



REPORT OF THE IRRIGATION & POWER TEAM  
ON  
**LAKKAVALLI PROJECT**  
(MYSORE STATE)

COMMITTEE ON PLAN PROJECTS  
NEW DELHI

NOVEMBER 1957.

GOVERNMENT OF INDIA  
COMMITTEE ON PLAN PROJECTS  
(IRRIGATION & POWER TEAM)



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REPORT  
ON  
LAKKAVALLI PROJECT  
MYSORE STATE

## LETTER OF TRANSMITTAL

*New Delhi, the 16th November 1957*

My dear Shree Pantji,

I have great pleasure in forwarding to you the Report of the Team for Irrigation and Power on Lakkavalli Project. The Report is the result of close study on all relevant facts and observation of necessary matters. The method followed was to consult the Project Authorities concerned at every step, the dominant thought being to do everything in close co-operation and in spirit of joint endeavour.

2. As the work of the Team proceeded, interim reports were submitted from time to time and thus no time was allowed to be wasted for such recommendations being implemented as were agreed and approved. The Report has the concurrence of the Consultative Committee which was appointed to advise on the technical questions. The Mysore Government and the Ministry of Irrigation and Power with whom the Report has been discussed are in general agreement with the conclusions and recommendations of the Team. For facility of implementation, the main recommendations of the Team have been placed as an appendix in the form of a tabular statement in accordance with the memorandum No. COPP/7/1/5/57 dated the 7th February, 1957 of the Committee on Plan Projects to the Leader of the Irrigation and Power Team.

3. I take this opportunity of thanking you for the close personal interest you have taken in the investigation as also the Secretary of the Committee on Plan Projects. The members of the Consultative Committee were extremely helpful and the guidance they gave to the members of the Team was constructive and far-sighted.

Yours sincerely,

N. V. GADGIL.

Shri Govind Ballabh Pant,  
Minister for Home Affairs,  
New Delhi.

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## INTRODUCTORY

The National Development Council constituted in September 1956 the Committee on Plan Projects with the Minister for Home Affairs as Chairman with a view to securing economy and efficiency in the utilization of financial and other scarce resources in the implementation of Projects included in the Second Five Year Plan. The Committee on Plan Projects better known as COPP set up the Irrigation and Power Team to conduct investigations on the Lakkavalli and Chambal Projects. The composition of the Team was as follows:

Shri N. V. Gadgil.

Leader.

Shri Lal Singh, *Ex-M.P.*, Director of Agriculture (Retd.), Punjab.

Shri M. Narasimhaiya, Chief Engineer for Irrigation (Retd.), Mysore.

Shri C. L. Handa, I.S.E., formerly Director Bhakra Dam Designs Directorate, Punjab.

Members for the Chambal Project.

Shri G. N. Pandit, I.S.E., formerly Superintending Engineer, Bombay.

Member for Lakkavalli Project.

The Team was guided by a Consultative Committee consisting of senior engineers:—

Shri A. N. Khosla, Vice-Chancellor, Roorkee University.

Shri N. N. Iengar, Adviser, Ministry of Iron and Steel.

Shri M. S. Thirumale Iyengar, Chief Engineer, Hirakud.

Shri R. K. Gupta, Managing Director, National Projects Construction Corporation.

Shri D. S. Borker worked as Secretary to the Consultative Committee as also to the Irrigation and Power Team.

2. The Irrigation & Power Team was required to make a study of various aspects of the two Projects with special reference to:—

(1) To study all aspects of the Project having a bearing on economy and efficiency with special reference to:—

- (a) Utilisation of trained personnel and materials;
- (b) Utilisation of machinery and equipment;
- (c) Construction—Plant lay-out;

(ii)

- (d) Adequacy of original estimates and designs as evidenced from actual construction of the Project;
- (e) Phasing of construction with a view to studying whether:
  - (i) Timely utilisation of benefits accruing from the Project has been ensured;
  - (ii) it is possible to accelerate accrual of benefits;
  - (iii) benefits could be increased by rephasing the Project at this stage;
- (f) Sufficiency of investigations conducted at the planning stage with a view to the formulation of Project Estimates;
- (g) The effect of the above study on the financial results of the Project, if any.

(2) Generally to assess the progress made in construction, the reasons for shortfall, if any, and to suggest measures for improvements in the future.

(3) To examine the possibility of decreasing dependence upon imported materials and equipment required for the Project.

(4) To examine whether adequate steps have been taken by the authorities concerned for fixing and realising the contemplated water rates, betterment fees and/or any other rates, cesses or taxes.

(5) Any other recommendation that the Team may like to make in order to ensure economy and efficiency in the construction of the Project.

3. The main burden of the investigation on irrigation side of Lakkavalli Project fell on Shri G. N. Pandit who was specially selected for this work. Shri N. N. Iengar, Electrical Adviser, Ministry of Iron & Steel, and a Member of the Consultative Committee on Irrigation & Power dealt with power aspects of the Project. Both of them visited the Project site a number of times for observation and collection of relevant data. It was followed by a visit by the Leader and Members of the Consultative Committee who held discussions with the Chief Engineer (Irrigation) and other officials of the Mysore Government. The tentative conclusions of the Team were formulated in May 1957 and the draft report was placed before the Consultative Committee towards the last week of August 1957. The report as modified was forwarded to the Mysore Government who were in general agreement with the recommendations made by the Team.

4. We take this opportunity to record our gratitude to Mysore Government for the facilities extended for the conduct of investigations and spirit of accommodation shown by the Chief Engineers, Irrigation and Electricity and other officials. We are specially indebted to Shri Indarjit Singh, Secretary, COPP, who took active part in the deliberations of the Team and gave generously his time and knowledge especially on financial and administrative aspects of the Report.

## 1. SCOPE OF THE PROJECT

1.1. The dependable annual yield is 1,00,000 mcft. at the dam site, range of variation being 75,000 mcft.—1,50,000 mcft. The utilisation for irrigation and power put together is 90 per cent of this yield. All possible expedients have been exploited in order to maximise generating capacity of the project, e.g.:

- (a) The Project is designed to generate power from discharges released into the river bed and also from the discharges released into the Right Bank and Left Bank Channels. The total installed capacity is 40,400 KW.
- (b) It is also planned to utilise water released for irrigation to the maximum extent, by reusing for additional irrigation, the water re-generated into nallas from the irrigated tract. This is proposed to be achieved by constructing pick-up weirs across them. The total area irrigated would be 2,34,000 acres.

1.2. There is a possibility of generating more power by slight modifications in the design and in the arrangements under which it has been planned in the manner indicated below:—

- (i) During good years surplus water is available. Besides, in the initial years, irrigation will not have developed fully and a proportion of the water earmarked for irrigation can be utilised for generation of additional power and energy by discharging this surplus into the river bed. It is suggested that during negotiations with the successful tenderers for the supply of machinery, maximum overload capacity for all the generating units be called for and incorporated in the final designs of the units. About 6,000 KW. overload capacity may be feasible.
- (ii) The fullest use of the supplies in the Lakkavalli storage for power can, however, only be secured if the regulation of water permits certain balances to be left over in the reservoir in good years to be utilised in subsequent lean years, thus increasing the level of firm energy generated annually. The utilisation of the waters of the Bhadra river is subject to an understanding which was arrived at in December, 1945, through the good offices of the Government of India, among the then Mysore, Madras and Hyderabad States. The two

States now concerned are Andhra and Mysore. According to Clause (2) of this agreement (*vide* app. II), out of the quantity of water impounded in the reservoir every year, 57,000 mcft. only could be utilised for irrigation on this Project and the balance should be released into the river undiminished within the same year. By implication, it appears that the said Clause operates to prevent Mysore State from maintaining a carry over in surplus years. The design of the Dam has been so prepared as to permit carry over to be maintained. The carry over, while beneficial to Mysore, need not affect adversely the Projects downstream. This is, however, a matter which requires joint consultations and the Team is glad to report that both Governments are agreeable to further discussions. It is suggested that the Irrigation and Power Ministry may provide the machinery for reaching final decisions.



## 2. ADMINISTRATION

2.1. The distinctive features of the administration of the Project are as follows:—

- (a) The ratio of the cost of establishment to the total cost of the Project works out at 4% which is considerably lower than the 10-12% ratio considered as desirable by the Nangal Seminar of Engineers. This may be mostly attributed to the lower scales of pay prevalent in the Mysore State as compared to other States, and partly it is due to certain under-staffing of the Project to which a reference will be made later.
- (b) The management of the Project is carried out with the assistance of a Consultative Committee of Engineers, a High-powered Committee of Administrators and Engineers and the Chief Engineer, Major Irrigation (South) who is also in-charge of the Sharavati Valley Hydro Electric Scheme and some other Projects of the State.

