PREPARED FOR

AGENCY FOR INTERNATIONAL DEVELOPMENT
DEPARTMENT OF STATE

TECHNICAL EVALUATION
OF
FEASIBILITY STUDIES
FOR

JRAGUNG DAM
AND
NGRAMBAT DAM

[illegible] ENGINEERING COMPANY

MAY, 1974

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May 6, 1974

TEC 442.10
Serial 2340

Subject: Technical Evaluation of Jragung and Ngrambat Dams, Jratunseluna Basin, Indonesia

Dear Mr. Vogel:

We are pleased to submit this Report, prepared for you under the terms of Basic Ordering Agreement No. AED/csd-2955, Task Order No. 1, Project No. 497-11-99-000.

The purpose of this report is to present a technical evaluation of the preliminary designs that have been completed to date for Jragung and Ngrambat Dams. These two dams are located in the Jratunseluna Basin in North Central Java; Jragung Dam will be on the Kali Jragung and Ngrambat Dam on the Kali Serang.

The report is divided into two parts; Part 1 is for Jragung Dam and Part 2 Ngrambat Dam.

For Jragung Dam two feasibility reports have been prepared; the first was prepared by NEDECO in December 1971; the second was also prepared by NEDECO in August 1973 and essentially consisted of the first report updated and revised.

For Ngrambat Dam the feasibility studies are presently being prepared by NEDECO and they are scheduled for completion in November of this year. A reconnaissance report was completed for this dam in July, 1973.

Jragung Dam

The site selected by NEDECO for Jragung Dam is less than a kilometer downstream from the confluence of the Kali Trima and the Kali Klampuk. The drainage area at the damsite is 94 square kilometers and ranges in elevation from 65 meters at the damsite to above 1200 meters at the headwaters. The reservoir capacity will be about 90 million cubic meters, and the maximum dam height approximately 50 meters.

We believe some additional investigations and studies of major technical significance are required before the probable maximum cost of Jragung Dam can be estimated. The probable maximum cost is what the construction cost will be for the dam and appurtenances if the worst possible conditions exist and all known contingencies are provided for. Additional subsurface explorations are required to know with more certainty the geology at the site and to determine the quantity and quality of the available construction materials. Additional studies are also required to complete the preliminary design of the spillway.

We believe that the Design Phase of the project can be conveniently divided into two stages to accommodate the additional studies required; Stage I will culminate with a Definite Project Report which will present preliminary designs and estimated construction costs for the dam and appurtenances. The Definite Project Report will present all the data and information required for financing the construction of the dam. This stage should take about 6 months and will include additional geological investigations, flood hydrological studies, and preliminary design studies. Stage II will include the detailed design and preparation of the contract drawings and specifications for tender and award of construction.

The preliminary design of the spillway prepared by NEDECO was based on a reservoir inflow flood, which was derived from a storm based on frequency techniques. An independent analysis based on the unit-hydrograph technique and storm rainfalls approximately equal to the maximum recorded daily rainfalls since 1870, gives flood hydrographs with substantially greater volumes and peak flows than those derived by NEDECO.

The consequences of failure for Jragung Dam will be very severe, probably resulting in a loss of life, because there are thousands of people who live and maintain their livelihood in the river valley immediately downstream from the dam. Therefore, it is suggested that no risk should be accepted for the spillway design and that this design should be based on the maximum probable flood. Additional studies should be made when the Definite Project Report is being prepared, to determine the maximum probable flood to be used for the spillway design studies.

Reservoir deposition from the sediment transported by the Kali Jragung appears to be no problem, but this should be investigated further as more data becomes available. The reservoir deposition was estimated from sediment concentrations that were recently collected for the Kali Serang. It is estimated that the reservoir deposition after 30 years will not exceed 9 million cubic meters, which is less than 10 percent of the capacity of the reservoir.

The geology at the damsite consists of a sequence of mudstone and sandstone beds with the mudstone being predominant. The bedding planes are almost vertical and the jointing is well developed and occurs in almost any direction. There is also evidence of considerable sliding along the bedding planes and joints.

There is a fault in the right abutment that crosses the axis of the dam where the crest of the dam will be about 30 meters above the ground elevation. While we were in the field, we observed a spring which occurs about half way up the slope on the right abutment. This might indicate that channeled flow occurs along the fault zone, which will be of major importance, and will require special treatment during design and construction.

The construction materials proposed for the dam embankment were never completely proven as to quantity and quality. This is an extremely critical factor in determining the appropriate dam section, which will affect the cost of the dam substantially.

A more than adequate volume of impervious material is available for the core, but the largest portion of it has swelling characteristics that make it quite unsatisfactory for use above minimum pool level. Its volume changes significantly with changes of water content; from compaction density it shrinks, opening large cracks, when exposed to drying, and it swells, losing strength, when immersed. This material may not be suitable for the core above the minimum reservoir level because, as proposed in NEDECO's Report, the reservoir will operate almost on an annual basis. Therefore, the reservoir level could be lowered to, or near, minimum pool every year and remain at that level for several months, which will create a dry condition for that portion of the core above minimum pool. It would be acceptable wherever below minimum pool level the confining pressure is greater than the swelling pressure.

Adequate pervious materials available for the shells of the dam have not been proven out. In NEDECO's Report two possible sources were identified; some unconsolidated gravels approximately 2 kilometers upstream from the damsite; and quarried sandstone which is located about 2 kilometers downstream from the site. Neither of these sources has been completely proven as to quantity and quality. Therefore, additional subsurface explorations are required to define more accurately the available pervious materials.

The embankment design and foundation treatment are dependent on several factors including shape of valley section, strength and permeability of the foundation and the characteristics of the available construction materials. Considering what is presently known, it is questionable that the design proposed by NEDECO is the most appropriate for the conditions expected at the site.

The embankment design proposed in NEDECO's Report consists of a central core dam keyed to a grout curtain. We believe there are valid reasons for considering a sloping core dam with an impervious reservoir blanket. The sloping core dam will provide the opportunity for the downstream shell to be constructed independent of the core and therefore, the embankment placement will not be controlled by inclement weather; second, the sloping core can be easily constructed with the reservoir blanket; third, because of the foundation conditions the reservoir blanket will probably be a more economical and effective means of controlling foundation leakage.

As previously mentioned, during the preparation of the Definite Project Report additional subsurface explorations should be made. These should include additional cored borings in the foundation; stripping along certain areas of the dam axis; test pits in the borrow areas; and cored borings in the quarry area.

At the quarry area, 2 kilometers downstream from the damsite proposed in NEDECO's Report, we believe there is an alternative damsite that may have considerable merit. The surface geology indicates that considerably less distortion has occurred. The proposed quarry area is the right abutment at this alternative site, therefore, the subsurface explorations for the right abutment can be accomplished at the same time the borings are cored for the materials investigation. Should any prohibitive technical aspect be discovered by the additional subsurface explorations at the present Jragung site, the alternative site should be more seriously considered.

Ngrambat Dam

The site selected by NEDECO for Ngrambat Dam is less than a kilometer downstream from the confluence of the Kali Serang and the Kali Uter. The maximum dam height will be more than 50 meters, and the reservoir capacity will be greater than 600 million cubic meters. The drainage area at the damsite is about 600 square kilometers.

As previously mentioned, the feasibility studies for Ngrambat are presently under way and are scheduled for completion in November of this year. The subsurface explorations have been completed at the site selected by NEDECO, but the layout studies and most of the preliminary design studies have just started. Therefore, there were no definitive designs for the dam section or spillway that could be reviewed. The concept for the dam embankment, however, was explained by NEDECO's Engineers.

We believe the foundation conditions for the damsite selected by NEDECO present problems which are so serious that consideration should be given to moving the damsite to an alternative site, which is located approximately 1 kilometer downstream. Both sites are underlain by a predominantly mudstone sequence with some interbeds of sandstone. At the present site, however, the core samples indicate there is a crushed zone of pervious material that underlies the river. This zone is approximately 30 meters wide and more than 50 meters deep, and it follows approximately the alignment of the river.

This crushed zone will create significant leakage problems unless it can be effectively cut off. Grouting will be difficult, and the results uncertain; furthermore, structural damage to the foundation could result from piping unless the foundation leakage can be controlled.

In addition, the strength of the crushed material in this zone is very poor. Therefore, the embankment slopes will have to be flattened to provide for a stable condition along a failure surface through this zone in the foundation.

There is evidence of gravity slumping in the abutment areas which may indicate there is a considerable thickness of unstable material that overlies the undisturbed rock. If this is the case, the affected mass will have to be excavated to create a stable, watertight foundation. Additional subsurface explorations will be required to determine the required excavation limits. In addition, this slumping in the abutments will also create difficulties with regard to the spillway layout.

The alternative damsite which, as previously mentioned, is about 1 kilometer downstream from the site selected by NEDECO, is composed of the same mudstone and sandstone sequence. However, based on a field reconnaissance investigation, site topography, and aerial photographs, there is considerably less distortion and no evidence that slumping has occurred. There appears to be a minor fault in the left abutment, but there is no evidence of a broken crushed zone of material underlying the valley section.

In any event, with only some preliminary subsurface explorations the merits of this alternative site could be determined. This will involve two or maybe three inclined borings cored across the valley section to determine if the characteristics in the valley are different from those at Ngrambat. If these borings indicate that no crushed zone or similar unfavorable condition exists, we believe the damsite should be moved to the alternative site and additional subsurface explorations be made as well as site topography. This information could then be used to prepare a preliminary design for the dam.

Acknowledgments

We are very appreciative of the assistance and cooperation extended by all those who contributed to the completion of this report. We wish to give special acknowledgment to the staffs of The Agency for International Development in Jakarta and Washington, D.C., the Directorate General of Water Resources Development of Indonesia, and NEDECO. Without their timely assistance we could not have completed this report on schedule.

Very truly yours,

TUDOR ENGINEERING COMPANY

John Williams

John Williams

JW:mm

FIGURE 1
JRATUNSELUNA BASIN

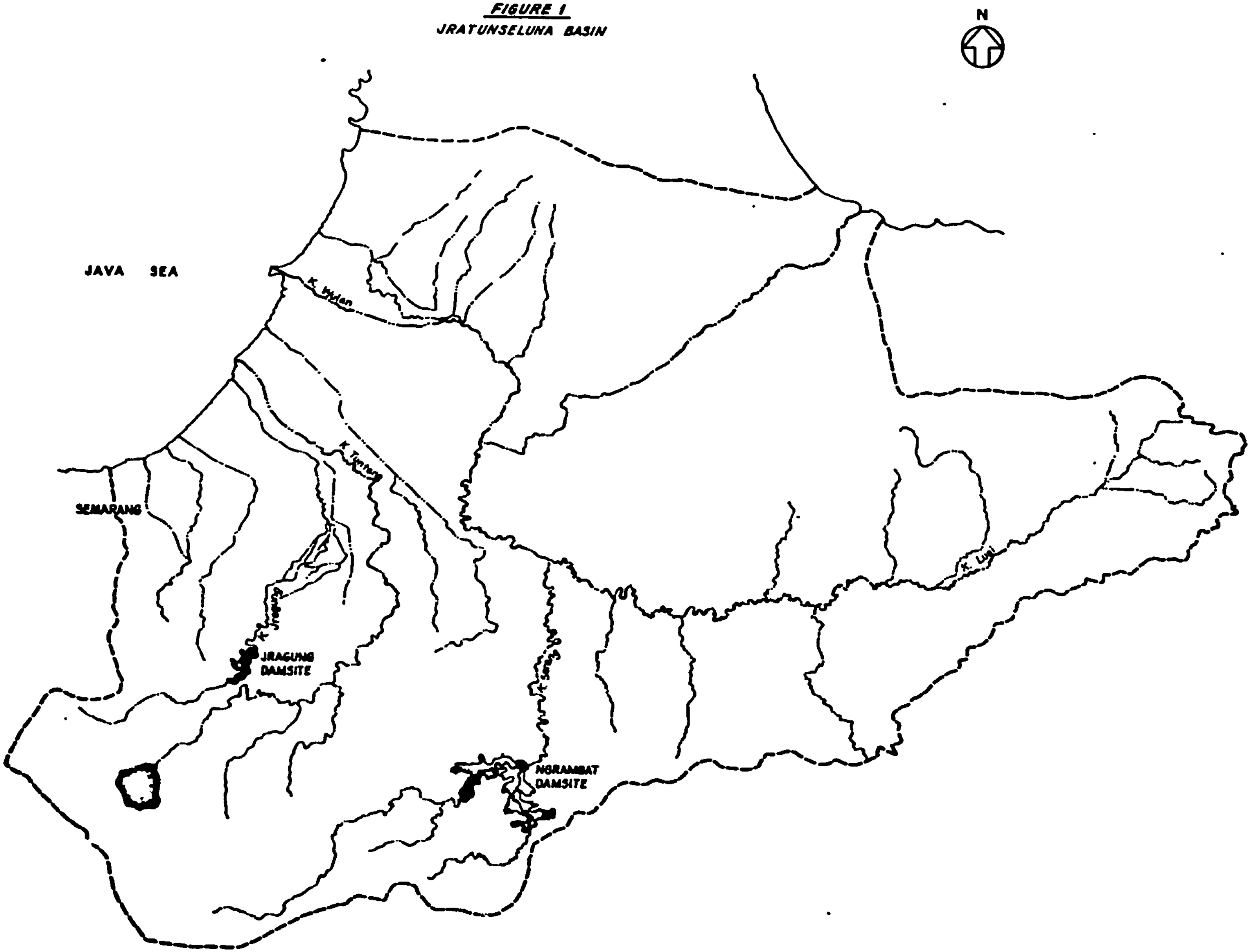
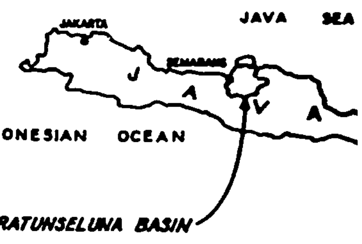


FIGURE 2
LOCATION MAP



PROJECT MAP
JRATUNSELUNA BAS

PART 1

JRAGUNG DAM

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INTRODUCTION

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INTRODUCTION

The purpose of this report is to present a technical evaluation of the preliminary design of Jragung Dam. This damsite is near Semarang in North Central Java on the Kali Jragung. The site selected by NEDECO is less than a kilometer downstream from the confluence of the Kali Trima and the Kali Klampuk.

