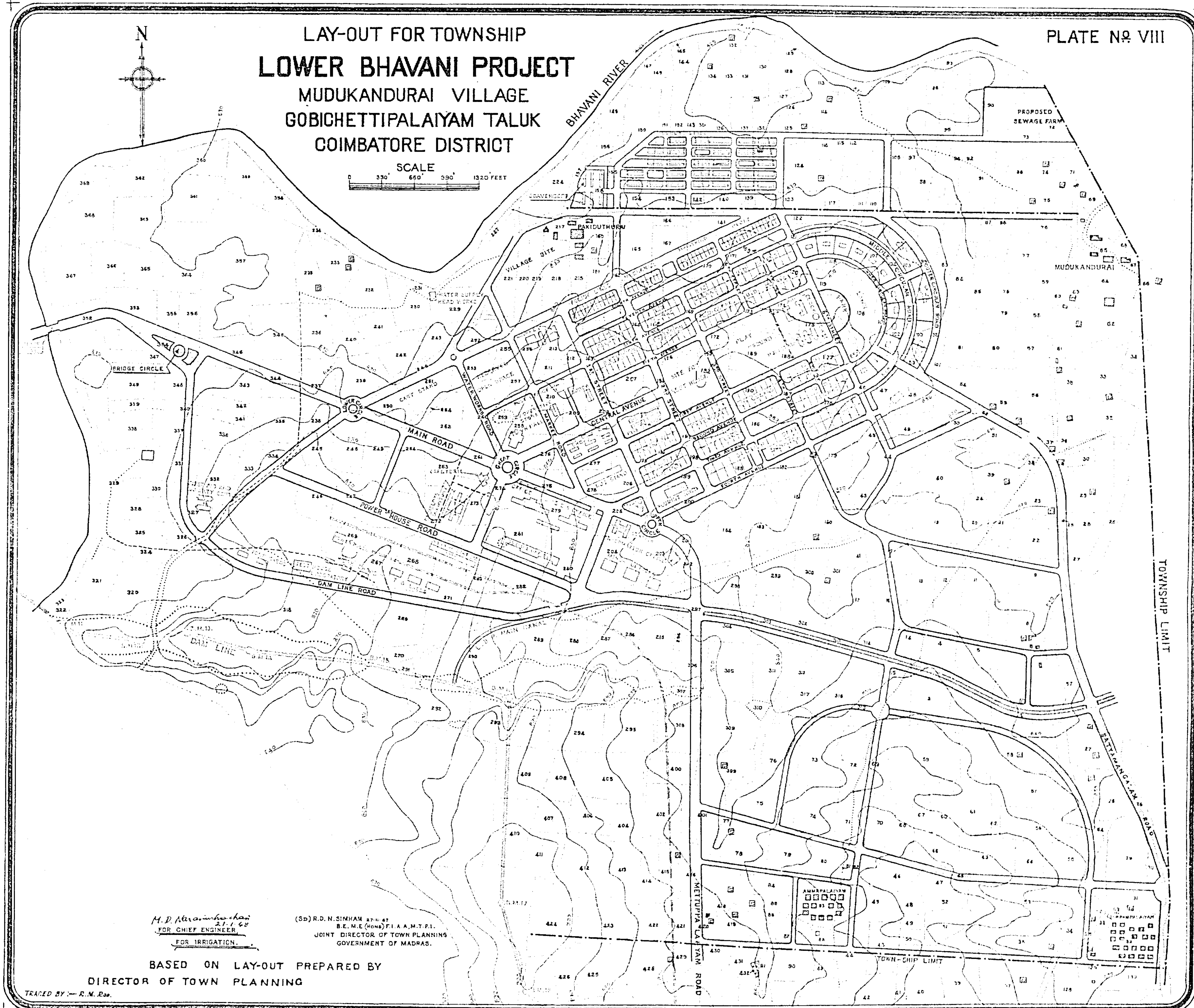

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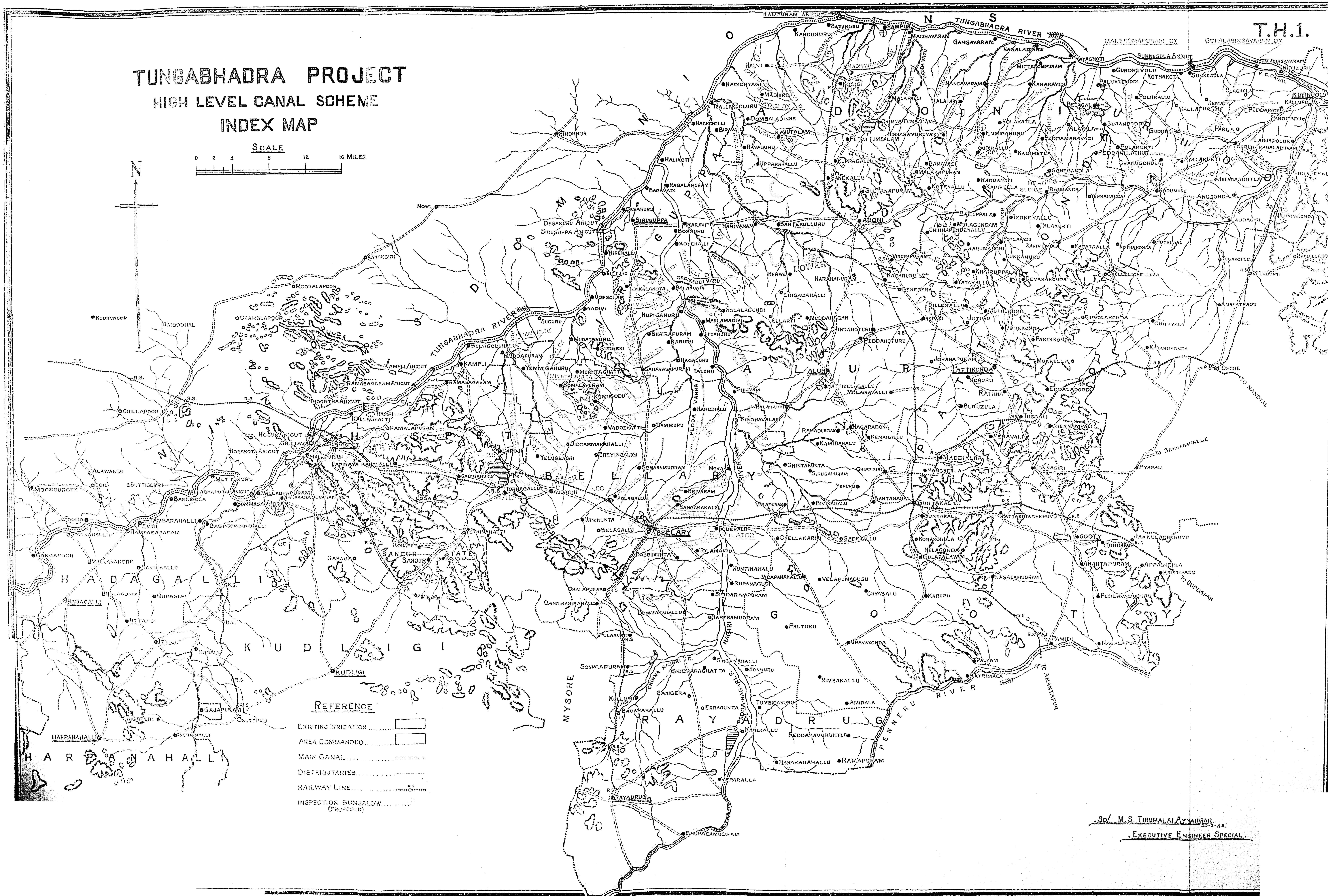

T.H.1.
TUNGABHADRA PROJECT
HIGH LEVEL CANAL SCHEME
INDEX MAP
SCALE
0 2 4 8 12 16 MILES.
N
TUNGABHADRA RIVER
PENNERU RIVER
HADAGALLI
KUDLIGI
HARPANAHALLI
HOSPET
BELLARY
ALUR
PATTIKONDA
ADONI
KURNOOL
GOOTY
RAYADRUG
SIRUGUPPA
MYSORE
SANDUR STATE
TO NANDYAL
TO BANGANAPALLE
TO CUDDAPAH
TO ANANTAPUR
REFERENCE
EXISTING IRRIGATION
AREA COMMANDED
MAIN CANAL
DISTRIBUTARIES
RAILWAY LINE
INSPECTION BUNGALOW (PROPOSED)
Sd/ M. S. TIRUMALAI AYYANGAR. 30-3-42.
EXECUTIVE ENGINEER SPECIAL.

TUNGABHADRA PROJECT

HIGH LEVEL MAIN CANAL UPPER cum RAJULABANDA CANAL

INDEX MAP

T.R.1.

SCALE

0 2 4 8 12 16. MILES.

N

REFERENCE

EXISTING IRRIGATION.....

AREA COMMANDED.....

MAIN CANAL.....

DISTRIBUTARIES.....

RAILWAY LINE.....

INSPECTION BUNGALOW.....(PROPOSED)

TRACED BY:- R.M. RAO

Sd/ M. S. TIRUMALAI AYYANGAR. 30-5-42.

EXECUTIVE ENGINEER SPECIAL.