2.2. The unique feature of these arrangements is the constitution of a Consultative Committee consisting of the two Chief Engineers of the State, six retired Chief Engineers of the State, retired Director of Hydraulic Research, Chief Engineer, Electricity Department, Secretary to the Government in the P.W.D. and the Under Secretary to Government, P.W.D., who acts as Secretary of the Committee. The technical decisions of the Committee are taken at a preliminary meeting under the chairmanship of the Chief Engineer concerned. The draft resolutions of this preliminary meeting are then ratified by the regular meeting of the Standing Technical Advisory Committee presided over by the Minister, P.W.D. According to convention the decisions of the Standing Technical Advisory Committee are invariably accepted although functionally the Committee has only the right to advise.

2.3. The administrative details connected with these decisions are then considered fully by a High-powered Committee of which Minister, P.W.D. is the Chairman. The Secretaries to Government in the Public Works, Finance and Development Departments, President, Stores Purchase Committee, two Chief Engineers and Shri M. Narasimhaiya act as members. The resolutions passed by this High-powered Committee constitute an authority for implementation. The effect of consideration given by this Committee is that routine departmental procedures are cut across at origin,

and a sense of expedition is introduced into the implementation of the Project. The High-powered Committee is virtually the Control Board for the Project.

2.4. The actual administration of the Project is with the Chief Engineer, Major Irrigation (South). The detailed working of the Project is supervised by a Superintending Engineer.

2.5. The three-tier arrangement above ensures that practical and administrative issues are given due consideration by persons qualified to undertake such responsibility. The arrangements may look, on the face of it, somewhat complicated but in actual operation they have considerable advantages over arrangements made for the execution of Projects in other States. The distinctive feature is the manner in which the available engineering talent in the State has been harnessed for the discussion of technical issues arising from the Project. The responsibility for details of designs and technical execution is thus shared between the existing Chief Engineers and the other engineering talent in the State. This enhances the confidence of the administrative agencies in the final designs and plans for execution which, in turn, enables expeditious implementation. Ad hoc consultations are decided upon by designing and executing authorities elsewhere as difficulties arise, but there is no continuous technical scrutiny by persons not burdened with the daily routine of designing and administration involved in the execution of the Projects. This feature of the Lakkavalli Project is worth copying and certain proposals, in this behalf, have been made by the Team in its report relating to the Chambal Project.

2.6. A reference has already been made to some under-staffing in the Project. The following suggestions are being made for strengthening its administration. They have been generally discussed with the Project authorities of the State Government, and are acceptable to them. The justification for each proposal is briefly indicated below. The Team has been constrained to suggest additional expenditure in the interest of more effective execution of the Project, as follows:—

- (i) The work on the Tunga Anicut Project is nearly completed, but the tempo of the progress on the Lakkavalli Project needs to be intensified immediately. The large and important works of the 2½ miles long tunnel on the Right Bank Channel, and the excavation of the Malebennur and Davangere Branches are to be started immediately and proceeded with at a rapid pace so as to synchronize with the completion of the Lakkavalli Dam. These works are situated at a distance from the site of the Lakkavalli Dam. The construction of the dam is reaching a stage when the construction of the power houses, installation of the turbines and the generating units, installation of sluice gates and crest gates, etc.,

will have to be undertaken according to schedule. These works will need considerable personal attention of the present Superintending Engineer. It is necessary that an additional post of Superintending Engineer should be created to take charge of the construction of the channel tunnel and the Malebennur and Davangere Branches. The total annual expenditure on this Project, hereafter, of 4-4½ crores of rupees is sufficiently heavy to justify the creation of a second Circle. A good deal of preliminary work has to be done in connection with the construction of the tunnel and the actual construction will need constant attention at a sufficiently high level. It is also desirable, in the interest of the timely completion of this work which has already been delayed, that the headquarters of the second Superintending Engineer should be fixed within an easy reach of the tunnel. It is understood, as a result of informal discussion with the representatives of the Mysore Government, that they accept the justification for the creation of an additional post of a Superintending Engineer.

- (ii) The arrangements for preparing designs need revision. The present practice is that both major and minor designs are prepared in the offices of the Executive Engineers and approved by the Chief Engineer. The latter has no central Designs Office. Since major Projects other than Lakkavalli are also being taken up for execution and it has been found, in actual practice, that major changes have to be made in designs, it is suggested that a Central Designs Office may be constituted under the Chief Engineers. This office should attend to major changes in design. There will also be day to day supervision of the evolution of designs by the Chief Engineer on whom ultimately rests the responsibility of approving them and for placing them before the Consultative Committee. It will also be possible for type designs to be standardised for other works. The minor designs may continue to be prepared by the Executive Engineers. It will also be necessary to locate a small designs cell of the Central Designs Office at the headquarters of the Superintending Engineer in order to maintain liaison with field officers and to render such local assistance as may be necessary to the Executive Engineers engaged on minor designs. The exact staff requirements for the designs organisations suggested above would require to be worked out in detail.
- (iii) The designs of the spillway and the stilling basin and certain other features of the dam were based upon the results of several hydraulic experiments carried out at the Research

Station at Krishnarajasagar. This station is under the administrative control of the Chief Engineer, General. The current procedure is that the estimate for the cost of conducting the model experiment has to be approved by the Chief Engineer, General. Also, the results of the tests are communicated by the Director, Research Station to the Chief Engineer, General, who transmits them to the Special Chief Engineer incharge of the Project. This procedure is lengthy as an unnecessary stage in the form of Chief Engineer, General, as the Controlling Officer is introduced in the transmission of papers. As the cost of the model studies is met with from the Project funds, the sanction to the estimates should be accorded by the Project authorities, under whose control and guidance the Research Officers could maintain close contact with the Project Engineers, readily visit the site of the work if necessary and promptly communicate the results of the tests to the Project authorities.

- (iv) The present laboratory facilities for the field research work and tests on this Project are not adequate. This is particularly necessary as the work is being mostly executed departmentally. The quality of work and strict observation of specifications have to be continuously watched and ensured. The Team would suggest that a separate organisation headed by an experienced senior Executive Engineer, directly responsible to the Chief Engineer, should be created for the purposes of inspection. This organisation should also be incharge of laboratory tests and should advise on variations required in the designs and techniques of concrete, mortars and earth-works, etc. The organisation will need a moderate staffing but its ultimate benefit would be well worth the expenditure incurred as is clear from the functioning of such organisations elsewhere.
- (v) There has been some difficulty in obtaining experienced store-keepers. When the work on the construction of the tunnel is undertaken, the responsibility for store-keeping will increase. The Team suggests that the Mysore Government, either itself or with the assistance of a Commerce College conduct a short course for training Store-keepers and Clerks.

### 3. PHASING OF CONSTRUCTION PROGRAMME

3.1. In a multipurpose or irrigation Project it is to an economic advantage if the construction programme is so arranged that benefits start accruing even before the Project is fully completed.

3.2. In the Lakkavalli Project the construction programme is such that a progressive accrual of irrigation benefits is secured (appendix-III):

- (a) The sluice of the Left Bank Channel is at +36 above river bed. The dam was raised above this level in 1955-56. Simultaneously the Left Bank Channel was completed and opened for irrigation (18,500 acres).
- (b) The sluices of the Right Bank Channel are located at R.L. + 100. The Right Bank Channel is divided into the following three Sections:—

Section I. Mile 0—48:—

Culturable command on main canal, 39,500 acres. Culturable command on Anavery Branch Ex-R.B. main canal 11,000 acres.

Section II. 2½ miles:—

Tunnel with its approaches.

No irrigation.

Section III. Main Canal from mile 51 to tail and Davangere and Malebennur Branches:—

Culturable commanded areas:

Malebennur Branch	60,000 acres
Davangere Branch	95,000 „
Harpanhalli Branch	10,000 „

3.3. The dam in the spillway section is proposed to be raised to a level +98 in the year 1958-59. This is just a few feet short of the cill level of the Right Bank Channel sluice. The phasing of the construction programme can be improved so as to obtain additional irrigation benefits one year earlier. The dam is to be raised to about + 106 with a smaller but stable cross section (masonry in flanks to be raised correspondingly in a similar manner). The works in Section I of the Right Bank Channel together with the Anvery Branch are to be completed simultaneously. Such a programme is practicable in view of the fact that additional

quantities of work involved are small (appendix—IV). The work on the construction of the main canal in Section I is already well advanced. There is one railway crossing in this Section which must be constructed in time. With the implementation of these suggestions irrigation facilities to an area of 50,500 acres will become available one year earlier without any extra cost. In the context of the present food situation, the Irrigation Development Committee will, no doubt, when apprised of the earlier introduction of irrigation on the Right Bank Channel, take all the necessary steps to ensure that lands are in readiness to receive the benefits.

3.4. The construction of the tunnel in Section II and the finalisation of the alignment of the Right Bank Channel and the Davangere and Malebennur Branches near the Sulekere tank are the two pre-requisites for the functioning of last and the most important reach of the Canal. The urgency of an early resolution of these problems is now recognised.

3.5. The actual construction of the tunnel should not take more than two years (including six months for procurement of machinery). Hence if energetic steps are taken from now, the tunnel should be ready by middle of 1959. By this time a major portion of the Malebennur Branch and some portion of the Davangere Branch should be completed. The canal work should be completed in all respects by 1960-61, which is also the year when the dam will be completed and full storage made available.