All of the previous design studies have been prepared by NEDECO in conjunction with an Indonesian counterpart staff from the Directorate General of Water Resources Development. The design studies previously completed by NEDECO and the counterpart staff are given in the List of References at the end of this report.

The most recent preliminary design of Jragung Dam is presented in NEDECO's Feasibility Report[1/] dated August, 1973. An earlier feasibility report[2/] was prepared by NEDECO in December of 1971. The 1973 report was apparently prepared to eliminate some of the deficiencies of the 1971 report.

We have reviewed all of the pertinent portions of the reports given in the List of References related to Jragung Dam. The proposed damsite and material sources were visited and inspected in the field. In addition, many worthwhile conversations were held with NEDECO's Engineers and the counterpart staff in Semarang and NEDECO's Engineers in the Netherlands.

In addition to the general issues pertinent to the design and construction of the dam, such as foundation considerations, section design and general layout, the USAID Mission in Jakarta requested that the spillway flood hydrology and the reservoir sedimentation be reviewed.

1/ NEDECO, The Netherlands, Jragung Dam, Flood Control and Irrigation Project, Feasibility Study, August 1973.

2/ NEDECO, Feasibility Study Water Resources Development, Djragung, Dolok, and Penggaron Basins, December 1971.

A detailed review of the construction cost of the dam was considered to be outside the scope of this technical evaluation. However, we have made a few comments in this regard because of some aspects that are obvious in NEDECO's Report.

The use of unskilled labor as a labor intensive alternative was considered in NEDECO's Report for some of the construction activities. It was considered primarily for stripping the dam foundation and excavation of the borrow material. The applicability of labor intensive methods was reviewed with regard to the construction of Jragung Dam.

CHAPTER II

HYDROLOGY

CHAPTER II

HYDROLOGY

Introduction

The hydrologic studies prepared by NEDECO for the Jragung Dam Feasibility Study consisted of water supply hydrology for the reservoir inflows, flood hydrology for the spillway design and sedimentation studies for the reservoir. Some of the basic data used are presented in Appendix I of NEDECO's Feasibility Report 1/, while other data are on file in NEDECO's office in Semarang.

Basic Data

The basic data that are available to prepare the various hydrological studies are summarized below.

Rainfall Data

There are thirteen rainfall stations that are presently in operation in the Kali Jragung Basin or very near the basin. Four of these stations are recording gages which were installed in December, 1972 or January, 1973. There are three additional stations that were in operation until 1945 and one terminated operation in 1932.

There appears to be sufficient rainfall data for the water supply hydrology; the data available for flood studies, however, is extremely limiting.

Streamflow Data

Prior to 1973 there were only two streamflow gaging stations on the Kali Jragung. One was at Paras which has a drainage area 133 Km^2 and the other at Ngipik which has a drainage area of 116 Km^2. The Paras Station was discontinued in 1912 and Ngipik in 1963. The data for both stations are subject to

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1/ NEDECO, The Netherlands, Jragung Dam, Flood and Irrigation Project, Feasibility Study, August 1973.

interpretation in terms of monthly volumes or daily flows. Only occasional data, if any, are available on flood flows for the Ngipik Station, and they are not considered to be of any use for developing design floods.

In November of 1972 a gaging station was installed at the Burangan Bridge just downstream from the Jragung Damsite. One flood has been recorded at this station, and it is discussed below.

There are data available for several other streamflow gaging stations on rivers adjacent to the Kali Jragung Basin. These data were utilized to develop a rainfall-runoff model for the water supply hydrology studies.

Sediment Data

There are no sediment data available for the Kali Jragung. Some sediment data were collected, however, for the Kali Serang at Sedadi, which has a drainage area of 868 Km^2. These data are presented in Table II-1.

Water Supply Hydrology

The reservoir inflows for the Jragung Reservoir were synthesized from a rainfall-runoff model. From the information given in NEDECO's Report[1/] the model was based, at least in part, on the rainfall-runoff characteristics of the Kali Tuntang and the Kali Serang.

The average annual runoff from the basin was computed to be about 1490 millimeters per year. The average annual rainfall for the basin is approximately 2600 millimeters. This gives an average annual loss of about 1110 millimeters per year which compares very well with the Kali Serang Basin. Therefore, on the basis of the data presented in NEDECO's Report[2/] it appears that the synthesized reservoir inflows are reasonable.

1/ Ibid.

2/ Ibid.

Flood Hydrology

The spillway design flood that is usually adopted is based on an analysis of the hydrological potentialities of the basin, with proper consideration given to the economical and practical aspects. For example, if there is a possible loss of life, as there will be if Jragung Dam fails, then the spillway design flood is well beyond that obtainable through frequency analysis.

The flood hydrology studies prepared by NEDECO for Jragung Dam are presented in Section 6 of Appendix I of NEDECO's Report 1/. Spillway design floods are presented, as well as maximum flood volumes for specified durations. These flood volumes were used in studying the flood control capabilities of Jragung Reservoir. No specific flood hydrographs were given for the diversion requirements during construction. However, a calculation was made to establish a relation between diversion discharge capacity and effective storage required for an upstream cofferdam for a flood with a return interval of once in 25 years.

No general method has been adopted for deriving spillway design floods on the Island of Java. This problem was discussed with the General Consultants to the Directorate of Planning and Programming. The General Consultants are presently attempting to consolidate data and criteria related to flood hydrology. It is intended that this information will be utilized in developing a uniform and generally accepted method for deriving spillway design floods for future projects. Presently, however, there is little agreement on what the criteria should be for spillway design floods.

One report 2/ was just recently published by the Directorate of Planning and Programming on maximum recorded daily rainfalls

1/ Ibid.

2/ Directorate of Planning and Programming, Directorate General of Water Resources Development, Ministry of Public Works and Electric Power, Maximum Recorded Daily Rainfall in Indonesia 1879 - 1970, August 1973.

in Indonesia. Although some of the rainfall data presented in that report are doubtful, it appears to be the best overall compilation available of maximum daily rainfalls in Java.

The spillway design flood prepared by NEDECO was compared to maximum floods derived by other methods. In addition, an independent preliminary estimate was made for a possible maximum flood for the Jragung Spillway. Before these comparisons are discussed, a brief summary of the spillway design flood derived by NEDECO is in order.

Spillway Design Flood Prepared by NEDECO

This flood was based on a storm of 360 millimeters, which was defined as being a 1 in 10,000 year storm. The rainfall was distributed as follows: 85 percent in the first 5 hours and the remaining 15 percent in the next 4 hours. The maximum intensity was 60 millimeters in 30 minutes.

The defined maximum storm was applied to a time-runoff model developed for the basin, and a peak discharge of 1,000 cubic meters per second was obtained. The time-runoff model was constructed by dividing the basin by isochrones of travel time. The basin was divided into seven isochrones whose times of concentration ranged from 30 minutes to 3.5 hours.

Comparisons

The spillway design flood for Jragung Dam prepared by NEDECO was compared to the Creager Curves. This comparison is shown in Figure 1 of Plate II-1. After making the appropriate conversions, the flood discharge derived by NEDECO was determined to be about 970 cubic feet per second per square mile; which, as shown, gives a Creager's C of about 50. For a basis of comparison most of the maximum floods that have occurred in the United States are enveloped by a C = 100 curve. In the typhoon areas of the Philippines and Formosa a C = 200 is deemed appropriate.

The maximum rainfall selected by NEDECO is compared with the world's greatest rainfalls shown on Figure 2 of Plate II-1.

It was also compared to the maximum recorded daily rainfalls in the Semarang area, which is shown on Figure 3 of Plate II-1.

Historical Floods

Only one historical flood of any magnitude has been recorded on the Kali Jragung at the Burangan Bridge Gage. This flood occurred on May 29-30, 1973 and had a peak discharge of almost 160 cubic meters per second. The hydrograph for this flood is shown on Figure 1 of Plate II-2.

Independent Derivation

Several procedures can be used to develop spillway design floods in areas of limited hydrological data, such as the Jragung Basin. The method used usually depends on the degree of accuracy required. For example, for a reconnaissance report the spillway design flood may be generally approximate. For a financing report or feasibility report, however, the spillway design flood should be sufficiently reliable so that no substantial variations are introduced at the time of final design and construction which will result in an increase in cost.

One common method that is used during the reconnaissance stage is use of the Creager Curves, which were previously discussed. A common method that is used when the feasibility report is prepared in the unit-hydrograph approach. This method was used as a preliminary check of the design flood derived by NEDECO. The unit-hydrograph, storm rainfalls and spillway floods developed are shown on Plate II-2.

Storm Rainfall. Daily rainfalls in excess of 400 millimeters have been recorded in or adjacent to the Jragung Basin[1/]. In the province of Semarang the maximum recorded daily rainfall is 600 millimeters at Besito, which is at an elevation of 89 meters above sea level. For the purposes of comparing NEDECO's spillway design flood with ones developed by the unit-hydrograph method two storms were selected. These were for a rainfall excess of 500 millimeters and 400 millimeters.

1/ Ibid.

The hourly distribution of storm rainfall was discussed in a report by Tanimoto[1/]. From the data presented in that report it appears that for individual storms the majority of the rainfall occurs in the first 10 hours. Depth duration curves were presented for several hourly rainfall stations in Java. There is an hourly station at Semarang and the data for this station were interpreted by Tanimoto as having characteristics different from other parts of Java. There does not seem to be any valid basis, however, for different rainfall-duration characteristics throughout Java. Therefore, based on the data presented in Tanimoto's Report the rainfall distribution for a rare event was assumed to be as shown in Table II-2.

Unit-Hydrograph. A 30-minute[2/] unit-hydrograph was derived both by synthetic means and from the May 29-30, 1973 flood hydrograph. Both of these unit-hydrographs are shown on Figure 2 of Plate II-2. The lag time[3/] for the basin appears to be between 1.5 and 2 hours, which is very short for a basin of the size of Jragung. This is probably due to the steep slopes that are prevalent throughout the basin. The synthetic unit-graph which has the longer lag time was selected to develop the spillway flood.

Reservoir Inflow Floods for Spillway Design. The reservoir inflow floods developed for the 500 and 400 millimeter storms and the unit-hydrograph derived are shown on Figure 3 of Plate II-2. As shown, for the 500 millimeter storm the peak flow is about 2,000 cubic meters per second and the flood volume is about 47 million cubic meters, while for the 400 millimeter storm the peak flow is about 1,600 cubic meters per second and the flood volume is about 38 million cubic meters. These flood

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1/ Tanimoto, Columbo, Plan Expert, Institute of Hydraulic Engineering, Revised and Enlarged Edition of the Hourly Rainfall Analysis in Java, 1971-1973.

2/ The rainfall duration of the unit-hydrograph is 30 minutes.

3/ Lag time is defined as the time from the center gravity of the rainfall duration to the hydrograph peak.

volumes are compared to the proposed storage capacity of Jragung Reservoir, which will be 90 million cubic meters.

As shown these derived reservoir inflow floods are considerably greater than the design flood developed by NEDECO. As previously discussed, it is quite possible that the maximum probable storm for the basin should be in the order of 400 or 500 millimeters. Therefore, it appears that additional studies should be conducted to determine with confidence what flood the spillway should be designed for.

Reservoir Sedimentation

Reservoir sedimentation or deposition is a very complex process which is dependent on many factors. In estimating reservoir deposition the first determination is the quantity of suspended sediment that is being transported by the streamflow. The sediment that is trapped in the reservoir is then determined. In addition, the distribution of deposited sediment in the reservoir is usually a factor. This is important because the sediment capacity of a reservoir is greater than the water capacity because the sediment deposition will slope upstream.

As previously mentioned, there are very little sediment data available in the immediate area. Some data were recently collected by NEDECO on the Kali Serang at Sedadi. These data were presented in Table II-1. These data are helpful for making rough estimates of the sediment concentrations. For example, from these data it appears that sediment concentrations greater than 5,000 parts per million are unusual, and those greater than that concentration probably occur only during floods. During the low flow season the concentrations are probably less than 2,000 parts per million.

The sediment discharges computed for the Kali Jragung at the damsite were based on the formula presented in Table II-3. As shown, the mean discharge-weighted concentration is assumed to be directly related to the sediment discharge moving in the stream.

The sediment discharge computations made for Kali Jragung at the Jragung Damsite are presented in Table II-4. A computation was made to estimate the suspended sediment transported by the May 29-30 flood. The discharge data used for the flood were the data at the Burangan Bridge, which has a drainage area of 101 square kilometers. This is slightly larger than the damsite drainage area, which is 94 square kilometers, but no attempt was made to reduce the flows.

The sediment transported annually by the low flows was also estimated. As shown in Table II-4, it was assumed that the average annual low flow is 3.0 cubic meters per second and that the average concentration is 2,000 parts per million.

The estimated reservoir deposition is presented in Table II-5. The average annual reservoir deposition estimated is based on the assumption that 10 floods similar to the May 29-30, 1973 flood will occur on the average each year. As shown in Table II-5 it was assumed that 60 percent of the sediment transported by the flood flows will be deposited in the reservoir, and 100 percent transported by the low flows will be deposited. Based on these assumptions, a reservoir deposition of approximately 360,000 metric tons of sediment per year is obtained.

The bulk density of the sediment deposited in the reservoir will be considerably less than the solid density because of interstitial water or gas that must be considered. The bulk density is usually related to particle size. The average particle size for the suspended sediment was observed to be about 0.1 millimeter. From laboratory studies[1/] it was determined that deposits for that particle size will have a specific weight of about 80 pounds per cubic foot[2/].

