MINISTRY OF PUBLIC WORKS AND ELECTRIC POWER

DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

DIRECTORATE OF RIVERS AND SWAMPS

TECHNICAL AND SOCIO-ECONOMIC FACTORS AS THEY AFFECT DAMSITE SELECTION IN THE CITANDUY RIVER SYSTEM

A SPECIAL REPORT

SUBMITTED BY:

ENGINEERING CONSULTANTS, INC.

DENVER, COLORADO U.S.A. BANJAR, INDONESIA

RELOCATION

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ECONOMICS

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2-Way Memo

Subject: Citanduy River Basin Study.

DATE OF MESSAGE
February 22, 1974
DATE OF REPLY

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To: Mr. Lester A. Robb
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Agency for International Development
Washington, D.C. 20523

5027-101

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USE BRIEF, INFORMAL LANGUAGE

Transmitted herewith is a copy of a supplemental report submitted by ECI at the February 19th Steering Committee meeting (copy also sent to Mr. Love, ASIA/CD). GOI has accepted the following projects outlined in ECI's reports as projects for feasibility studies.

1. A Comprehensive Water Management Scheme for the Lower Citanduy/Ciseel River System.

2. Reclamation Scheme for the Segara Anakan & Environs.

Received. Thanks

J. G. Howe

From: Walter H. McAleer
American Embassy (USAID/ENGR)
Jakarta, Indonesia

1. TO BE RETAINED BY ADDRESSEE

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ENGINEERING CONSULTANTS, INC.

PROYEK CITANDUY
PATAKUMAN
BANDUNG, WEST JAVA
INDONESIA

February 15, 1974

Director General of
Water Resources Development
Ministry of Public Works
and Electric Power
Jalan Pattimura 7/20
Post Box No. 23/KBT
Kebayoran Baru
Jakarta. Republic of Indonesia

Attn : Director of River
and Swampy Areas
Development.

Our file : 1138(C)/2
17/74
Subject : Special Report, Dam
Site Analyses,
Citanduy Project.

Dear Sir :

In compliance with the decision reached at the Steering Committee Meeting held in Jakarta on December 18, 1973, the Consultant has undertaken additional comparative analyses of the potential dam sites currently identified in the Citanduy River System. The results of these additional considerations have been compiled in a special report titled "Technical And Socio-Economic Factors As They Affect Damsite Selection In The Citanduy River System." It gives us great pleasure to submit for your consideration twenty five (25) copies of that report.

You will note that we have avoided comparisons on a monetary basis. As we have explained previously, such comparisons require more exact knowledge of potential costs and benefits than we have available at this point in time. Such studies will be made on all potential dam sites in subsequent Master Plan and feasibility studies.

On the other hand, we believe that comparison based on such factors are engineering, geology, hydrography, topography, economic, social and environmental impact has indicated quite clearly that some damsites should definitely be relegated to a lower order of priority, while others should be given top consideration at an early date. It is interesting to note that an analysis of all these factors substantiates our previous conclusion that the Banjar and Binangun No.2 damsites had the greatest potential for flood control measures.

However, there are other factors which may be equally as important as the technical function of flood control. Furthermore, since November 30, 1973, the rapidly changing world energy situation has caused us to reassess the power potential of the alternate damsites. As a result, the Consultant now concludes that as a multiple-purpose dam the Matenggeng damsite should be moved to a top level of priority.

We sincerely hope that this special report will enable the Steering Committee to now give full approval and to direct the Consultant to proceed with his recommended first priority feasibility study; namely, "A Comprehensive Water Management Scheme For Lower Citanduy/Ciseel River Systems."

Yours truly,

Engineering Consultants, Inc.

Encl: As noted

Gifford E. Rogers
Resident Manager

CC:
1. Engineering Consultants, Inc.
   Denver, Colorado, U.S.A.
   Attn : Mr. Cecil M.Langford
   Project Sponsor
2. United States Aid Mission to Indonesia
   Embassy of the United States
   Attn : Mr. Walter McAleer

GER/n

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TECHNICAL AND SOCIO-ECONOMIC FACTORS AS THEY AFFECT DAM SITE SELECTION IN THE CITANDUY RIVER SYSTEM

INTRODUCTION

At the last Steering Committee Meeting held in Jakarta on December 18, 1973, the Consultants recommendation for a first priority feasibility study, "A Comprehensive Flood Control Scheme For The Citanduy River System", was accepted provisionally. Qualified approval was given because the Committee wanted the Consultant to conduct further comparative analyses of the alternate dam sites currently identified in the Citanduy River System.

The Consultant willingly agreed to comply with this request, and explained that in any case such analyses would be required for the Master Plan. However, the consultant did attach a condition of his own; the analyses would be limited to dam site comparison on the basis of presently available information of a technical, economic, social, and environmental nature. No attempt would be made at this point to produce benefit/cost ratios, internal rates of return, or other monetary evaluation of the various alternate dam sites. Obviously, investigations of such intensity must be limited to later studies at the feasibility level and in studies made for the master plan.

During the course of the discussion by the Steering Committee of our proposed first priority feasibility study, it became apparent that there were various misconceptions concerning the basic recommendation, the contemplated scope of work, and the procedures to be followed. The consultant explained that many of the points under discussion

could only be settled in the preparation of the Master Plan, while other doubts would be resolved during the preparation of the feasibility studies.

However, subsequent deliberations by the Consultant gave rise to the idea that some of the misconception could be dispelled by merely changing the name of the proposed projects, Consequently, on page 1-20, of our document "Recommendation For Second Priority Feasibility Studies", we proposed changing the name of the first priority study to "A Comprehensive Water Management Scheme For The Lower Citanduy/Ciseel River System". We feel that the change in name clarifies that the scope of the proposed feasibility study will include the broad aspects of reclamation, irrigation, drainage, and water supply for the specific area.

At the previously mentioned meeting of the Steering Committee, the Consultant also got the distinct impression that it was a foregone conclusion that one or more dams would be included in our proposed feasibility study and that furthermore the Consultant had already decided specifically which dam or dams would be included. This is another misinterpretation which should be set straight.

We wish to emphasize that flood control which is a part of water management, traditionally is carried out though the following approaches :

1. Down stream measures
   a. Channel improvement
   b. Diversion to floodways and/or other basins
   c. Confinement though levees and/or dikes
   d. Off-channel storage
   e. Other measures

2. Up stream measures
   a. Multiple purpose storage dams
   b. Flood control dams
   c. Other structures

3. Any combination of upstream and downstream measures.

In our report "Recommendations For First Priority Feasibility Studies", we mentioned on page IV-12 that, in the absence of constraints, the only components required for a simple and effective flood control scheme for the lower Citanduy basin would be flood control reservoirs located on main stem rivers upstream of their emergence on the flood plain. However, on page V-32, we further stated that both the value of the land and the density of population within the Citanduy Project Area places restraints on a comprehensive flood control plan. Because of this, it would be necessary to formulate a plan which would not only fully utilize existing flood control features, but would also be augmented by some combination of additional upstream and/or downstream measures. The exact combination would have to be determined in the course of the feasibility study.

We further stated that, on the basis of information then available, two damsites had been identified as having potential for controlling downstream flooding. These two sites were Banjar on the Citanduy River and Binangun No. 2 on the Ciseel River. Note that we emphasized their apparent desirability on the basis of their function as flood control measures. Again we stated that which dam, if any, to be proposed would have to be determined in the feasibility study. This was our third recommendation stated on page VI-5. We at no time meant to imply that consideration of other possible dam sites would be excluded. On the contrary, all possibilities would be investigated on

a reconnaissance level, in the Master Plan. Furthermore, we stated that should more detailed investigations reveal that either Banjar or Binangun (or both) would not be feasible, we would not hesitate to search for other alternatives. It was again emphasized that one of the primary objectives of the proposed feasibility study was to propose an optimum comprehensive flood control plan according to the criteria previously mentioned.

The many questions which arose, some very valid and some motivated by misconceptions, resulted in the decision for provisional approval of the Consultants proposal and the agreement to conduct further analyses so that the problem could be resolved at the Steering Committee Meeting scheduled for February 19, 1974. The object of this document is to present the results of the additional analyses and our conclusions concerning the comparative desirability of the various dam sites according to information which has become available since November 30, 1973.

In addition to this introduction and background discussion, the report consists of five parts :

1. Engineering Factors.
   a. Embankment Height/Embankment Volume
   b. Storage Capacity/Embankment Volume
   c. River Water Yield/Embankment Volume
   d. Present Reduction of Maximum Flood Peak/Embankment Volume
   e. River Power/Embankment Volume
   f. Reliability Factors
      1) Available hydrology
      2) Available mapping
      3) Foundation Investigation
   g. Relocation

2. Geologic Factors.
   a. Geologic Conditions
   b. Materials
   c. Sedimentation
   d. Seismic Reaction

3. Socio-Environmental Factors.
   a. Land Use
   b. Resettlement
   c. Relocation
   d. Environmental Impact

4. Least Cost Comparison - Flood Control Dams

5. Conclusions

It will be noted that additional considerations have modified somewhat the order of the project standings since the release of the report on November 30, 1973. In doing this, we feel that we have been responsive to the suggestions of the Steering Committee. The new information reflects more thorough review and analysis of various factors, principally as a result of developments in the world energy situation.

ENGINEERING FACTORS

Previous Evaluations

Six damsites were considered in our First Priority Recommendation Report of November 30, 1973. The location and extent of each reservoir is shown on Plates 1 to 5. We have prepared a graphical comparison of the damsites shown on Plate 7 and a comparison table for the damsites shown on Plate 8. All of the data used to prepare the comparison was presented in the November 30, 1973 report and does not represent the results of further study by the Consultants. The comparisons do illustrate the basis upon which we made some of our conclusions regarding the damsites in the report.

The graphical comparison shown on Plate 7 illustrates the potential of each damsite by the use of appropriate curves. Curves for five basic parameters are plotted versus the embankment volume in MCM. The embankment volume was chosen as the basic parameter because it is very indicative of the cost of each dam. Experience shows that the embankment cost represents approximately 50 to 60 percent of the cost of constructing a dam.

Plate 8 shows a comparison of the evaluation factors, used to rank the damsites, which were shown in graphical form on Plate 7. The evaluation factors include engineering, water supply, flood control and power considerations for each damsite and some combinations.

The conclusions that were reached from the damsite comparisons and as stated in our November 30, 1973 report were :

1. The Binangun No. 2 and Banjar Dams offer the greatest possibilities for flood control in the Ciseel and Citanduy River Basin flood producing area.

2. The Binangun No. 2 Dam would be the most effective multipurpose structure, having a significant potential for irrigation development.

3. Matenggeng Dam also has significant potential as a multipurpose structure since it includes hydro-power. However, it is not as effective for flood control as the Banjar and Binangun No. 2 Dams.

4. The other dams are too small to offer significant flood control or multipurpose benefits.

Further Evaluations

Banjar Damsite :

The proposed Banjar Dam, although it offers a significant degree of flood control on the Citanduy River, had some characteristics which required further consideration. They were :

1. The inundation of a 30 hectare reservation and monument which commemorates an ancient local legend called Ciung Wanara.