3.6. In view of the fact that there are definite prospects on this Project for the commencement of irrigation and power benefits without a time lag, the full quota of funds for the completion of the balance of the job needs to be made available.

#### 4. FEATURES OF DESIGNS AND CONSTRUCTION

4.1. The design of the masonry dam follows modern practice in respect of assumptions for uplift, provision for consolidation and curtain grouting, drainage gallery, effective arrangement for dissipation of energy of the spillway discharge based on hydraulic model experiment etc.

4.2. In respect of the earth dams in the saddles, the design is based on the modern concepts of soil mechanics. This work, however, remains to be done and arrangements for field quality control need to be established as suggested.

4.3. It is desirable to install instruments in the masonry and the earth dams for collecting data on their behaviour. The information sought for the masonry dams would be on temperatures, deflection, uplifts and stresses; and for the earth dams, it will be on consolidation settlement and pore pressures. Such instruments could be installed at a small cost and their observation entrusted to the maintenance staff.

4.4. It has been an established practice in the Mysore State to use mortar of lime and surkhi (1:4) for constructing masonry. This mortar develops fair strength and produces water-tight masonry. The specifications for this mortar were originally evolved on the Vanivilas-sagar Dam in 1892 and were later adopted on the construction of the Krishnarajasagar and other dams.

4.5. The masonry with the lime-surkhi mortar is found water-tight and economical. In spite of the comparatively heavy cost of stone at Lakkavalli as Rs. 50—60 per 100 cft., due to long leads, the average cost of rubble masonry for the hearting of the dam is not exceeding Rs. 1.25 per cft. exclusive of overhead charges (*vide* App. V). Test holes drilled in the body of the dam could take only an insignificant amount of grout, showing the excellence of the masonry.

4.6. There is no laboratory control on the raw materials used for the manufacture of lime and surkhi during the stage of construction. Results of tests of the mortar cubes performed, continuously, show a wide variation of strengths (*vide* App. VI). If lime kankar and soils used in the manufacture of mortar are subjected to tests it would be possible to standardize the product and reduce the variations of the mortar strengths to narrower limits. Such standardization will lead to the adoption of higher permissible stresses in the masonry and permit adoption of more economical cross sections of dams. Therefore, it is suggested in para 2.6 (iv) to provide a suitable organisation to control this very

important aspect. This organisation provided with a well equipped laboratory should also be able to design the concrete mixes in accordance with modern scientific methods, so as to obtain mixes of required workability and strength with the least possible amount of cement.

4.7. A few pieces of heavy earth-moving machines, namely, tractors, power shovel and end-dumpers are used on the dam construction. These machines, unless properly matched and made full use of, do not give economical performance. For the period of 12 months from 1st April 1956 to 31st March 1957 the shovel worked for 490 hours while the tractors & the dumpers worked for an average period of 830 and 790 hours only. The dumpers which were used for conveying mortar are loaded manually and the machines are idle during the period of loading which is over half an hour at a time. This operation is therefore inefficient & uneconomical. Diversion of these machines to the saddle earth dams or other suitable work is indicated.

4.8. The average daily progress of rubble masonry in the dam is about 13,000 cft. In the further work that has to be done, the average progress will have to be pushed upto about 15,000 cft. per day so as to attain the targets. With proper organization and planning it should not be difficult to achieve the progress in view of the fact that the maximum daily progress has been 25,000 to 30,000 cft. We have been assured by the Chief Engineer, Mysore, that he would be able to achieve this target without any additional staff.

4.9. On the Lakkavalli Project, a number of further sub-classifications of each of the main strata (*viz.* soil, murum, soft rock and hard rock) is introduced. As admitted by Executive Engineers in charge of works, it is not possible to follow these numerous classifications in actual practice. Therefore, the piece-workers are paid at average rates. It is, therefore, desirable to follow only few broad classifications which would minimise doubts regarding correctness of classifications and avoid the possible disputes or abuse.



## 5. CANAL WORKS NEEDING URGENT ATTENTION

5.1. *Tunnel in miles 52 of the Right Bank Channel.*—Speedy construction of this tunnel has become a matter of crucial importance. Major portion of irrigation included in the Project is in the command of the Malebennur and Davangere Branches, which take off from the Right Bank Channel beyond the tunnel. Hence unless the tunnel is completed expeditiously the development of irrigation will be seriously throttled. An indent for the tunnel construction machinery costing Rs. 39 lakhs is at the moment pending with the Government of Mysore.

5.2. Appendix VII shows a scheme for constructing the tunnel together with a list of equipment which is considered sufficient for completing it in 18 months. According to this scheme, the investment in the tunnel machinery can be reduced by Rs. 10 lakhs.

5.3. *Alignment of the Right Bank Channel and the Davangere and Malebennur Branches near the Sulekere tank.*—In the original Project, provision was made for the Right Bank Channel, after emerging from the tunnel, to drop in the existing Sulekere tank and to take off the two branches from this tank. The tank is a fairly large one and is formed by a short earth dam constructed a few centuries ago. As the levels adopted in the original Project were not quite suitable, it was subsequently decided to take off the Right Bank Canal from the Lakkavalli Dam at a level ten feet higher than originally intended. Further increase in the level at the tail end of the tunnel was gained by easing certain curves and thereby shortening its length. Dropping the canal into the tank was then no longer obligatory and alternative alignments were investigated in detail for bypassing the tank. These alternative alignments which became a subject of some controversy, were under consideration. In the meantime the construction of Section III of the Right Bank Channel and the Branches was consequently held up. After studying the problem, personal visits to the site and discussions with the Mysore Engineers, the Team has recommended proposals contained in appendix (VIII) adoption of which results, on the basis of estimates furnished by the State Government, in a saving of Rs. 20—54 lakhs over all other possible alternatives.

## 6. DEVELOPMENT AND MANAGEMENT OF IRRIGATION

6.1. A special feature of the Lakkavalli Project is that the soil, health and economic surveys of the commanded areas were taken up at the same time as administrative approval was given to the Project. These surveys were carried out in great detail and completed expeditiously.

6.2. These surveys were carried out under the direction of the Bhadra Reservoir Development Committee. The terms of reference of this Committee included the determination of the contribution (betterment charges) and water rates to be recovered from the agriculturists, and sending up recommendations to Government. They had to finalise the alignments of the channels, examine the nature of soils in the commanded areas and recommend the best plans for raising crops suitable to the soil. Consequent on the development of irrigation, effect of malaria in the area and ways and means of preventing it had also to be decided upon. A survey of the economic well-being of the population in the area had also to be made. In short a detailed survey of the commanded area from all aspects had to be conducted and final recommendations made for avoiding and overcoming the evil effects of introducing wet cultivation, and the means for achieving the best results from the Project.

6.3. The following officers were appointed as members of the Committee.

- (1) Revenue Commissioner—*Chairman*.
- (2) Chief Engineer of Mysore.
- (3) Director of Agriculture.
- (4) Director of Public Health.
- (5) Superintending Engineer, Tungabhadra Valley Circle.

The Assistant Engineer, Bhadra Reservoir Project served as the Secretary of the Committee.

6.4. The Sub-Committee consisting of the following officers representing different departments was formed to carry out the actual work of surveys and field investigations.

- (1) Assistant Commissioner.
- (2) Assistant Engineer.
- (3) Assistant Director of Agriculture.
- (4) Health Officer.

These sub-committees were assisted by appropriate subordinate staff.

6.5. The total cost of surveys for the gross commanded area of 3,77,164 acres was Rs. 3,50,000 and the work was completed well in advance of the construction work. 494 villages were surveyed. Average cost of surveys per village works out at Rs. 710.

6.6. The entire area was divided into a number of zones and detailed reports for each zone together with zone map were prepared by the Sub-Committees and submitted to the main Committee. A sample of a zone report and a zone map are enclosed (Appendix IX).

6.7. A summary of the recommendations of the Bhadra Reservoir Development Committee's report is at Appendix X.

6.8. To implement the recommendations of the Bhadra Reservoir Development Committee, Government appointed another Committee (*vide* Appendix XI). This Committee is taking all the necessary measures to promote a rapid and planned development of irrigation in the Project area. The Committee also deals with the problems of rehabilitation of population displaced from the reservoir area.

6.9. *Water rates and contribution.*—In August 1954 Government of Mysore constituted a Committee under the Chairmanship of the Minister of Agriculture to examine the question of rationalisation of scales of water rates and contribution in respect of irrigation works in the State.

6.10. The recommendations of this Committee were accepted by Government with certain modifications (*vide* Appendix XII). These orders will be applicable to the Lakkavalli Project.

6.11. It is thus seen that all the necessary steps have been taken to prepare a sound plan for irrigation and there is a high level committee to implement the same. Government interest has also been secured by fixation of betterment charges and water rates. However, judging from the rates for perennial crops that are prevalent in contiguous States, there seems to be scope for an upward revision of water rates on this Project.

