THE REPUBLIC OF INDONESIA

SURVEY REPORT
ON
SAGULING HYDROELECTRIC
POWER DEVELOPMENT PROJECT

March 1973

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

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PREFACE

February 28, 1973

The Government of Japan decided to accept a request from the Government of the Republic of Indonesia for survey and study of Saguling Hydroelectric Power Development Project in Indonesia and entrusted the Overseas Technical Cooperation Agency, Tokyo, Japan (hereinafter referred to as OTCA) to execute the above survey and study.

The OTCA organized a survey team composed of six experts headed by Mr. Keitaro Kadowaki, Deputy Manager, Construction Department, the Kansai Electric Power Co., Inc., Osaka, Japan.

The survey team stayed in Indonesia for about forty five days, starting from Tokyo, Japan in October, 1972. During its stay in Indonesia, the survey team made field investigations of reservoir area, route of waterway and power house sites, collection of data concerning hydrology, topography, geology and power situation, and discussions with the Indonesian Authorities such as PUTL (Ministry of Public Works and Power), PLN (Perusahaan Umum Listrik Negara) and BAPPENAS (National Development Planning Agency).

The field investigations were finished successfully by the support and cooperation extended to the survey team by the Government of the Republic of Indonesia, and the survey team returned to Japan as scheduled with fruitful results. After its return to Japan, the survey team made studies of the collected data and analyses of its findings obtained by the field investigations and compiled the results of such studies and analyses into this report.

As mentioned in this report, Saguling Hydroelectric Power Development Project is required to be implemented soonest possible, because the Project is found very much promising from all aspects. It is also recommended in this report that the survey and study made by the survey team are only preliminary study of this Project and therefore further studies and investigations recommended herein should be continued for prompt development of this project.

On behalf of the OTCA, I wish to express my deepest appreciation to the directors and officers of numerous departments of the Government of the Republic of Indonesia for their kind assistance and cooperation extended during the course of this survey.

Very truly yours,

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

February 28, 1973

Letter of Transmittal

Mr. Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency
Tokyo, Japan

Dear Sir,

I am pleased to transmit the report entitled "Survey Report on Saguling Hydroelectric Power Development Project".

The survey team for this project stayed in Indonesia from October 16 to November 29, 1972 and conducted field investigations with the positive assistance of the counterpart officers of Perusahaan Umum Listrik Negara, Ministry of Public Works and Power, the Government of the Republic of Indonesia, and the other concerned peoples in Indonesia.

During its stay in Indonesia, the survey team made reconnaissance of the site and its related area, collected data relevant to the project and had discussions with the officers of the Government of the Republic of Indonesia and Embassy of Japan in Jakarta, and submitted to your Agency the tentative report dated December 28, 1972 based upon the field investigations.

This report submitted herewith contains the results of office studies made by the survey team after its return to Japan.

As concluded in this report, Saguling Hydroelectric Project is technically and economically feasible and will produce energy of about 2,000 million kWh per year with installed capacity of 600 MW. The produced power will be delivered to the West and Central Java Power Systems at lower cost than power from alternative thermal sources. The completion of this project will also serve to fulfil additional water requirements for irrigation, municipal water supply and other uses.

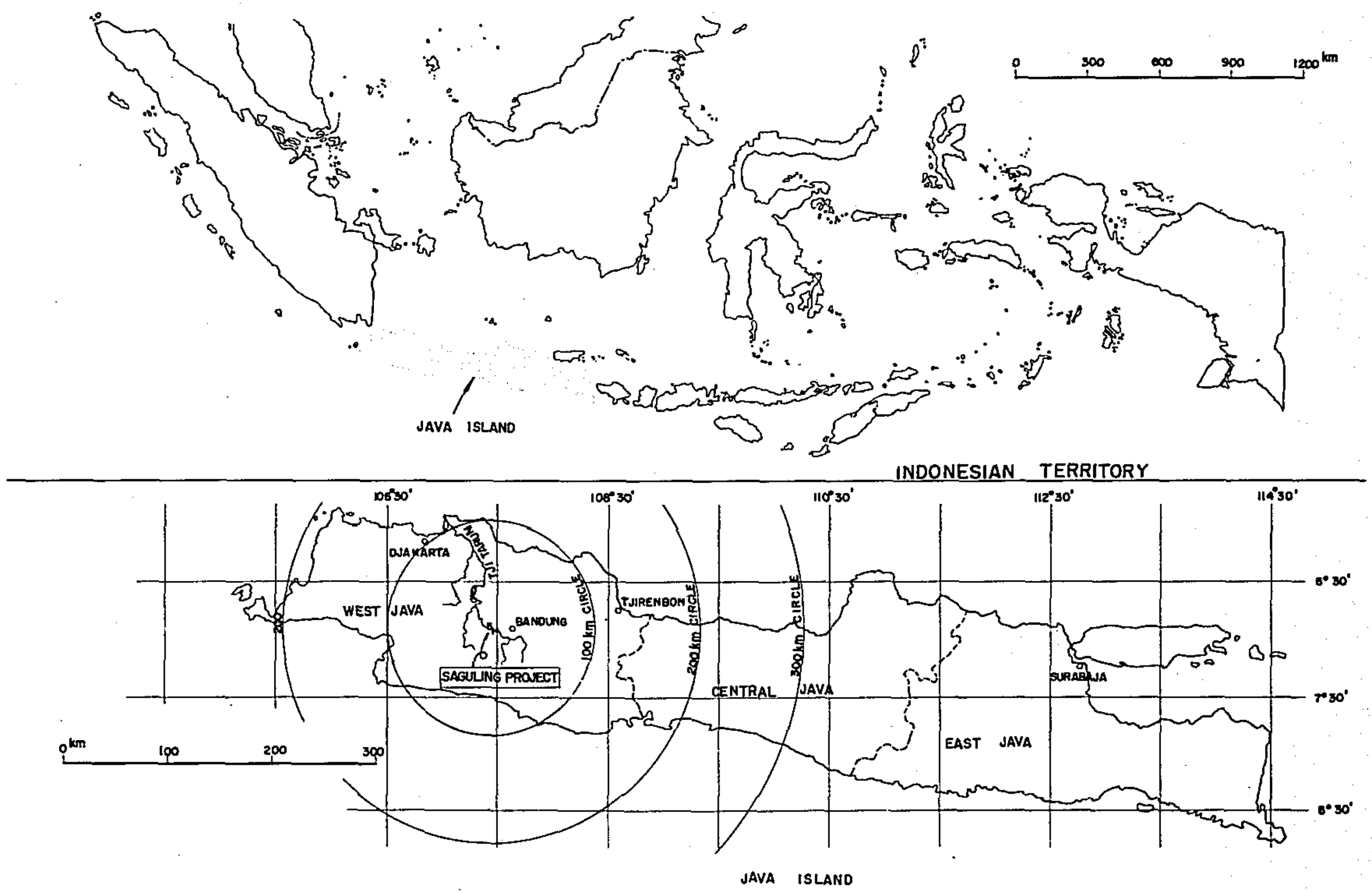
For improvement of the reliability of the power systems, Saguling Hydroelectric Power Project should be developed as early as possible. Accordingly, I, on behalf of the survey team, wish to recommend that the Government of the Republic of Indonesia will continue further studies and investigations recommended herein.

On behalf of the survey team, I wish to express its appreciation to the people concerned for their supports and cooperations extended to the team during the field investigations and the preparation of this report after its return to Japan.

Very truly yours,

Keitaro Kadowaki

Keitaro Kadowaki
Chief of the West Java
Hydro Power Survey Team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EAST JAVA
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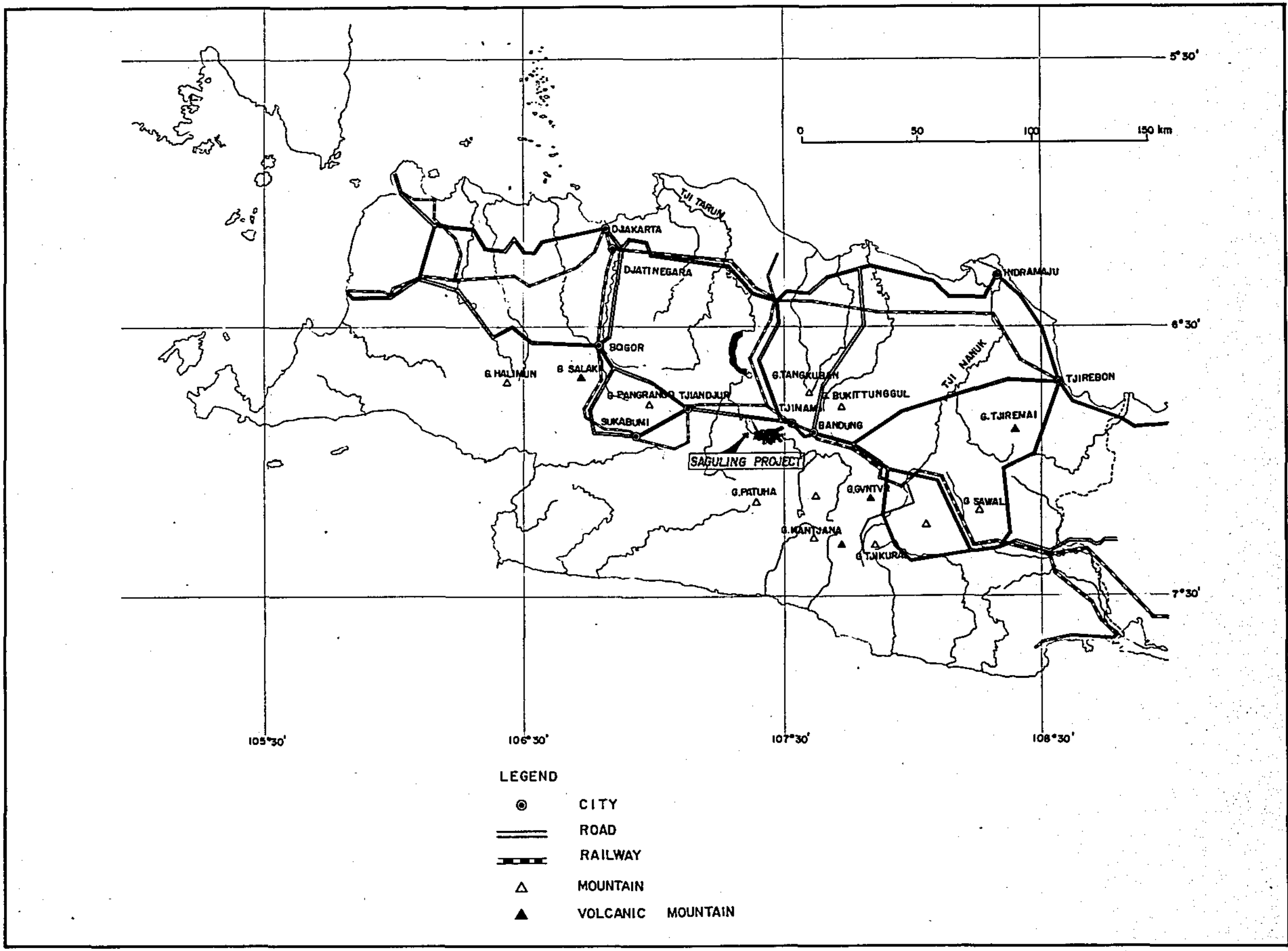
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G. BUKITTUNGGUL
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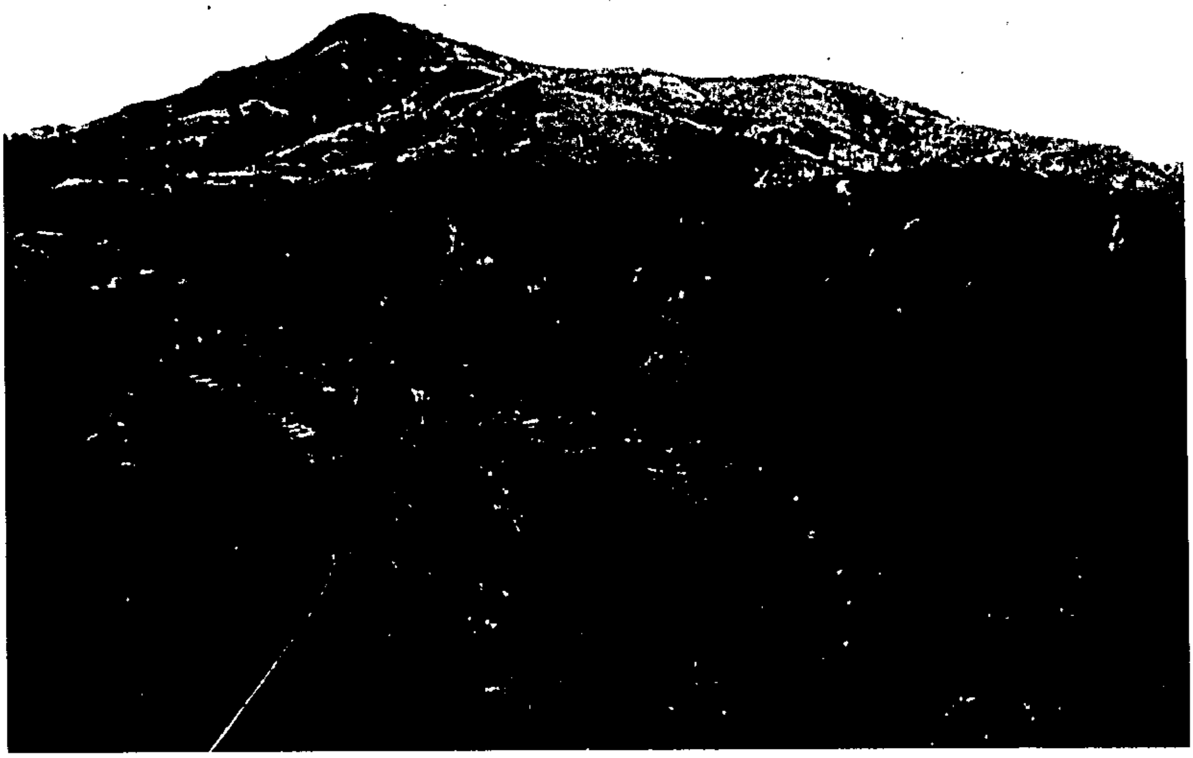
TJIMAHI
BANDUNG
SAGULING PROJECT
G. PATUHA
G. GUNTUR
G. SAWAL
G. KANTJANA
G. TJIKURAI
LEGEND
CITY
ROAD
RAILWAY
MOUNTAIN
VOLCANIC MOUNTAIN