2. Major highway and railroad relocations would be required.

On January 10, 1974 three ECI staff members attended a meeting with Government officials and civic leaders from the Ciamis area. We were able to apprise them of our activities to date and to elicit some discussion on the proposed inundation of the historical area. As expected, the local historical society would be opposed to a loss of this site which is purported to be one of the two remaining historical sites in West Java. However, local opposition does not

appear to be strong enough to preclude further consideration of this site. It is, however, a significant factor to be weighed in the evaluation of the social impacts of the damsite.

The consultants' also studied possible schemes for the relocation of the railroad and highway. These schemes are shown on Plate 5 and consist of the following possibilities.

1. The railroad could be realigned to follow a high ridge running between the Citanduy and Cimuntur rivers and the proposed main dam and saddle dam. The elevation of the ridge is well above the maximum flood pool elevation. The relocation would require a bridge approximately 500 meters long to carry the railroad across the Citanduy river. The length of the relocated section would be approximately 5.4 km and the maximum grade would be 1% which is well within the established limits.

2. Several alternatives exist for relocating the highway.
   a. Realign the highway to parallel the railroad relocation using the same bridge to cross the Citanduy River, Then across the top of the dam back to the original highway location.

   b. Upgrade the existing secondary road from Banjar-Cimaragas-Manonjaya-Ciamis for approximately 33 Km.

   c. A combination of a and b i.e. upgrade the secondary road and make a connecting road across the top of the dam joining the northern and southern routes.

The railroad and highway relocations are technically feasible, although they would represent a significant cost item, probably 15% of the construction cost of the Banjar Dam.

Banjar Multipurpose Damsite :

The proposed Banjar Damsite does offer the possibility of being used for multipurposes i.e.flood control and water supply. We could provide a permanent storage pool that could provide a firm water yield of 44 to 68 MCM/mo, depending upon the operation of the reservoir. The firm water yield is based on dry year inflows to the reservoir and is water that would be available 100 percent of the time. The firm water yield would have a potential of providing irrigation water for 20,000 hectares and for providing a potable water supply to the town of Banjar.

The previously mentioned characteristics of the damsite would still remain i.e. inundation of the historical reservation and the costly railroad and highway relocations. In addition, reservoir sedimentation problems would be introduced due to the formation of a permanent pool resulting in a significant loss of capacity to dead storage. There would also be a reduction in the flood control capability of the reservoir due to a reduction in the flood storage capacity. The control of a flood peak at Bridge 1452 would be reduced by approximately 5 percent.

The cost of providing a multipurpose facility, as opposed to a single purpose, would increase significantly. The increase in cost could be expected to be on the order of 30 percent. The cost increase would be due to the increase in civil works and foundation work that would be required.

Alternate Banjar Scheme :

Due to the previously mentioned characteristics of the proposed Banjar Damsite, the consultants's have investigated the possibility of an alternative scheme. It would be possible to construct two dams upstream of the proposed damsite as shown on Plate 6. The first dam could be built on the Citanduy river approximately 2 Km upstream of its confluence with the Cimuntur river. The dam would be 55 meters high and would have a storage capacity of 89 MCM. The second dam could be built on the Cimuntur river approximately 2.5 Km. upstream of its confluence with the Citanduy river. The dam would be 55 meters high and would have a storage capacity of 46 MCM, Both dams would be for the single purpose of flood control.

The advantages of the alternate scheme would be :

1. The historical reservation would not be affected.
2. The costly railroad and highway relocations would not be required.
3. Even though two dams and appurtenent works are required, this scheme would be approximately 20 percent less costly than the Banjar single purpose dam. This is primarily due to the fact that the relocations are not required.

The disadvantages of the alternate scheme, as compared with the Banjar Damsite, would be :

1. Control of the flood producing area would be reduced from 52 percent to 45 percent because the Cirende and Ciliur rivers are left uncontrolled.
2. Available storage capacity would be reduced by nearly two thirds, from 350 MCM to 135 MCM. Therefore the alternate scheme has no multipurpose possibilities.

3. The flood control capabilities are reduced by nearly 40 percent due to less storage and less control of the flood producing area.

Plate 9 shows a comparison of the evaluation factors for all of the Banjar alternatives discussed above.

Flood Control Analysis :

All of the evaluations discussed above, with respect to flood control, were based on routing maximum flood peaks through each reservoir. The present composite reduction of the flood peak at the flood plain was assumed to be directly related to the percent reduction of a flood peak at the damsite and the percent of the flood producing area controlled. While this method of evaluation gives a clear picture of the potential of each site, it does not recognize the differences in hydrologic factors such as the lag time between flood peaks reaching the flood plain.

In order to provide a more detailed computation of the flood control potential of each damsite, an analysis was made for storms with a return period of 50, 100 and 200 years respectively. The analysis was based on the work of the Hydraulic Institute in Bandung as published in their study of "Flood Design-Citanduy Project" of December 9, 1972 by Ir. Soeharto. By making a frequency study of rainfall in the project area, deriving synthetic unit hydrographs for the major watersheds and computing flood hydrographs, the Institute was able to calculate the magnitude of 50, 100 and 200 year storms at railroad bridge 1452. The flood discharges are 3440 CMS, 4020 CMS and 4220 CMS respectively.

By applying similar techniques, we were able to compute design storms and flood hydrographs for each reservoir and the Citanduy rivers' major tributaries. The storms were then routed through their respective reservoirs and the appropriate hydrographs were combined to compute the reduced magnitude of flood peaks at bridge 1452.

The results of this analysis are shown on Plate 10. They can be summarized as follows.

1. The percent reduction of flood peaks at the damsites is the same as our previous evaluations.
2. The Banjar Damsite, either as a single or multipurpose facility, still offers the greatest potential for flood protection.
3. The alternate Banjar scheme is less effective for flood control than the Banjar or Matenggeng Damsites.
4. The Matenggeng Damsite is more effective for flood control than in our previous evaluations. This is due to the fact that it controls flood peaks which reach bridge 1452 sooner than those from upstream tributaries.
5. The remaining Citanduy river damsites have no significant potential for flood control.
6. Combinations of the Ciamis and Manonjaya damsites with Matenggeng are less effective than the Banjar Damsite.

Other Factors

Reliability factors :

The availability of basic data i.e. hydrology, mapping and foundation investigations has a direct bearing on the strength of a feasibility study suitable for attracting international financing.

Plate 11 shows the consultants' estimate of the relative strength of each damsite with respect to the availability of basic data.

The hydrologic ranking of each site is an evaluation of the strength and reliability of rainfall and runoff data, length of record, effectiveness of measuring equipment and the quality of technical work. The other factors are self explanatory.

Plate 11 illustrates the need to improve upon basic data particularly for the Banjar and Binangun No. 2 Damsites. The needs were pointed out in our "Mapping and Basic Data Report" of September 30, 1973 and Addendum No. 1 of November 15, 1973.

Conclusions : (Engineering Factors Only)

1. The Banjar Damsite, either single or multipurpose, offers the greatest degree of flood control on the Citanduy river.

2. The Binangun No. 2 Damsite offers the best possibility for flood protection on the Ciseel river. Furthermore, it has multipurpose uses and appears to be the most efficient multipurpose dam in terms of relative cost.

3. The Matenggeng damsite ranks just behind the Banjar Damsite for the purpose of flood control. It would be a multipurpose dam, including hydro power for use as a peaking plant. Recent increases in fuel prices have upgraded the overall feasibility of this site. The biggest disadvantage is the high capital investment required.

4. The alternate Banjar scheme is not as effective for flood control as Banjar or Matenggeng. It is a single purpose scheme i.e. flood control, and requires a smaller capital investment than the other damsites.

5. None of the other damsites appear to be able to generate enough flood control or multipurpose benefits to justify the large capital investments required.

GEOLOGIC FACTORS

GENERAL

In the accompanying table an attempt has been made to evaluate the relative merits from a geologic standpoint of the five damsites under consideration for inclusion in the plan of development of the water resources of the Citanduy Basin. It should be emphasized that no foundation exploration has been carried out at the Matenggeng axis that is discussed here; that no exploration or testing of any kind has been performed at the Binangun Damsite; and that, as of February, exploration at Ciamis-Cikembang had only recently been started. Therefore, the evaluations given herein are not based on similar degrees of geologic assurance for each site.

All the sites seem to be fairly satisfactory from a geologic point of view. All would have rapid sedimentation rates but because size, shape, purpose, and inflow of the several reservoirs differ, annual percentages of storage volume loss would vary from site to site. In much the same way, all dams would be subject to large scale earthquakes at least several times during their service lives. Since the earthquake factor for all these sites would be about the same, the inferred elasticity of the foundation was used in the choice of one site over another with regard to seismicity.

Of the other factors used, probably the type of diversion facilities required and the quality, quantity, and proximity of materials, particularly shell material, are of the greatest significance in the effect of geology on the cost of the construction.

In the following paragraphs a few words will be said about each of the sites and which factors are of significance in their ranking as they do.

MANONJAYA

Manonjaya Damsite ranks first geologically because all the materials required to construct a dam at this location can be obtained in adequate quantities within a very short distances. In addition, foundation conditions for the embankment and appurtenant works are generally good; bearing capacity of the foundation rock would be high, seepage would be moderate and a grouting program would probably be successful in reducing it still farther, and tunnelling conditions for constructing the diversion facilities should be fairly good.

The major drawback of the site is that the diversion tunnel would be required. Neither the single Banjar Dam nor the Binangun Dam would require similar expensive measures for diversion during construction and this may also be true at the Ciamis Damsite.

MATENGGENG

This site ranks second for nearly the same reasons that Manonjaya is first, foundation conditions are generally good and materials are almost equally available, though at somewhat greater distances. The damsite was given a low rating for reservoir conditions as the exploration program indicated high coefficients of permeability associated with the sedimentary rocks of the abutments. The values obtained are so high that they could easily be in error in which case a better rating for the damsite would develop. However, its second ranking would not be changed, only enhanced. As at Manonjaya, a diversion tunnel would be required.

CIAMIS - CIKEMBANG

The rather good ranking of these two dams for availability of shell material from alluvial terraces could be in error but this problem should soon be resolved by the current drilling program. If pervious fill does not develop into a difficulty, the construction of the two dams should be considered routine with no particular problems anticipated. It may even be possible to divert the river through a surface channel rather than by tunnel during construction.

BANJAR

Two schemes of damming the Citanduy and the Cimuntur near their confluence are under consideration. From a geologic point of view the single dam would probably be more desirable even though a saddle dam almost as large as the main dam would be required. This is because only one spillway and outlet works would be necessary and because diversion could be made by channel.

There are two factors which cause this site to be ranked fourth. They are the apparent lack of any rock suitable for quarrying for rockfill or riprap and the problem of locating a satisfactory alignment on suitable foundation material for the outlet works and possibly the spillway also.

It appears certain that the two dam alternate would average somewhat lower than the single dam in geologic desirability but it would probably not drop below Binangun Damsite in the ranking.

BINANGUN

The Binangun Damsite ranks last in a number of the geologic categories under consideration. However, it must be remembered this would be a long, low dam that would not impose any great load on its foundation, that it could probably be built of local impervious material by judicious management and drainage of borrow areas, and that sand and gravel for interior drains in the dam might be processed from the tuff deposits of the right abutment or crushed from the andesite of the left.

CONCLUSIONS

Although the Manonjaya site appears most satisfactory from a geologic viewpoint, it should be reiterated that this ranking does not prorate the importance of the individual factors. Manonjaya, for instance, would require a long, costly diversion tunnel for construction.