6.12. For an orderly development of irrigation in accordance with the programme of crop Planning envisaged by the Bhadra Reservoir Development Committee and also to ensure economical use of water it is necessary that there should be an effective control over the management of irrigation. Particularly, in the present case limited supplies are available and any inadequacy in management will result in a reduction of the total acreage to be developed under irrigation and thus the possibility of discontent among cultivators situated at the tails of the channels may arise.

6.13. In Bombay, Punjab and some other States, it is the Irrigation Department that is responsible for the management of irrigation upto the point of preparing assessment papers. Regulation of canals has necessarily

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These sub-committees were assisted by appropriate subordinate staff.

6.5. The total cost of surveys for the gross commanded area of 3,77,164 acres was Rs. 3,50,000 and the work was completed well in advance of the construction work. 494 villages were surveyed. Average cost of surveys per village works out at Rs. 710.

6.6. The entire area was divided into a number of zones and detailed reports for each zone together with zone map were prepared by the Sub-Committees and submitted to the main Committee. A sample of a zone report and a zone map are enclosed (Appendix IX).

6.7. A summary of the recommendations of the Bhadra Reservoir Development Committee's report is at Appendix X.

6.8. To implement the recommendations of the Bhadra Reservoir Development Committee, Government appointed another Committee (*vide* Appendix XI). This Committee is taking all the necessary measures to promote a rapid and planned development of irrigation in the Project area. The Committee also deals with the problems of rehabilitation of population displaced from the reservoir area.

6.9. *Water rates and contribution.*—In August 1954 Government of Mysore constituted a Committee under the Chairmanship of the Minister of Agriculture to examine the question of rationalisation of scales of water rates and contribution in respect of irrigation works in the State.

6.10. The recommendations of this Committee were accepted by Government with certain modifications (*vide* Appendix XII). These orders will be applicable to the Lakkavalli Project.

6.11. It is thus seen that all the necessary steps have been taken to prepare a sound plan for irrigation and there is a high level committee to implement the same. Government interest has also been secured by fixation of betterment charges and water rates. However, judging from the rates for perennial crops that are prevalent in contiguous States, there seems to be scope for an upward revision of water rates on this Project.

6.12. For an orderly development of irrigation in accordance with the programme of crop Planning envisaged by the Bhadra Reservoir Development Committee and also to ensure economical use of water it is necessary that there should be an effective control over the management of irrigation. Particularly, in the present case limited supplies are available and any inadequacy in management will result in a reduction of the total acreage to be developed under irrigation and thus the possibility of discontent among cultivators situated at the tails of the channels may arise.

6.13. In Bombay, Punjab and some other States, it is the Irrigation Department that is responsible for the management of irrigation upto the point of preparing assessment papers. Regulation of canals has necessarily

to be done by the Irrigation Department as a part of its technical work. Annual irrigation programmes, the water requirement of crops, wastage or unauthorised use of water, untoward consequences of irrigation under certain circumstances, such as water logging and salt efflorescence, are closely allied matters ultimately linked with the regulation of canals and as such ought to be under the unified control of the Irrigation Department. The Bombay Public Works Department have under the control of the Executive Engineers fully manned establishment dealing with applications from cultivators to receive irrigation for crops, the programme for issuing water to the authorised crops, preparation of assessment papers, checking malpractices by taking penal actions against offending irrigators. The Irrigation Department also conducts periodical surveys of damaged areas and subsoil table and is responsible for preparing and executing drainage scheme. These surveys also enable the Department to determine the areas in which perennial crops should be permitted. Thus the Irrigation Department has a control over the irrigation management in a full measure resulting in an efficient and economic use of water. Therefore it is strongly recommended that the Government of Mysore may follow Bombay's pattern as far as possible.

6.14. From the proceedings of the Special Committee constituted to inquire into the depletion of the Krishanarajasagar some years ago (Appendix XIII) it is seen that it was intended to introduce on the Irwin Canal the "Block System" of irrigation prevailing in Bombay, with suitable modifications, but, for various reasons, this has not been done nor any other system introduced and haphazard irrigation has resulted. Such a state of affairs should not be allowed to occur on the new areas in the command of the Lakkavalli Channels.

6.15. Now, that irrigation has commenced on the Left Bank Channels, immediate steps need to be taken as indicated above.

## 7. POWER GENERATION .

7.1. In order to utilise the waters stored in the Bhadra Reservoir for power generation as well, two power stations are being constructed—One at the right bank of the river with two machines each rated at 7,200 KW. utilising the irrigation waters to be discharged into the right bank canal, and the other at the left bank with one machine of 2,000 KW. utilising the waters to be discharged into the left bank canal and two machines of 12,000 KW. each discharging waters into the river below the dam.

7.2. An average daily discharge of 627 cusecs has to be maintained in the river below the dam-500 cusecs for irrigation of lands under the Bhadra Anicut (which is located about 8 miles downstream of the Dam) and 127 cusecs for industrial and domestic water supply below the Anicut. This water is proposed to be utilised for power generation in the two 12,000 KW. units which may be called river-bed units.

7.3. It is found that in a year (1937-38) of average run-off, commencing with reservoir level at 123 on 1st July, full irrigation requirements under the two canals can be met throughout the year and a discharge of 627 cusecs can be maintained throughout the year in the river below the Dam. Besides, a surplus of 23826 mcft. of water will have to be let out in the river bed in order to bring down the lake level to 123 by the end of June as there should be no carry-over according to the terms of the agreement. During a lean year (1938-39) however, it would not be possible to maintain a discharge of 627 cusecs in the river bed right through the year. From December 15 to June 15, this discharge will have to be limited to the natural inflow in the river which is much below 627 cusecs. It is understood from the P.W.D. Engineers that river discharges in a lean year could be reduced to 327 cusecs during the wet months so as to increase the flow in the dry period (December—June) of the year.

7.4. The two power stations will feed into the existing transmission grid of the State. As the discharges into the two canals have to be continuous, the power generated in the three units discharging into the canals will also be continuous. The discharge through the river-bed units can however, be varied so that they operate during the system peak hours only. It has been found that even in the leanest year, it is possible to develop a firm peak output of 25,000 KW. from the proposed installation of generating units. The canal units will be operating continuously while the river bed units would operate during the morning and evening peak hours only.

7.5. In order to enable the Mysore power system to accept a firm additional load of 25,000 KW. at the *system load factor*, it would be necessary to carry over waters from surplus years to lean ones or to supplement

the energy resources at Lakkavalli by those available in the rest of the Mysore State power grid say at Sharavathi.

7.6. As the system load grows up, the peaks of the load curve become sharper and the energy in a given peak cut-off decreases. Consequently, with the same quantity of water, it would be possible to generate power at Lakkavalli to meet a *peak* demand of more than 25,000 KW. It is not possible to put in an additional penstock pipe now. However, absence of this provision is not considered to be an appreciable loss of resources in view of the fact that a very large generating station is projected to be developed in the State at Sharavathi during the 2nd Plan period. It is suggested that during the final negotiations with the successful tenderer, as much overload capacity as is practicable should be called for and incorporated in the final designs of the generating units. It is desirable to provide some extra penstock openings when building such dams in future. It will generally be found in expanding integrated power systems, that as the systems expand, additional hydro generating capacity can be utilised economically with the same water resources.

7.7. As it is not possible to forecast the nature of a monsoon season in advance, it would appear to be necessary to regulate the reservoir levels in the following pattern. As the monsoon months are generally from July to September, the storing of the monsoon inflows in the reservoir should be regulated so as to have it full (level 186) on the 1st October. The lake may then be depleted to the lowest possible by the following June and then the level built up again to 186 during July to September. If it is found during July that the monsoon may not be normal during that year, the discharge in the river bed could be suitably reduced so that the lake level could be built up as near to 186 as possible by the end of the South West monsoon.

7.8. There is no doubt that the power and energy from this Project would be utilised as soon as it is made available owing to the acute power shortage prevailing in the State.



## 8. CONSTRUCTION COSTS

8.1. The rates of wages of staff and labour are a feature of the economy of the Mysore State. The cost of masonry and of canal excavation is remarkably low. This is due, in no small measure, to the large number of labourers, skilled and unskilled, who have been employed on masonry and excavation works for years together and have attained a high degree of efficiency.

8.2. The rates for the main items of construction are given in appendices XIV—A to H.

8.3. The cost of Rs. 940 per acre of irrigated area and Rs. 915 per KW. of firm power may appear to be high having regard to the low rates of construction prevailing in the State. The factors contributing to the high overall cost are:—

- (a) High cost of constructing storage dams as against the comparatively low cost of diversion weirs where the canal supplies can be met with from the run-of from the river.
- (b) High cost of constructing the main canals, which pass through difficult terrain, involving heavy rock cutting and numerous cross drainage works. The Right Bank Channel involves excavation in rock cuts, as much as 60 feet deep and one  $2\frac{3}{4}$  mile long tunnel.