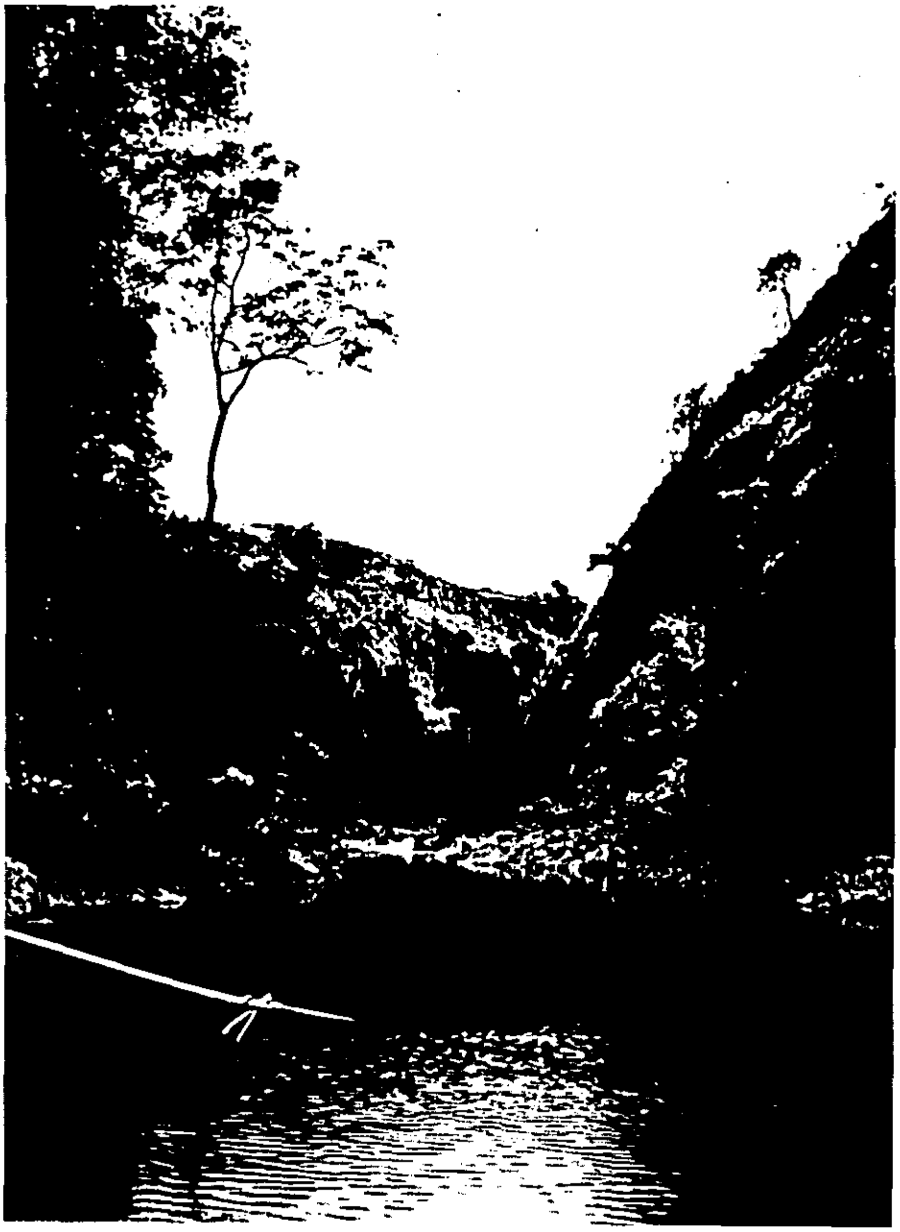
UNITS

mm	millimeter
cm	centimeter
m	meter
km	kilometer
mm^2	square millimeter
m^2	square meter
km^2	square kilometer
ha	hectare
m^3	cubic meter
m^3/sec.	cubic meter per second
ton	metric ton
m/sec.	meter per second
kW	kilowatt
kWh	kilowatt-hour
MW	megawatt
MWH	megawatt-hour
kV	kilovolt
MV	megavolt
MVA	megavolt-ampere
rpm	revolution per minute
Hz	Hertz
o	degree of angle
g	acceleration of gravity
m^3/sec-M	cubic meter per second - Month
mill	U.S. mill
$	U.S. dollar
EL.	the height above mean sea level
H.W.L.	high water level
L.W.L.	low water level
T.W.L.	top water level
N.W.L.	normal water level
F.W.L.	flood water level

View of the dam sites from downstream



View of Chisaguling cliff from the
opposite side of the Tjitarum River



View of foundation of the lower midstream dam site from down stream

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SECTION 1.

INTRODUCTION

1. INTRODUCTION

1.1. Authorization

The Government of the Republic of Indonesia requested the Japanese Government for a technical assistance to conduct preliminary investigations of Saguling Hydroelectric Power Project. The Japanese Government accepted this request and authorized OTCA to carry out the survey.

In carrying out the survey, OTCA requested the Kansai Electric Power Co., Inc., Osaka, Japan for cooperation in providing members of the survey team. OTCA organized the survey team consisting of six experts headed by Mr. Keitaro Kadowaki, Deputy Manager, the Kansai Electric Power Co., Inc. and sent the team to Indonesia in October, 1972.

1.2. Scope of the Work

The work was to consist of field investigations, including site reconnaissance and collection of relevant data, and office studies sufficient to assess the technical and economic possibility of hydroelectric development of Saguling Hydroelectric Power Station on the River Tjitarum which has the largest potential in West Java, the Republic of Indonesia.

The survey team was directed to prepare and submit a report of its survey to

a) select a most optimum site from among the proposed sites and determine the most optimum development scale of dam, reservoir and power station for the selected site, on the basis of the available West Java long range power system planning data,

b) work out layout studies of the power station at the selected site and give basic considerations of transmission and substation facilities associated with this power station,

c) prepare approximate estimates of capital costs for the recommended developments of the power station and the transmission and substation facilities,

d) make an economic study concerning the cost of power, the comparison with the power cost of an alternative thermal plant, and the schedule of expenditures.

1.3. Formation of the Survey Team

Chief	Mr. Keitaro Kadowaki	Deputy Manager, Construction Department, the Kansai Electric Power Co., Inc., Osaka, Japan.
Member (Geology)	Dr. Haruo Tanaka	Managing Director, the New Japan Engineering Consultants, Inc., Osaka, Japan.
Member (Dam and power station engineering)	Mr. Shujiro Nagano	Engineer, Construction Department, the Kansai Electric Power Co., Inc., Osaka, Japan.
Member (Project planning)	Mr. Kiyoshi Sugiki	Engineer, Construction Department, the Kansai Electric Power Co., Inc., Osaka, Japan.
Member (Electrical engineering)	Mr. Hiroyuki Ichikawa	Assistant Chief, Facilities Section, Public Utilities Bureau, Ministry of International Trade and Industry, the Japanese Government.
Member (Construction method and calculation of quantities)	Mr. Masayoshi Yamashita	Engineer, Construction Department, the Kansai Electric Power Co., Inc., Osaka, Japan.

1.4. Exchange Rate of Japanese Yen to U.S. Dollars

The exchange rate (as of November, 1972) of one U.S. dollar (U.S. $1. -) to three hundred Japanese Yen (¥300. -) has been used in this report.

SECTION 2.

CONCLUSIONS AND RECOMMENDATIONS

2. CONCLUSIONS AND RECOMMENDATIONS

2.1. Conclusions

The conclusions and recommendations of the survey and studies are summarized herewith:

a) Hydroelectric power development at Saguling site on the River Tjitarum is technically and economically feasible. While additional investigations will be required to establish further details, the recent preliminary study has fully demonstrated the feasibility of Saguling Hydroelectric Power Project.

b) 600 MW can be developed at Saguling Hydroelectric Power Project site, and Saguling Hydroelectric Power Station will produce energy of about 2,000 million kWh per year, and the produced power will be delivered to the expanding West and Central Java Power Systems at lower cost of Japanese Yen 2.42 (8.1 mills) per kWh than that from alternative thermal sources estimated to cost Japanese Yen 3.68 (12.3 mills) per kWh.

c) Comprehensive studies of the present conditions of downstream flood control, irrigation and city water supply as well as the dam sites on the neighbouring rivers indicate that it will be most adequate to develop Saguling site principally for hydroelectric generation purpose, with the supplemental function being seeked for other purposes.

d) Since the Djatiluhur Hydroelectric Power Station, one of the largest power sources in West Java at present, must be operated principally for irrigation purpose, stable availability of power production is adversely affected by drought conditions. Development of Saguling site for the purpose of electric power generation will help to solve this problem and will further serve to improve the reliability of the West Java Power System.

e) Saguling reservoir with the effective storage capacity of 700 million m^3 will also contribute to the solution of urgent problems involving additional irrigation water requirements and additional municipal water supply, and the tourist resorts development.

f) The estimated development period of Saguling Hydroelectric Power Project will be approximately 9 years, of which 4 years will be required for site investigations and detailed design and 6 years for the construction work.

g) Saguling Hydroelectric Power Project will consist of a storage dam, a water conveyance system and a 600 MW power station. The approximately estimated capital cost is Japanese Yen 46,000,000,000.- ($153,333,000.-), of which Japanese Yen 34,000,000,000.- ($113,333,000.-) are offshore expenditures and Japanese Yen 12,000,000,000.- ($ 40,000,000.-) are local expenditures. If the 270 kV transmission line envisaged in this report is constructed from the power station to Tjigereleng on the one wing and to Tjiwang on the other wing, a further approximately estimated Japanese Yen 7,400,000,000.- ($ 24,667,000.-) is required of which Japanese Yen 5,200,000,000.- ($ 17,334,000.-) are offshore expenditures and Japanese Yen 2,200,000,000.- ($ 7,333,000.-) are local expenditures.

2.2. Characteristics and Advantages of the Project

The main characteristics of the recommended scheme for the proposed development are summarized on TABLE 1.

Saguling Hydroelectric Power Project has the following advantages.

a) The high water level of Saguling site will be EL. 650 m and the project site is so profitable that construction of a dam only 88 m high will create a reservoir with the effective storage capacity of about 705,000,000 m^3.

b) The river gradient from the dam site to the power house one is as steep as approximately 1 to 25 and the average river discharge is as abundant as 76 m^3 per second. Those topographic and hydrological features provide an ideal hydroelectric power development site.

c) The project site is located at the place less than 100 km far from Jakarta, capital and economic center of Indonesia, and also from Bandung, educational city. Saguling Hydroelectric Power Station is favourably located to supply abundant power at cheaper cost to the two important areas. After interconnected with the Central Java Power System, the power station will function as a main power station in the interconnected West Java - Central Java Power System. Thus, it will contribute greatly to the stabilization of the people's livelihood and the development of the economic conditions in Java.

d) Access to the site is much easier and the execution of the construction works is not so difficult, favourably located near a trunk road connecting Jakarta with Bandung.

2.3. Following Studies and Survey

It is recommended that, in 1973 as an intermediate stage, the instructions should be issued to the qualified consulting engineers by mid 1973

a) to carry out site investigations including drilling work, seismic prospecting and topographic surveys;

b) to undertake the necessary engineering work which will be required for preparation of the definite plan.

TABLE 1. SUMMARY OF MAIN CHARACTERISTICS OF SAGULING HYDROELECTRIC POWER DEVELOPMENT SCHEME RECOMMENDED AT THIS STAGE

Type of dam	:	rockfill 88 m high
Type of power station	:	conventional
Type of waterway	:	pressure tunnel
Catchment area	:	2,283 km^2
Gross storage capacity	:	1,105,000,000 m^3
Effective storage capacity	:	705,000,000 m^3
Effective head	:	362.2 m
Maximum discharge	:	200 m^3/sec.
Installed capacity	:	600 MW (150 MW x 4 units)
Plant production:		
Sent-out (at sending end)		2,042,000,000 kWh
Delivered (at receiving end)		1,941,000,000 kWh
Approximate capital cost:		
Saguling Hydroelectric Power Project		Japanese Yen 46,000,000,000.- ($153,333,000.-)
Associated transmission/substation		Japanese Yen 7,400,000,000.- ($ 24,667,000.-)
Power costs:		
Sent-out (at sending end)		Japanese Yen 1.98 (6.6 mills)/kWh
Delivered (at receiving end)		Japanese Yen 2.42 (8.1 mills)/kWh*

* including the construction cost of associated transmission and transformers.

SECTION 3.