1/ United States Department of Interior, Geological Survey, Techniques of Water-Resources Investigations of the United States Geological Survey, Fluvial Sediments Concepts, Book 3, Chapter C1, 1970.

2/ This is equivalent to 1283 kilograms per cubic meter.

Using the above specific weight as the bulk density, the average annual reservoir deposition was determined to be approximately 280,000 cubic meters. Based on that deposition rate the total deposition in 30 years will be 8,400,000 cubic meters. This estimated deposition in 30 years is approximately 9 percent of the storage capacity of the proposed Jragung Reservoir, which will have a capacity of about 90 million cubic meters.

TABLE II-1

SEDIMENT DATA

KALI SERANG

Date	Discharge (cubic meters per second)	Sediment[1/] Discharge (cubic meters per second x 10^{-6})	Sediment Concentration (parts per million)
27 Nov 73	30	5,072	3,472
30 Nov 73	35	39,670	NA[2/]
2 Dec 73	300	145,950	NA
4 Dec 73	135	45,570	NA
6 Dec 73	80	32,884	NA
8 Dec 73	60	11,213	2,440
8 Dec 73	60	7,700	3,516
11 Dec 73	490	111,395	NA
12 Dec 73	200	24,043	3,695
16 Dec 73	80	36,740	7,949
16 Dec 73	60	28,368	3,321
18 Dec 73	220	35,670	NA
19 Dec 73	310	40,020	5,688
19 Dec 73	450	69,440	4,569
19 Dec 73	165	35,585	3,187
10 Jan 74	55	13,029	3,124
10 Jan 74	55	11,734	2,189
12 Jan 74	80	22,358	2,013

1/ For suspended sediment with a grain size greater than 50 microns.

2/ Not available

TABLE II-2

RAINFALL DISTRIBUTION
RARE STORM EVENTS

Time (Hours)	Percentage of Total Storm
1	30
2	52
3	68
4	78
5	86
6	90
7	93
8	96
9	98
10	100

TABLE II-3

SEDIMENT DISCHARGE FORMULA

$Qs = Qw \times Cs \times K$[1/]

Qs is the sediment discharge in metric tons per day

Qw is the water discharge in cubic meters per second (M^3/s)

Cs is the concentration of suspended sediment in parts per million (PPM)

$$K = \frac{86{,}400 \text{ seconds per day} \times 1 \text{ ton per cubic meter}}{1{,}000{,}000}$$

$$= 0.0864$$

K is a coefficient that is based on the unit of measurement of water discharge and that assumes a specific weight of 2.65 for sediment.

1/ United States Department of the Interior, Geological Survey, Techniques of Water-Resources Investigations of the United States Geological Survey, Computation of Fluvial-Sediment Discharge, Book 3, Chapter C3, 1972.

TABLE II-4

SEDIMENT DISCHARGE COMPUTATIONS

KALI JRAGUNG

May 29-30, 1974 Flood:

Time (Hour)		Qw[1/] (M^3/sec)	Cs[2/] (PPM)	K + 24 hr.	Qs (Metric Tons)
May 29	9a	6.0	7,000	0.0036	151
	10	83.0	7,000	0.0036	2092
	11	55.0	7,000	0.0036	1386
	12n	158.0	7,000	0.0036	3982
	1	95.0	7,000	0.0036	2394
	2	130.0	7,000	0.0036	3276
	3	122.0	7,000	0.0036	3074
	4	80.0	7,000	0.0036	2016
	5	60.0	7,000	0.0036	1512
	6	50.0	7,000	0.0036	1260
	7	40.0	7,000	0.0036	1008
	8	35.0	7,000	0.0036	882
	9	31.0	7,000	0.0036	781
	10	27.0	7,000	0.0036	680
	11	25.0	7,000	0.0036	630
	12m	22.0	7,000	0.0036	554
May 30	1	20.0	7,000	0.0036	504
	2	18.0	7,000	0.0036	453
	3	16.5	7,000	0.0036	416
	4	15.0	7,000	0.0036	378
	5	14.0	7,000	0.0036	353
	6	13.0	7,000	0.0036	328
	7	12.0	7,000	0.0036	302
	8	11.0	7,000	0.0036	277
					28689

Annual Sediment Transport from Low Flows:

Assume: Qw = 3 M^3/sec
Cs = 2000 PPM

Qs = Qw x Cs x K
= 3(2000)(0.0864)(365)
= 189,216 tons/year

1/ See Plate II-2

2/ Assumed. See concentration data for Kali Serang, Table II-1.

TABLE II-5

RESERVOIR DEPOSITION

Assumed Trap Efficiencies:

Low Flows	100%
Flood Flows	60%

Reservoir Deposition (Metric Tons/Yr):

Low Flows	189,200(1.00)	=	189,200
Flood Flows 1/	10(28,700)(0.60)	=	168,420
	TOTAL		357,620

Reservoir Deposition (Volume):

Assumed Bulk Density = 1283 Kg/M^3 2/

Annual Volume = $\frac{357,620,000}{1283}$

= 278,700 M^3/yr

Say 280,000 M^3/yr

10-year Volume = 2,800,000 M^3

20-year Volume = 5,600,000 M^3

30-year Volume = 8,400,000 M^3

1/ Ten floods similar to the May 29-30 flood were assumed to occur on the average each year.

2/ A bulk density of 1283 Kg/M^3 is 80 lb/ft^3.

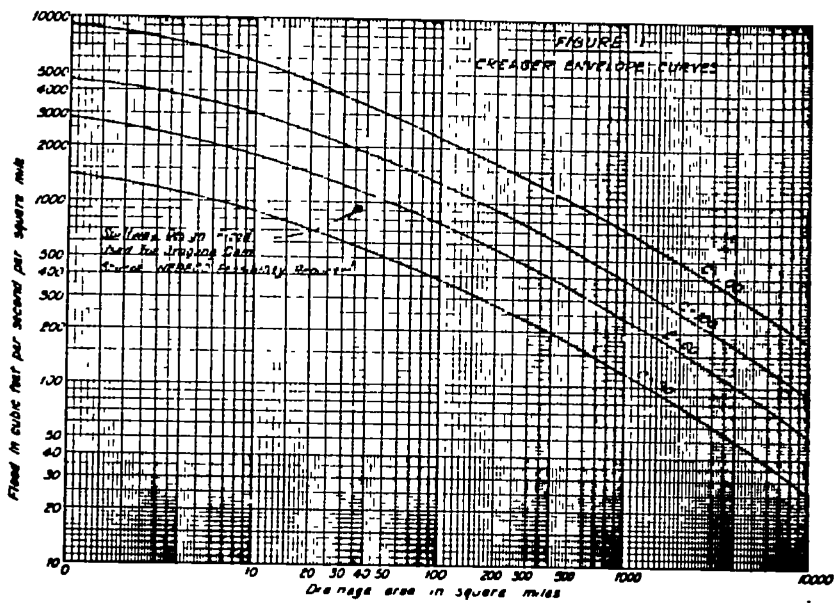


FIGURE 1
CREAGER ENVELOPE CURVES

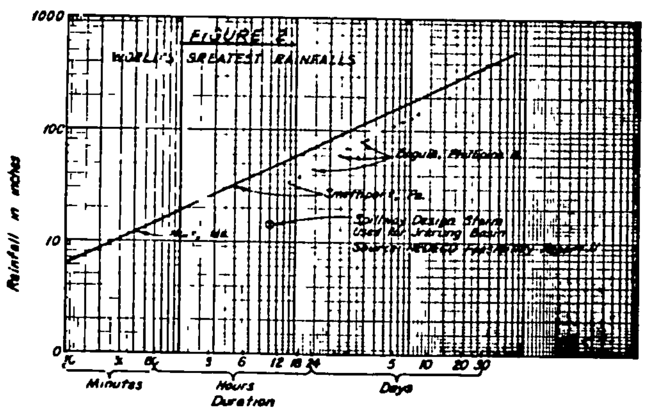
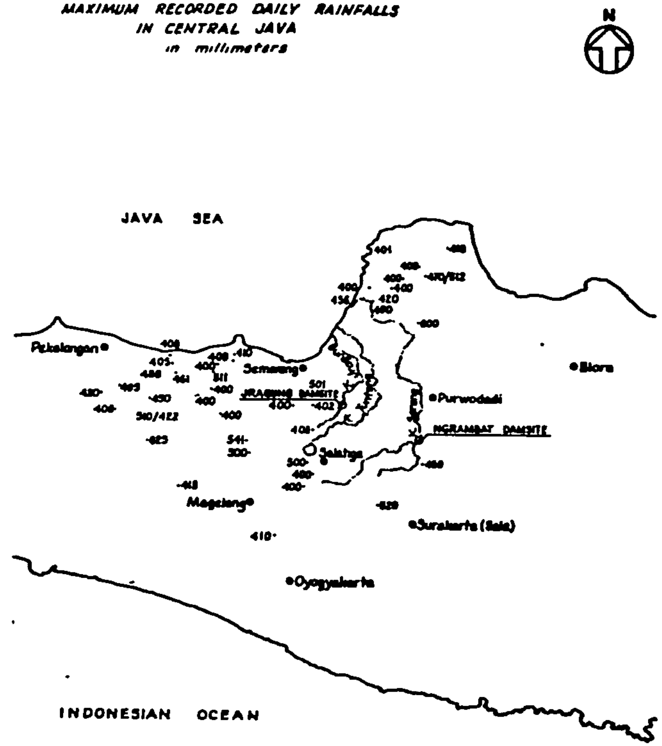


FIGURE 2
WORLD'S GREATEST RAINFALLS

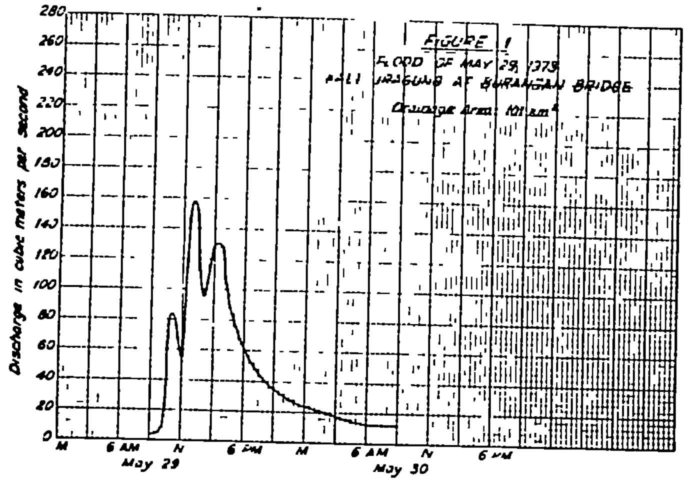
FIGURE 3
MAXIMUM RECORDED DAILY RAINFALLS
IN CENTRAL JAVA
in millimeters

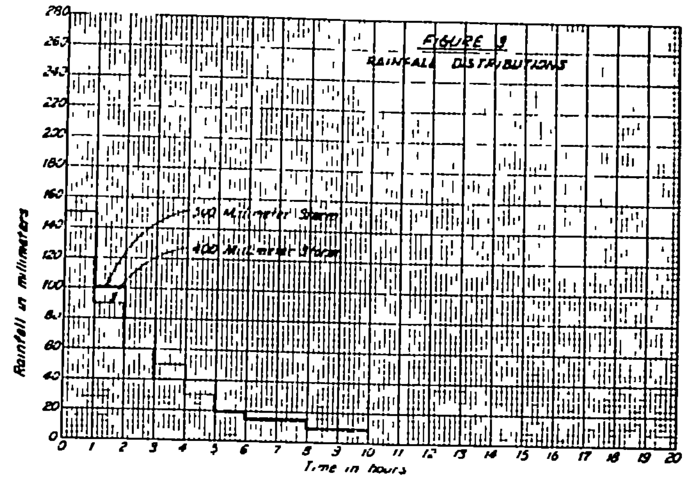


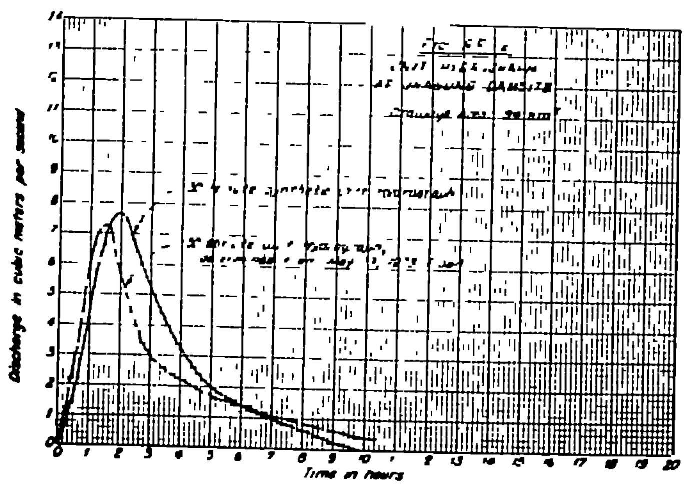
Source: Directorate of Planning and Programming, Directorate General of Water Resources Development, Ministry of Public Works and Electric Power, Maximum Recorded Daily Rainfall in Indonesia, 1879-1970, August, 1973.