8.4. The works are mostly being carried out departmentally in an economical manner. Stones for the dam are being supplied by piece workers whose rates are determined periodically on the basis of quotations invited publicly. Lime Kankar and bricks for Surkhi are acquired in the same manner. Grinding of mortar is done departmentally. The masonry work for the dam is carried out by masons and other workers employed on nominal muster rolls and the gangs are given set tasks to ensure good quality. The excavation of canals is being carried out through pieceworkers and only the masonry structures on the canals are being excavated through contractors.

8.5. Bulk of the work is thus being carried out departmentally. This has not only resulted in a work of good quality at economical rate, but has afforded a high degree of construction experience to the Project engineers. Departmental work needs greater strength of establishment for supervision but in Mysore little difficulty has been experienced in the matter of staffing.

8.6. The estimated cost of the Project was Rs. 17.75 crores. (The original Project estimate of Rs. 8.88 crores having been based on arbitrary rates of 25% over the pre-war rates, cannot be taken for the purpose of comparison). The estimate is now under revision and the cost is likely to go up to Rs. 24-25 crores. This increase has resulted mainly due to increased quantities of works consequent on an increase in the scope of the Project and the important items which have led to this excess are listed below:—

(a) *Dam*

- (1) Increase in the height of the dam to impound additional storage.
- (2) Increase in cost of land acquisition due to increased area of submergence.
- (3) Increase in the quantity of the excavation for foundations due to the necessity of deeper excavation to reach sound rock.
- (4) Cost of extensive drilling and grouting for consolidation and curtain grouting.
- (5) Increased cost of protection works below the spillway.

(b) *Canals*

Increased work on the excavation, masonry and tunnel works due to the increased capacities of the canals to serve a greater area, the irrigated command having been increased from 1,80,000 acres to 2,34,200 acres.

(c) Increased cost of power houses and power plant due to the firm power generation having been raised from 12,682 KW. to 25,000 KW., the installed capacity for the firm power generation now being 40,000 KW.

The general rise in prices of material and wages of labour is also bound to reflect in the revised cost of the Project.

8.7. On this Project minimum use is being made of cement. Steel is being used on such items as gate structures etc., where its use is unavoidable. Some steel is being used on canal structures where there may be scope for a further saving. As the construction is not mechanised the outlay on machinery has been comparatively small (app. XV-XVI). The construction of the tunnel, however, has to be fully mechanised and it is essential that foreign exchange to the tune of Rs. 30-40 lacs be made available.

8.8. In spite of the cost of the dam and the heavy cost of canals, the Project is expected to be self-supporting. It has certain particularly good features such as detailed investigations for localization of irrigation, economy

in the use of steel and cement, conservation of foreign exchange involved in the purchase of foreign machinery and materials etc. which could be adopted by other Projects where circumstances permit. This Project deserves to be assured of timely and adequate grants to enable its completion within the target date.

November 16, 1957.

N. V. GADGIL,  
*Leader.*

## 9. SUMMARY OF REPORT

9.1. The Project is designed to impound 90,000 million cubic feet of water on the River Bhadra, irrigating 2,34,000 acres of land in Mysore State, and generating 25,000 KW. firm power, installed capacity being 40,400 KW.

9.2. The Project was initially started in 1947 and at the time of writing this report *i.e.*, by June 1957, an expenditure of roughly 9 crores was incurred out of Rs. 24 crores, the estimated cost of the Project. The dam is raised to nearly half the total height and irrigation was started on the left bank canal during the last year (1956-57). The excavation of the main canal is nearly complete in the first 50 miles, beyond which it has to cross a hill range through a tunnel, approximately 2½ miles in length. This tunnel is yet to be started, to facilitate which special machinery worth about Rs. 30 to 40 lakhs would be necessary and the Team has recommended to Government of India to release the necessary foreign exchange required to purchase such of the machinery as might not be available from the surplus on other Projects in the country. The Government of Mysore have been aware of the urgency of this work and are now busy in taking all the necessary steps to expedite the execution, since the Project is scheduled to deliver irrigation water up to the tail end by 1961 June. Also, the report has suggested an alternative list of machinery which would save about Rs. 10 lakhs.

9.3. The Irrigation and Power Team noted that there was another factor holding up the execution of the canal beyond the tunnel portion *viz.* the problem of by-passing the Shantisagar Reservoir, within a few miles after the tail of the tunnel. This problem could be solved by recourse to any one of a number of alternatives which were being discussed by the Mysore Engineers. The Team of Engineers and the Members of the Consultative Committee after discussing the matter with the State Engineers, proposed one of the alternatives, which happens to be the easiest and cheapest bringing a saving of Rs. 20 to 50 lakhs over the other possible alternatives.

9.4. The Team has found the construction staff as generally sufficient and efficient. However, they have made recommendations to strengthen the organisations incharge of the designs and quality control over construction materials and techniques. The report reveals that the establishment charges on this project are only 4% of the outlay, as against 10 to 12% as considered normal by the Engineers' Seminar. The reasons for

this are reported to be mainly due to the very low scales of salaries prevailing in the State and partly due to the understaffing as mentioned before.

9.5. The Report suggests the creation of another Circle under a Superintending Engineer to take up the construction of the Hiremalali Tunnel and the works beyond, so as to enable finishing of the work before the scheduled date.

9.6. The Report appreciates the Mysore practice of appointing a Standing Technical Advisory Board, consisting of the Chief Engineers of the State and retired Chief Engineers of the State and presided over by the Minister for P.W.D. The Engineers work almost honorarily and provide an excellent consultation at all the stages of planning, designing and execution of Projects. This practice is recommended for emulation by other States engaged in construction of development Projects.

9.7. The Report notes with appreciation the excellent manner in which the problem of Development of Irrigation has been tackled by the Mysore Government, who appointed a Committee known as Bhadra Reservoir Development Committee consisting of a Revenue Commissioner as a Chairman, with Chief Engineer, Director of Agriculture, Director of Public Health and the Superintending Engineer of the Project, as members. This Committee prepared the Irrigation Development Report, which not only surveyed all the irrigable area from irrigation point of view, but also from agricultural and health point of view, and prepared zone maps for irrigation with the proposed crop patterns for each village.

9.8. To implement the recommendations of the above Committee, another Committee was appointed, so as to expedite actual development of irrigation on the pattern set and enable the State and Society to realise the benefits of the Scheme without loss of time as soon as the irrigation facilities become available.

9.9. The State has also seen to it to decide the Betterment Levy etc. However, the report reveals a scope for and recommends recourse to upward revision of water rates, as they are lower than those obtained in the Bombay State. In order that the irrigation management and administration should not be slack and haphazard, the Report recommends the adoption of the Block-system and the Canal Rules and the system of irrigation management, as practised in the Bombay State, as far as possible.

9.10. As Bhadra is in the Inter-State River Basin of Tunga Bhadra Valley, which covers the erstwhile States of Mysore, Hyderabad and Madras the utilization of the waters by the different States is subject to an agreement reached between these three States. With the recent reorganization of the States, the position has changed and it is only Mysore and Andhra Pradesh that have rights over these waters. Hence the report.

points out the need for revising this agreement. Also, it is recommended that the earlier restrictions in regard to carrying over the waters in the Bhadra Reservoir from year to year should be removed, as such a carry-over would increase the firm electrical energy out-put annually, without affecting the interests of the State lower down.

9.11. The Report appreciates the fact that this Project is mostly carried out by utilizing only the local labour and material, without adopting much mechanisation, and avoiding rare and costly building materials like cement which are very sparingly used, as the bulk of the masonry is all in lime mortar.

9.12. In conclusion the Report recommends expeditious sanction of adequate funds for the Project to enable its completion within the target date.

*\*List of Appendices*

- I. Principal features of the Lakkavalli Project.
- II. Clause 2 of the Mysore-Madras Agreement regarding sharing of Tungabhadra Waters.
- VII. A note on the construction plant for the Hiremalali Tunnel.
- VIII. A note on the alternative alignment of the Right Bank Channel—Section III—and Davangere and Malebennur Branches.
- XVI. List of machinery required for Hiremalali Tunnel—(As planned by the project Authorities).

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## APPENDIX NO. I

### *Principal features of Lakkavalli Project*

#### (a) Dam

1. Location . . . . . Latitude 13°42'  
Longitude 75°30'20"

The site is at a narrow gorge through which the Bhadra river flows, about one mile west of the Lakkavalli village, district—Chikmagalur.