COLLECTED DATA AND INFORMATION

3. COLLECTED DATA AND INFORMATION

In preparing this report, the following reports which were collected in Indonesia by the survey team were referred to.

a) A Federal Development-Project for the Western Part of Java, December 1948, by Prof. Dr. Ir. W. J. Blommestein.

b) Meteorological Data No. 8 Part 1, Mean Rainfall in Java and Madura, 1931 - 1960, by Lembaga Meteoroligi dan Geofisika, Jakarta.

c) Meteorological Data in Indonesia, November 1970, by Mr. Tadashi Tanimoto, Colombo Plan Expert for IHE.

d) Central Java Long Range Plan for Power System Development, November 1970, by Chas. T. Main International, Inc., together with supplemental report.

e) A brief outline of seismicity and earthquake engineering problems in Indonesia, October 1971, by Mr. T. Boen.

f) Djatiluhur Irrigation Rehabilitation Project, Development Credit Agreement (Progress Report No. 3), June 1972 by Coyne et Berrier, Paris.

g) West Java Power System Long Range Plan, August 1972, by Chas. T. Main International, Inc.

SECTION 4.

SAGULING HYDROELECTRIC DEVELOPMENT

4. SAGULING HYDROELECTRIC POWER DEVELOPMENT

4.1. Power Load Forecast in West Java Power System

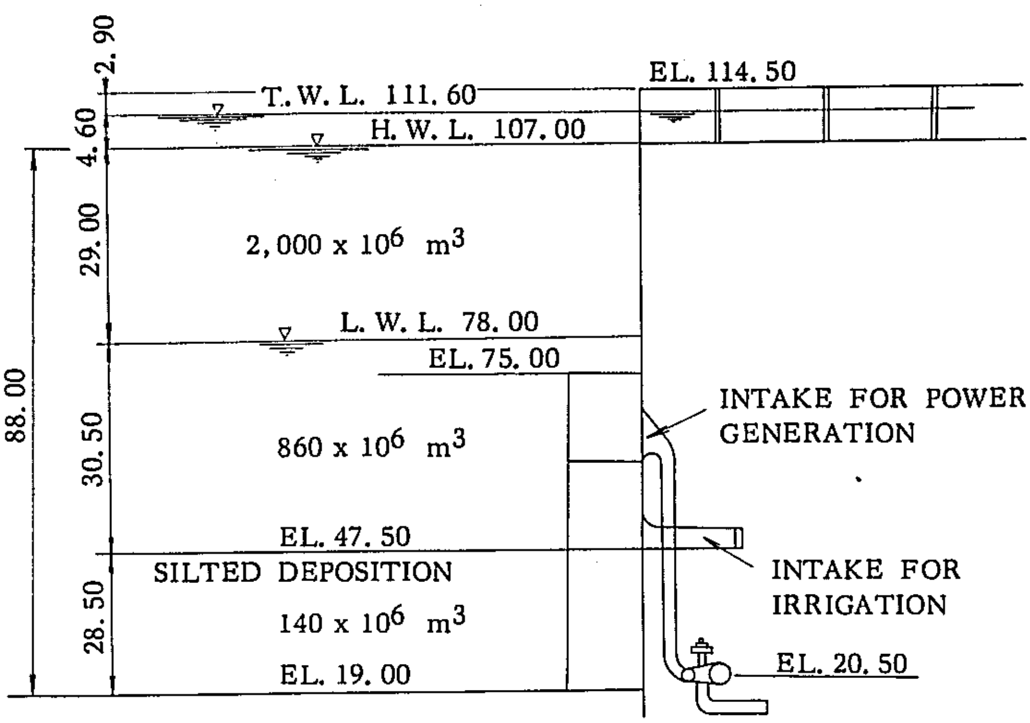
West Java including Jakarta and Bandung is the operating districts of Exploitasi 11 and Exploitasi 12 of PLN. The peak load of the West Java Power System in 1971 was about 200 MW. The installed capacity of those power stations in the West Java Power System was 310 MW in 1972, but the power supply capability was 260 MW, when a largest single generating unit in the System was put aside as reserve. This net generating capability of 260 MW includes the recognized firm output of 90 MW Djatiluhur Hydroelectric Power Station.

The water allocation of Djatiluhur reservoir is shown on FIG. 1. The total effective storage capacity of Djatiluhur dam is 2,860 million m^3, of which 2,000 million m^3 between EL. 78.00 m and EL. 107.00 m can be used for power generation. In plenty water years, the power can be produced constantly, because the drop of the water level is small even after supply of the water requirements for irrigation. However, in drought years, it is likely that the power production will be impossible, restricted by the water requirements for irrigation. In this case, Djatiluhur Hydroelectric Power Station can not generate 90 MW, which will result in unbalance of the power demand and supply.

As the power demand will increase, prompt development of power sources which will be able to supply power not merely abundantly but also stably will be an urgent task.

It is assumed that an interconnection between the West Java Power System and the Central Java Power System will be completed by 1982 when Saguling Hydroelectric Power Station will be commissioned. Accordingly, Saguling Hydroelectric Power Development was studied on the basis of long-range power demand forecast of the West Java - Central Java interconnected system.

FIG. 1 BRIEF DESCRIPTION OF DJATILUHUR PROJECT



Design Features of Djatiluhur Project

Purposes: flood control, irrigation and power generation

Item		Unit	Dimensions
Name of river			Tjitarum
Catchment area		km^2	4,505
Reservoir	Gross storage capacity	10^6 m^3	3,000
	Allocation to power generation	"	2,000
	Allocation to irrigation	"	2,860
	Sediments	"	140
Dam	H. W. L.	m	107
	Height	"	105
	Crest length	"	1,200
	Volume	10^3 m^3	9,100
	Spillway capacity	m^3/sec.	3,000 (reserve-2,000)
Power Station	Maximum output	MW	125
	Maximum discharge	m^3/sec.	270
	Generated energy	10^3 MWH	700

Long-range demand forecasts of West Java Power System and Central Java Power System prepared by Chas. T. Main International, Inc. have been used for the studies. The same long-range demand forecasts indicate the power demand and the sequence of the development of the power sources from 1972 to 1990 will be as shown on FIG. 2. In the same demand forecasts, the annual load factor is assumed approximately 60%.

4.2. Concept of Tjitarum River Comprehensive Development

4.2.1. Profile of the River Tjitarum

The River Tjitarum originates from the mountaineous area with an elevation of approximately 2,000 m surrounding the Bandung valley in West Java, flows northward, gathering waters coming from the plain around the city of Bandung, and ends into the Java Sea. Its length is approximately 350 km and the catchment area is approximately 6,000 km^2. It is the third biggest river in Java, next to the River Solo and the River Brantas. (See FIG. 3)

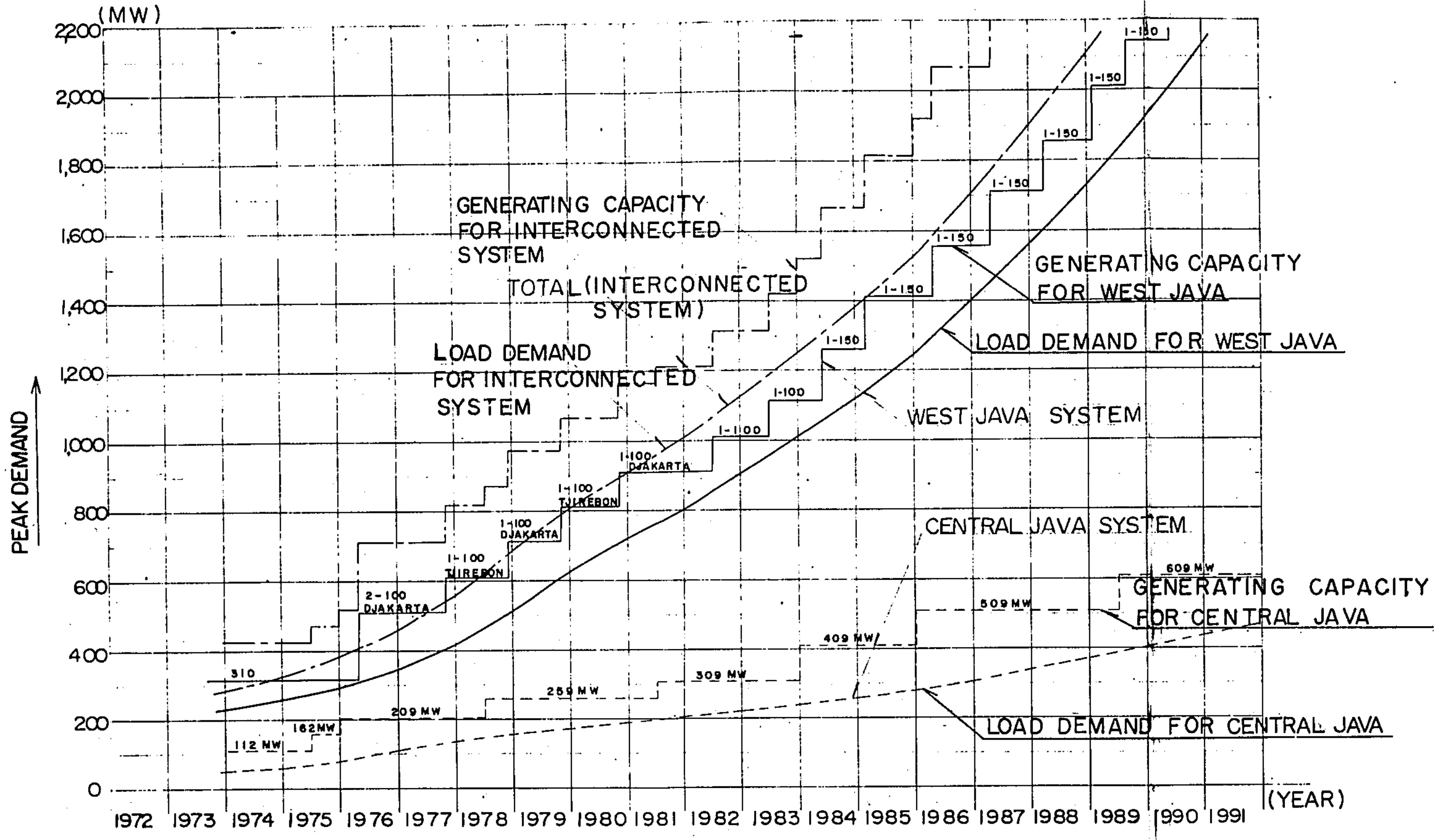
The River Tjitarum flows through the plain with an average gradient of 1/4,500 in its downstream section up to approximately 90 km upstream of the river mouth and the catchment area in this section is almost the same. In other words, the catchment area of the river reaches 100 percent at the point up to approximately 90 km upstream of the river mouth.

Djatiluhur Dam is located around 140 km upstream of the river mouth and serves for flood control, irrigation and power generation. The river gradient in this section up to Djatiluhur dam from the point 90 km far from the river mouth is almost the same as the lower section up to 90 km upstream of the river mouth. The River Tjitarum occupies 75% of the whole catchment area at the Djatiluhur dam site.

Its midstream section from Djatiluhur dam to the point about 90 km upstream of the river mouth has an average river gradient of about 1/400 through the midstream mountaineous area, and the catchment area at this point occupies about 38% of the whole catchment area.

FIG. 2 LOAD FORECASTS IN WEST AND CENTRAL JAVA SYSTEMS BY CHAS T. MAIN INTERNATIONAL, INC.

(MOST PROBABLE LEVEL)



The section from the point to Saguling site about 230 km upstream of the river mouth forms the steepest rapids in the midstream portion of the River Tjitarum and the average river gradient in this section is approximately 1/25.

The upstream from Saguling dam site located about 235 km upstream of the river mouth, flows through the plain near the city of Bandung. The average river gradient in this upstream section is approximately 1/650. Upstream of the point about 300 km upstream of the river mouth, the main stream of the River Tjitarum becomes a rapid stream in its upstream section. (See FIGS. 4 and 5)

On the River Tjitarum and its neighbouring rivers, there are possible dam sites as shown on FIG. 6 and TABLE 2 within the jurisdiction of PN Djatiluhur covering the basins of the River Tjitarum and the other rivers on the seaside plain.