Matenggeng, Ciamis-Cikembang, and Banjar, though ranked second, third, and fourth, are very close in numerical average and certainly their geologic aspects would be a minor consideration in selecting among them.

Binangun is a low dam while the others, except perhaps the Banjar single dam, can be considered fairly large. This would definitely add to Binangun's attractiveness; from a geologic point of view, it is almost always less difficult to build a low dam than a high one.

GEOLOGIC FACTORS AFFECTING DAM SITE RATING

	BANJAR	BINANGUN	MATENG-GENG	MANON-JAYA	CIAMIS-CIKEMBANG
GEOLOGIC CONDITIONS					
DAM	3	4	2	1	2
OUTLET WORKS	4	5	1	2	3
SPILLWAY	3	4	3	1	4
DIVERSION	1	2	4	4	3
RESERVOIR	3	4	5	1	1
MATERIALS					
CORE	1	5	3	2	2
SHELL	3	5	3	2	2
SAND & GRAVEL	1	5	2	2	3
RIPRAP	5	1	2	3	4
SEDIMENTATION	4	1	2	5	4
SEISMIC REACTION	4	5	3	3	3
ARITHMETIC AVERAGE	2.9	3.6	2.7	2.3	2.8
RANK	4	5	2	1	3

SOCIO-ENVIRONMENTAL FACTORS

The chart shows the land use within the reservoir sites. The most important considerations are the extent of settlements and the amount of rice land that would be inundated. The social cost of losing the other lands would not be as significant a factor.

The Matenggeng site would affect about 77 hectares of settlements and yards. These could probably be relocated quite readily within the vicinity. The extent of riceland inundated would be about 470 hectares.

The Banjar site would displace 106 hectares of settlements and yards. A single-purpose dam would not fill every year. Consequently, the land could be farmed to some extent on an interruptible basis, although the people could not live in the reservoir area. The loss of rice land and orchard trees would not be 100 percent, although there would be some risk in farming.

At the Binangun site, the permanent reservoir pool could not be farmed, but the flood surcharge area could be farmed on an interruptible basis. About 110 hectares of settlements and yards would require re-establishement above the high water line.

At the present moment, we are not aware of any monuments or cultural sites other than the Ciung Wanara reservation at Banjar damsite. This area covers about 30 hectares and consists largely of dense natural forest. The matter of whether to forego the superior advantages of the Banjar damsite in order to preserve the area is a government policy issue that the consultants cannot resolve.

As a final note, it should be appreciated that any flood control facilities-whether levees, dams or floodways-will have some effect on land uses and on people in the areas where the works are to be located. Seldom would these people be in favor of giving up their land to provide flood protection for somebody else. Improvements can not be made without some degree of readjustment, however. Compensation payments would be made to people giving up their land as a part of project costs.

LEAST COST COMPARISON - FLOOD CONTROL DAMS

The process of selection between several alternative damsites involved consideration of what each dam would accomplish and what each dam would cost. For multiple purpose dams, a cost apportionment was made to each purpose. A comparison made on this basis reveals the damsite best suited to the purpose being analyzed, which in this case is flood control.

Having prepared preliminary estimates of cost and estimates of the flood control capabilities of the several dams - all on a comparable basis - it was possible to rank them according to the least cost criterion. This process is also known as "value engineering". Another term used to describe it is "cost-effectiveness".

The advantage of this sort of analysis lies in the fact that it gives a relative standing of the effectiveness of several alternatives at an early stage in an investigation before all the detailed results of cost-benefit studies are complete.

In this case we have prepared flood routing analyses which show the percentage of control of the flood peaks which each dam can accomplish. The other side of the coin is the remaining amount of the flood peak which cannot be controlled by the dam. Knowing what is controlled and what is not controlled, we can assign-on a comparative scale for the watershed area-damages prevented and remaining damages for each dam or for any combination of dams. It is helpful to think of the remaining damages in terms of the risk of flooding after the dam is in operation.

It is important to recognize that some dams will be more effective in controlling floods than will other dams. This depends chiefly on their location and their capacity to store the peak flows.

What is equally important is what the dam will NOT do-that is, what remaining risk still prevails with the dam in operation. The objective, of course, is to minimize the sum of the total costs. These total costs consist of the dam cost plus the remaining damages.

The least-cost combination of dam costs and remaining damages indicates the most feasible and economic formulation for the project on the basis of presently available information. See plate 12.

You will note on the portion of the chart for the Citanduy river that the dam sites are listed in the order of their total costs. These costs are plotted on a relative scale so that a comparison can be readily made between any of the alternatives.

First observe that the Matenggeng dam has the shortest bar on the chart for the Citanduy. This means that its total costs for construction plus the remaining damages offer the least-cost solution for any single dam. The solid portion of the bar in each case shows the relative cost of the dams. The clear portion of the bar shows the remaining damages.

It is of interest to observe that the Banjar damsite does not prove out to be quite as efficient as the Matenggeng because it has a significantly higher assigned flood control cost while accomplishing only slightly better control of the flood peaks. The Matenggeng damsite feasibility has been improved over our earlier appraisal by utilization of the power plant for peaking in place of base load generation.

Note also that a combination of Matenggeng and Banjar accomplishes the most control of any combination in the Citanduy, as shown by the relatively short length of the clear bar on the graph.

On the Ciseel River, the best site is the Binangun No. 2 site which controls the river at its entrance to the flood plain.

Control on both rivers is essential to full attainment of flood protection in the flood plain. The most economically efficient combination would be to construct Matenggeng and Binangun dams and put up with the remaining damages. This would indicate that step-by-step development would be desirable so that the most needed works would be constructed first. When financing constraints relax, the complete system should be constructed. The complete system indicated here would be Matenggeng, Binangun and Banjar.

One final comment : note that in every case there are remaining damages that dams will not prevent. These must be prevented, to the extent practicable, by downstream river control facilities such as floodways, levees, etc.

CONCLUSIONS

As a result of these analyses, the Consultant has drawn certain conclusions:

1. Because of obvious disadvantages and inherent weaknesses, certain of the proposed dam sites should be relegated to a reconnaissance level of investigation and their place in the order of development priorities determined in the Master Plan. These are the Manonjaya, the Ciamis, and the Cikembang sites.

2. The Banjar damsite offers the greatest degree of flood control on the Citanduy River. Raising this dam from a single-purpose to a multiple-purpose dam enhances its efficiency. Relocation and resettlement costs, as well as cultural considerations would be greater.

3. The Binangun No. 2 damsite offers the greatest degree of flood control on the Ciseel River. From a cost standpoint, it appears to be one of the most efficient multiple-purpose dams. Resettlement costs and flooding of productive rice lands would be costly.

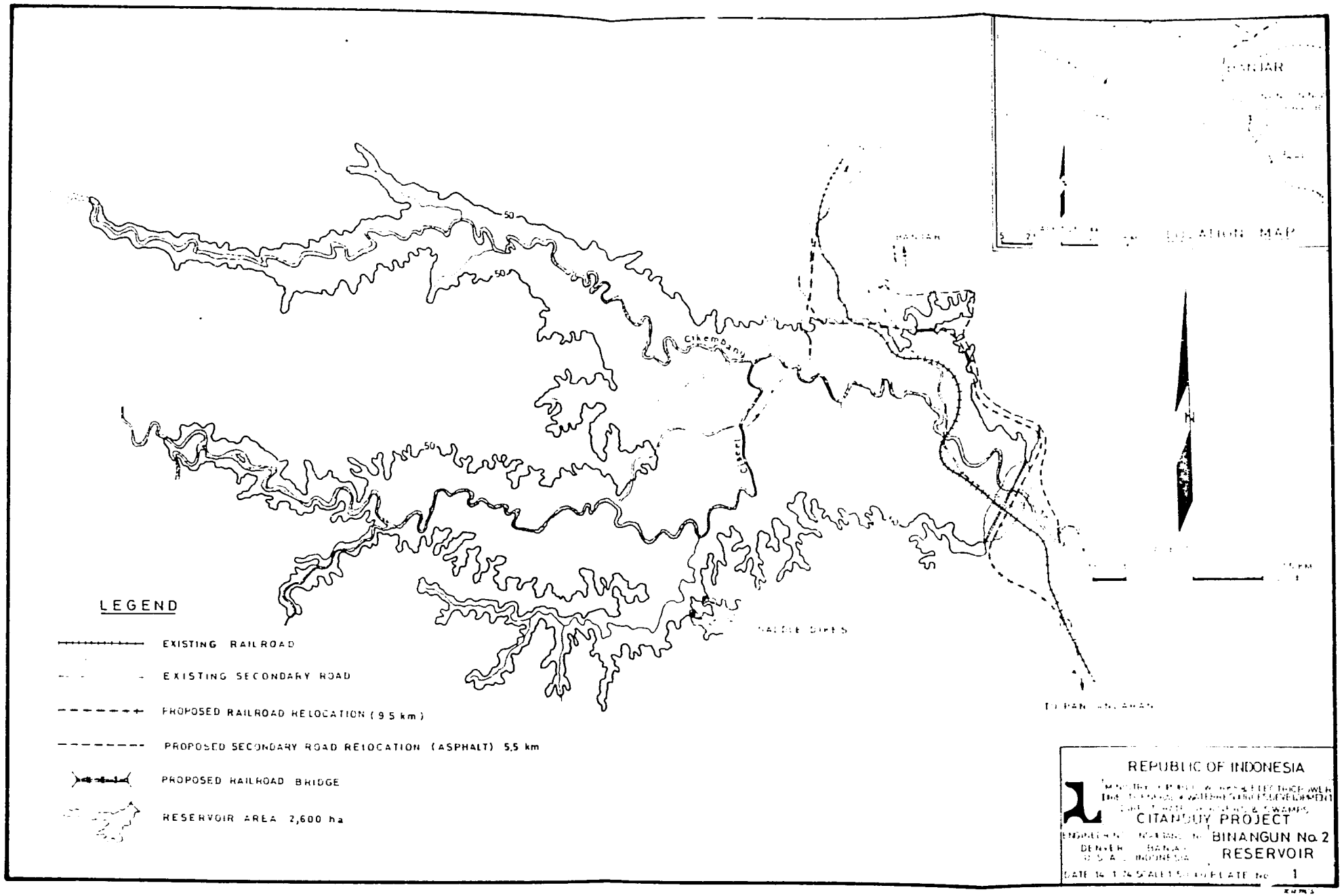
4. The Matenggeng dam ranks just behind the Banjar dam with respect to degree of flood control on the Citanduy. The recent changes in the world power picture enchance its position as a hydro-power producer. Resettlement costs and agricultural production losses must be considered.