2. Catchment area] . . . . . 760 sq. miles.
3. Annual rainfall in the catchment . . . 46 to 202 inches
4. Maximum flood experienced (computed) . 94,600 cusecs.
5. Design flood . . . . . 1,20,000 cusecs.
6. Height of masonry dam over deepest foundation . . . . . 247 feet.
7. Length of dam at F. R. L. . . . . 1,385 feet.
8. Length of earth dam in first saddle on left bank . . . . . 1,400 feet.
9. Length of earth dam in second saddle on bank . . . . . 780 feet.
10. Area of water spread at F.R.L. . . . 45.53 sq. miles.
11. Maximum stress developed in masonry of dam . . . . . 10 T./sq. foot.
12. Effective storage capacity of reservoir above +100 . . . . . 63,000 m.c. ft.
13. Free board (masonry dam) . . . . . 8 feet.
14. Sill of irrigation sluice on right bank (2 Nos. 8' × 15') . . . . . +100 (above river bed)
15. Sill of irrigation sluice on left bank (6' × 12') . . . . . +36 (above river bed)
16. Spillway Gated spillway with crest gates 4 Nos. 60' × 23½'
17. Sill of under sluices (2 Nos. × 6' × 15') . . +45 (above river bed)

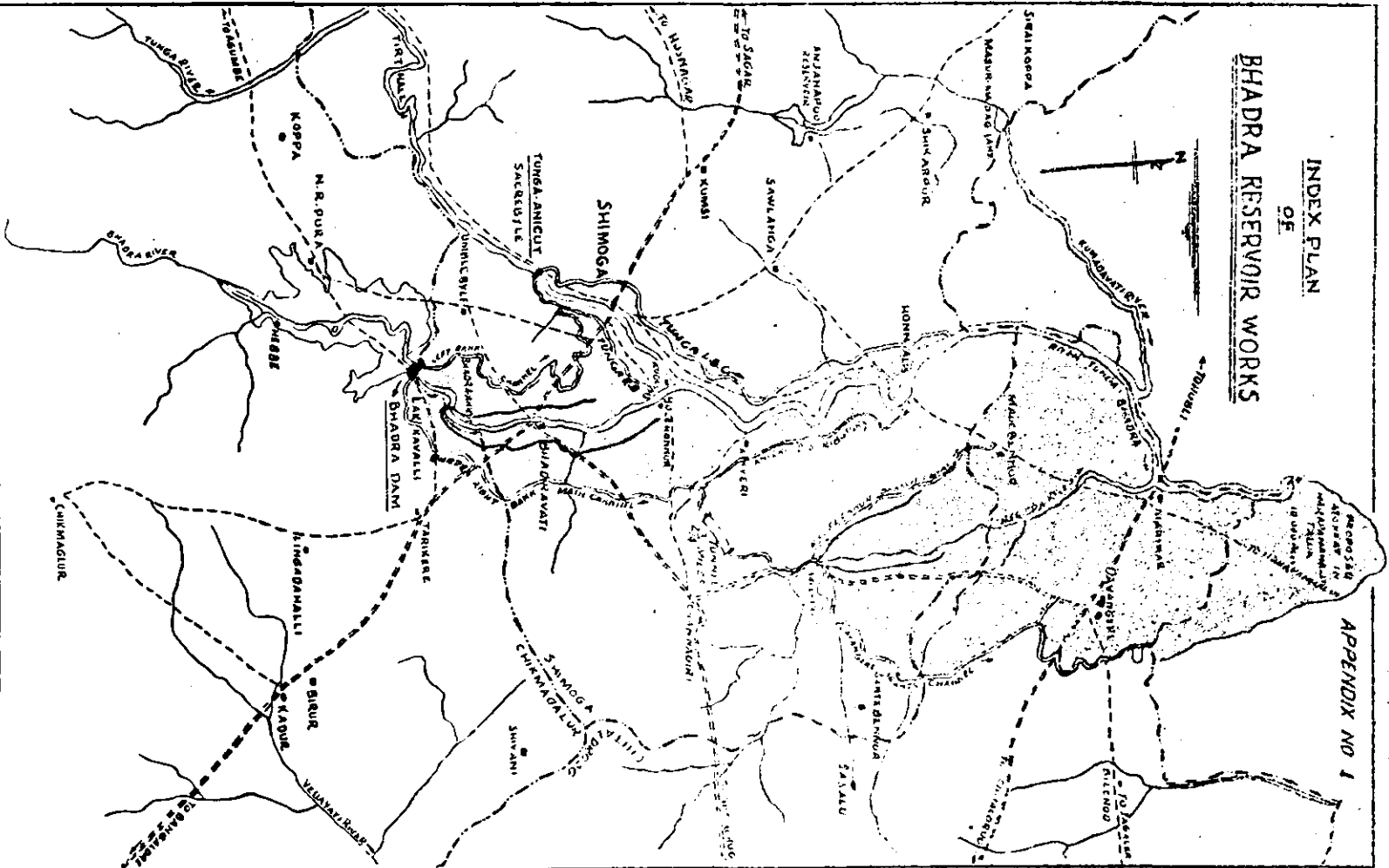
*(b)* Power Plant

	Right bank units	River bed units	Left bank units
1. No. of penstocks . . . .	2	2	1
2. Dia. of penstocks in feet . .	10	10	6
3. KW capacity of each machine .	7,200	12,000	2,000
4. Total KW installed capacity .	14,400	24,000	2,000
5. Total KW installed capacity of Project.	..	40,400	..
6. Firm peak in KW . . . .	..	25,000	..

*(c)* Canals.

1. Full designed discharge of left bank canal at head.	..	335 cusecs	..
2. Full designed discharge of right bank canal at head.	..	2,500 cusecs.	.
3. Total length of Canals . . .	..	220 miles	..
4. Total irrigated area. . . .	..	2,34,200 acres	..

**INDEX PLAN  
OF  
BHADRA RESERVOIR WORKS**



(Part) APPENDIX II

CLAUSE 2 OF THE MYSORE-MADRAS AGREEMENT REGARDING SHARING  
TUNGA-BHADRA WATERS.

2. The Government of Madras agree to the Government of Mysore increasing the capacity of the Lakkavalli Reservoir beyond the limit permissible under clause I in order to enable the Government of Mysore to have additional storage, solely for power purposes the supply required for such purposes being drawn off through the sluices; but such additional storage shall be returned without diminution (except diminution by reason of evaporation and percolation) within the same year to the river Bhadra below the existing Bhadra Anicut through sluices or in such other manner as may be mutually agreed upon by the Governments of Madras and Mysore and in accordance with the working tables and rules of regulation approved by the Chief Engineers of the two Governments.

## APPENDIX VII

### A NOTE ON THE CONSTRUCTION PLANT FOR THE HIREMALALI TUNNEL

The total length of the tunnel is 13,600 ft.

Four mine shafts are being presently driven at site to provide more headings. From each shaft two headings will be driven, and the operations will be so phased that with a single set of equipment the work can proceed uninterruptedly on both faces. Compressor and blowers will be installed at mine-head and pipe lines run down the shaft to both faces. While at one face drilling and blasting operations will be in hand, mucking equipments such as N.G. Wagons, mine loader and mine head hoists will be working against the other face. After every four hours or so the two operations are switched over, thus providing continuous operation. For efficient working, about 1,000' is considered to be the maximum drive of the two headings from either side of the shaft, as otherwise it would be increasingly difficult to switch over operations and delays will result.

Although four shafts are being sunk, it would suffice to obtain equipment for working only two mine heads at a time. Air compressor and blower stations will be provided at the end headings and also with the mine headers at the shafts which are being worked.

The plant and equipment necessary for these operations has been figured on the basis of 2 shifts working although there is no reason why the work should not go on round the clock. Similarly 300 working days have been assumed in one year whereas it may be possible to continue the work throughout the year by staggering labour. Anyway there are the possibilities which can further improve the time schedule but no scaling down of construction plant on these accounts is contemplated.

It is understood that some of the rocks are water-bearing. It is recommended that one drill hole should be carried to about 20-30 feet ahead to tap such water bearing seams and promptly seal them by pumping grout into them under pressure through the drill hole.

The total period of construction has been taken to be  $1\frac{1}{2}$  years, 300 days for excavation and 350 for lining, with an over-lap of 200 days. The lining operations are proposed to be started as soon as work from a shaft has been completed. This should be after about 100 days of the beginning of operations.  $\left(\frac{1,000'}{10'/\text{day}} = 100 \text{ days}\right)$

The total cost of equipment as per this programme works out to about Rs. 28.70 lakhs against Rs. 39.04 lakhs as provided, basing the costs on existing Project figures.

Abstract of costs (In Rupees)

1. Pneumatic equipment	..	..	3,60,000
2. Hoisting equipment	..	..	96,500
3. Drilling equipment	..	..	4,44,400
4(a). Pumps	..	..	2,10,000
4(b). Colony W.S.	..	..	16,000
5. Electrical equipment	..	..	6,83,500
6. Transport equipment	..	..	3,41,000
7. Miscellaneous T. & P.	..	..	3,28,140
8. Workshops	..	..	93,500
9. Telephone equipment	..	..	30,000

26,03,040

Add 10% for spares .. .. 2,60,304

28,63,344

say 28.63 lakhs

The provision made in the Project for items 4(b), 5, 8 and 9 has not been reduced although there appears to be some scope for economising in item 5 Electrical equipment.

*Construction equipment requirements.*

Length of the tunnel = 13,600 ft.

Assume driving rate

7 ft./8 hours shift a day on dry heading

& 3 ft./8 hours shift on wet heading.

Assume 50% to be wet headings.

∴ Average progress per heading =  $\frac{7+3}{2} = 5$  ft.

(Compare rate of 5 ft. shift assumed in S. T. A. Sub-Committee's note).

Assume 2 shift work,

average progress/heading/day = 10 ft.