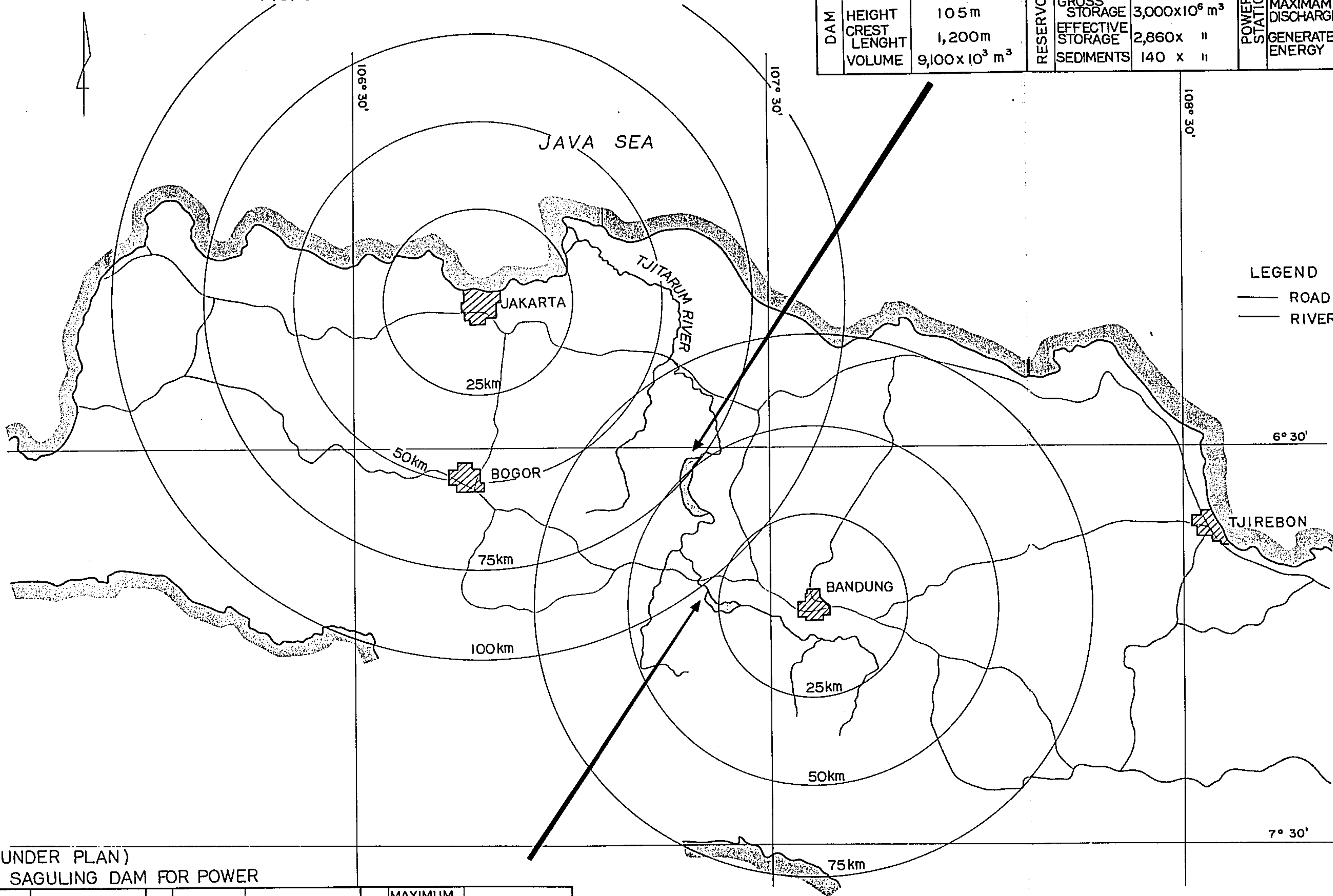
4.2.2. Power Sources

It is evident from FIG. 4 that Saguling Project site has the largest potentiality for hydroelectric power development.

At Saguling site, a high head which is indispensable for hydroelectric power generation can be developed with the construction of a short conduit. In addition, the site topography provides a splendid dam site for regulating reservoir necessary for stable generation of power. On the River Tjitarum, there are no other sites favoured with three conditions for power generation of sufficient discharge, suitable topography as dam site and high head, than Saguling site. Saguling site is an ideal one for hydroelectric development.

Tjirata dam site downstream of Saguling site has a possibility for hydroelectric development, because this site is blessed with sufficient discharge and topographical conditions suitable for construction of a large-scale reservoir.

FIG. 3 LOCATION OF SAGULING SITE



(EXISTING) DJATILUHUR DAM FOR FLOOD CONTROL, IRRIGATION AND GENERATION

DAM		RESERVOIR		POWER STATION	
TYPE	ROCKFILL	F.W.L	EL. 107m	MAXIMUM OUTPUT	125MW
HEIGHT	105m	GROSS STORAGE	3,000x10^6 m^3	MAXIMAM DISCHARGE	270m^3/sec
CREST LENGHT	1,200m	EFFECTIVE STORAGE	2,860x "	GENERATED ENERGY	700x10^{3}MWH
VOLUME	9,100x10^3 m^3	SEDIMENTS	140 x "		

(UNDER PLAN)
SAGULING DAM FOR POWER

DAM		RESERVOIR		POWER STATION	
TYPE	ROCKFILL	F.W.L	EL. 650m	MAXIMUM OUTPUT	600 MW
HEIGHT	88m	GROSS STORAGE	1,105x10^6 m^3	MAXIMUM DISCHARGE	200 m^3/sec
CREST LENGTH	657m	EFFECTIVE STORAGE	705 x "	EFFECTIVE HEAD	362m
VOLUME	3,000x10^3 m^3	DEAD WATER	300 x "	GENERATED ENERGY	2,040x10^{3}MWH

FIG. 4 PROFILE OF THE RIVER TJITARUM

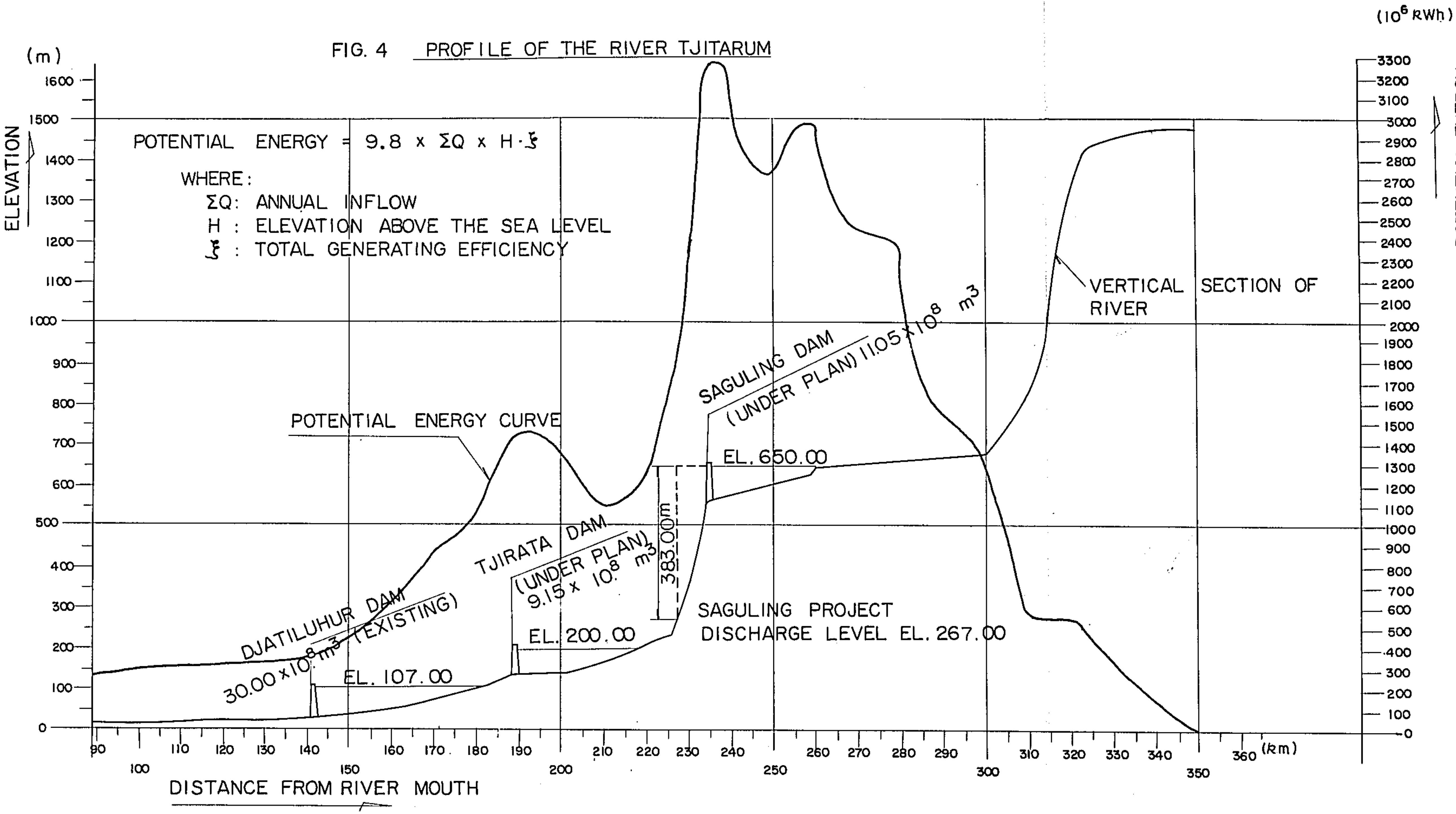


FIG. 5 - CATCHMENT AREA OF THE RIVER TJITARUM

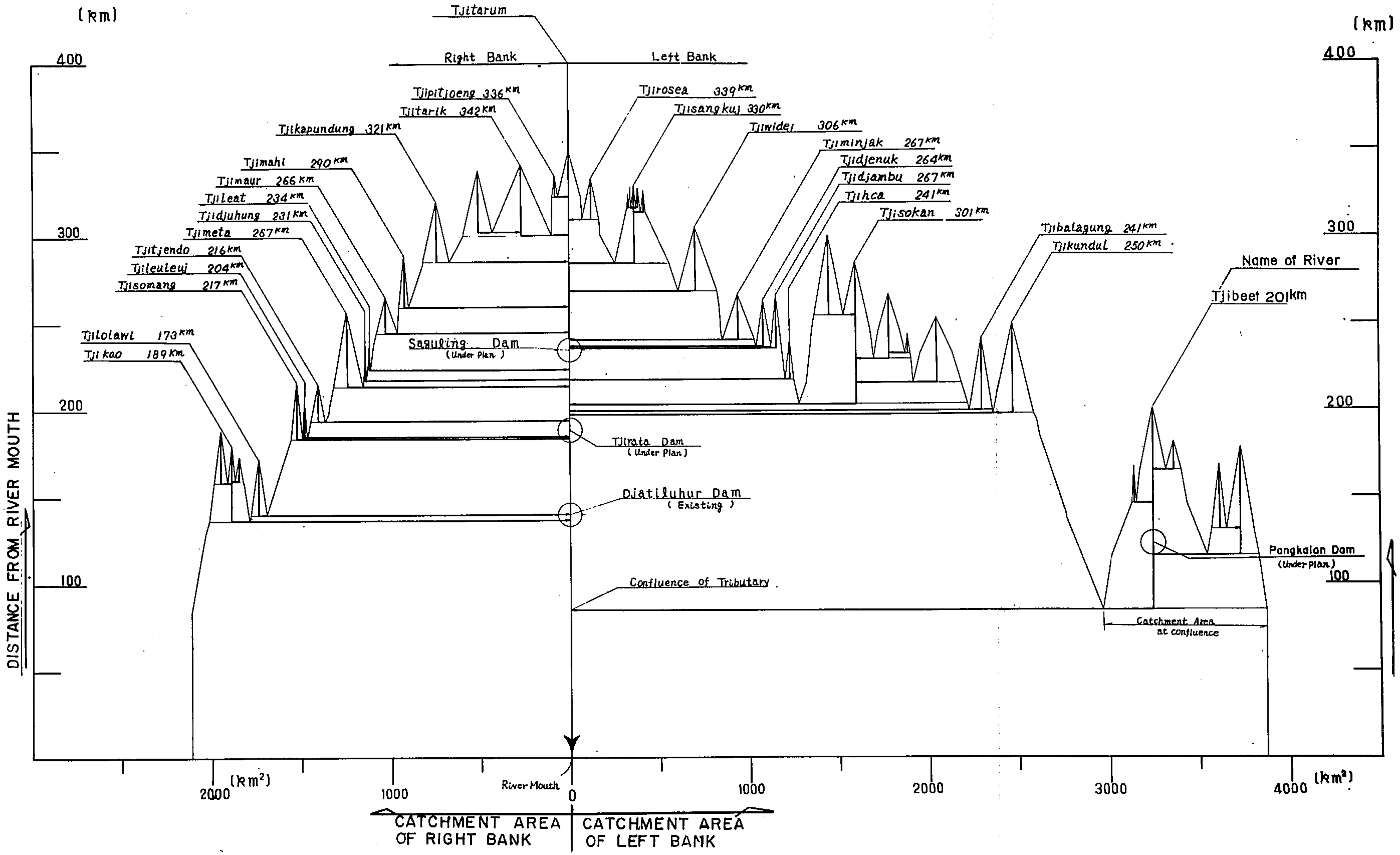


FIG. 6 POSSIBLE DAM SITES ON OR NEAR THE RIVER TJITARUM
(DATA GIVEN BY DEPARTMENT P.U.T.L)