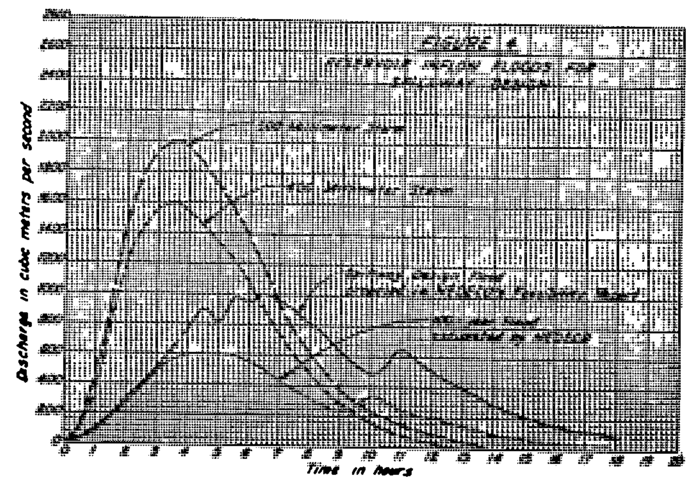
[1] NEDECO, The Netherlands, Jragung Dam, Flood and Irrigation Project, Feasibility Study, August 1973

HYDROLOGIC COMPARISONS
JRAGUNG BASIN









FLOOD HYDROLOGY
JRAGUNG RESERVOIR

CHAPTER III

GEOLOGY

CHAPTER III

GEOLOGY

NEDECO's Site

General

The site selected by NEDECO for the Jragung Dam is in a gorge cut by the river through a narrow ridge. The valley floor is about 40 meters wide at approximately elevation 65 meters. The walls rise rather steeply to approximately elevation 100 meters. Then the slopes flatten so that the 120-meter contour, which is the approximate maximum reservoir elevation, is about 200 meters from the river on the left abutment, and 600 meters away on the right abutment. On the right abutment the crest does not climb significantly above this elevation for at least another kilometer. The left wall of the gorge rises steadily to about elevation 150 meters, then it drops again about a kilometer from the river to a saddle at about elevation 100 meters before climbing and staying above the general reservoir elevation.

The generalized geology for this site is shown on Plate III-1.

Site Geology

The site selected by NEDECO is formed by a sequence of mudstone and sandstone beds which cross the river with a strike almost at right angles to the direction of flow and with almost a vertical dip. The mudstones are predominant; the sandstones generally are a meter or less in thickness, but several are from 5 to 8 meters thick.

Because of its resistant sandstone beds, the sequence as a whole forms a sharp ridge that can be traced long distances across country. The fact that the sequence as a whole is so consistent raises some doubt about the rapid internal facies changes which have been shown in NEDECO's Feasibility Report[1/].

1/ NEDECO, The Netherlands, Jragung Dam, Flood and Irrigation Project, Feasibility Study, August 1973.

Much of the mudstone is compacted and without significant cementation even where it contains enough lime to be called a marl. Much of it contains a high percentage of clay and slakes on exposure. The sandstones are fine to medium grained, dense, hard and generally well cemented with calcite.

Jointing is well developed and closely spaced. The dominant members of the joint system are either vertical -- parallel or perpendicular to the bedding -- or horizontal. The jointing is closer spaced, 10 centimeters or so, in the mudstone but also passes on somewhat larger spacing through the sandstones.

The folding, flexing and distortion which has set the beds on end has also caused considerable sliding along bedding planes and joints. This movement caused a crushing and grinding which, especially in the mudstones, formed thin zones of soft, very weak material.

The most striking feature of the groundwater in the abutments is the spring in the right abutment. Although general springs occur around the base of the ridge as would be normal for such a steep sided ridge, this spring occurs about half way up the abutment. Obviously perched, the spring flow must be a result of progressive erosion by groundwater of a channel along an originally somewhat easier flow path. It is as yet uncertain whether the channeled flow is along the oblique fault crossing somewhere in the vicinity, or along a bedding plane, or along some as yet unknown feature.

The artesian flows[1/] from the borings in the valley probably reflect normal unconfined flow from the abutments into the river, but whether such flow is general throughout the sequence or only in selected beds and zones is unknown at the moment.

Water pressure tests in the borings[2/] show that much of the mass is essentially impervious during the relatively short

1/ These flows were observed in the field by NEDECO personnel, although they are not mentioned in the NEDECO Feasibility Report. We also observed these flows.

2/ See page III-4, Appendix III, Ibid.

period of a test, but that many of the zones are open both in the mudstone and in the sandstone.

Except for these general points, the structural competence and water retention characteristics of the site are yet to be determined.

Significant Regional Characteristics

Since the details of the site geology have yet to be completely determined, the regional geology is important as the basis for interpreting the few facts known. The general picture of the regional geology as shown in Figure III-17 of NEDECO's Feasibility Report may well be true, but it seems to conflict at a number of points with the aerial photography of the area and to leave several important questions unanswered.

A strong distortion in the vicinity of the site is suggested by several regional features, i.e., a lineation along that stretch of the river, and a sharp change in the strike of the ridge from northwest on the left of the river to north on the right of the river. The fact that borings cannot be correlated within the site area could result from a distortion of beds.

The fact of distortion is only significant to the project as an indicatrix that well developed, possibly highly weathered stressed zones may cross the dam axis or reservoir rim. A fault has been mapped as obliquely crossing the left abutment; the aerial photography suggests another may parallel the mapped one, and a fault may cross the rim to the left of the dam. More significant, although apparently no notable offset occurs across the river at the site, the same lineation observed along this stretch of the river seems to mark a significant structural event upstream, possibly a drag fold of considerable magnitude, and a flexure downstream.

All this could be answered by a combination of coincidence, facies change, and flexure rather than faulting; however, the data necessary for discrimination are not yet available.

Unconsolidated Deposits

In the present flood plain, on river terraces, and at the general 150-meter elevation, masses of unconsolidated sand, silt, and clay occur; they occur in part as alluvium, in part as residuum of weathering, in part as volcanic ash. Virtually all this material has some percentage, usually a rather large percentage, of montmorillonite or dickite clays which change volume significantly with changes in water content. Some sandy deposits on the present flood plains and low terraces have a relatively minor percentage of such clays, but their size and distribution is yet unknown. Tertiary gravel deposits have been found on the 150-meter level, but neither their unit characteristics nor their distribution is yet known in detail.

Seismic Activity

The general area is active seismically, occurring as it does at the margins of several interacting crustal plates of continental dimensions. The Intensity data referred to by NEDECO's Feasibility Report suggests relatively minor local effects from shocks deep below the Java Sea to the north. Information on Magnitudes and locations of hypocenters are undoubtedly available also. This data should be collected as discussed in the next section on Engineering Geology.

Alternative Sites

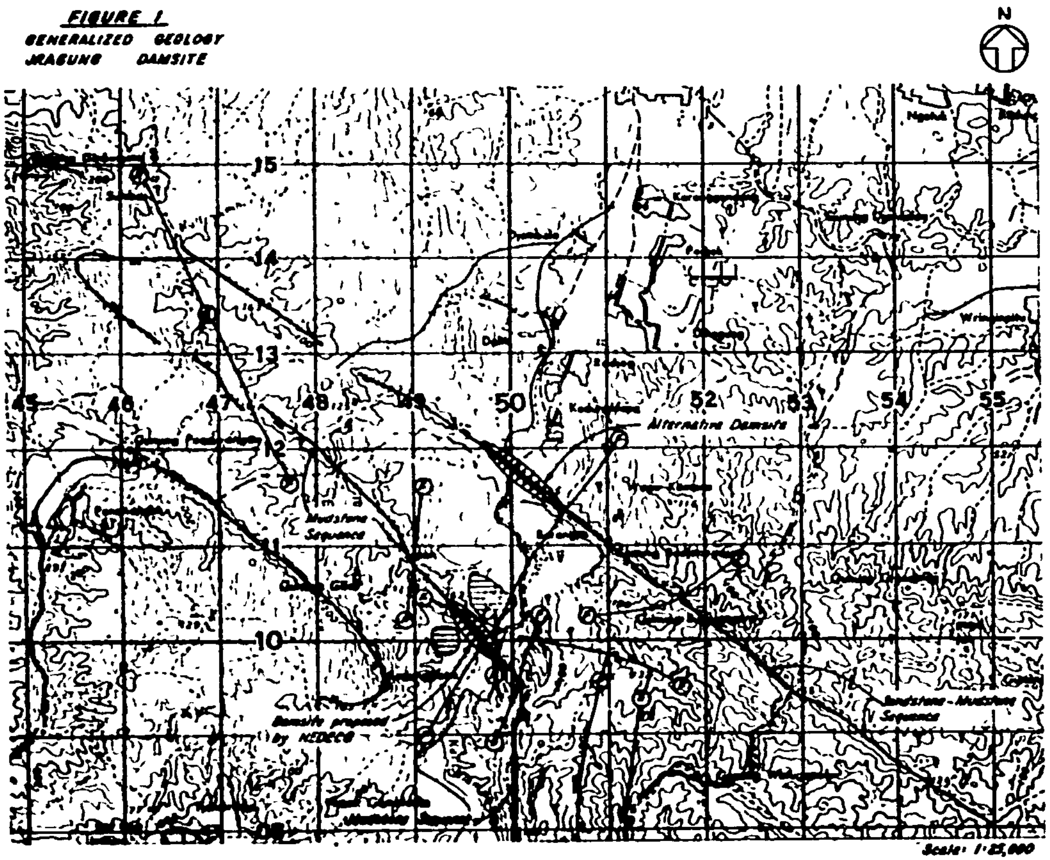
A preliminary investigation was made using the 1:50,000 topographic maps and the aerial photographs to determine if there are any alternative damsites on the Kali Jragung. No topographically feasible site exists between the NEDECO site and the intersection upstream of the major tributaries that form the Kali Jragung. An alternative site does exist, however, about two kilometers downstream from NEDECO's site. At this site the right abutment rises steeply from about elevation 40 meters to about 125 meters, and remains about there for a kilometer or so before climbing gradually to about elevation 150 meters. The left abutment rises to about elevation 60 meters where it continues for about a kilometer until it climbs to about elevation 150 meters where it remains for another kilometer with some low points before climbing higher. The valley floor is broad and flat between this alternative site and the site selected by NEDECO. Two tributaries also join the Kali Jragung between the two sites, and it appears the drainage area is increased by about 15 percent at this downstream alternative site.

The generalized geology for this site is shown on Plate III-1.

This site has the same sequence of beds as the NEDECO one with approximately the same attitude. The regional geology map developed by NEDECO shows a small offset across a fault under the river and a high angle thrust fault running parallel to the bedding. From our regional geological studies, there appears to be no evidence for the latter. The topographic, geomorphological evidence suggests that much less distortion has occurred at and around this site than at the site selected by NEDECO. This is suggested by no apparent lineations and no change in the strike of the ridge.

FIGURE 1

GENERALIZED GEOLOGY
JRAGUNG DAMSITE



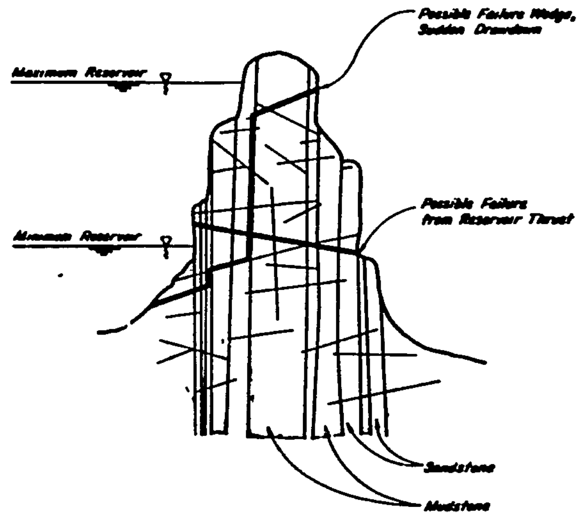
LEGEND

Jragung damsite & Downstream alternative
Slump area
Fault

Bedding Altitudes
±90° (vertical)
±60°
±45°
±30°
±0° (horizontal)

FIGURE 2

GENERALIZED SECTION OF ABUTMENTS
JRAGUNG DAMSITE



GEOLOGY
JRAGUNG DAM

CHAPTER IV

ENGINEERING GEOLOGY AND CONSTRUCTION MATERIALS

CHAPTER IV

ENGINEERING GEOLOGY AND CONSTRUCTION MATERIALS

Introduction

Although a safe dam can undoubtedly be designed and constructed at the site selected by NEDECO, foundation problems will be numerous and difficult. In fact, the foundation may significantly affect the design and cost of the dam as well as require extensive remedial treatment itself. As discussed in this chapter in a later section, considerable additional foundation information is required before the costs involved in establishing a stable, watertight barrier can be properly evaluated. Furthermore, questions regarding the quantity and quality of construction materials for the dam embankment are still unresolved. Acceptable materials that can be used for the construction of the dam are undoubtedly available, but neither the appropriate dam section nor its cost can be determined until the quality, quantity and location of each material is determined.

Foundation Seepage

Two distinctly different aspects of leakage are involved at the damsite selected by NEDECO; one concerns laminar flow through the generally fractured and jointed mass, and the other concerns turbulent channeled flow, possibly with foundation erosion, through disturbed zones.

The most critical aspect is that of the channeled flow because if unchecked this can endanger the structure as well as cause total drainage of the reservoir. The spring on the right abutment demonstrates that channeled flow does occur in the foundation, even under low and natural groundwater gradients. If the channeling of the spring flow is along bedding surfaces parallel to the axis, its direct importance is secondary and relates only to the distribution to cross zones or fractures of reservoir water at full head. If the spring receives its flow from a zone crossing the bedding and the dam axis, it is of major importance; this zone and any others that may exist must be identified and studied sufficiently so that suitable treatment can be allowed for.

Laminar flow through the generally fractured rock may not be present in the abutment as a whole, but may be restricted primarily to the sandstone layers. With this condition the leakage through the mudstones would be confined to closely jointed or shattered zones spaced rather widely apart. Successful grouting of these mudstone zones might require washing to remove soft plastic material before injection of grout. This additional work might well be more than compensated for, because even after washing, the grout takes may still be much less than in the fractured sandstones.

These leakage problems are not restricted to the immediate dam area, but also may exist at a number of low points along the reservoir rim where faults or shear zones cross. Therefore, similar special treatment may be required in those areas.

The same general leakage problems are present at the downstream alternative previously mentioned. It is quite possible, however, that fewer channeled zones exist at this site because there is less distortion suggested from the topographical and geomorphological evidence.