5. The most economically efficient combination of dams appears to be the Matenggeng and the Binangun No. 2.

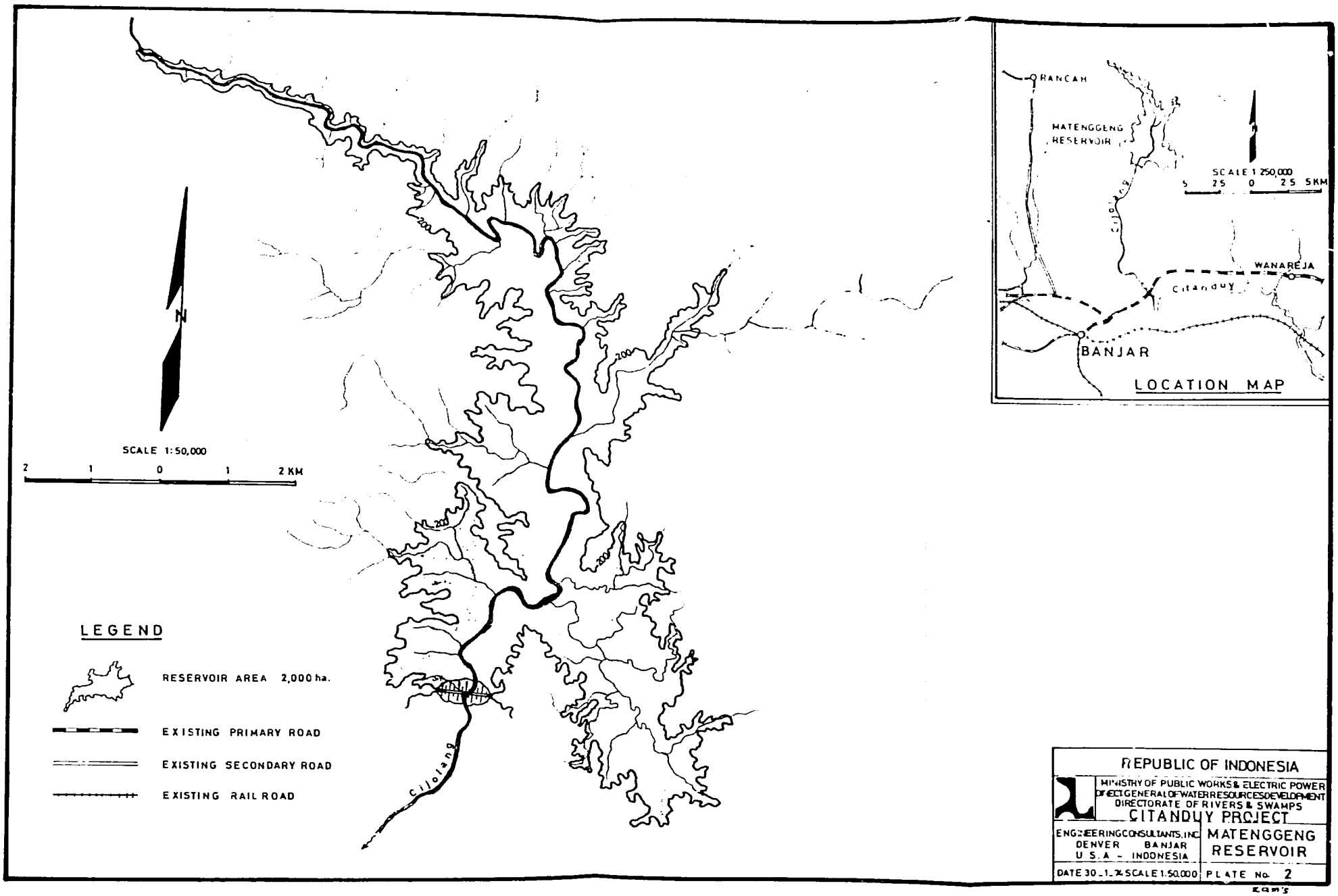
6. The next best two-dam combination of flood control dams for the rivers appears to be the Banjar and Binangun No.2.

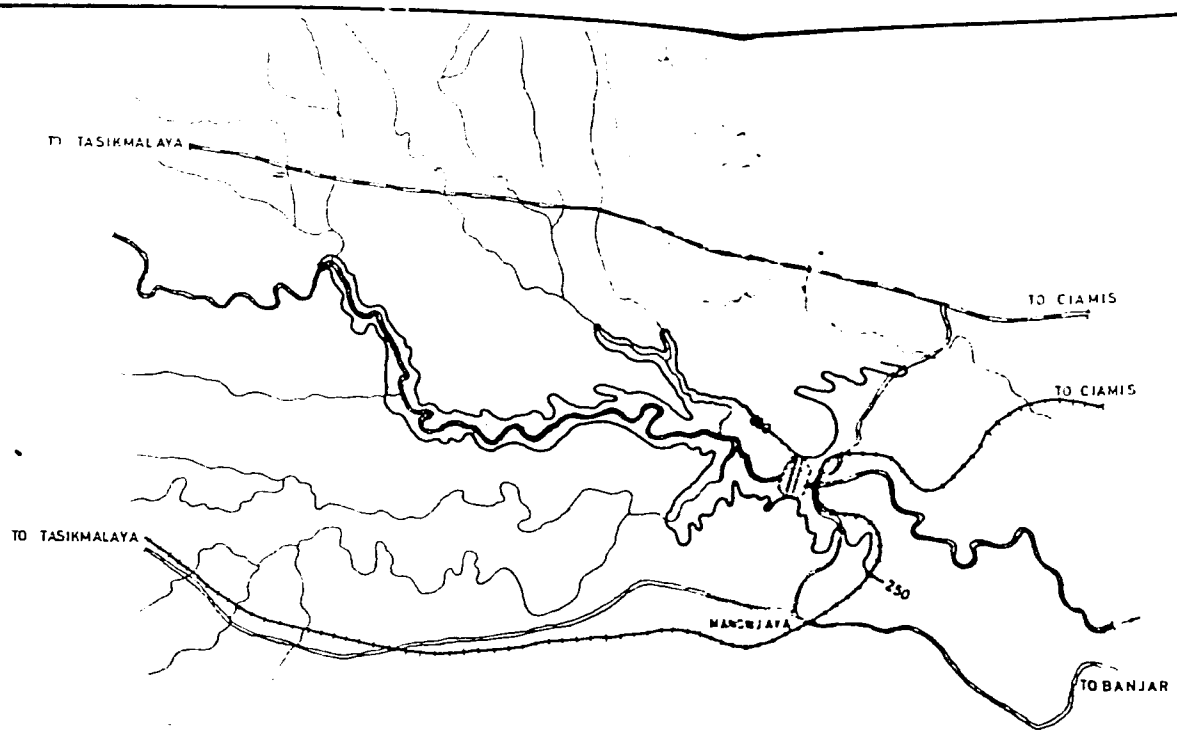
7. Alternate Banjar dam has limited possibilities as a single-purpose flood control dam because of the great reduction in flood control effectiveness as compared with the original Banjar site.

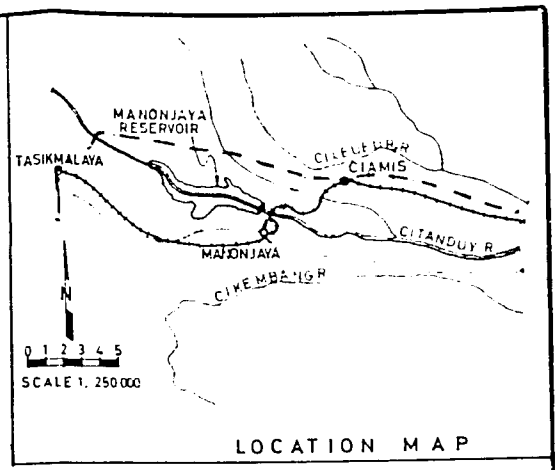
8. In view of a notable increase in revenue producing potential, a high reliability rating, a relatively high flood control potential (alone or in combination), and relatively low rating in adverse social and environmental impact factors; Matenggeng should be considered as one of the best dam site possibilities.



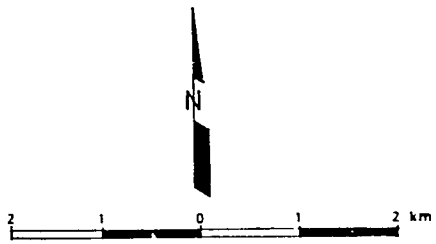
LOCATION MAP
BANJAR
50
Cikembang
Cikeel
SADDLE DIKES
LEGEND
EXISTING RAILROAD
EXISTING SECONDARY ROAD
PROPOSED RAILROAD RELOCATION (9.5 km)
PROPOSED SECONDARY ROAD RELOCATION (ASPHALT) 5.5 km
PROPOSED RAILROAD BRIDGE
RESERVOIR AREA 2,600 ha
REPUBLIC OF INDONESIA
CITANDUY PROJECT
BINANGUN No. 2
RESERVOIR
DENVER
U.S.A.
INDONESIA
PLATE No. 1


N
SCALE 1:50,000
2 1 0 1 2 KM
LEGEND
RESERVOIR AREA 2,000 ha.
EXISTING PRIMARY ROAD
EXISTING SECONDARY ROAD
EXISTING RAIL ROAD
Cijolang
RANCAH
MATENGGENG RESERVOIR
SCALE 1:250,000
5 2.5 0 2.5 5 KM
WANAREJA
Citanduy
BANJAR
LOCATION MAP
REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS & ELECTRIC POWER
DIRECT GENERAL OF WATER RESOURCES DEVELOPMENT
DIRECTORATE OF RIVERS & SWAMPS
CITANDUY PROJECT
ENGINEERING CONSULTANTS, INC
DENVER BANJAR
U.S.A - INDONESIA
MATENGGENG RESERVOIR
DATE 30-1-74 SCALE 1:50,000
PLATE No. 2





LOCATION MAP



LEGEND

- EXISTING RAILROAD.
- EXISTING PRIMARY ROAD.
- EXISTING SECONDARY ROAD.
- RESERVOIR AREA 325 ha.