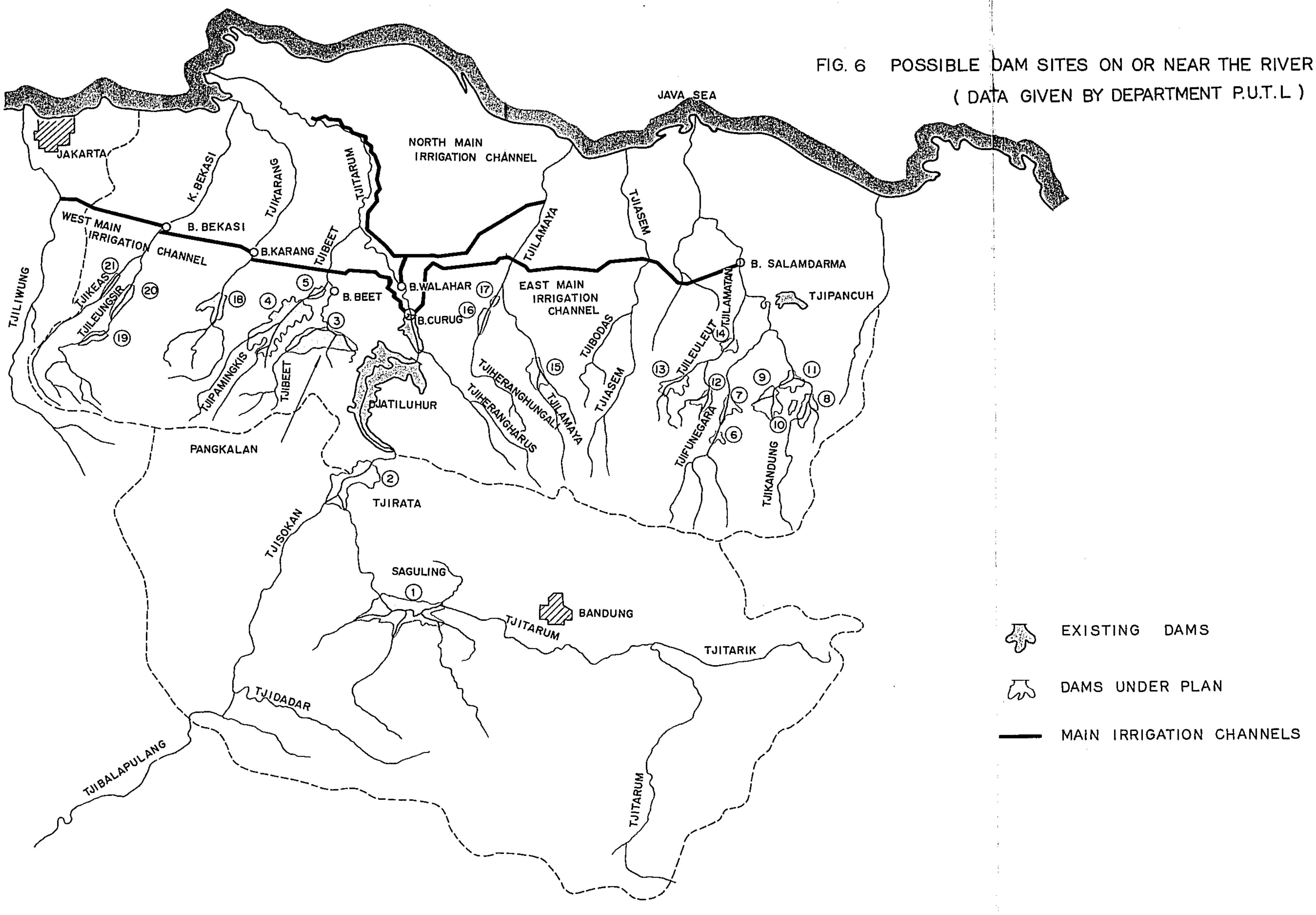


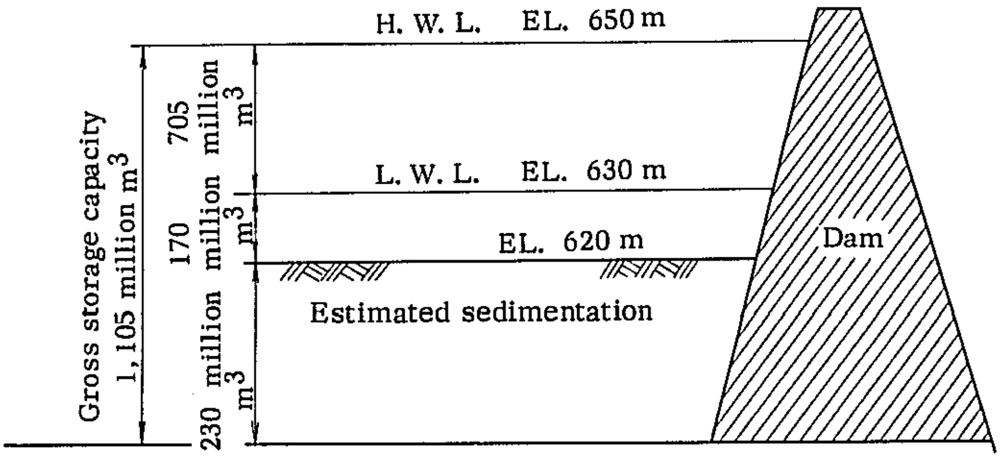
TABLE 2 POSSIBLE DAM SITES ON THE RIVER TJITARUM AND SEASIDE RIVERS

(Data provided by Department P.U.T.L.)

Number of Dam	River Name	Reservoir Name	① Catchment Area (km²)	② Yearly Flow (x10⁶ m³)	③ Elevation		④ Dam Height (m)	⑤ Dam Volume (x10⁶ m³)	⑥ Reservoir Volume (x10⁶ m³)	⑦ Reservoir Area (ha)	⑥/⑤ Reservoir Efficiency	②/① Runoff Height (m)
					Foundation (m)	H.W.L. (m)						
0	TJITARUM	DJATILUHUR	4,500	5,500	+27.00	+107.00	85.00	12	3,000	8,300	250	1.222
1	"	SAGULING	2,280	2,820	+562.00	+642.50	83.00	1.5	725	3,500	483	1.237
2	"	TJIRATA	4,090	5,000	+127.00	+200.00	78.00	3	915	3,800	305	-
3	TJIBEET	PANGKALAN	480	720	+28.00	+62.50	38.00	1.4	950	6,200	678	1.500
4	TJIPAMINGKIS	TJIPAMINGKIS	265	320	+23.00	+50.00	30.00	1.8	350	5,000	184	1.208
5	"	"	-	320	+20.00	+23.00	6.00	0.02	2	-	100	-
6	TJIPUNEGARA	TJIPUNEGARA	300	350	+80.00	+121.00	44.00	2.5	35	290	14	1.167
7	"	"	320	380	+52.00	+72.00	23.00	0.165	19	260	115	1.188
8	TJIKANDUNG	TJIKANDUNG	220	200	+48.50	+72.00	26.50	0.55	73	680	132	0.909
9	TJIBEBER	TJIBEBER	35	40	+50.00	+97.00	50.00	2.72	180	900	66	1.143
10	TJIBERANG	"	8	-	+52.00	+72.00	23.00	0.16	10	120	60	-
11	TJIKANDUNG	TJIKANDUNG	290	300	+26.00	+47.00	24.00	0.125	22	300	176	1.034
12	TJILAME	TJILAME	27	3	+48.00	+72.00	27.00	1.20	25	320	20	1.111
13	TJILAMATAN	TJILAMATAN	115	120	+54.00	+72.00	21.00	0.30	200	500	65	1.043
14	"	"	170	-	+40.00	+47.00	10.00	0.03	4.50	170	150	-
15	TJILAMAJA	TJILAMAJA	150	150	+57.00	+72.00	18.00	0.27	24	480	88	1.000
16	TJIHERANG	TJIHERANG	160	200	+45.00	+62.50	20.00	0.82	31.60	450	35	1.250
17	"	"	200	6	+38.00	+47.00	12.00	0.20	6	350	30	-
18	TJIKARANG	TJIKARANG	-	-	+41.00	+47.00	-	-	4	-	-	-
19	TJILEUNGSIR	TJILEUNGSIR	260	300	+49.00	+72.00	26.00	0.40	27	280	67	1.154
20	"	"	300	350	+34.00	+47.00	16.00	0.18	16	325	100	1.167
21	TJIKEAS	TJIKEAS	-	-	+29.00	+50.00	21.00	0.20	13.80	190	69	-

On the River Tjitarum, three sites of Djatiluhur, Saguling and Tjirata can be developed for large capacity hydroelectric power developments. On one of the tributaries, the River Tjibeet, there is a promising dam site named "Pangkalan". Because of its small basin, however, the hydroelectric power development of such a large capacity as the above three sites can not be expected.

The capacity of the reservoir for Saguling Hydroelectric Power Project will be illustrated as below:



The effective storage capacity of 700 million m^3 will bring a good result in increase of water supply for other purposes in drought years.

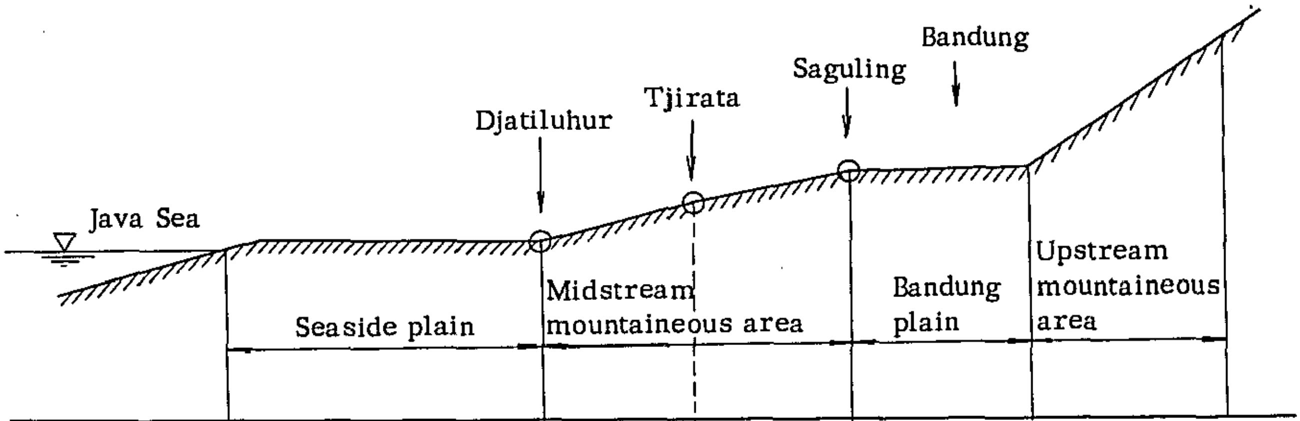
The storage of 170 million m^3 between the lowest water level for power generation, EL. 630 m, and the estimated sedimentation level, EL. 620 m, can not be used for power generation but for irrigation and municipal water supply.

However, the use of this 170 million m^3 for other purposes will make the power generation impossible, which will result in large loss of the benefit produced by several times as much head as Djatiluhur Hydroelectric Power Station. From a viewpoint of the stable supply of power, its loss is very much large.

In view of those considerations, it is the best method for Tjitarum River Comprehensive Development that Saguling site will be developed mainly for power generation and supplementarily for other purposes.

4.2.3. Flood Control

The basin of the River Tjitarum can be classified in terms of the river gradient into four groups; (i) the mountaineous area in the upstream, (ii) the plain part around Bandung, (iii) the mountaineous area in the midstream, and (iv) the plain near the coast of the Java Sea.



Distance from river mouth	0 km	140 km	190 km	235 km	300 km	350 km
Catchment area	6,000 km^2	4,505 km^2	4,090 km^2	2,283 km^2		
Ratio to the total catchment area	100%	75%	68%	38%		
Storage capacity of each dam site		3.0×10^9 m^3	0.9×10^9 m^3	1.1×10^9 m^3		
Storage volume per catchment area (km^2)		670×10^3 m^3	220×10^3 m^3	480×10^3 m^3		

On the basin of the River Tjitarum, the flood control will be required for the seaside plain along the main stream of the River Tjitarum and the area near Bandung where the river gradient is gentle. Djatiluhur dam fulfills an effective function for flood control on the seaside plain. The effect of flood control by Saguling dam will be limited to the area between Saguling site and Djatiluhur site. Its effect of flood control will be extended indirectly to the seaside plain through Djatiluhur dam and directly to the area between Saguling site and Djatiluhur dam. However, such indirect effect will be relatively small, and large portion of the storage capacity of Saguling dam should not be allocated for flood control.

Further investigations should be done for localized flood controls of the basins of the River Tjibeet and other rivers.

4.2.4. Irrigation and Municipal Water Supply

4.2.4.1. Existing Condition of Irrigation

The basin of the River Tjitarum is cultivated to a considerable extent. The accurate arable area is unknown but it may fairly be said that farms are seen in every place of the basin.

Particularly fertile rice fields spread on the seaside plain in the downstream of the River Tjitarum.

Djatiluhur dam irrigates rice fields in the seaside plain and the ultimate irrigated area of Djatiluhur irrigation programme is intended to be 261,000 ha.

As of 1972, parts of the proposed water channels in the same Djatiluhur irrigation programme have not been completed yet and irrigation water is supplied from Djatiluhur dam to rice fields of 224,500 ha for crop in rainy season and those of 210,000 ha for dry season crop. (See FIG. 7 and TABLE 3)

The necessary water for irrigation is intaken from small rivers on the seaside plain flowing directly into the Java Sea and the shortage in the water for irrigation is ultimately supplemented by Djatiluhur dam through the west,