Foundation Stability

The abutments are crisscrossed by surfaces along which relative movement has occurred and formed thin seams of soft weak clays. Some of these are essentially vertical, others are essentially horizontal. It seems not only possible but quite likely that some of the rock masses bounded by these seams will be unstable under reservoir operation conditions, especially since the condition of a drained reservoir after sudden drawdown will prevail for long periods of time. In fact, the simple question of stability against downstream movement of the abutment resting on such a horizontal seam requires study, since the abutment is rather thin; locally there may be additional mass needed. A typical abutment section of the geology is shown on Figure 2 of Plate III-1.

The same general problems apply to the downstream alternative, but it seems possible that fewer failure surfaces exist there, and the abutments are a bit more massive.

Construction Materials

Core

Although there is an unlimited amount of impervious material available about 10 kilometers from the damsite, most of it contains a high percentage of severely swelling clays. Extensive study of the rheology of these clays will be necessary to establish their useability. However, in an impervious material which contains a relatively small percentage of these swelling clays, the difficult characteristics of swelling and cracking could probably be avoided. This is because the volume change of the entire mass will be proportionally small. Such a material might be processed as the fine fraction of a dirty gravel similar to the material found at Nglanji[1/] near the Ngrambat Damsite. Some of the recent alluvium is probably suitable in quality for the core. This material ranges in size from gravels to very fine sand. However, it may require hand excavation and stockpiling because it may occur only in a number of small lenses. It is possible though, that by stockpiling early, a number of different materials could be used and satisfactorily mixed by properly layering the stockpile.

Pervious Fill

No source has been proven out for this material. The gravels from the borrow area mentioned in NEDECO's Feasibility Report[2/] have not been explored by testpit, and neither their

---

1/ Dirty gravels were found near Nglanji when investigations were being made for materials for Ngrambat Dam.

2/ NEDECO, The Netherlands, Jragung Dam, Flood and Irrigation Project, Feasibility Study, August 1973.

quality nor quantity is completely known. If, as believed by NEDECO, these gravels are the same as those at Nglanji, they are quite impervious and will require processing by removal of fines to produce pervious fill. The alternate material proposed by NEDECO is quarried sandstone at the alternate damsite mentioned herein. It appears that a sufficient quantity of material could be quarried from the sandstone beds of the mudstone sequence. However, the cost of quarrying a sufficient quantity of material of proper quality has not been determined.

Random Fill

Gravelly material of relatively high strength but possibly low permeability can be obtained from Nglanji type gravels. No processing will be required, but the quantity available is unknown. Most of the excavation required at the damsite will probably be of little use except in uncompacted weight-type berms.

Filter

Filter material will have to be processed, possibly by hand from recent alluvium. Washing selected portions of Nglanji gravels might provide an adequate material, as might crushing some of the better sandstones. However, the quality and quantity of these sources for this material has yet to be determined.

Riprap

Selected material from sandstone quarry operations might provide enough riprap for the dam. Blasting tests in selected areas will be required to determine if this source of material is adequate.

Aggregates

Hand processing of recent alluviums might provide adequate materials for aggregate, as might crushing of some of the better sandstones, but neither source has been proven out as to quantity, quality or cost.

materials testing:

blasting tests

crushing tests

other lab tests
corrosion
etc

grouting tests

Seismic Effects

Though acceleration is a significant factor, the effects of earthquake are at least as dependent on duration and dominant wave length of the shock and its relation to the natural frequency of the structure concerned. Therefore, the use of Intensity Ratings derived from shock effects on wholly different types of structures is an inadequate basis for design. Seismographs from the different hypocenters should be studied to determine the proper design quakes to be used. One should be studied from each typical area of origin. This was not done for the Jragung site.

Additional Explorations Required

The NEDECO Feasibility Report mentions that additional explorations are required for both the foundation and for the construction materials. We believe that these investigations could be made during the first stage of design as inputs for the Definite Project Report.

The additional explorations required for the Definite Project Report are as follows:

1. A continuous strip of bedrock should be exposed on the upstream face of the ridge to locate any disturbed zones. This should be done for the full length of the dam axis and 100 meters beyond each end of the axis. The strips should be cleared and stripped, by machine or hand.

2. All cross structures found should be intercepted approximately along the axis by cored borings to determine the attitude of the zone and its basic characteristics. All borings should be water pressure tested and individually broken zones tested separately.

3. A pair of inclined borings should cross beneath the valley to determine the location and nature of any disturbed zones in that area. They also should be water pressure tested.

4. An adit is required into the right abutment to locate and study the mapped fault, to determine the control on the spring, to evaluate the condition of the horizontal jointed and fractured zones, and to determine the strength characteristics of the thin crushed zones along the bedding planes, joints and shears.

5. Crossed borings should be drilled below the valley at the alternate damsite to determine the foundation conditions there.

6. 1:5,000 topo should be prepared for the alternate damsite.

7. Cored borings should be drilled to prove out the quality and quantity of the pervious material available from the main sandstone member of the sequence crossing at the alternative downstream damsite. Although somewhat less than 2,000,000 cubic meters bank measure will be needed, 3,000,000 cubic meters should be proven out. The drilling pattern should consist of pairs of holes perpendicular to the bedding and on 250-meter spacing along the ridge, one near the crest of the upstream sandstone dip slope, and one at the base of the sandstone slope. Borings should go a meter or so into the first major mudstone bed, and probably should be on the order of 10 meters long.

8. There should be blasting tests on this sandstone to determine type of material available at what cost.

9. There should be crushing tests on the sandstone to determine its characteristics for aggregate, sand, and filter.

10. Test pits are required to determine the quality and quantity of non-swelling core material available. Several exploratory test pits should be sunk in a likely part of the terrace gravels to determine if their fine fraction is suitable for core. If so, enough testpits

should be placed on a 100-meter grid to prove out about 400,000 cubic meters of such fine fraction. If the material proves unsatisfactory for core, testpits should be sunk in the recent alluvium progressing both up and downstream to prove out a similar amount of material suitable for hand processing a satisfactory core material.

CHAPTER V

DESIGN AND CONSTRUCTION

CHAPTER V

DESIGN AND CONSTRUCTION

Introduction

The preliminary designs prepared for a feasibility report should represent a technically feasible design which will serve as a sound basis for cost estimates. The preliminary designs presented in NEDECO's Feasibility Report for Jragung Dam and Appurtenances, however, are closer to a reconnaissance level of design than a feasibility level. The general arrangement for the dam and appurtenances proposed in NEDECO's Report are shown on Plate V-1. Additional field explorations and design studies are required to establish with confidence the technical feasibility of any particular design, as well as the absolute maximum cost for the dam.

Possibly the biggest questions remaining relate to the materials available for the construction of the dam. However, there is some doubt that the dam section proposed in NEDECO's Feasibility Report is the most desirable design. That dam section proposed has a central core with a cutoff grout curtain. In light of the critical foundation conditions, a sloping core with an upstream blanket might be more appropriate.

The spillway design proposed in NEDECO's Report also appears to have some deficiencies. As discussed in Chapter II, Hydrology, it is quite possible that additional studies may indicate that the spillway capacity should be increased. In addition, the spillway location selected in NEDECO's first feasibility report[1/] might have more merit than the presently proposed location. The spillway proposed in the first report was located in the saddle which is approximately 2 kilometers west of the damsite.

1/ NEDECO, Semarang, Feasibility Study Water Resources Development, Djragung, Dolok, and Penggaron Basins, December, 1971.

The type of diversion proposed by NEDECO also deserves some discussion. A diversion tunnel located in the left abutment is proposed in NEDECO's Report. A cut and cover conduit might be more practical in light of the possible problems of tunnelling in the sandstone and mudstone beds.

Dam Section

The dam section proposed in NEDECO's Feasibility Report consists of a central core earthfill or rockfill dam. A grout curtain under the central core is proposed as a foundation cutoff. The impervious material proposed for the core will contain a high percentage of the swelling clays, which have been previously discussed. The pervious materials proposed for downstream and upstream shells of the dam are unconsolidated gravels or quarried sandstone.

We believe consideration should be given to a sloping core dam with an upstream blanket. This opinion is based on the following factors:

1. It permits the use of relatively impervious fill for most of the section, requiring free draining fill only for the filters and for the thin upstream shell. Then if gravels similar to those found at Nglanji are found in sufficient quantity, the downstream shells of the dam could be borrow run material while the core and the upstream shell could be processed from the fine and coarse portions respectively of the gravel.

2. It permits the downstream shell to be placed considerably ahead of the core, thus freeing the construction somewhat from the control and hazards of wet weather.

3. It fits better with a blanket, which may prove to be the best method of leakage control if many zones of channeled flow occur.

A section for the sloping core dam with an upstream blanket is shown on Figure 2 of Plate V-1.

Use of Materials

As mentioned in the previous chapter, there are some major outstanding questions regarding the quantity and quality of construction materials. This is especially true for the materials required for the shell of the dam which is the largest volume of material required. If the unconsolidated gravels are proven to be adequate they will probably provide a cost savings over the quarried sandstone. However, much less exploration is required to prove the adequacy of the quarried sandstone, and this exploration is required anyway to establish a source of material for the filters, aggregate and riprap.

The impervious material available that consists of the swelling clays can be used for the core which is below minimum reservoir level. Below that level the swelling clays can be used since they will not be exposed to changes of water content, and they will be confined. Above the minimum pool some material with a low percentage of such clays is required. A silty fine sand, such as is found in the recent valley alluviums will be adequate, as will a dirty gravel. Possibly both of these materials will require processing. As previously mentioned, the quantity and quality of that type of material must be proven by additional investigations.

Stability Analysis

The stability analysis presented in NEDECO's Feasibility Report consists of several slip circle analyses for the dam section. This certainly provides some kind of a picture of the stability of the dam section itself apart from the foundation. We believe, however, that there are other factors which should be considered to complete the stability analysis for the conditions that exist at the proposed damsite.

The thin abutments and the presence of horizontal seams of weak gouge dictate that an analysis be made for horizontal sliding of the ridge for the condition of full reservoir head.1/

1/ See Figure 2, Plate III-1.

This condition should also include the effects of an earthquake in both the reservoir and the rock.

The condition of the foundation is such that the stability analysis of the dam must include the specific geometry of the foundation rather than considering that failure will occur along some idealized slip circle. If both the near horizontal jointed zones and the vertical bedding surfaces have a significant film of very weak gouged clays, the wedge situation may well be more critical than the circle.

A similar analysis must be made for the ridge slopes in the vicinity of the dam because their failure might endanger the dam as well as possibly breaching the rim. In addition, similar analyses should be run at the many low saddles in the rim where failure might breach the rim. Although it seems rather unlikely from the topography, the question of a slide generated water-wave topping the dam is not unreasonable and should be analyzed.

Concerning the seismic effects, the pseudostatic method of analysis used by NEDECO, in which a force due to seismic acceleration is assumed as a static force in the stability analysis, has the questionable dignity of usage and should be run primarily as an extra check. However, if the analysis of past earthquakes, as discussed in the previous chapter, shows the possibility of any significant quake, a dynamic analysis should also be made.

Foundation Treatment

The prevention of channeled flow through the cross zones is the biggest problem in the control of under leakage at the Jragung sites. If a grout curtain is used, each of the cross zones must be found, investigated, and a cutoff design made, because commonly such zones cannot be grouted effectively. Therefore, with the design proposed in NEDECO's Report, they will have to be excavated and backfilled with concrete. Additional explorations are required to insure that no zones are missed. Some of the horizontal zones may be as bad as some of the vertical fault zones.

Relatively little exploration will be required to determine the feasibility of a reservoir blanket of conservative length which would treat the whole area as one. Furthermore, if many cross zones of channeled flow occur, the blanket may well be the most economical and effective means of controlling leakage. Such a blanket could be used with a central core dam, but an inclined core would be preferable if a reasonably strong core material is found.

Spillway

The spillway design presented in NEDECO's Feasibility Report consists of an ogee-crested side channel with a concrete lined chute. The total crest length proposed is 75 meters with 25 meters being an emergency spillway that will normally contain a fuse plug. It is proposed that the emergency spillway not operate unless a flood greater than the 100-year flood occurs.

The chute proposed in NEDECO's Report will be concrete lined, 15 meters wide and 5 meters deep. A stilling basin for dissipation of the energy is proposed at the termination of the chute.

The spillway capacity is not stated in NEDECO's Report. However, they do state that the surcharge for the spillway design flood was calculated to be 2.75 meters[1/]. Using the flood routing diagrams[2/] presented in the hydrology appendix of their report gives a spillway discharge of almost 700 cubic meters per second.

The general layout of the spillway proposed by NEDECO is shown on Plate V-1.

As stated in NEDECO's Report, the spillway design proposed is based only on preliminary calculations. Some preliminary cost estimates were made, and on the basis of minimum cost the spillway location was moved from the saddle proposed in NEDECO's first Report to the location shown on Plate V-1.

1/ See page IV-5, NEDECO, The Netherlands, Jragung Dam, Flood and Irrigation Project, Feasibility Study, August 1973.

2/ See Figure I-40, Ibid.

As mentioned in Chapter II, the consequence of failure for Jragung Dam will be sufficiently severe, probably resulting in the loss of life. This is because there are thousands of people who live and maintain their livelihood in the valley immediately downstream from the dam. Therefore, it is suggested that no risk should be accepted, and that the spillway should be designed for the maximum probable flood.

As also discussed in Chapter II, it appears that there are valid reasons for the maximum probable flood being considerably greater than the spillway design flood adopted in NEDECO's Report. In terms of overall safety, this may affect the spillway location; for example, if the spillway capacity is doubled the saddle location, which is more than a kilometer from the dam, might prove to be more favorable from a safety standpoint.

Furthermore, based on conversations with NEDECO personnel in the Netherlands, it was concluded that very little is known about geological or soil conditions at each location. No subsurface explorations have been made at either location. Without this information it is difficult to accurately compare the costs of excavation and concrete lining required.