Days available for work = 300

∴ No. of headings required =  $\frac{13,600}{3,000} = 4.5$

Adopt 6 headings, being provided by 2 mine heads (and shafts) providing 4 headings and 2 end faces.

Time cycle per 8 hour shift.

1. Drilling  $2\frac{1}{2}$  — 3 hours.  
Smoke clear 30 minutes
2. Mucking  $3\frac{1}{2}$  —  $4\frac{1}{2}$  hours.

These two operations to be alternated at the two faces being driven from a shaft.

Total quantity of excavation = 41,42,221 cft.

$$\text{Quantity /ft. run} = \frac{41,42,221}{27 \times 13,600} = \frac{306}{27} = 11.3 \text{ cu. yd.}$$

Excavation/face =  $7 \times 11.3 = 79.1$  say 80 cu. yds.

Assume  $1\frac{1}{2}$  ft. of hole is required per cu. yd. of rock excavated.

$$\therefore \text{Length of holes required/face} = \frac{80 \times 3}{2} = 120 \text{ ft.}$$

Assume progress of a jack hammer (drifter) 8 ft./hr. or 20 ft./ $2\frac{1}{2}$  hrs.

$$\therefore \text{No. of drifters required/headings} = \frac{120}{20} = 6, \text{ provide } 7$$

AIR required/jack hammer=80-90 cu. ft. @ 100 psi.

$\therefore$  A 750-1000 cu. ft. capacity air compressor at each heading will meet the job requirements.

N. G. Tip wagons.

No. 1 cu. yds. tip wagons trips per 4 hrs. ( $\frac{1}{2}$  shift)=80

$$\text{Rate of loading required by mine loader} = \frac{80}{4} = 20 \text{ cu. yd.}$$

### List of Equipment

#### I. Pneumatic Equipment

1. Stationery Air Compressors 750 CFM at 100 psi 4.
2. Stationery Air Standby . . . 2 3,60,000

#### II. Hoisting Equipment

1. Pit head frame . . . . .	2	30,000
2. Winch hoisting gear etc. . . . .	2	30,000
3. Cages for 1 cu. yd. mine cars. . . . .	5	12,500
4. Tugger Hoists for portals . . . . .	2	24,000
Total . . . . .		96,500

### III. Drilling Equipment

1. Drilling jumbos . . . . .	6	36,000
2. Drilling Rods . . . . .	{ 700	42,000
	{ 600	48,000
	{ 200	18,000
3. Wet jack hammers required 28 at 7/face+50% spare	42	33,600
4. Air legs. . . . .	42	21,000
5. Mine Car loaders required 4+2 Standby	6	1,20,000
6. High pressure blowers . . . . .	4	16,800
7. Exhaust fans . . . . .	2	10,000
8. Exhaust ducting with couplings 12000' and hangers.		96,000
9. Electric grinder . . . . .	6	3,000

Total . . . . . 4,44,400

IV (a) Pumps. . . . . 2,10,000

Reduce by 25% i.e. provide 26 pumps

IV. (b) Colony Water Supply . . . . . 16,000

V. Electrical Equipment . . . . . 6,83,500

VI. Transport Equipment . . . . .

1.	}		
2.			
3.			
4.			
5.			
6.			
		No change. . . . .	3,41,000

7. Diesel Locos. 2 ft. gauge. . . . . 4 1,20,000

#### VII. Miscellaneous T. & P.

Reduce 20% as No. of mine-cars required 60-80, Trolley track 20,000 instead of 30,000 ft. etc. . . . . 3,28,140

VIII. Workshops. . . . . 93,500

IX. Telephone equipment . . . . . 30,000

Total . . . . . 26,03,040

Add 10% for spares. . . . . 2,60,304

28,63,344

Say Rs. 28.63  
lacs



## APPENDIX No. VIII

### A NOTE ON THE ALTERNATIVE ALIGNMENTS OF THE RIGHT BANK CHANNEL—SECTION III AND THE MALEBENNUR AND DAVANGERE BRANCH CHANNELS.

The alignment of the Right Bank main channel upto its exit from the tunnel and some distance beyond up to the point D has been finally fixed. The two branches, Malebennur and Davangere, take off from the tail reach of the Right Bank Channel and command a substantial area.

2. A large tank known as the Sulekere tank (Shanti Sagar) lies in the path of the Right Bank Channel. This tank has its own catchment area of 226 sq. miles has an atchkat of 6,000 acres and irrigates about 4,500 acres. Its gross capacity at F.S.L. (1982.78) is about 3,800 m.c.ft. and water spread about 6,000 acres. The tank is formed by the construction of an earth dam across a narrow gorge in the Sulekere Valley and is of an ancient origin. The dam has a very heavy section, being about 100 ft. wide at the top and having nearly 18 ft. free board.

3. The alternative proposals for the alignment of the Right Bank Channel and its branches are described below:

- (I) The Malebennur Branch Channel on a falling contour along DR + R . The Davangere Branch Channel on a falling contour along DFJVGWH (Southern and Eastern peripheries of the tank).
- (II) The Right Bank Channel on a falling contour along DR1 R2. The Malebennur Branch Channel to start from R2. The Davangere Branch Channel on falling contour along R2 PO (skirting a hill slope), crossing the Sulekere Valley below the Sulekere dam along ON by means of an aqueduct or a canal syphon, continuing along the near side of the hill situated on the right flank of the Sulekere dam, crossing the waste weir channel of the tank over an aqueduct and finally joining the alignment in proposal I at H.
- (III) The Right Bank Channel to terminate in the tank as shown by DK in the plan. The Malebennur Branch Channel to take off from the tank along XR1 R2. The Davangere Branch Channel to take off from the tank along YH.
- (IV) The Right Bank Channel as in proposal II. The Malebennur Branch Channel as in proposal II. The Davangere Branch Channel on a falling contour along R1 LM, crossing over

the bund in a R.C.C. trough and continuing beyond the bund along the alignment in proposal II. This last alternative is the one recommended by the Team.

4. According to the estimates prepared by the Project Authorities the Proposal I is the costliest (Rs. 167 lakhs). It has also the following technical disadvantages.

(a) The alignment of the Davangere Branch passes through or very close to a number of villages and to avoid these costly detours will be necessary, thereby further increasing the cost. Alternatively either the villages will have to be shifted or the channel will have to be taken through covered ducts to safeguard the health of the villages.

(b) The Channel cuts across some minor irrigation tanks and will intercept them from their commands. The tanks situated on the downstream side (tank side) will have to be breached to prevent a situation in which these tanks will remain full perpetually, giving rise to unhealthy condition and growth of malaria.

(c) The construction of certain cross drainage works for the channel will present serious difficulties. Some of the drainage valleys are very flat and the flood waters will spread over wide areas and will come up against the u/s Channel bank in long lengths.

(d) Due to seepage from the channel the strip of land between the channel and the Sulekere tank is likely to become water logged permanently, giving rise to problems of rehabilitation. The soils in the area are clayey and effective drainage will be difficult or at any rate very expensive. The proposal is now looked upon with disfavour by all parties on account of the serious disadvantages. The proposal may not therefore be considered any further.

5. Proposal II, which is estimated to cost Rs. 127 lakhs is free from objections (a) and (b) in para. 4, applicable to proposal I. The objection (d) in the case of this proposal is not of much consequence, the area of the strip being very small. The team however considers that the cost of the construction of the length PN of the channel along fairly steep bill slopes is both difficult and underestimated. For crossing the Sulekere Valley below the dam two alternatives have been suggested (i) an aqueduct supported on pile foundations or (ii) a canal syphon. These structures are estimated at 19 and 16 lakhs respectively. The foundation for these structure consists of saturated clayey soils and trial bases up to depths of 40 ft. have failed to show hard stratum. In the design R.C.C. piles, 40 ft. deep have been provided. These might have to be much deeper. The superstructure rises 90 ft. above ground level. The estimated cost (Rs. 19 lakhs) of this 1,300 ft. long structure carrying a discharge of 1,142 cus. involving costly centerings is on the low side. So also a canal syphon

with a head of 90 ft. must cost more than Rs. 16 lakhs. With such high head it would be obligatory to use steel pipes, encased in concrete and the design does not provide for such construction. This major C.D. work may cost as much as Rs. 40 lakhs. This, together with the increased cost of constructing the channel length PN, mentioned earlier, is likely to increase the cost of proposal II by another Rs. 25 lakhs at least, bringing the total cost to Rs. 152 lakhs.