FIG. 7 IRRIGATION AREA OF DJATILUHUR

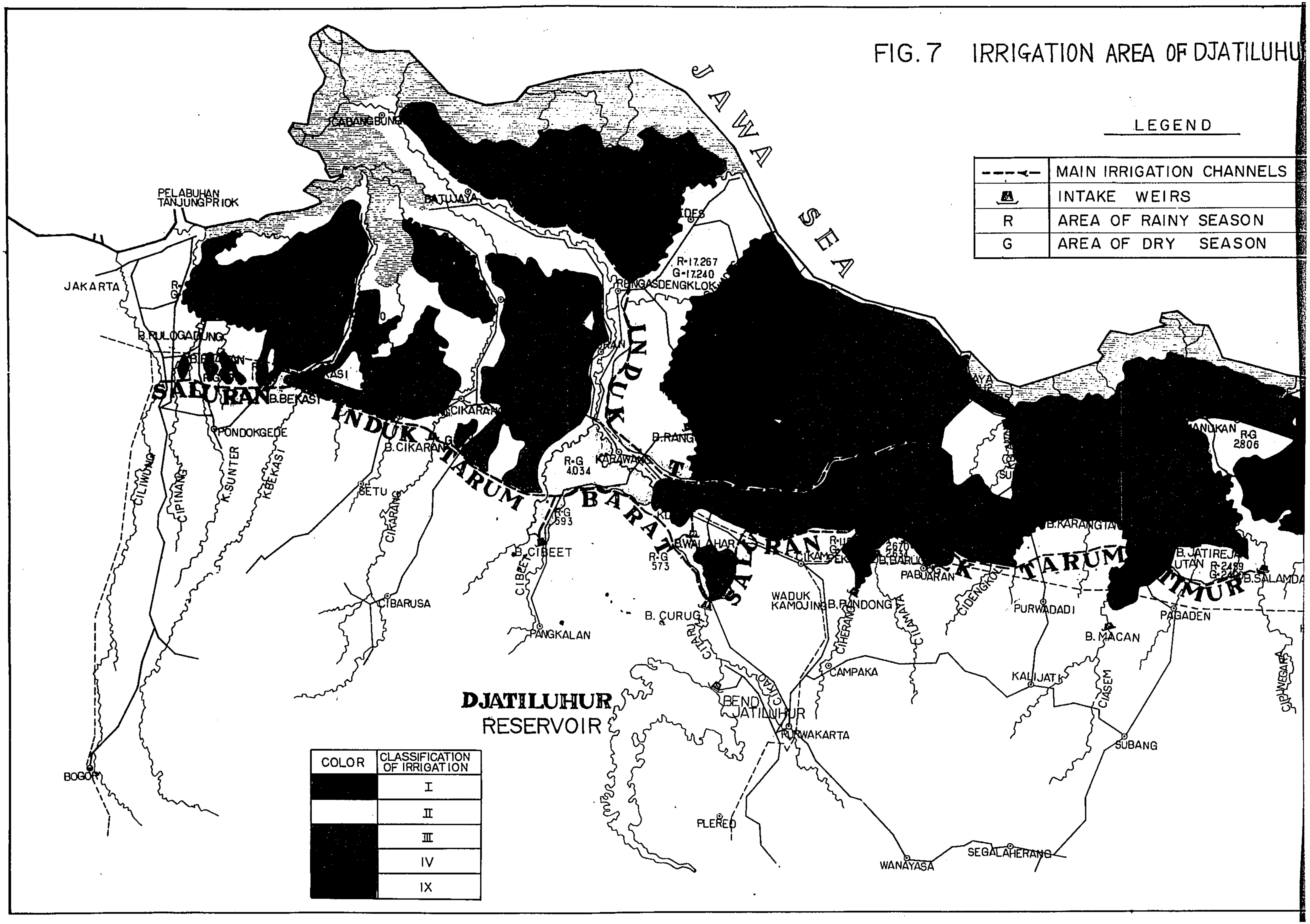


FIG. 7 IRRIGATION AREA OF DJATILUHUR

LEGEND

---<--	MAIN IRRIGATION CHANNELS
(symbol)	INTAKE WEIRS
R	AREA OF RAINY SEASON
G	AREA OF DRY SEASON

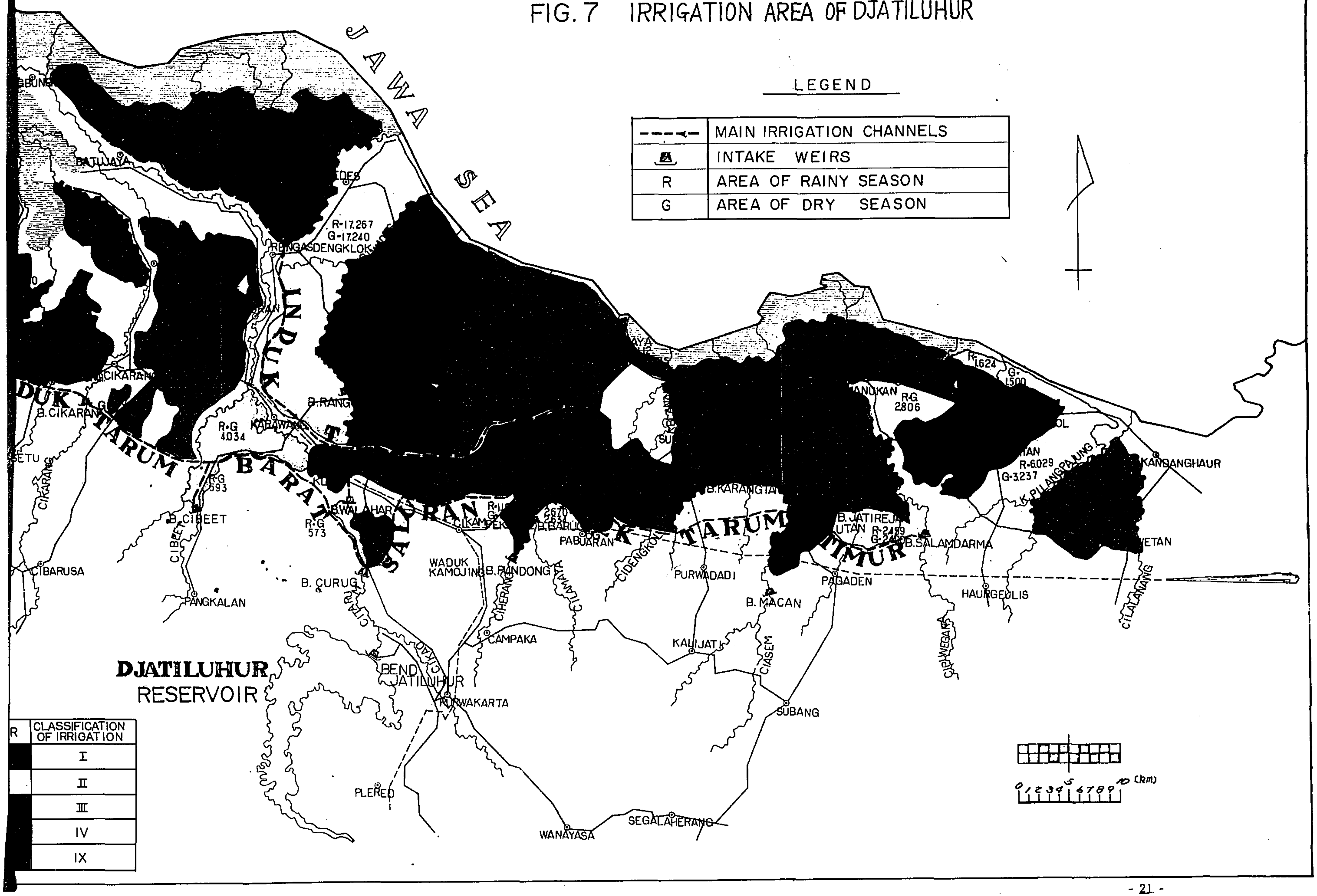
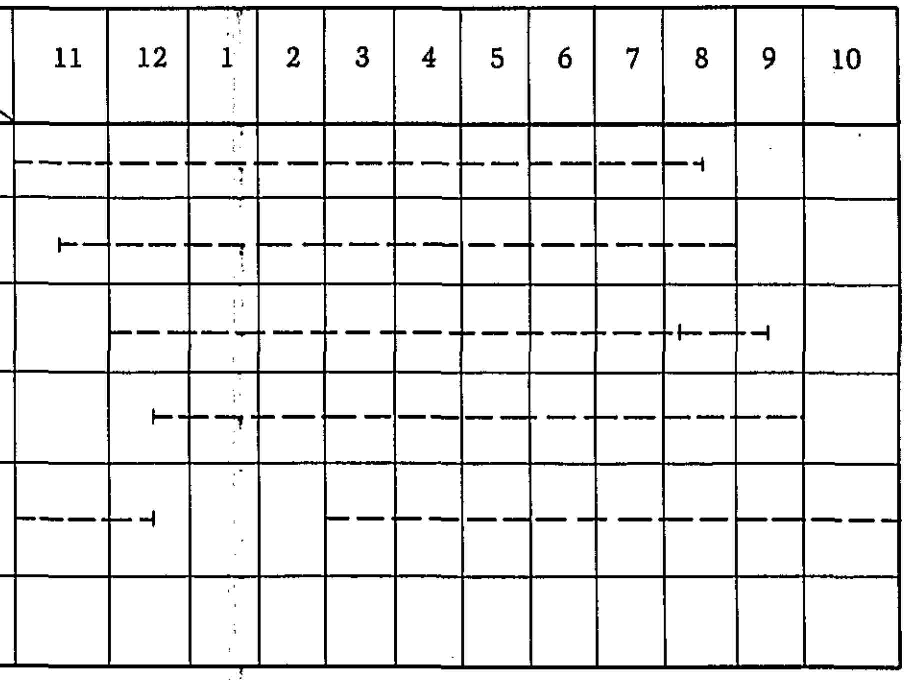


TABLE 3 DJATILUHUR IRRIGATED AREA BY SEASON (from 1972 to 1973)

(ha)

Irrigated Area	Planned Area	1972 - 1973 Irrigated Area											Total
		Rainy Season					Total	Dry Season					
		I	II	III	IV	IX		I	II	III	IV	IX	
West Tjitarum	84,606	-	5,200	18,323	19,477	12,000	55,000	-	5,200	16,673	19,127	10,500	51,500
North Tjitarum	80,039	19,725	17,267	20,997	22,050	-	80,039	19,700	17,240	20,960	20,200	-	78,100
East Tjitarum	96,172	15,725	12,918	21,095	39,723	-	89,461	15,216	9,943	18,206	37,035	-	80,400
Total	260,817	35,450	35,385	60,415	81,250	12,000	224,500	34,916	32,916	55,839	76,362	10,500	210,000

Water Requirements			Classification	Month / Rainy Season/Dry Season
Rainy Season	Dry Season	Supply of Water		
2 months	2 months	1.2 /sec/ha	I	Nov. 1 / Apr. 1
1.5 months	1 month	1.0	II	Nov. 15 / Apr. 15
1.5 months	1 month	0.8	III	Dec. 1 / May 1
-	0.5 month	0.4	IV	Dec. 15 / May 15
5 months	4.5 months		IX	Mar. 1 / Aug. 1
0.1 ℓ/sec/ha is to be reduced from Dec. 1 to Apr. 15.				



north and east Tjitarum main irrigation channels. According to the 1972 irrigation programme, the volume of water to be supplied by Djatiluhur dam is specified as about 3, 700 million m^3.

We estimated the necessary water volume for supply to the ultimate irrigated area in Djatiluhur irrigation programme. As a result, we obtained about 4, 300 million m^3 as the necessary water volume. Djatiluhur irrigation programme will be finished upon realization of the supply of water for irrigation to rice fields of 261, 000 ha.

In the basin of the River Tjitarum, there are places where additional production of rices can be expected by irrigation. Accordingly, dams for agricultural water sources, other than Djatiluhur dam should be considered for cultivation of new irrigated areas.

4. 2. 4. 2. Existing Condition of Municipal Water Supply

A report entitled "Djatiluhur Irrigation Rehabilitation Project" indicates the demand for municipal water supply in Jakarta is as follows.

Year	Population (thousand)		Unit (ℓ/day)	Municipal Water Requirement	
	Total population	Water supply population		Disposed water (m^3/sec.)	Raw water (m^3/sec.)
1972	5, 150	2, 800	150	4. 85	5. 30
1975	5, 500	3, 600	170	7. 00	7. 65
1980	6, 100	4, 700	190	10. 55	11. 40
1985	6, 700	5, 500	200	12. 75	14. 05
2000	8, 300	7, 100	220	18. 00	19. 90

Although now under investigations, it is said that the requirements of water for river purification in Jakarta are 8 m^3/sec.

Adding both requirements, the total water requirements in Jakarta will be as follows;

(Unit: m^3/sec.)

Year	Municipal water	Water for river purification	Total
1972	5.3	8.0	13.3
1975	7.65	8.0	15.65
1980	11.40	8.0	19.40
1985	14.05	8.0	22.05
2000	19.90	8.0	27.90

These water requirements can not be filled up with the water supplies from the existing water sources and Djatiluhur reservoir. The water to be supplied additionally from other rivers neighbouring the River Tjitarum is as per the following table.

(Unit: m^3/sec.)

Item \ Year	1972	1975	1980	1985	2000
(1) Raw water demand	13.30	15.65	19.40	22.05	27.90
(2) Existing supply capability	1.0	1.0	1.0	1.0	1.0
(3 Water requirements (1) - (2)	12.30	14.65	18.40	21.05	26.90
(4) Water supply from Djatiluhur dam	10.8	10.8	10.8	10.8	10.8
(5) Water supply to be supplemented by other rivers	1.5	3.85	7.6	10.25	16.1

Furthermore, the urban area of Jakarta city expands rapidly eastwards. At an area south of Tanjung Priok, it seems that agricultural facilities may not be newly built or improved. It is estimated that the water demand both for drinking and industrial use in the above area will be 6.95 m^3/sec. in 1985. The shortage in water supply to Jakarta will, therefore, be 500 million m^3/year, even after addition of water supply (1.5 m^3/sec.) from Tjiliwung in the neighbourhood of Jakarta, with the following calculation.

$$10.25\ m^3/sec. - 1.5\ m^3/sec. + 6.95\ m^3/sec. = 15.7\ m^3/sec.$$
$$\fallingdotseq 500 \text{ million } m^3/year$$