Therefore, during the Definite Project Report stage, discussed in the Project Schedule Section of this chapter, additional investigations and studies are required to complete the preliminary design of the spillway.

Diversion during Construction and Outlet Works

In NEDECO's Report a 3-meter diameter diversion conduit is proposed. This conduit was assumed to be partly in open cut and partly tunneled. It is proposed that the upstream berm will be constructed first as a cofferdam and then incorporated into the dam.

An outlet conduit with a diameter of 1.4 meters is proposed for the downstream part of the diversion conduit. The control works for the outlet conduit will be located near the end of the conduit which will discharge into the spillway stilling basin.

Possibly some consideration should be given to a cut and cover conduit for the entire length of the diversion conduit. This is only mentioned because of the possible difficulties in supporting the tunnel through the sandstone and mudstone beds.

Labor Intensive Methods

NEDECO's Feasibility Report suggests that possibly unskilled labor can be used for stripping the dam foundation and for excavating the borrow pits. We agree that this is a possible method of construction which will probably yield economic benefits for the Semarang Area.

During our stay in Indonesia we visited the construction site of Lalung Dam. This facility is near Sala and has been under construction for several years. This embankment has been almost completely constructed by hand. Equipment is only used to haul the material for the borrow areas to the embankment. The laborers in the borrow areas can excavate from 1.0 to 1.5 cubic meters of material per day. The wages are about 150 Rupiahs per day for the laborers to about 200 Rupiahs per day for the foremen.

At Lalung Dam it appears that the average crew size for excavation of the borrow areas is about 10. Therefore, each crew can excavate between 10 and 15 cubic meters per day.

NEDECO's Report estimates that approximately 2,600,000 cubic meters of material are required for the random fill portion of Jragung Dam. Assuming a production rate of 1.0 cubic meters per day and virtually zero shrinkage results in 2,600,000 man days for excavating the material from the borrow area. Further assuming a construction period of 4 years with 250 working days per year results in a total number of laborers of 2,600. This is approximately 260 crews for just excavating this material alone, not including dam foundation stripping or other construction activities.

The 260 excavation crews calculated above are compared to the 4 or 5 crews that were observed at Lalung. To our knowledge the number of workers and crews at the jobsite is greater than has ever been attempted before for dam construction in Indonesia, which suggests that there could be management and administrative difficulties beyond what has originally been encountered. These difficulties should be explored so that construction is not delayed by labor problems during a critical period such as the time closure is being made.

In any event, the type of organization formed and management methods used for the labor intensive methods should be in accordance with acceptable practices. It also should allow for any unique cultural or political aspects of the area. The system to be used should be carefully considered and thought through by the Indonesians to insure a successful operation. This is especially important because of the magnitude of the project in terms of number of laborers.

In addition to the construction activities that might use great numbers of unskilled labor as suggested in NEDECO's Report, we believe there are other activities that will be appropriate for labor intensive methods. Some of these additional activities could even affect the design of the dam section. This pertains primarily to the material to be used for the impervious core of the dam.

The need for finding material with low clay percentage for the upper portions of the core and blanket furnishes an opportunity to use hand labor with significant benefit to the design. From reconnaissance along the river valley, it seems quite certain that enough granular material, low in swelling clays, is available for the core, but it probably is in lenses and masses too small to develop by machine. It is possible, if further field investigations so indicate, that these lenses could be developed by hand labor, starting before construction and

and stockpiling for later machine placement and compaction. It is also possible that instead of processing the recent alluvium, hand labor could be used to process Nglanji type gravels into impervious fine gravel for the core and pervious coarse gravel for the upstream shell.

In conclusion, it is quite possible that hand labor could be used more intensively than that proposed in NEDECO's Report if the management and administrative details are satisfactorily thought through.

Project Schedule

As previously mentioned in this report some additional investigations and studies are required before the absolute maximum cost of Jragung Dam will be known. The additional investigations will include foundation exploration and materials investigations. Furthermore, it was concluded that additional flood hydrology studies are required to determine the probable maximum flood for the design of the spillway. All of these additional investigations and studies should then be drawn together to determine the effect on the preliminary design and cost of the dam.

In light of the foregoing we believe the project schedule for the design and construction of Jragung Dam should be accomplished in three stages: Stage I being the additional investigations and studies required to produce a Definite Project Report; Stage II being Final Design; and Stage III being construction. The project schedule recommended for the design and construction of Jragung Dam is presented on Plate V-2. No detailed breakdown is shown for Stage III construction because of the uncertainties in design. This breakdown should be detailed, however, in the Definite Project Report.

The activities scheduled for Stage I and Stage II are based on a starting date for the engineering of January 1, 1975. For example, under Stage I it is assumed that the foundation explorations can be accomplished during the months of January, February and March. January is in the middle of the wet season while March is near the end. Foundation drillings are not appreciably affected by the wet season as they have been accomplished for adjacent damsite investigations during this period.

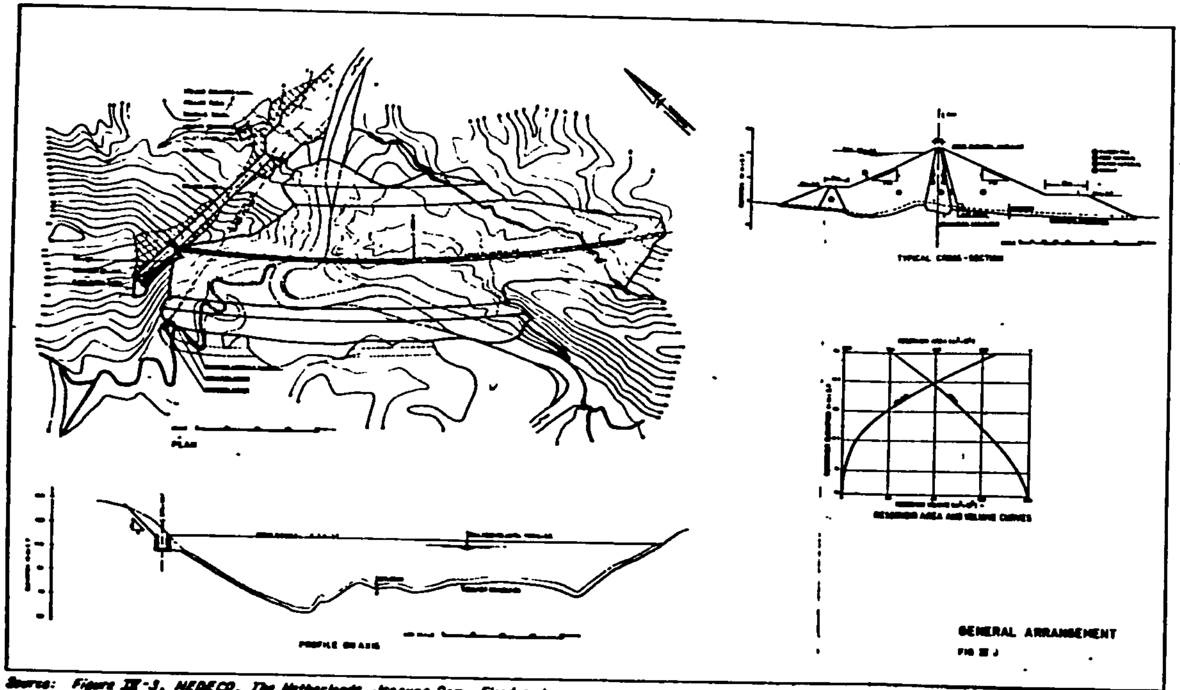
However, some difficulty might be encountered, due to wet conditions, in the field investigations required for the borrow area. Therefore, these investigations are scheduled for March and April, which is near the end of the wet season.

The preliminary design studies for the Definite Project Report will commence when sufficient information from the foundation explorations and the materials investigations are available. These preliminary designs will be the basis for the cost estimates that will be presented in the Definite Project Report.

It is expected that Stage I and the preparation of the Definite Project Report will require about 6 months. Subsequent to the completion of a draft report, there might be as much as 4 or 5 months required for review and finalization. This review and finalization of the Definite Project Report, however, should not delay the final design if the recommendations made in the report are favorable.

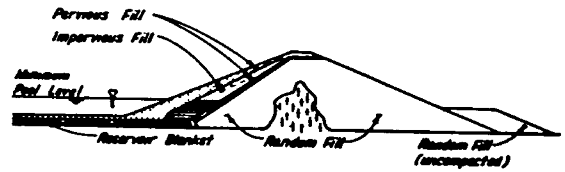
Assuming the Definite Project Report is favorable, the final design work could begin as early as June, 1975. The final design activities shown on Plate V-2 were scheduled on that basis.

FIGURE 1
PRELIMINARY DESIGN OF JRAGUNG DAM
PREPARED BY NEDECO



Source: Figure IX-3, NEDECO, The Netherlands, Jragung Dam, Flood and Irrigation Project, Feasibility Study, August 1973

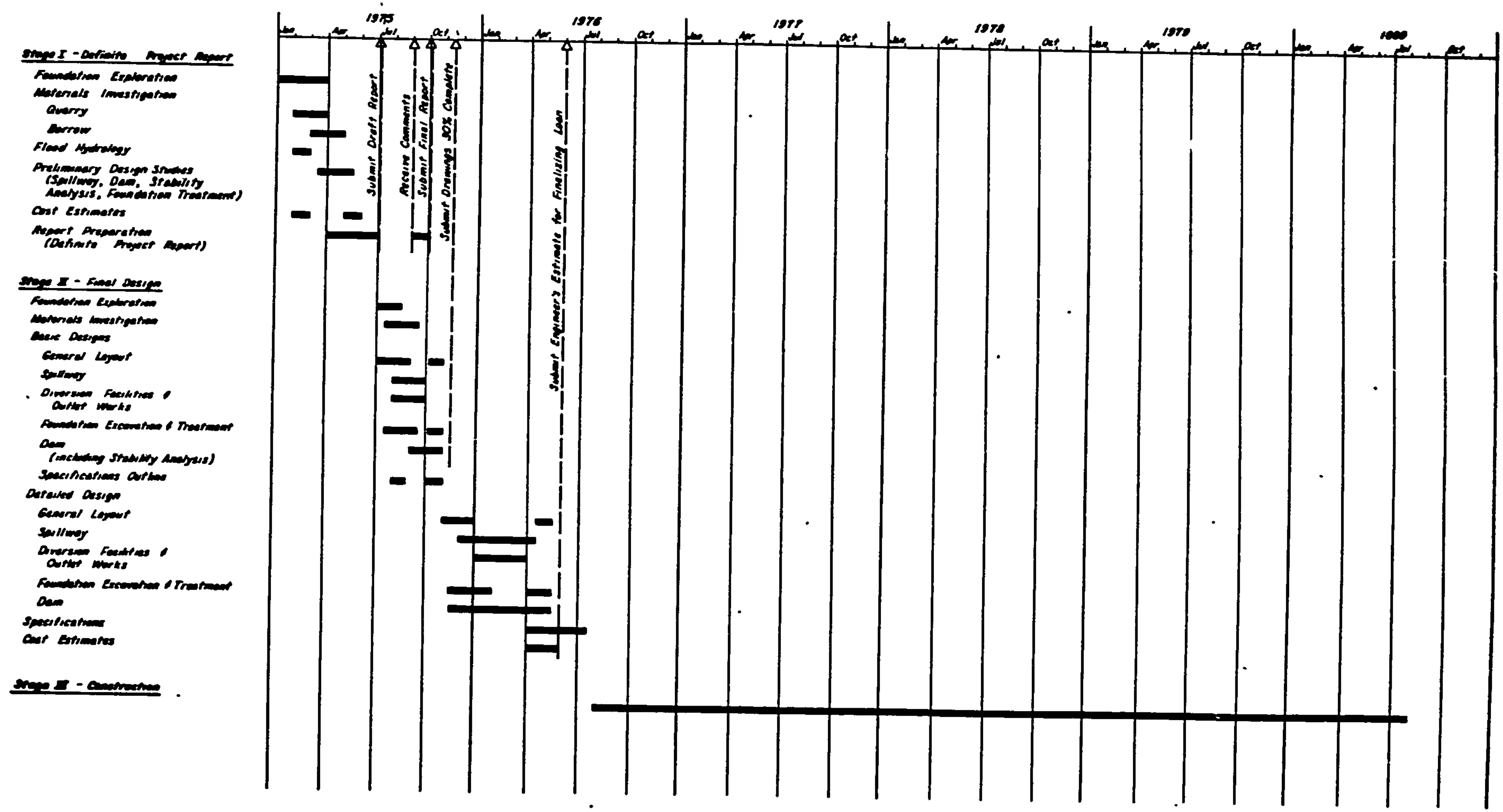
FIGURE 2
MODIFIED DAM SECTION



NOTE:

The swelling clays may be used for Impervious Fill below the Minimum Pool Level and for the Reservoir Blanket. Above the Minimum Pool Level the Impervious Fill should be non-swelling material.

PRELIMINARY DESIGN
JRAGUNG DAM



PROJECT SCHEDULE
JRAGUNG DAM

CHAPTER VI

CONSTRUCTION COSTS

CHAPTER VI

CONSTRUCTION COSTS

A complete review of the construction costs estimated by NEDECO for Jragung Dam is considered to be outside the scope of this technical evaluation. However, in reviewing NEDECO's Report some issues were apparent with regard to the cost estimates which we believe should be mentioned.

The unit prices used by NEDECO were based on unit prices for similar types of construction recently experienced in Indonesia[1/]. The main sources of information were the Ministry of Public Works and the State Electricity Corporation PLN.

Unit prices from other recently completed projects or projects that are presently under construction do provide a basis for checking estimated construction costs. They are also useful in estimating the order of magnitude of cost of a project, which is usually done for reconnaissance level studies.