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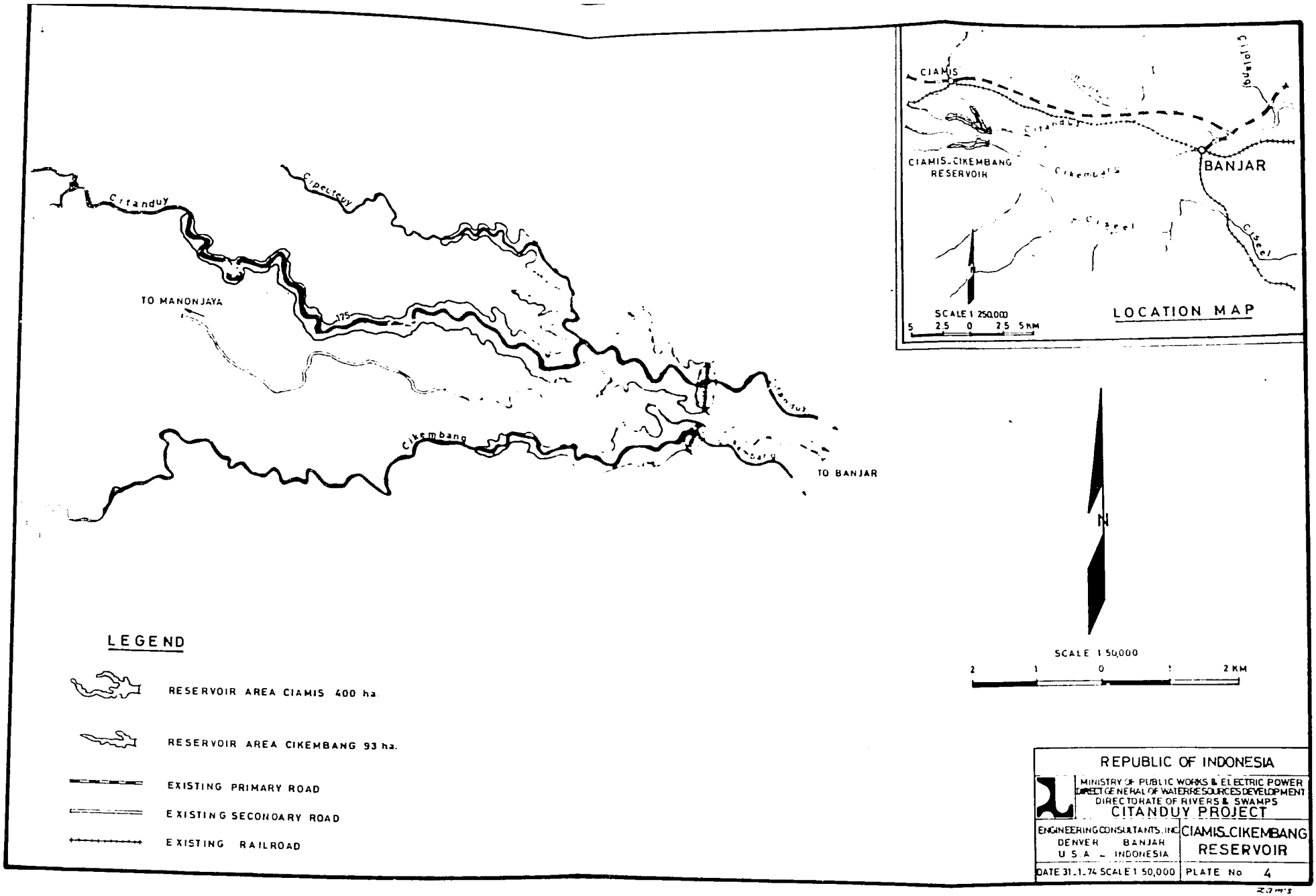
DENVER-BANJAR
U S A - INDONESIA

MANONJAYA RESERVOIR

DATE 1-2-74 SCALE 1 50 000

PLATE No 3

A M



Citanduy
Cipeuteuy
TO MANONJAYA
175
Cikembang
TO BANJAR
CIAMIS
CIAMIS-CIKEMBANG RESERVOIR
BANJAR
Citanduy
Cikembang
Ciseel
Ciseel
SCALE 1:250,000
5 2.5 0 2.5 5 KM
LOCATION MAP
N
SCALE 1:50,000
2 1 0 1 2 KM
LEGEND
RESERVOIR AREA CIAMIS 400 ha.
RESERVOIR AREA CIKEMBANG 93 ha.
EXISTING PRIMARY ROAD
EXISTING SECONDARY ROAD
EXISTING RAILROAD
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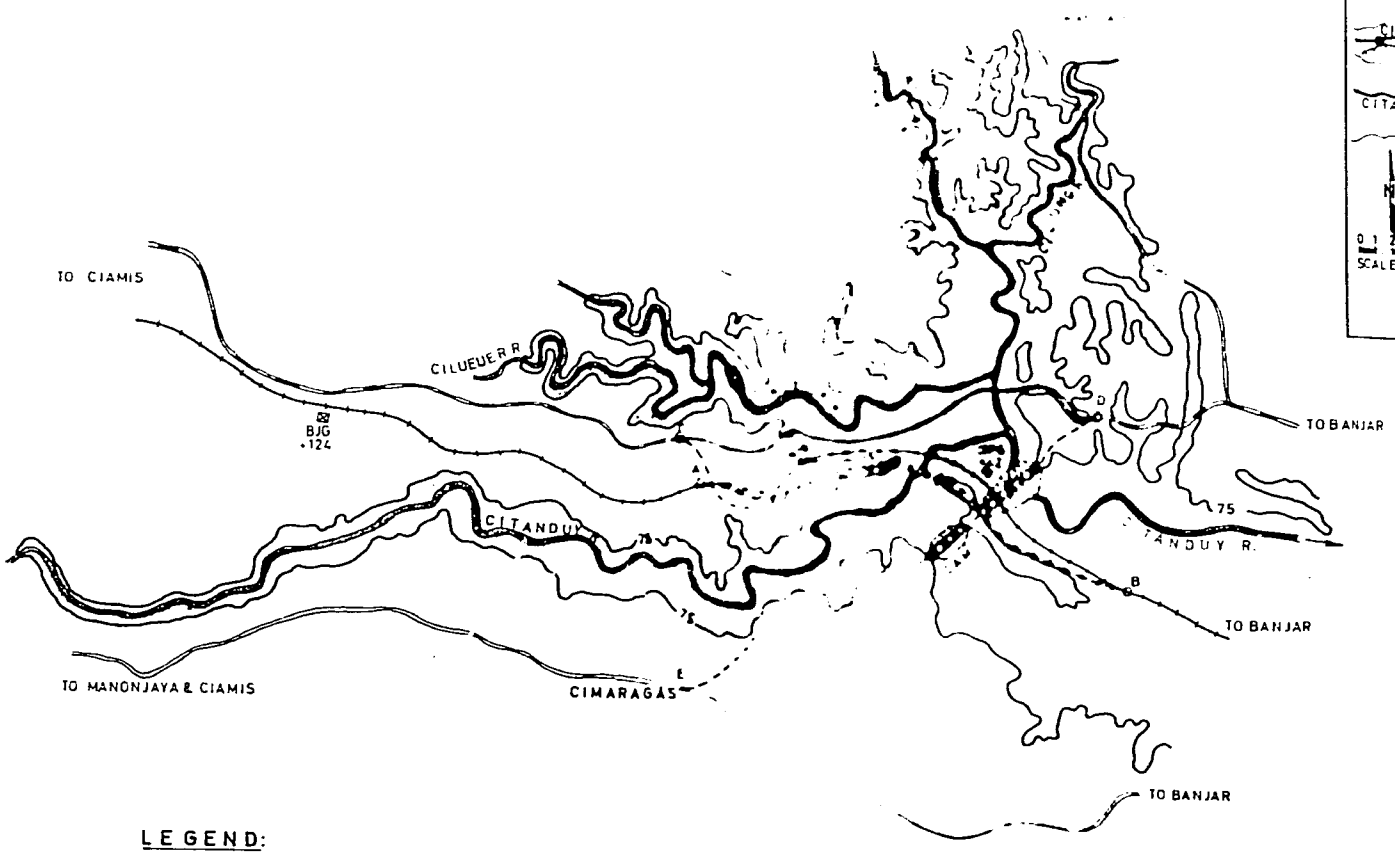
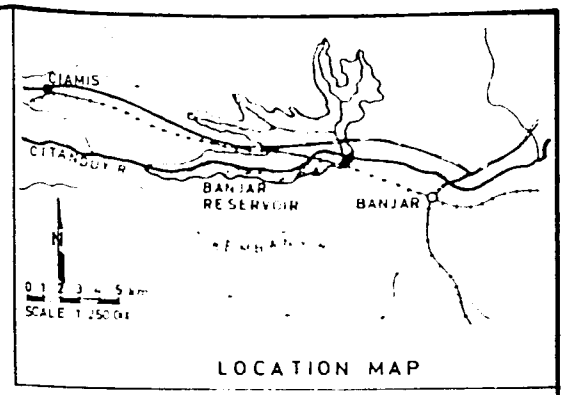
DIRECTORATE OF RIVERS & SWAMPS
CITANDUY PROJECT
ENGINEERING CONSULTANTS, INC
DENVER BANJAR
U.S.A. - INDONESIA
CIAMIS-CIKEMBANG RESERVOIR
DATE 31-1-74 SCALE 1:50,000
PLATE No 4





LOCATION MAP

LEGEND:

- EXISTING RAILROAD
- EXISTING PRIMARY ROAD
- PROPOSED RAIL ROAD RELOCATION A-B 5.4 km
- PROPOSED PRIMARY RELOCATION SCHEMES
  - a) TASIKMALAYA - CIMARAGAS-BANJAR 32 km
  - b) PARALLEL TRACK C-D 5 km
  - c) CIMARAGAS DAMSITE TRACK E-D 5 km
- PROPOSED BRIDGE (ACROSS THE RESERVOIR AREA)
- RESERVOIR AREA 1,740 ha
- EXISTING SECONDARY ROAD.

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DENVER - BANJAR
U.S.A. INDONESIA

BANJAR RESERVOIR

DATE 30-1-73 SCALE 1:50 000 PLATE Nº 5

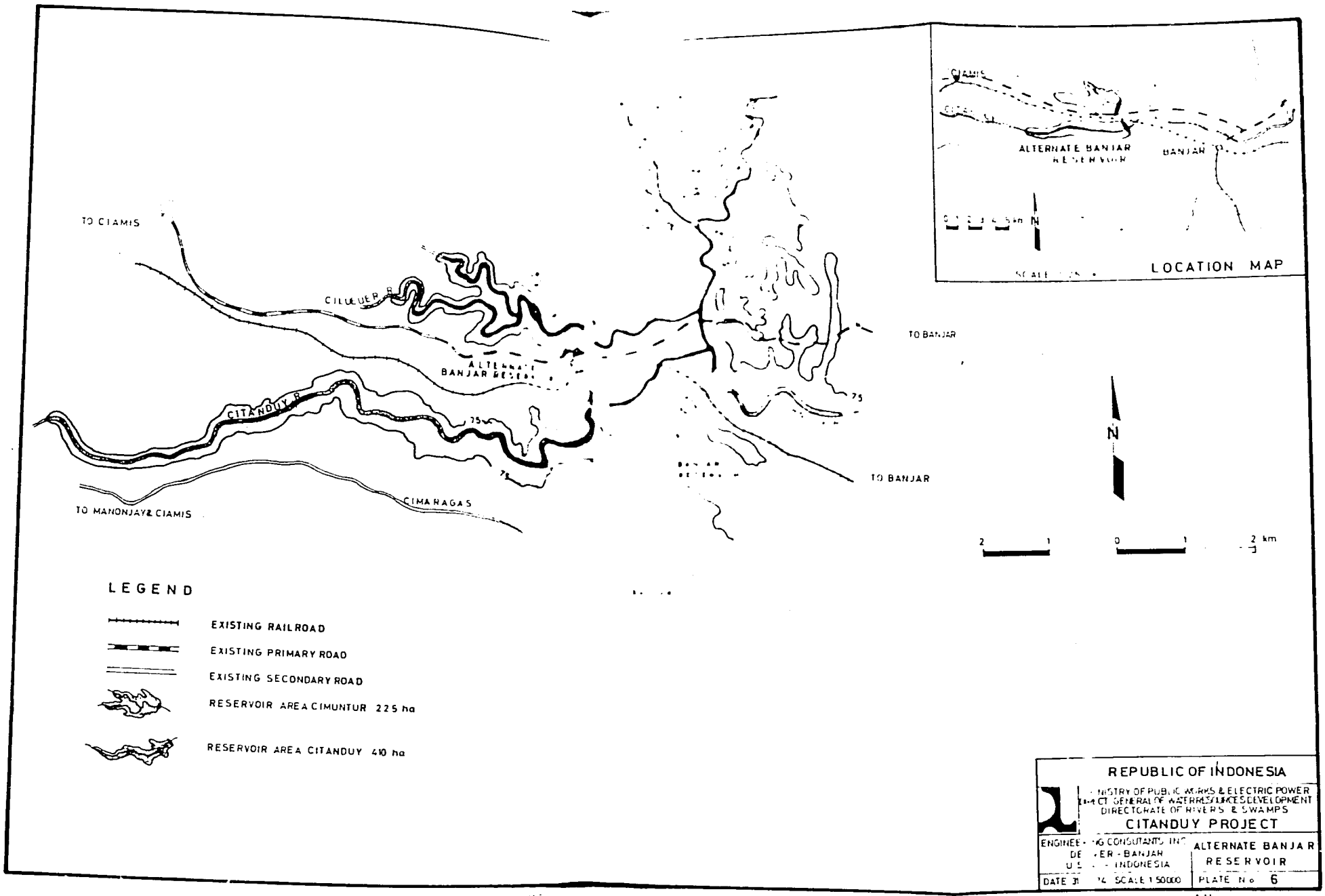
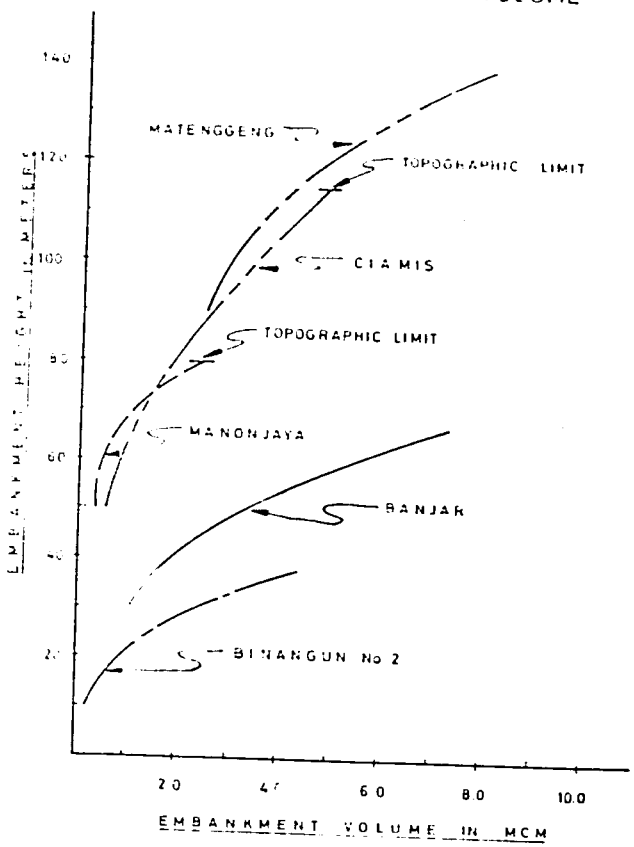