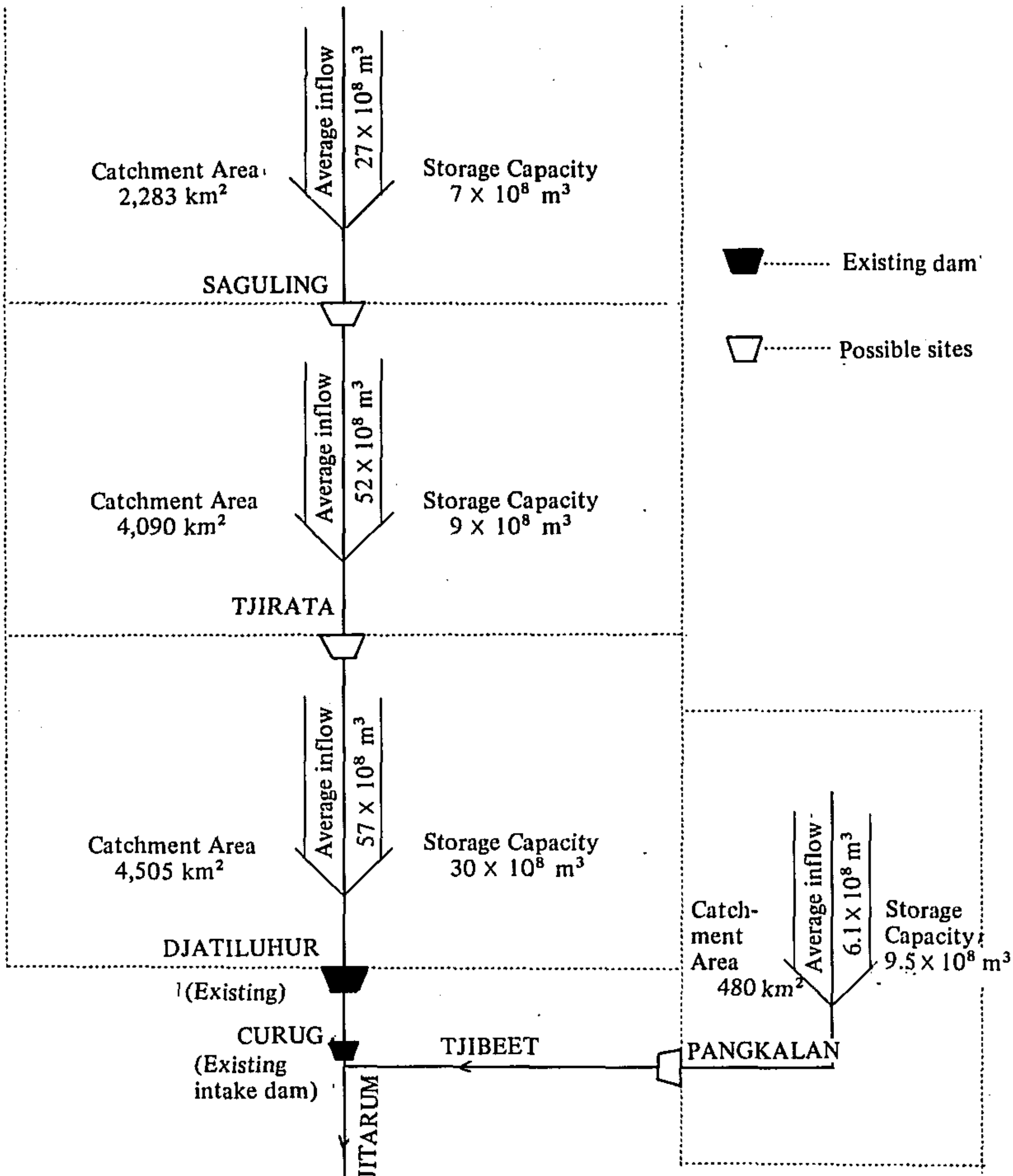
4.2.4.3. Supply of Additional Water Requirements for Irrigation and Municipal Water

The average inflow into Djatiluhur reservoir (catchment area: 4,505 km^2) is about 5,700 million m^3 per year. The plan for supply of agricultural and municipal water should be worked out on the basis of 10 years return period drought year. The 10 years return period drought inflow to Djatiluhur reservoir is estimated approximately 4,400 million m^3 which is approximately equivalent to about 4,300 million m^3, the necessary water requirement for irrigation from Djatiluhur dam. (See FIG. 8)

In more extreme drought years than the 10 years return period drought years, Saguling reservoir will supplement the water supply for irrigation from Djatiluhur reservoir effectively. In the past fifty years, continuation of drought years was recorded several times. The extreme drought periods were 1925 to 1927 and 1963 to 1966. During those periods, the water supply for irrigation might be naturally short.

In establishing a plan for expansion of irrigated area of more than 261,000 ha which is a final target of the existing Djatiluhur irrigation programme, a new dam site should be considered. At present, such plan for expansion of irrigated area is not studied on the basin of the River Tjitarum. In future when such expansion of irrigated area will be required, Tjirata dam site and Pangkalan dam site on the River Tjibeet will be candidate sites.

FIG. 8 INFLOW TO DAM SITES ON THE RIVER TJITARUM



Inflow in per return period

(10^6 m^3)

Year / Dam site	Dry Year 50	30	20	10	5	Average	Rainy Year 5	10	20	30	50
DJATILUHUR	3,827	3,969	4,111	4,394	4,820	5,670	6,804	7,229	7,655	7,938	8,363
TJIRATA	3,478	3,607	3,736	3,994	4,382	5,153	6,183	6,571	6,958	7,214	7,601
SAGULING	1,723	1,796	1,940	2,010	2,300	2,728	3,377	3,236	4,023	4,237	4,454
PANGKALAN	410	422	438	469	513	605	725	772	816	847	891

The problem is the same for supply of municipal water. Especially, Pangkalan dam site on the River Tjibeet is not developed and the whole discharge of this river flows into the Java Sea. The development of this site should be made for the effective use of water resources. The catchment area of this dam is as small as 480 km^2, but its storage capacity is as large as 950 million m^3. Accordingly, there is some possibility that water will be diverted from the main stream of the River Tjitarum and will be stored in Pangkalan reservoir. The annual inflow from its own catchment area is approximately 500 million m^3 in a 10 years return period drought year which is equivalent to the water shortage in municipal water. Located near Jakarta, Pangkalan dam site may be developed to cope with the future demand for municipal water in Jakarta.

4.2.5. Other Utilizations

The sightseeing and recreation are also included in the benefits of Saguling Hydroelectric Power Project Development.

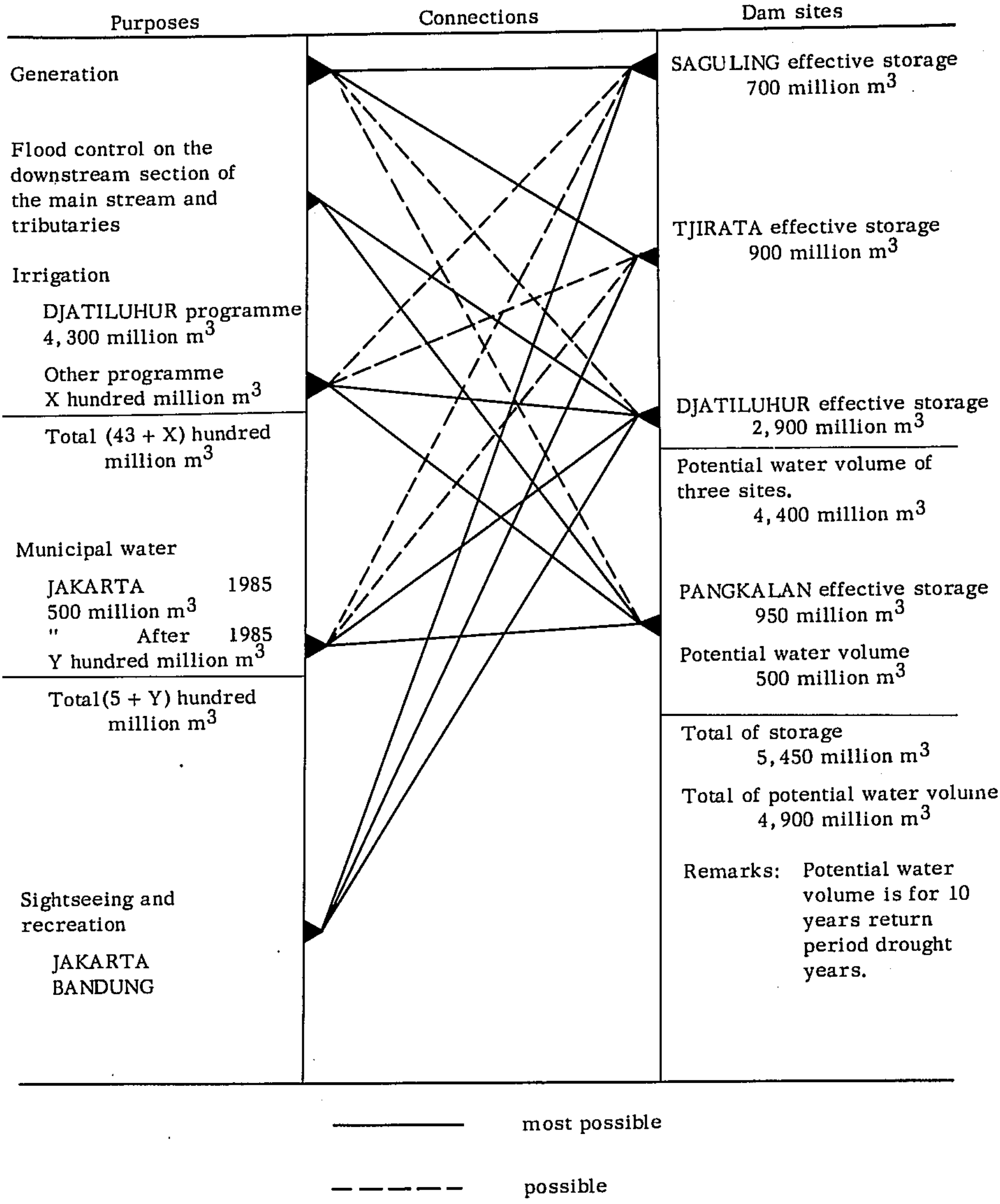
Dam sites proposed on the River Tjitarum are located near Bandung and Jakarta having tremendous populations and have large utility values for sightseeing, resorts and fishing and boating.

A large volume of water for irrigation is intaken from Curug Weir downstream of Djatiluhur. Downstream of this weir, the discharge coming from the upper section of the River Tjitarum is decreased. Accordingly, any merit for navigation can not be expected with the construction of Saguling Hydroelectric Power Project.

4.2.6. Tjitarum River Comprehensive Development

As mentioned before, the combinations between the dam sites on the basin of the River Tjitarum and its neighbourhood and the purposes for developments are shown on FIG. 9.

FIG. 9 COMBINATIONS BETWEEN DAM SITES AND PURPOSES FOR DEVELOPMENT



For hydroelectric power developments, Saguling site should be developed first. After that, Tjirata dam site and other economical dam sites will be developed.

For supplies of agricultural and municipal water, Djatiluhur dam serves as a key dam, but Pangkalan and Tjirata dam sites will be developed for future expansion.

Small possible dam sites on the seaside area will be developed for irrigation on the basis of long-term plan, and water allocated now for irrigation in Djatiluhur reservoir may be transferred to the needs for municipal water.

For flood control, the development of Tjirata dam site can be considered in case of need, but a plan for localized flood control should be established concerning Pangkalan dam site and other tributaries.

Putting the above together, a recommended concept for comprehensive development of the River Tjitarum is summarized on FIG. 10.

4.3. Studies of Saguling Hydroelectric Power Project Development Capacity

4.3.1. Studies of Storage Capacity

4.3.1.1. Storage Capacity and Reservoir Area to Storage Water Level

The storage capacity curve of Saguling reservoir was calculated with aerographic maps at a scale of 1/5,000.

The relation of the water level of the reservoir with the storage capacity and the reservoir area is shown on FIG. 11. The storage capacity will be $1,105 \times 10^6$ m^3 at EL. 650 m and the reservoir area will be 58 km^2 at EL. 650 m.

4.3.1.2. Sediments

On the assumption that sediment transport of river water will be 1 mm per year and that service life of the dam will be 100 years, the estimated amount of sediment accumulation in Saguling reservoir for the life of the dam will be;

$1,000\ m^3/km^2/year \times 2,283\ km^2 \times 100\ years = 228.3 \times 10^6\ m^3$

Therefore, the sedimentation level will be EL. 620 m, assuming that sediments will accumulate horizontally.

4.3.1.3. Determination of Lowest Water Level of the Reservoir

The sedimentation level has been determined to be EL. 620 m. Then, the lowest water level of the reservoir has been determined to be EL. 630 m, because the lowest water level should be higher by water depth equivalent to two times as much as the internal diameter of the waterway than the sedimentation level in order to avoid cavitation. Accordingly, the water between EL. 620 m and EL. 630 m will be dead water, the volume of which will be $171.7 \times 10^6\ m^3$.

4.3.1.4. Maximum Capacity of Reservoir

There is a road which branches off southwards from a trunk road connecting Jakarta with Bandung and crosses the River Tjitarum around the end of the proposed Saguling reservoir, leading to Tjililin.

Aerographic maps at a scale of 1/5,000 for the area around the end of the proposed Saguling reservoir are not available. Accordingly, we cannot study an effect of the reservoir upon the level of ground water in Bandung on the maps. However, it is likely that, if the high water level of the reservoir is planned more than EL. 650 m, the reservoir will have some influence upon the level of ground water in Bandung elevated approximately at 700 m.

After the field reconnaissance of the area around the end of the proposed reservoir and the studies of reservoir water levels proposed by the previous reports, it is concluded that the maximum water level of the reservoir will be EL. 650 m.