However, when a feasibility report is being prepared for a high dam in a remote area or developing country, the usual practice is to estimate the cost from a contractor's viewpoint. This is especially important in the case of the construction of a dam because each damsite is unique. The type of materials required for the construction of a large earthfill dam, the distance of the borrow areas from the damsite, and the type of foundation material to be excavated are all factors which are unique to each site. Therefore, for a feasibility level cost estimate the usual practice is to derive the unit prices on the basis of the labor, equipment and materials required with an allowance for the contractor's profit.

The construction cost of Jragung Dam was estimated by NEDECO for two different methods of construction, a capital intensive method and labor intensive method. In the capital intensive method equipment will be used as much as possible for all

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1/ See page IV-7, Ibid.

excavations and the handling of material. In the labor intensive method unskilled labor will be used to the maximum in the excavation and handling of materials.

Since considerably more labor will be required to construct the dam utilizing labor intensive methods, it appears reasonable to expect that the local currency component will be substantially greater for that method when compared to the capital intensive method. However, the estimated construction costs prepared by NEDECO[1] indicated no difference in the local currency component for the two methods.

In reverse, since there will be less equipment needed for the labor intensive method, the foreign currency component for that method should be less than the capital intensive method. This difference, however, should not be substantial because it will primarily only involve the equipment required to load the borrow material and strip the foundation area. The same equipment will be required for hauling, placing and compacting which are the major portions of the equipment. For the foreign currency component, however, NEDECO shows a decrease of more than $4.5 million. This is a reduction in the foreign currency component of more than 50 percent.

These cost anomalies were discussed with the NEDECO personnel in the Netherlands and no satisfactory conclusion was reached. It is suspected that the reasons for the apparent discrepancies are partly due to the use of unit prices from other jobs and the arbitrary division of the foreign currency and local currency components adopted for the unit prices[2].

1/ See tables on pages IV-13 and IV-14, Ibid.

2/ See page IV-16, Ibid.

PART 2

NGRAMBAT DAM

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Introduction

The Ngrambat Damsite is on the Kali Serang about 60 kilometers from the City of Semarang. The site selected by NEDECO is less than a kilometer downstream from the confluence of the Kali Serang and the Kali Uter, and it is near the village of Dumbang.

The purpose of this report is to provide a technical evaluation of the preliminary design studies that have been completed to date by NEDECO for Ngrambat Dam. The studies for the feasibility report are presently under way, with a scheduled completion date of November, 1974.

A reconnaissance level design was presented in an earlier report[1/] prepared by NEDECO in July, 1973. That report also presented a reconnaissance level design for another dam on the Kali Serang called Nglanji Dam. The site proposed for Nglanji Dam was about 10 kilometers upstream of the Ngrambat Site; the Nglanji Damsite, however, has since been abandoned and all present and future studies by NEDECO concern the Ngrambat Site.

At the site selected by NEDECO for Ngrambat Dam the field explorations are virtually complete. Forty borings were made at selected locations in the vicinity of the damsite. We inspected the cores and part of our comments presented herein are based on those findings.

The topographic mapping at the site has been completed. NEDECO was in the process of preparing preliminary layouts for the dam and spillway while we were in Semarang. In addition, the stability analysis was just started for various dam sections. This work is being carried out in the Netherlands.

The site selected by NEDECO for Ngrambat Dam appears to have some serious problems related to the foundation; furthermore, these foundation conditions will undoubtedly have a significant

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1/ NEDECO, Semarang, Jratunseluna Basin Development Plan, Supporting Report V, Dams, July 1973.

effect on the design of the dam section. In light of these apparent design difficulties, we believe there is an alternative site about 1 kilometer downstream from the site selected by NEDECO that might have more merit. The advantages and disadvantages of both of these sites are discussed in this report.

Hydrology

The hydrology studies for Ngrambat Dam have not been completed by NEDECO. It does appear, however, that there are considerably more streamflow data available on the Kali Serang. For example, there is a streamflow gage on the Kali Serang at Sedadi which has been in operation since 1956. This gaging station is approximately 20 kilometers downstream from the damsite and has a drainage area of 868 square kilometers.

Geology

General

The site selected by NEDECO for the Ngrambat Dam has a valley width of about 100 meters and side slopes of 5 or 6 to 1 from a valley elevation of about 40 meters to a terrace elevation of about 100 or 125 meters. Much of the area around the site clearly shows the structure of the underlying rock; but several areas, including the damsite, show a hummocky, rather innocuous terrain with little consistent picture of the bedrock structure.

About 1 kilometer downstream the alternative site suggested herein has a right abutment which rises sharply for 10 meters or so before sloping off to crest height, and a rather long sloping left abutment. The topography of this downstream area accurately reflects the structure of the underlying rock.

The entire area, from the site selected by NEDECO to the alternative site, is underlain by a predominately mudstone sequence with some interbeds of sandstone. The mudstone is compact, without significant cementation, and contains a high percentage of clay and considerable calcite. The sandstones range from fine grained to breccia with fragments several centimeters on a side, mostly with calcite cement. Most of the sandstones are less than 1 meter thick, but several are as much as 5 meters. The mudstones slake on exposure.

The area is generally seismic, but the only information available to date is that furnished for the feasibility report for Jragung Dam. Allegedly most shocks originate from hypocenters deep below the Java Sea to the north. Local Intensities have been low to medium. More information is necessary, especially on magnitudes, hypocenters, durations and frequency spectrums to determine the seismic effects of the area.

The reconnaissance geology for the area is shown on Plate 1.

NEDECO Site

At the site selected by NEDECO the bedding is quite contorted on both abutments, and borings have demonstrated that a 50-meter wide zone of crushing and distortion underlies the valley section to a depth of 50 meters or more.

The geomorphological evidence seen in the field and on the aerial photographs indicates that gravity slumping has occurred over large areas of this mudstone terrain, including the abutments of the site selected by NEDECO. Some of this slumping has occurred in the normal landslide type of failure, but in other areas gravity induced viscoelastic creep has operated. Under the latter conditions some of the beds maintain continuity so that locally the sharply flexed and distorted mass has the appearance of having been deformed at depth by tectonic forces. The two origins can be differentiated generally since the gravity induced features are controlled by the topographic surface.

If this slumping has occurred in the abutment areas, as evidence suggests, a significant thickness of jumbled material overlies the undisturbed rock in both abutments, especially in the right abutment.

The origin of the 50-meter wide crushed zone which extends along and below the river is related to a major tectonic event, either a fault or a tight flexure; the depth to which it extends rules out the possibility that it is related to gravity slumping. The general regional map shows a major fault in the area, but local evidence is ambiguous.

Alternative Site

The downstream site previously mentioned is composed of the same mudstones and sandstone sequence as at the site selected by NEDECO. Here, however, the beds are not distorted in detail. The continuous exposure in the 10-meter scarp forming the right bank of the river at the bend shows the beds almost vertical and without any disturbance or distortion except for a minor fault downstream of the bend. This minor fault seems to be vertical and strikes across the river, crossing the left abutment 10 to 20 meters above the river level. Field reconnaissance and the geomorphological evidence seen on the aerial photos indicate that slumping has not occurred here, rather that the nearly vertical attitude of the beds continues far into both abutments and beyond.

In addition to the recent alluvium in the valley, field reconnaissance and the aerial photos suggest that deposits of granular unconsolidated material form fairly thick deposits on the lower, and possibly higher terraces. These deposits may well be analogous with those at Nglanji, which is 6 kilometers upstream, where exposures of the terrace gravels have clayey, silty sands filling the space between pebbles and cobbles. Lenses of silt, sand and clay mixtures occur within the general mass of the gravels found at Nglanji.

Engineering Geology and Construction Materials

NEDECO Site

Although a safe dam can probably be designed and constructed at this site, the relative costs will probably be very high, even if the only problems posed were those by the wide crushed zone in the valley section and by the slumped abutments.

The existing foundation conditions created by the crushed zone in the valley are so poor that very flat slopes will be required for the embankment. The flat slopes will be necessary to broaden around the toes of the slopes the transition zone between areas of high and low stress.

The crushed zone will also create significant leakage and piping problems. Grouting of such a mass will be very difficult, and the results will be uncertain. An ineffective grout curtain could result in structural damage to the foundation because this zone consists of material that is erodible and pipable.

If the abutments actually have slumped as previously mentioned, the whole affected mass will have to be excavated to establish a stable watertight foundation. Exploratory adits will be required at several points in each abutment to determine whether such slumping has occurred and, if so, what the limits of excavation should be.

Alternative Site.

At this site the geometry of the surface rock exposures seems to preclude the presence of any significant zone of crushing and distortion at the dam axis in the valley section. Bedding there and in both abutments is expected to be vertical and undistorted. A thin zone of crushing may cross the left abutment 10 or 20 meters above the existing river level; however, at this elevation the treatment of the zone will not present any significant problems. No significant slumping has occurred on either abutment.

The leakage control at this site should present fewer problems than those present at the site selected by NEDECO. Adequate leakage control could probably be provided with an upstream blanket, which would be conservative, but considerably easier to investigate and design than a grout curtain. In any event, it is very likely that the investigations required to design an effective feature for leakage control will not be as extensive as at the site selected by NEDECO.

Construction Materials

The same construction materials will be utilized at either site. These materials will consist of pervious shell, impervious core, random fill, filters, riprap and concrete aggregate.

Pervious Fill. The terrace gravels seen at the borrow area near the Nglanji damsite, 6 kilometers upstream, are not pervious. They could be processed, however, to furnish pervious gravels by removing some of the fine fraction. Similar gravels probably occur closer to the Ngrambat area. Neither the quantity, nor quality, nor location of suitable material has yet been completely proven.

Impervious Core. Although unlimited quantities of clays are available, they all contain a high percentage of swelling montmorillonites and dickites. These clays could be used for core below the minimum reservoir level where the continuing pressures are greater than the swelling pressures; above that level there could be serious problems created by cracking when the material drys or weakening in strength when immersed. Therefore, we believe the best source of impervious core will be the fine fraction of dirty terrace gravels such as seen at the Nglanji site. With a proper selection of screen size, the fine fraction will be impervious core with a suitably small percentage of swelling clay, and the large fraction will be a stable pervious gravel for the upstream shell. Neither the quality, nor quantity, nor location of suitable material has yet been completely proven.

Random Fill. The same type of terrace gravels as found at Nglanji furnishes a material which, though relatively impervious, will have a high strength under drained conditions.

Filter. The same type of terrace gravels as at Nglanji could be processed to furnish filter, but quality, quantity and location have not as yet been completely proven.

Concrete Aggregate and Riprap. No local source has been proven; therefore, for a conservative feasibility design these materials should be priced as coming from some distant source.

Seismic

Though ground acceleration is significant, the effects of an earthquake are at least as dependent on duration and dominant frequency of the shock wave and its relationship to the natural frequency of the structure concerned. The use, therefore, of Intensity Ratings derived from shock effects on a wholly different type of structure is an inadequate basis for design. Seismographs from each hypocenter should be studied to determine the earthquakes that should be used for design.

Additional Explorations Required for Feasibility

As previously mentioned, the foundation conditions in the valley section at the site selected by NEDECO present serious stability problems as well as leakage problems. In fact, we believe these problems are so serious in terms of foundation treatment cost and embankment cost that some preliminary field investigations should be made as soon as possible at the alternative site, which is approximately 1 kilometer downstream. If the preliminary subsurface explorations at the alternative site support the surface evidence, then we believe the damsite should be moved to the alternative location.

These preliminary subsurface explorations should consist of two inclined borings cored in the plane of the axis. One should be drilled from each abutment so that they cross below the valley section to determine if the characteristics in the valley are different from those at Ngrambat. These borings should be water tested by geologic feature.

If these borings indicate that no crushed zone exists in the river valley, then the subsurface exploration should be continued. Mapping of the surface geology at and around the alternative site should be aided by exposing bedrock along a continuous strip by trenching and stripping along the left abutment to expose whatever geologic features cross the axis. In addition, the full length of the axis should be covered by crossed inclined drill holes in the plane of the axis. They should also be water tested by geologic feature.

Any features mapped on the surface or found in the general borings crossing the axis should be intersected at some depth and off the axis with borings and water tested to get additional information on orientation and characteristics.

There should also be some additional explorations to establish the quantity and quality of construction materials. Test pits should be sunk on a grid not greater than 100-meter spacing to prove out at least one and a half times the volume of terrace gravels needed for the embankment. Pilot processing for whatever is needed should be done to determine quality of product and cost.

Design and Construction

There is very little to comment on regarding the design and construction of the dam and appurtenances because NEDECO's studies have not progressed to the point where any preliminary designs are available. Furthermore, as previously discussed, we believe there are valid reasons for considering the alternative site for the dam.

There are some design considerations, however, which should be mentioned regarding the materials for the embankment design.

Embankment

Unless a pervious material is found for use upstream of the core, either the upstream slope must be flattened to attain stability despite sudden draw down conditions in the shell, or pervious material must be produced by processing some of the available material such as the impervious terrace gravels seen at the Nglanji site.

The decision is one of cost. At one end of the spectrum of possible sections is an unzoned homogeneous section except for a downstream toe drain; this will be a section with very flat slopes and the maximum amount of material, but with the minimum processing. At the other extreme is a section with vertical central core and an upstream shell all pervious; this will be a section with minimum material, but half of it will require processing.

Between the two extremes is a section with an inclined core on a filter drain, and a thin pervious upstream shell. Such a section will have an upstream pervious shell equal in volume to the coarse fraction from which the fine fraction had been removed to produce an impervious core of suitable thickness. The majority of the section will be downstream and consist of the unprocessed gravels; the total embankment volume will be less, and the upstream slopes steeper than those for the unzoned dam because of the free draining shell and the drain underlying the core. These various dam sections are shown on Figure 2 of Plate 1.

The sloping core could be easily constructed in conjunction with the reservoir blanket suggested for the conservative feasibility design, and will still be appropriate if the grouted cutoff was proven to be less costly by continued studies. It will also permit the construction of the downstream shell to proceed ahead of the core, thereby reducing the control of inclement weather on the construction schedule.