TO CIAMIS
CILUEUER R.
ALTERNATE BANJAR RESERVOIR
CITANDUY R.
75
TO MANONJAYA CIAMIS
CIMARAGAS
TO BANJAR
TO BANJAR
N
2 1 0 1 2 km
LOCATION MAP
ALTERNATE BANJAR RESERVOIR
BANJAR
N
LEGEND
EXISTING RAILROAD
EXISTING PRIMARY ROAD
EXISTING SECONDARY ROAD
RESERVOIR AREA CIMUNTUR 225 ha
RESERVOIR AREA CITANDUY 410 ha
REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS & ELECTRIC POWER
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
DIRECTORATE OF RIVERS & SWAMPS
CITANDUY PROJECT
ENGINEERING CONSULTANTS INC
DEVELOPER - BANJAR
U.S. - INDONESIA
ALTERNATE BANJAR RESERVOIR
DATE 31 74 SCALE 1:50000
PLATE No 6
A.M.

FIGURE 1

EMBANKMENT HEIGHT
VS.
EMBANKMENT VOLUME

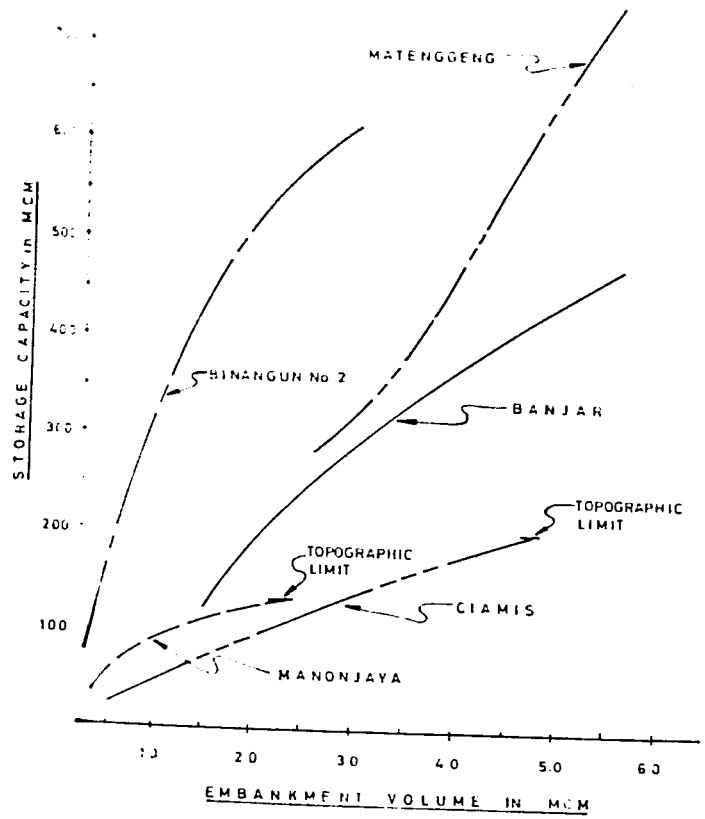


COMMENTS:

1 THE HEIGHT OF THE CIAMIS & MANONJAYA DAMS ARE LIMITED BY TOPOGRAPHY.

FIGURE 2

STORAGE CAPACITY
VS.
EMBANKMENT VOLUME



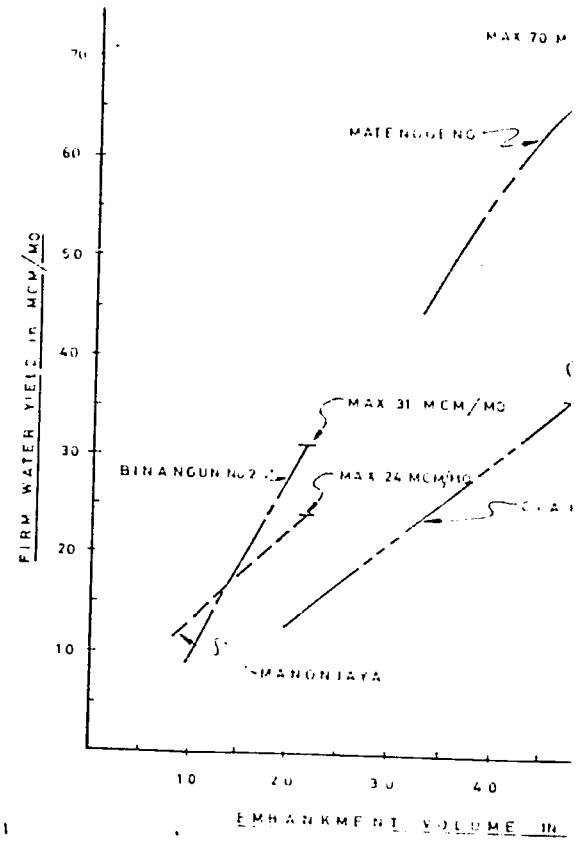
COMMENTS:

BINANGUN No.2 HAS THE GREATEST AMOUNT OF STORAGE CAPACITY PER MCM OF EMBANKMENT VOLUME.

THE RATIOS ARE: BINANGUN No 2 - 245 MCM/MCM, MATENGGENG - 130 MCM/MCM, BANJAR - 85 MCM/MCM, MANONJAYA - 59 MCM/MCM & CIAMIS - 42 MCM/MCM (See note 3 of EVALUATION FACTORS)

FIGURE 3

FIRM WATER YIELD
VS.
EMBANKMENT VOLUME



COMMENTS

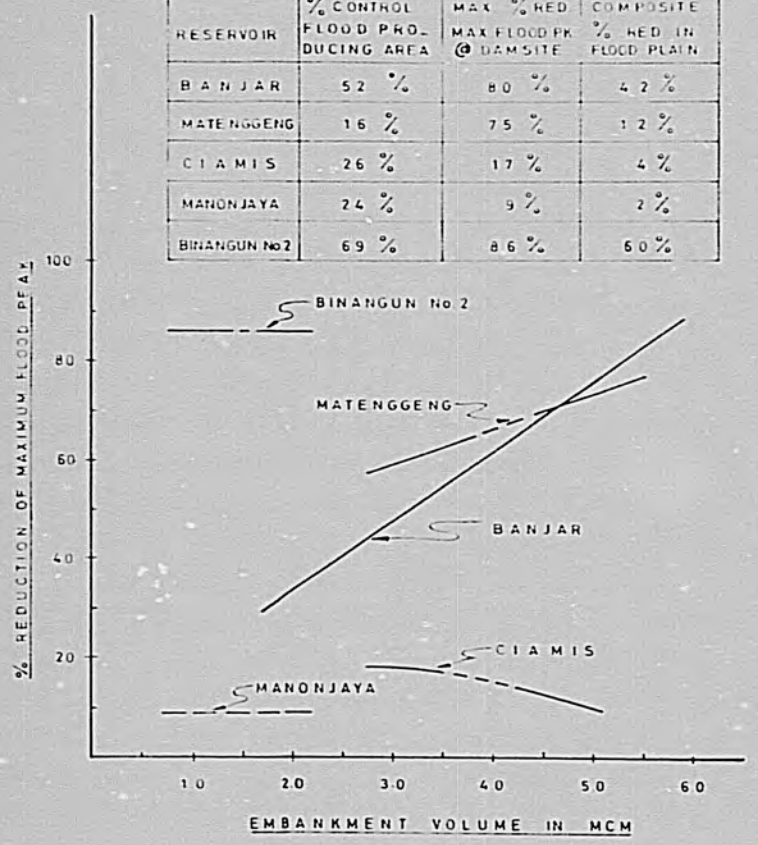
1 BINANGUN No 2 HAS THE HIGHEST RATIO OF FIRM PER MCM OF EMBANKMENT VOLUME.