6. Proposal III is estimated to cost Rs. 56 lakhs. As, however, the Branch Channels take off at much lower levels, their further lengths, particularly of the Davangere Branch Channel will involve additional excavation, as compared with proposal II, where these pass through hill saddles. This additional cost is estimated at Rs. 38 lakhs, bringing the total cost to Rs. 94 lakhs. The objectionable features of this proposal are enumerated below:

(a) The water level in the tank will remain at a high level throughout the year and there will be a dense growth of weeds along the shallow fringe of the lake, favourable to mosquito breeding, giving rise to a serious incidence of malaria. In the Mysore State great importance is attached to the question of health of population and to appreciate the implication of this question it is worth-while recalling the fact that 112 old tanks in the command of the Irwin Canal, ex-Krishnarajasagar reservoir had to be breached to check malaria. The condition of the affected villages has been vividly described in official reports. "Tanks in the atchkat areas situated below the channel will be full always due to the collection of seepage water from the channel, as well as from the atchkat above. Incidental to this the water table rises, dampness comes up and marshy areas are formed. All these conditions are so favourable for the breeding of mosquitoes that the area soon gets malarial and the deadly disease overtakes the population resulting in heavy mortality. Awful stories are told of the sufferings of the people due to the scourage of malaria. Several villages have gone out of existence. In some, it is said there are no male members at all, all of them having succumbed to malaria. It is even said that the young men of some of the villages affected by malaria are denied brides for marriage from other villages. The evil does not confine itself to human beings only, but has spread to cattle also. There is a terrible growth of weeds in the shallow portions of the tank water spread, which gives rise to enormous growth of snail population. The cattle that go to the tank for drinking water, catch a kind of disease called 'Liver Fluke Disease', which is due to the snails harbouring in the weeds of the tank. The breaching of tanks and other anti-malaria measures have gone a long way in mitigating the evil and restores the people of the tract to their original health and stamina in a large measure". In the face of these facts, based upon previous experience, it is not surprising that there

is a vehement opposition to the proposal of tailing the channel into the Sulekere tank.

It has been argued that by regulating the discharge of the Right Bank Channel the level of water in the tank could be varied at will and thereby the growth of weeds prevented. This proposition is not free from practical difficulties. The main canal has a discharge of 2,500 cusecs and is 58 miles long and the effect of its regulation will take a considerable time to reach the tank. When the tank is full from the discharge from its own catchment there is every possibility of wastage of canal water over the waste-weir. From the tables prepared showing the operation of the channels and the resulting levels in the tank it is seen that the variation in the water levels is of the order of a very gradual variation of 4 feet only, as against a much larger variation which occurs under the present conditions. Any attempt to introduce larger variations by manipulating the discharges of the main canal will affect the generation of power resulting in a direct loss of power and of revenues.

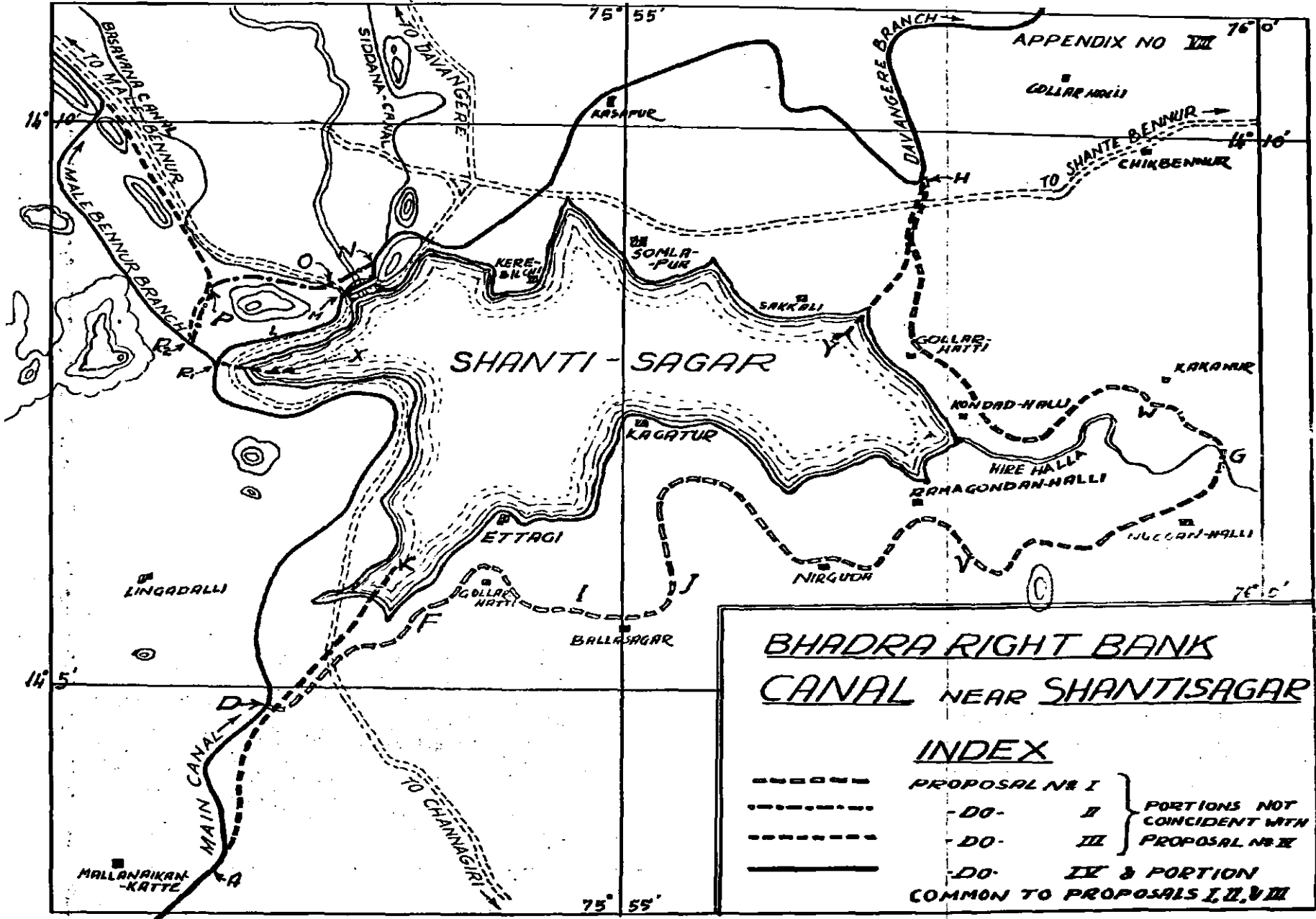
(b) The Malebennur and the Davangere Branch Channels taking off from the tank will have their bed levels several feet lower than those in proposal II. This factor not only results in a substantially increased cost of excavation of the channels in proposal III but to gain the same command they have to be excavated in a longer lengths. This must also result in an additional cost, which has yet to be computed.

7. Proposal IV. This proposal has none of the disadvantages of proposal III and the objectionable features of proposal II. This possibility of taking the Davangere Branch over the Sulekere bund has been examined by the Project authorities and an estimate of cost prepared. It had however been considered that it was undesirable to take the channel over the bund because the bund was old. The Team considers that it is possible to construct a reinforced concrete duct on the bund without affecting the security of the bund or causing any danger to the tank. There should be no risk in taking the channel in a concrete trough over the bund, with copper strip joints to allow for any slight settlement. The load on the foundation is of the order of half a ton per sq. ft. only. The cost of this proposal may be about Rs. 113.5 lakhs. The advantages of this proposal are:

- (a) It leaves the Sulekere tank undisturbed;
- (b) It is the cheapest practical proposal;
- (c) It does not involve any difficult construction such as the aqueduct or syphon across the sulekere valley which would need at least two years for completion and consequently the date of opening the Branch Channels can be advanced by one full year.

(d) This proposal has found favour with practically all the members of the standing Technical Advisory Committee and the Project Authorities.

*N. B.*—The benefits accruing on account of irrigation on the Davangere and Malebennur Branches being made available earlier by one season have not been computed, but they would be substantial.



**BHADRA RIGHT BANK  
CANAL NEAR SHANTISAGAR**

**INDEX**

-----	PROPOSAL NO I	} PORTIONS NOT COINCIDENT WITH PROPOSAL NO II
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- - - - -	DO- III	
—————	DO- IV & PORTION COMMON TO PROPOSALS I, II, & III	

(PART) APPENDIX No. XVI

LIST OF MACHINERY REQUIRED FOR HIREMALALI TUNNEL WORKS—  
RIGHT BANK CHANNEL—SECOND—BHADRA RESERVOIR.

(As planned by the Project Authorities)

“ABSTRACT”

Sl. No.	Sub-Head	Cost in Rs.
1.	Pneumatic Equipments . . . . .	5,60,000
2.	Hoisting Equipment . . . . .	4,69,000
3.	Drilling Equipment . . . . .	6,07,800
4.	(a) Pumps . . . . .	2,80,000
	(b) Colony Water Supply . . . . .	16,000
5.	Electrical Equipment . . . . .	6,83,500
6.	Transport Equipment . . . . .	4,01,000
7.	Miscellaneous Tools & Plant . . . . .	4,08,300
8.	Workshop . . . . .	93,500
9.	Telephone Equipments . . . . .	30,000
		<hr/>
		35,49,100
10.	Spare Parts 10 Per Cent of Items 1 to 9 (Approx.)	3,54,910
		<hr/>
		39,04,010
	or say . . . . .	39,04,000

NOTE :—The Abstract Estimate comprises not only the machinery required for tunnelling but also for other services such as water supply and lighting to colony etc.