Seismic Considerations

The pseudostatic analysis assigns a static force in stability analyses as the seismic effect. The scalar value is adjusted by judgment from ground accelerations in the past. For continuity with past design methods this analysis should still be made, but a sounder basis for design, one involving fewer assumptions and a closer approximation to reality, is a dynamic analysis. If there is a possibility of any significant shocks, a dynamic analysis should also be made.

Labor Intensive Methods

A number of jobs can be done by hand labor without sacrificing quality. Exploration for gravels can be done with test pits and trenches. Processing of natural materials to change their characteristics, such as separating the fine and coarse fractions of a dirty gravel, can be done by hand labor with the product stockpiled for later machine transport, spreading and compaction. Clearing and stripping and dental excavation also are adaptable to such methods. These activities were discussed in Part 1 with regard to the construction of Jragung Dam.

FIGURE 1
RECONNAISANCE GEOLOGY
NGRAMBAT DAMSITE -- SERANG RIVER

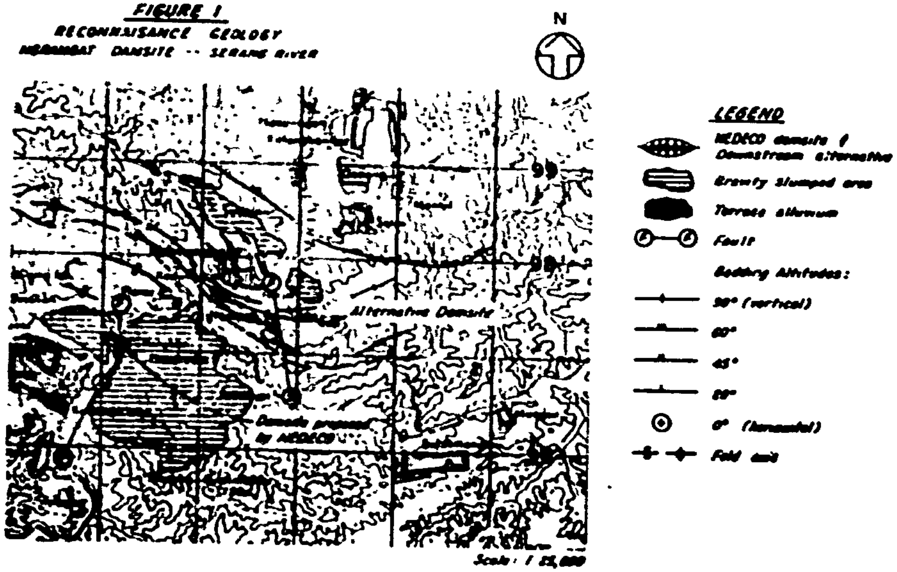


FIGURE 2
POSSIBLE GENERALIZED GEOLOGIC SECTION
ALONG AXIS OF DAM SELECTED BY NEDECO

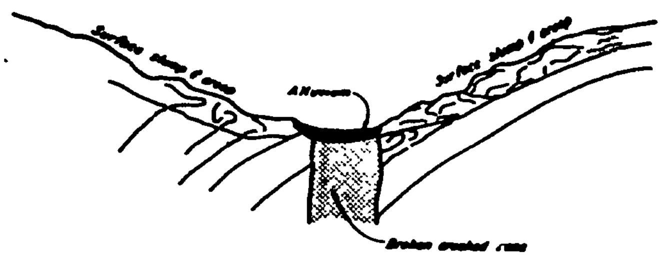
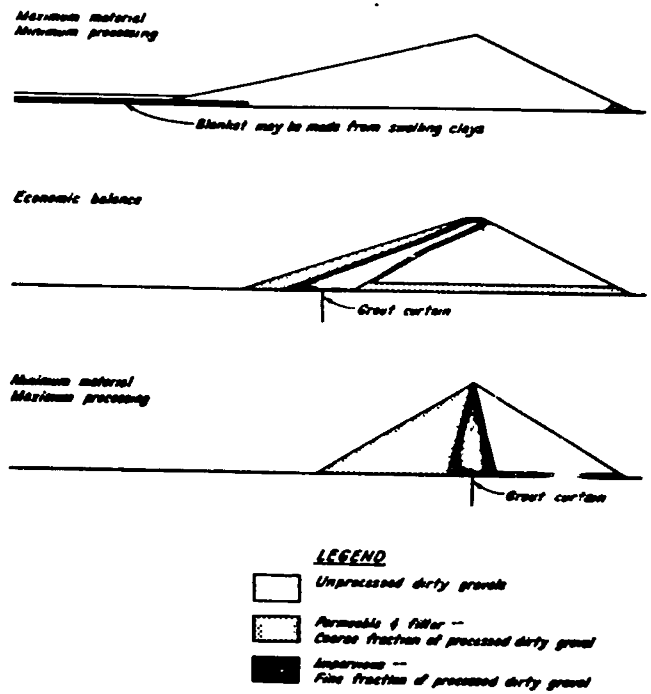


FIGURE 3
RANGE OF SECTIONS POSSIBLE
USING DIRTY GRAVELS AS AT NGLANJI



GEOLOGY
NGRAMBAT DAM

FIGURE 1

RECONNAISANCE GEOLOGY
NGRAMBAT DAMSITE -- SERANG RIVER

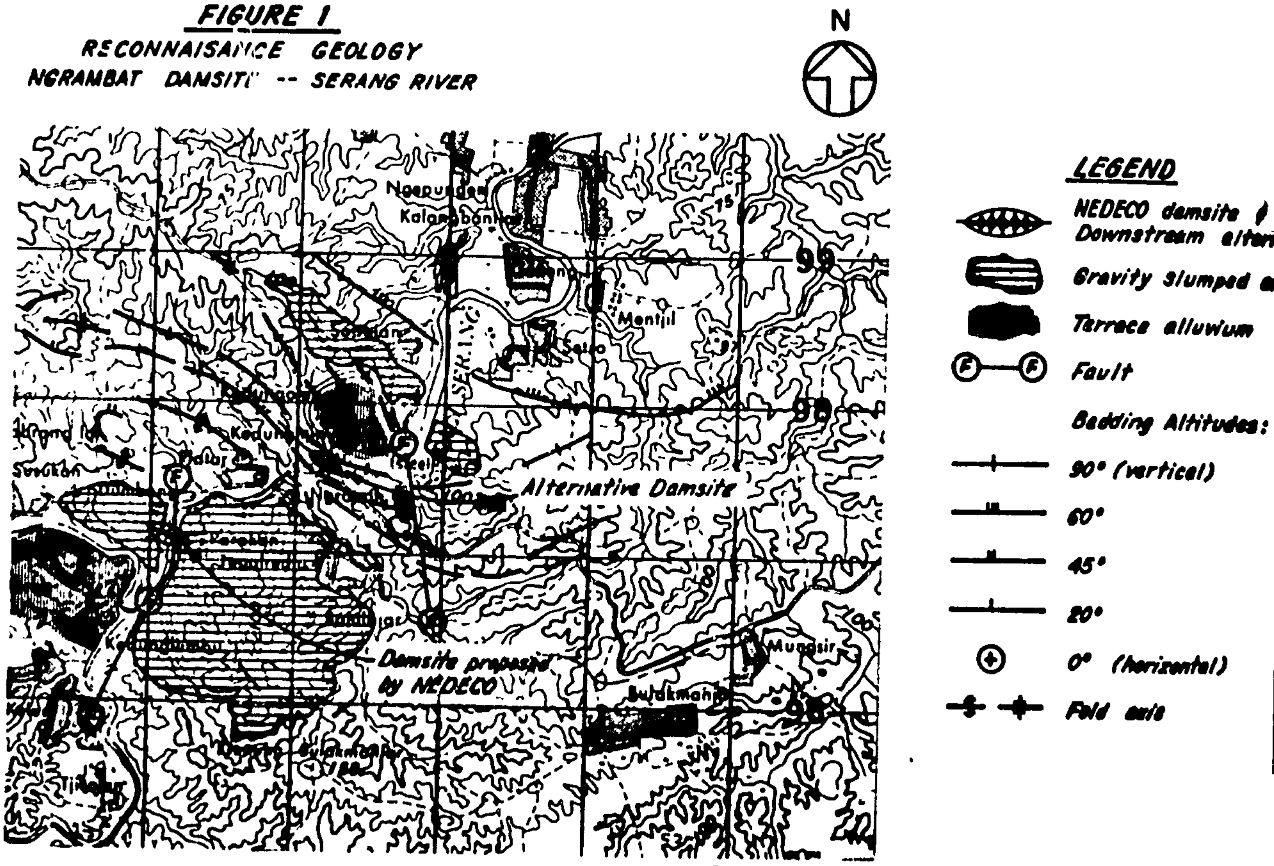


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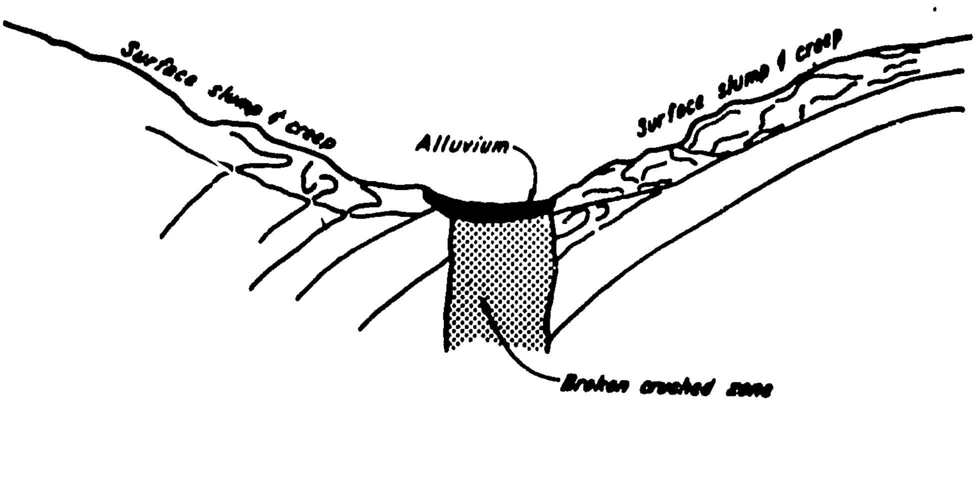
FIGURE 2

POSSIBLE GENERALIZED GEOLOGIC SECTION
ALONG AXIS OF DAM SELECTED BY NEDECO



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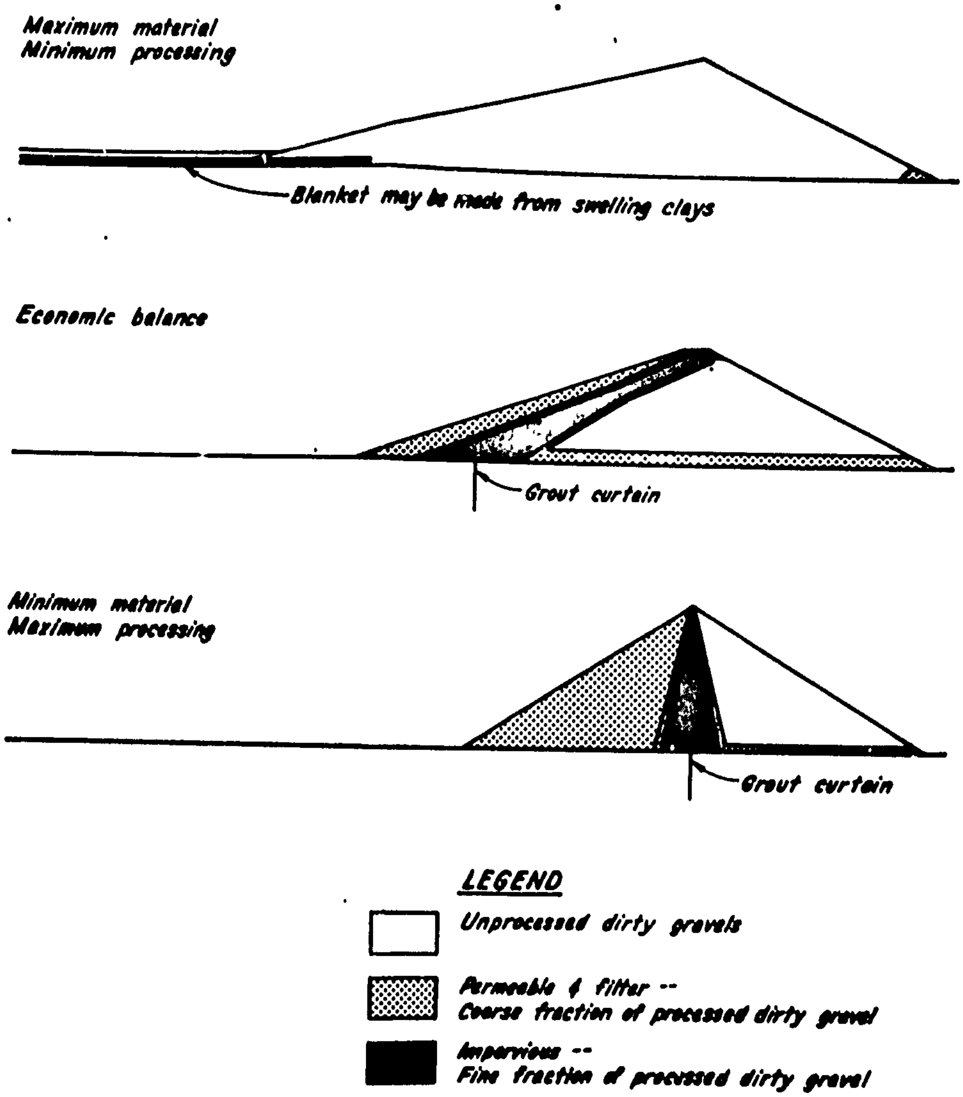

GEOLOGY
NGRAMBAT DAM

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