2 THE RATIOS ARE BINANGUN No 2 - 14 MCM/MO, MATENGGENG - 13 MCM/MO/MCM, MANONJAYA - 11 & CIAMIS - 8 MCM/MO/MCM.

FIGURE 4

% REDUCTION OF MAX. FLOOD PEAK VS EMBANKMENT VOLUME

RESERVOIR	% CONTROL FLOOD PRODUCING AREA	MAX % RED MAX FLOOD PK @ DAMSITE	COMPOSITE % RED IN FLOOD PLAIN
BANJAR	52 %	80 %	42 %
MATENGGENG	16 %	75 %	12 %
CIAMIS	26 %	17 %	4 %
MANONJAYA	24 %	9 %	2 %
BINANGUN No2	69 %	86 %	60 %



COMMENTS:

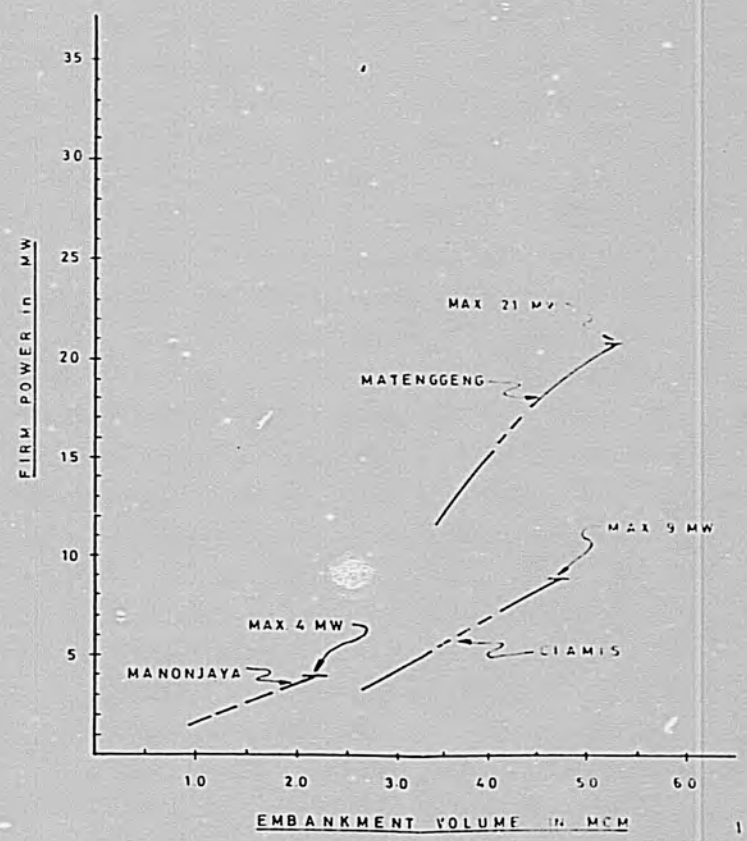
1 SEE NOTES FOR DEFINITIONS OF PARAMETERS.

2 THE BINANGUN No 2, BANJAR & MATENGGENG DAMS HAVE THE GREATEST POTENTIAL FOR REDUCING FLOOD PEAKS AT THE DAMSITE

3 THE BANJAR & BINANGUN No 2 DAMS GIVE THE GREATEST OVERALL PROTECTION.

FIGURE 5

FIRM POWER VS. EMBANKMENT VOLUME



COMMENTS:

1. MATENGGENG HAS THE GREATEST POTENTIAL TO PRODUCE FIRM POWER.

2. EACH SITE HAS POTENTIAL FOR PEAKING POWER

LEGEND

- BANJAR DAM
- BINANGUN No 2 DAM
- MATENGGENG DAM
- CIAMIS DAM
- MANONJAYA DAM

NOTES:

1 THE FIGURES SHOWN ARE COMPARATIVE ESTIMATES BASED ON A PRELIMINARY ANALYSIS OF EACH SITE

2 FOR PURPOSES OF COMPARISON A ROCKFILL EMBANKMENT WAS ASSUMED FOR EACH SITE

3 IN FIGURE 4, THE PERCENT MAX REDUCTION OF FLOOD PEAKS IS A MEASURE OF THE AVAILABLE FLOOD STORAGE CAPACITY AND ATTENUATION OF MAJOR FLOOD PEAKS BY RESERVOIR ROUTING.

4 IN FIGURE 4, THE PERCENT CONTROL OF THE FLOOD PRODUCING AREA(FPA) IS THE RATIO OF THE DRAINAGE AREA CONTROLLED TO THE TOTAL AREA PRODUCING MAJOR FLOODS. THE FPA IS 2500 KM^2 & 500 KM^2 FOR THE CITANDUY & CISEEL RESPECTIVELY.

5 IN FIGURE 4, THE COMPOSITE PERCENT REDUCTION IS A MEASURE OF THE EFFECTIVENESS OF EACH SITE IN REDUCING MAJOR FLOOD PEAKS AT THE FLOODPLAIN

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DIRECTORATE OF RIVERS & SWAMPS

CITANDUY PROJECT

ENGINEERING CONSULTANTS, INC
DENVER U.S.A. BANJAR INDONESIA

DAMSITE COMPARISONS

DATE 7.1.74 SCALE — PLATE No. 7

LAND USE WITHIN RESERVOIR SITES
Project Citanduy - Banjar

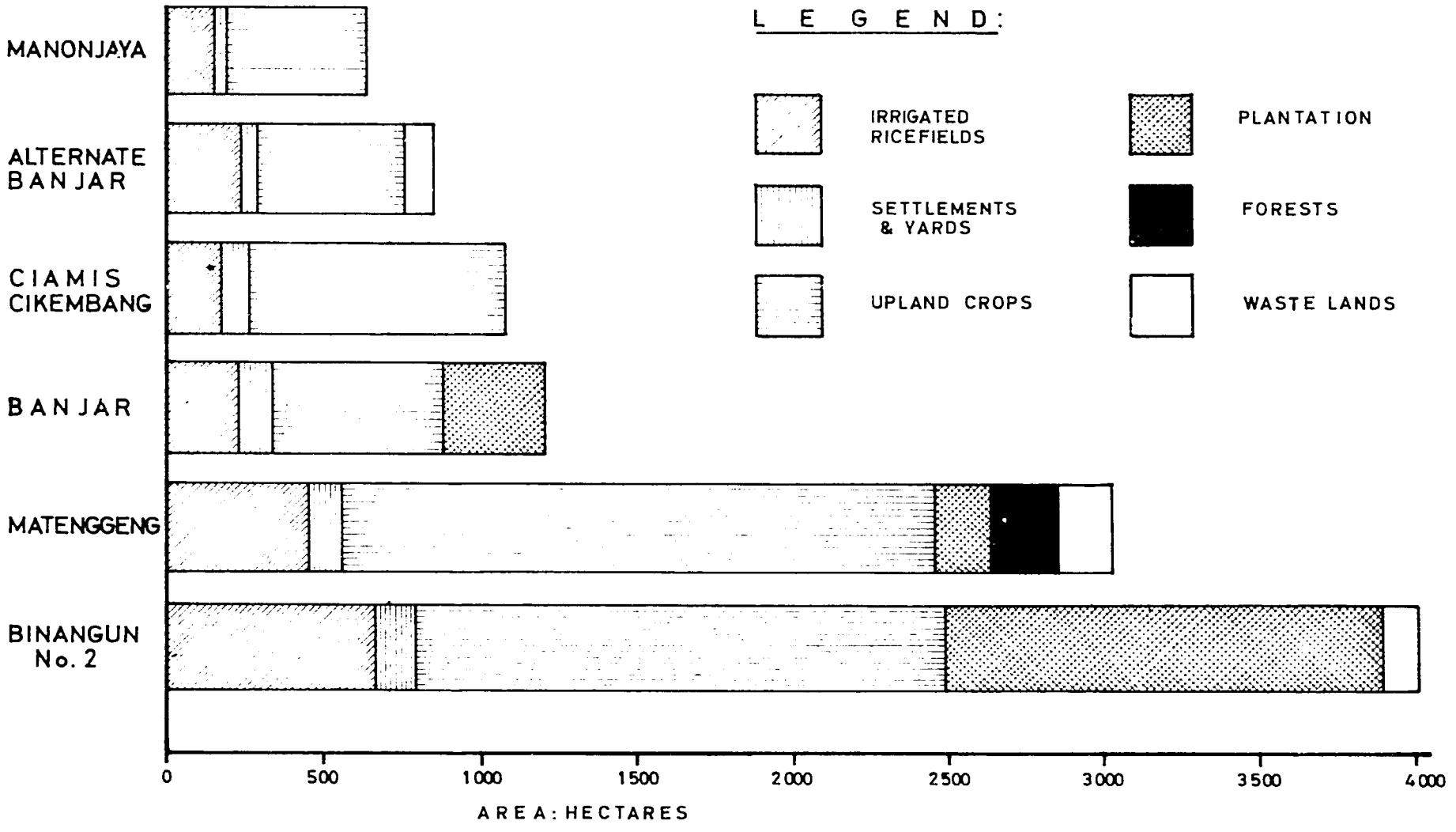

PLATE No. 13

A.M.

DAMSITE	50 YEAR FLOOD CONTROL						100 YEAR F		
	AT DAMSITE			AT BRIDGE 1452			AT DAMSITE		
	FLOOD PEAK	PEAK OUT FLOW	% RED. OF PEAK	FLOOD PEAK W/O DAM	FLOOD PEAK W/ DAM	% RED. OF PEAK	FLOOD PEAK	PEAK OUT FLOW	% RED. OF PEAK
MATENGGENG	853	207	76 %	3440	2330	32 %	913	229	75 %
CIAMIS	956	787	18 %	3440	3235	6 %	1016	855	16 %
MANONJAYA	956	870	9 %	3440	3375	2 %	1016	940	7 %
BANJAR	1671	248	85 %	3440	2122	38 %	1818	253	86 %
BANJAR MULTIPURPOSE	1818	900	50 %	3440	2188	36 %	1818	1010	44 %
ALTERNATE BANJAR	* 956 ** 811	273 276	71 % 66 %	3440	2644	23 %	1016 852	280 286	72 % 66 %
MATENGGENG WITH CIAMIS	SEE ABOVE	–	–	3440	2232	35 %	SEE ABOVE	–	–
MATENGGENG WITH MANONJAYA	SEE ABOVE	–	–	3440	2285	34 %	SEE ABOVE	–	–

* CITANDUY RIVER DAM

** CIMUTAR RIVER DAM

100 YEAR FLOOD CONTROL					200 YEAR FLOOD CONTROL					
DAMSITE		AT BRIDGE 1452			AT DAMSITE			AT BRIDGE 1452		
EAK T FLOW	% RED. OF PEAK	FLOOD PEAK W/O DAM	FLOOD PEAK W/DAM	% RED. OF PEAK	FLOOD PEAK	PEAK OUTFLOW	% RED. OF PEAK	FLOOD PEAK W/O DAM	FLOOD PEAK W/DAM	% RED. OF PEAK
229	75 %	4020	2850	29 %	1000	265	74 %	4220	3070	27 %
855	16 %	4020	3837	5 %	1126	970	14 %	4220	3942	6 %
940	7 %	4020	3972	1 %	1126	1057	6 %	4220	4137	2 %
253	86 %	4020	2567	36 %	2036	270	87 %	4220	2600	38 %
010	44 %	4020	2670	34 %	2036	1220	40 %	4220	2780	34 %
280 286	72 % 66 %	4020	3148	22 %	1126 862	291 289	74 % 66 %	4220	3225	24 %
–	–	4020	2629	35 %	SEE ABOVE	–	–	4220	2752	35 %
–	–	4020	2782	31 %	SEE ABOVE	–	–	4220	2947	30 %

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CITANDUY PROJECT

FLOOD CONTROL COMPARISON

10

DAMSITE	RELIABILITY FACTORS				
	HYDROLOGIC RANKING	AVAILABLE MAPPING			FOUNDATION INVESTIGATI
		TOPOGRAPHIC	AERIAL	RANK	COMMENTS
MATENGGENG	5	1:50,000 ; 1:5,000	1 : 15,000	2	NONE AT CONSULTANTS' SELECTED SITE. INVESTIGATION @ SITE "C" APPROX. 1 km UPSTREAM OF CONSULTANTS' SITE
CIAMIS	2	1:50,000 ; 1:5,000	NONE	3	INVESTIGATION IN PROGRESS
CIKEMBANG	6	1:50,000 ; 1:5,000	NONE	3	INVESTIGATION IN PROGRESS
MANONJAYA	1	1:50,000 ; 1:5,000	1 : 20,000	1	INVESTIGATIONS COMPLETED
BANJAR	3	1 : 50,000	1 : 20,000	5	NO INVESTIGATION
BINANGUN No.2	4	1 : 50,000	NONE	6	NO INVESTIGATION

NOTES :

1 THE ABOVE RANKINGS RELATE THE RELATIVE STRENGTH OF EACH SITE WITH REGARD TO BASIC DATA REQUIRED TO PERFORM A FEASIBILITY STUDY.

2. THE HYDROLOGIC RANKING OF EACH SITE IS OUR HYDROLOGISTS' EVALUATION OF THE STRENGTH AND RELIABILITY OF RAINFALL AND RUNOFF DATA, LENGTH OF RECORD, EFFECTIVENESS OF MEASURING EQUIPMENT AND QUALITY OF THE TECHNICAL WORK.

REP

RELIABILITY FACTORS

DAMSITE	HYDROLOGIC RANKING	AVAILABLE MAPPING			FOUNDATION INVESTIGATIONS	
		TOPOGRAPHIC	AERIAL	RANK	COMMENTS	RANK
MATENGGENG	5	1:50,000 ; 1:5,000	1:15,000	2	NONE AT CONSULTANTS' SELECTED SITE INVESTIGATION @ SITE "C" APPROX. 1 km UPSTREAM OF CONSULTANTS' SITE	3
CIAMIS	2	1:50,000 ; 1:5,000	NONE	3	INVESTIGATION IN PROGRESS	2
CIKEMBANG	6	1:50,000 1:5,000	NONE	3	INVESTIGATION IN PROGRESS	2
MANONJAYA	1	1:50,000 1:5,000	1:20,000	1	INVESTIGATIONS COMPLETED	1
BANJAR	3	1:50,000	1:20,000	5	NO INVESTIGATION	6
RINANGUN No 2	4	1:50,000	NONE	6	NO INVESTIGATION	6

NOTES

1. THE ABOVE RANKINGS RELATE THE RELATIVE STRENGTH OF EACH SITE WITH REGARD TO BASIC DATA REQUIRED TO PERFORM A FEASIBILITY STUDY.

2. THE HYDROLOGIC RANKING OF EACH SITE IS OUR HYDROLOGISTS' EVALUATION OF THE STRENGTH AND RELIABILITY OF RAINFALL AND RUNOFF DATA, LENGTH OF RECORD, EFFECTIVENESS OF MEASURING EQUIPMENT AND QUALITY OF THE TECHNICAL WORK.

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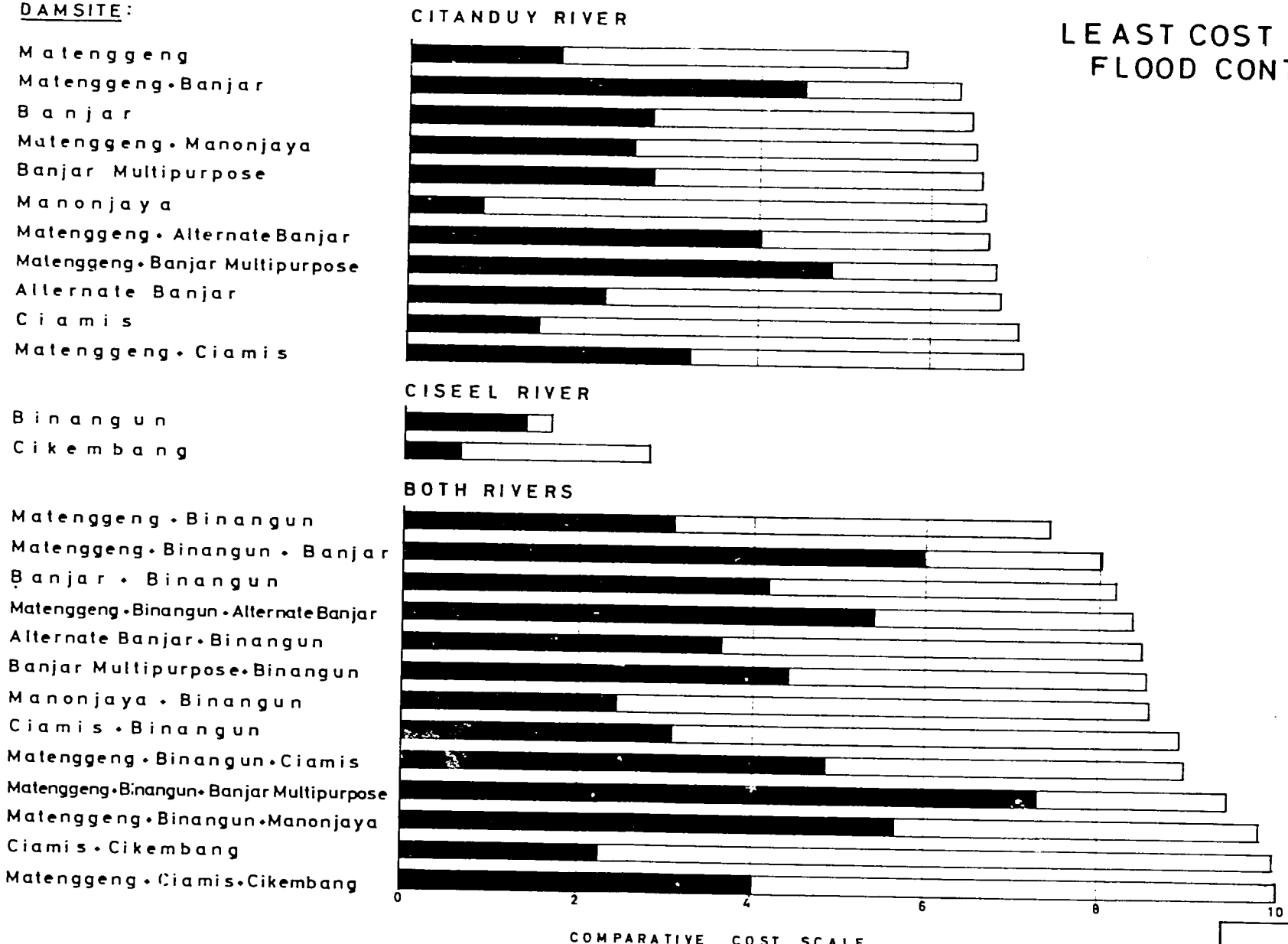
COMPARISON OF RELIABILITY FACTORS

PLATE No. 11

LEAST COST C
FLOOD CONTR



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DIRECT
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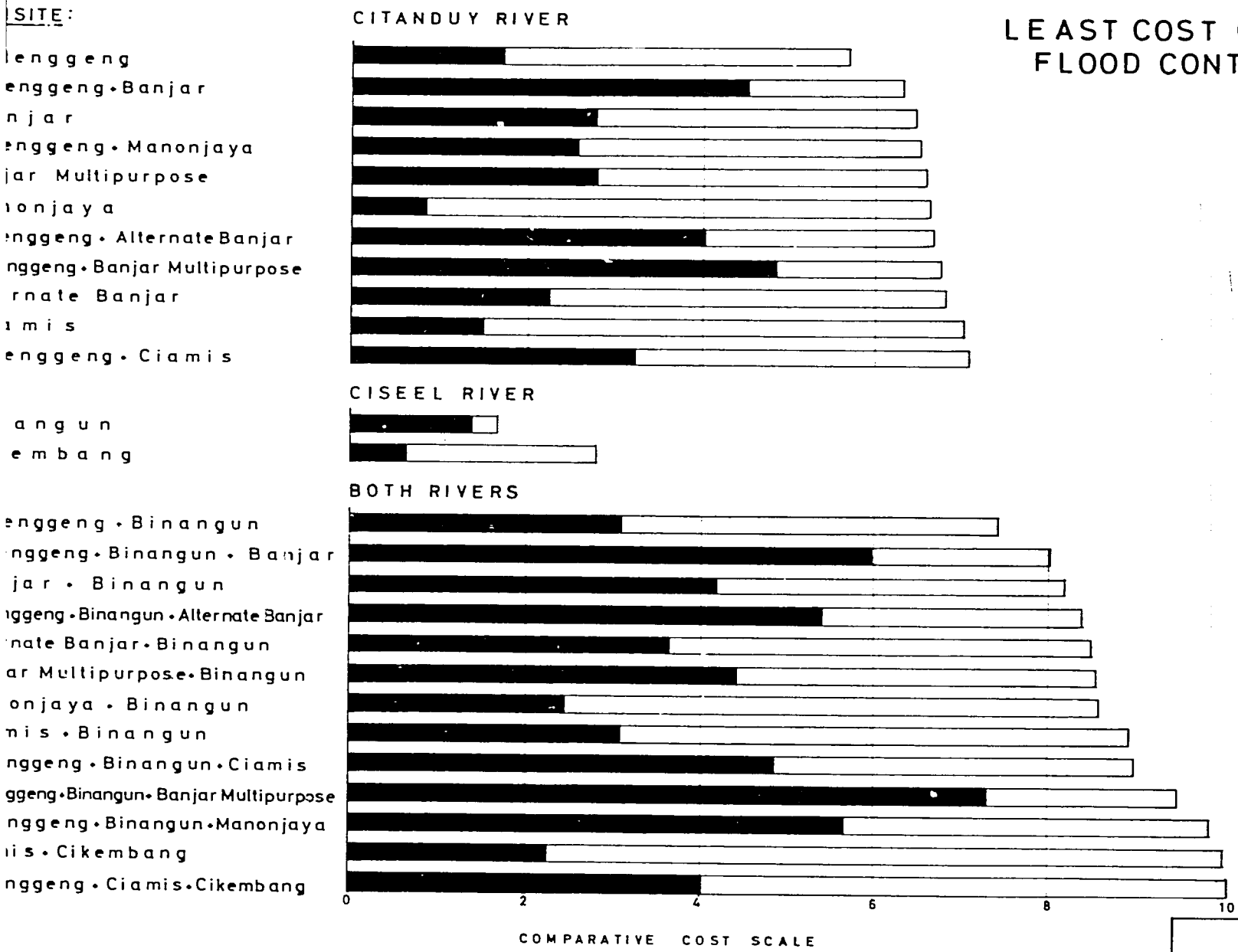
ENGINEERINGC
DENVE
U.S A.

DATE 13-2-1

LEAST COST COMPARISON FLOOD CONTROL DAMS



LEGEND:

DAM COSTS

REMAINING DAMAGES

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DIRECT GENERAL OF WATER RESOURCES DEVELOPMENT
DIRECTORATE OF RIVERS & SWAMPS

CITANDUY PROJECT

ENGINEERING CONSULTANTS INC
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U S A - INDONESIA

FLOOD CONTROL

DATE 13-2-1974

PLATE No. 12

A.M