FIG. 10 COMPREHENSIVE DEVELOPMENT OF TJITARUM RIVER BASIN

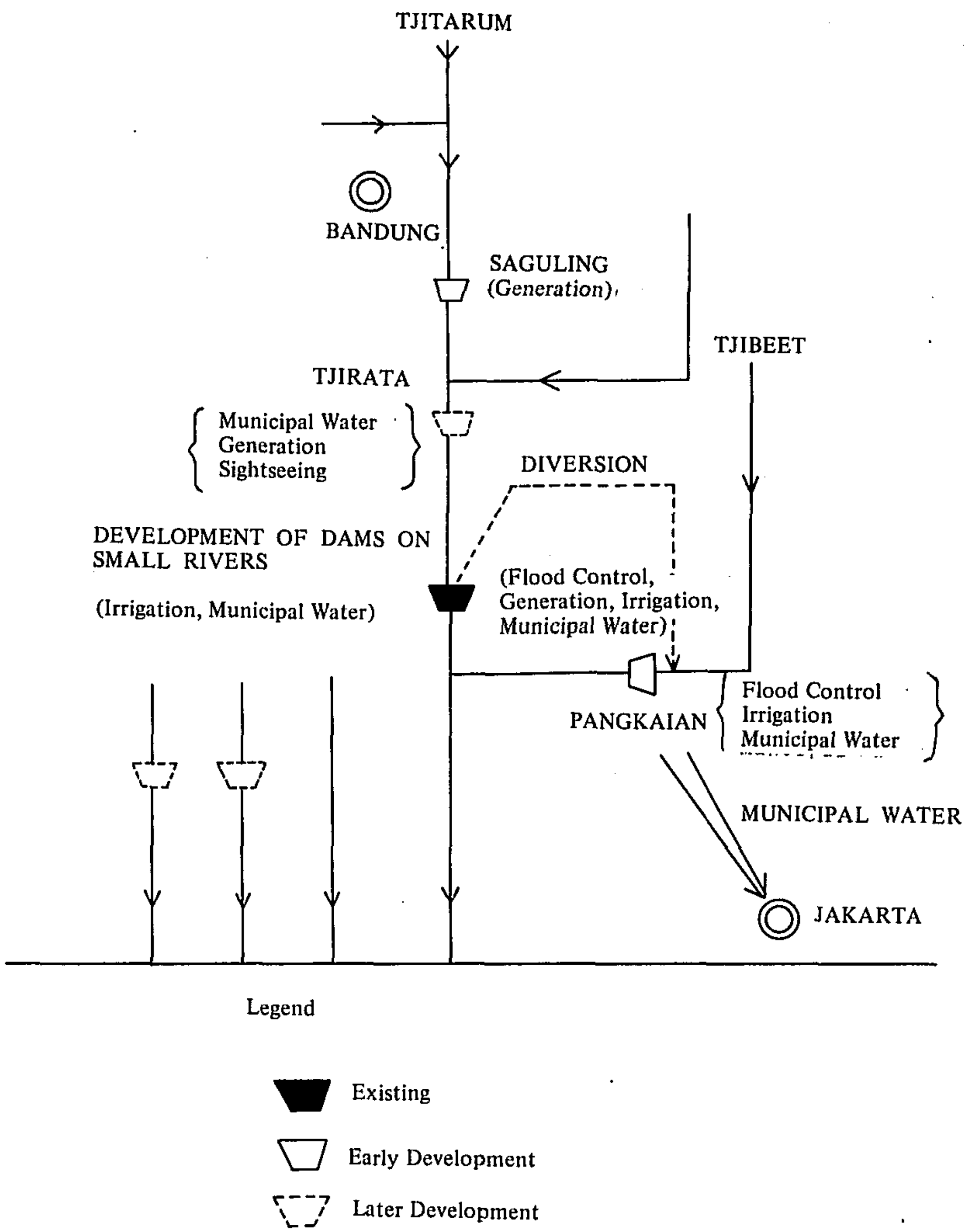
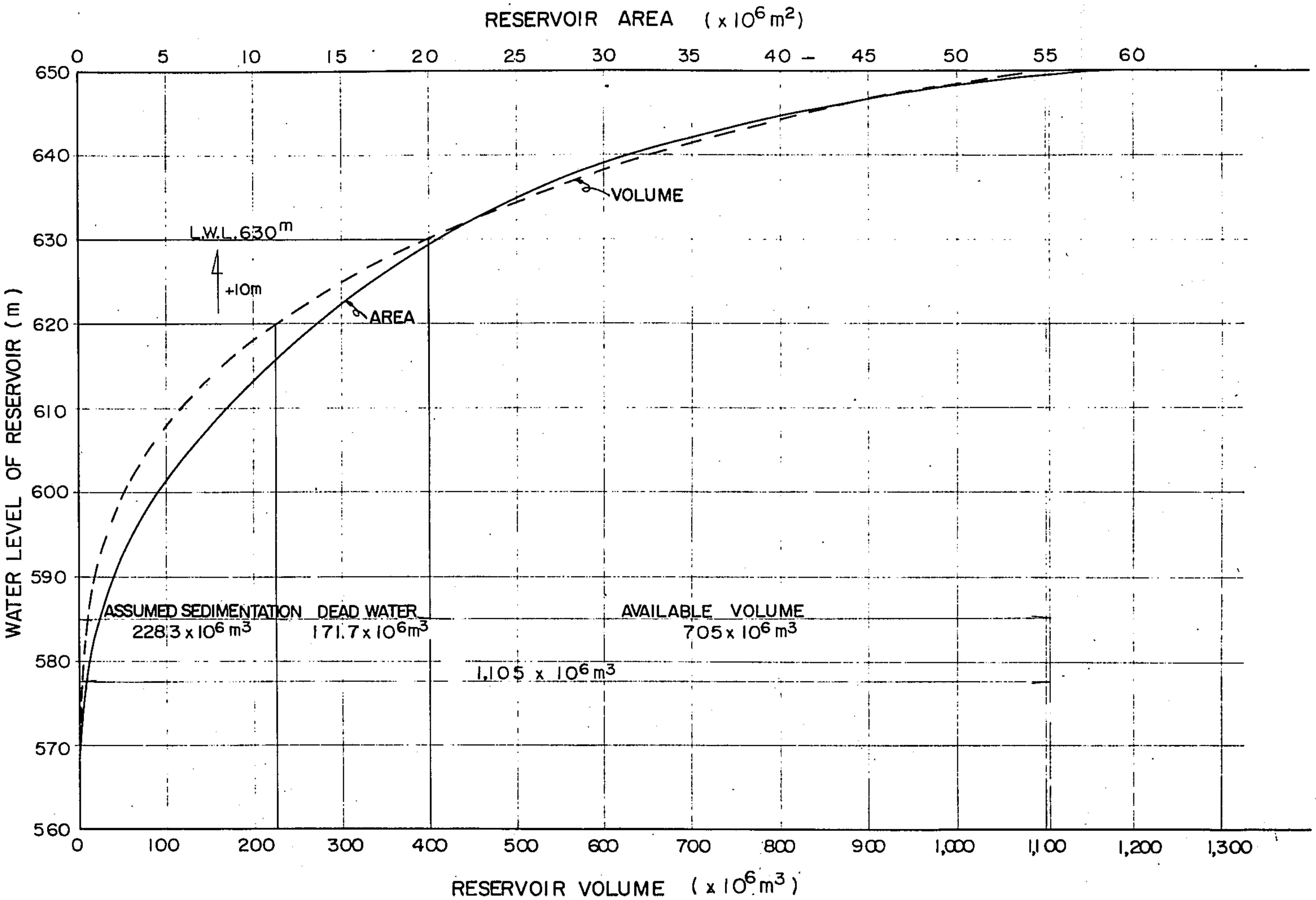


FIG. 11 RESERVOIR AREA AND VOLUME CURVE



4.3.2. Determination of Dam Height

The following alternatives have been compared with.

Features / Alternative	H.W.L. of reservoir (m)	Effective storage capacity ($10^6 m^3$)	Maximum discharge (m^3/sec.)	Maximum output (MW)
(1)	580	5	56.0	142
(2)	635	115	78.4	236
(3)	640	255	106.0	324
(4)	645	425	139.6	439
(5)	650	705	194.8	613

The economic comparison of the alternatives has been made with the help of electronic computers. As a result, we have obtained the following figures of B/C (Benefit/Cost) and B-C (Benefit – Cost).

Unit: 1 million Yen ($ thousand)

	B/C	B-C
H.W.L. = EL. 580	2.09	1,250 ($ 4,167)
H.W.L. = EL. 635	1.78	1,663 ($ 5,543)
H.W.L. = EL. 640	1.94	2,381 ($ 7,937)
H.W.L. = EL. 645	1.61	2,344 ($ 7,813)
H.W.L. = EL. 650	1.64	3,027 ($10,090)

This shows the larger the dam height is, the larger the B-C is. However, restricted by the topographic condition, the H.W.L. 650 m of the reservoir will be most optimum for the dam scale. Accordingly, EL. 650 m has been determined as the H.W.L. of the proposed reservoir.

4.3.3. Determination of Installed Capacity of Power Station

It is needless to say that Saguling Hydroelectric Power Station should be designed as peak-load power station. Peak-load power stations can be put in power systems for peak hours of more than six hours. In view of the existing and future conditions of the West Java Power System, it is proper that this power station should be designed a peak-load power station serving for peak hours of 6 hours.

Accordingly, the ultimate capacity of Saguling Hydroelectric Power Station has been determined so as to serve for 6 hours peak load. For 51 years from 1919 to 1970, the minimum firm discharge becomes 48.7 m^3/sec. in case the H.W.L. of Saguling reservoir is EL. 650 m.

It is most reasonable that we should adopt 48.7 m^3/sec. (about 50 m^3/sec.) as the firm discharge.

Accordingly, the maximum discharge has been calculated by:

$$50 \text{ m}^3/\text{sec.} \times \frac{24 \text{ hrs.}}{6 \text{ hrs.}} = 200 \text{ m}^3/\text{sec.}$$

The output of the Saguling Hydroelectric Power Station has been determined as follows:

Firm output = 9.8 x Firm Discharge x Effective Head x Mechanical Efficiency

$$= 9.8 \times 50 \text{ m}^3/\text{sec.} \times 362.2 \times 0.87$$

$$\fallingdotseq 150 \text{ MW}$$

$$\text{Maximum output} = 150 \text{ MW} \times \frac{24 \text{ hrs.}}{6 \text{ hrs.}} = 600 \text{ MW}$$

As number of units, two 300 MW units are technically possible. However, four 150 MW units has been recommended for stability of the power system.

4.3.4. Studies of Method for Development

Two methods for development of Saguling Hydroelectric Power Station can be considered: the one is one stage development of 600 MW and the other two stage development in concert with the expansion of the power demand. We have set up two alternatives for study.

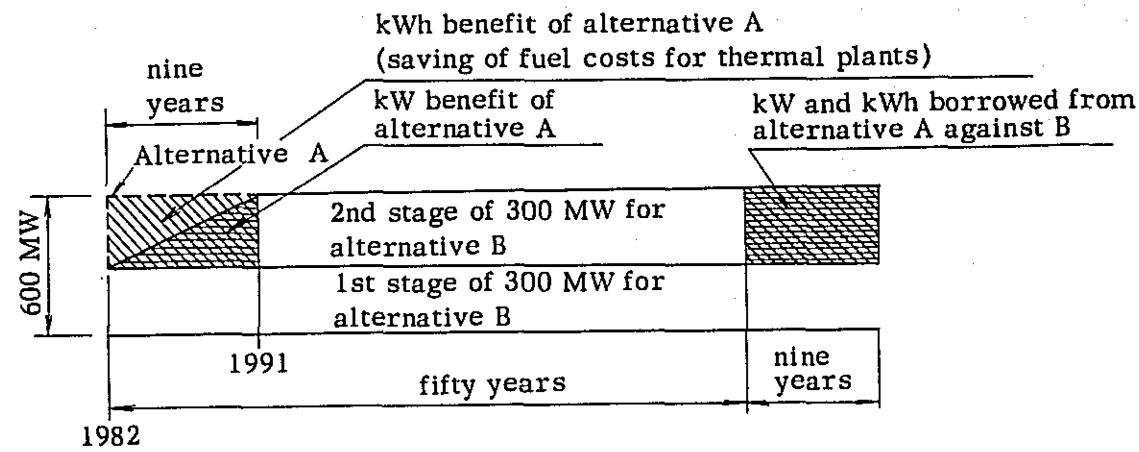
Alternative \ Feature	Develop-ment	Number of conduit	Transmission voltage (kV)	Output (MW)
A	1 stage	2	270	600
B	2 stages	2	270	1st stage 300 2nd stage 300

The time difference between the one stage development and the two stage development is estimated to be nine years.

The following table shows a difference in the generated energy between the one stage development and the two stage development.

Method for development	Maximum discharge (m^3/sec.)	Annual average potential energy (10^3 MWH)	Remarks
One stage development (A)	200	2,041	There is few dif-ference in the effect upon Djatiluhur Dam
Two stage development (B)	100	1,712	
Difference	100	329	

In the two stage development, the capital investment for the 2nd stage can be postponed by 9 years. There is a difference in kW and kWh caused by the time interval of 9 years between the alternative A and the alternative B.



For a comparative study of the alternatives A and B, the yearly benefit of the alternative A has been converted to the present worth in 1982, and the capital costs for 2nd stage of the alternative B have been converted to the present worth in 1982, as the investment of capital costs for the 2nd stage can be postponed by 9 years. The rate of return was changed between 0% and 20% in calculating the present worth.

TABLE 4 and FIG. 12 show the total costs of each alternative calculated at the present worth in 1982 to modify a difference in the benefits among the alternatives A and B.

From TABLE 4 and FIG. 12, it is known that the alternative A is economical in case the rate of return is up to 13% and the alternative B is economical at the rate of return of more than 13%.

The rates of return for public projects in Indonesia range usually from 10% to 14%. We wish, therefore, to recommend the one stage development of 600 MW. Additionally, this method will bring the following secondary effects:

a) At an emergency time when Djatiluhur Hydroelectric Power Station can not be operated in an extreme drought year or thermal power plants suffer damage, this power station will serve as reserve power.

b) Through the execution of the construction work, Indonesian engineers, technicians and labourers engaged in the construction work will become skilful. Once those skilful forces will be scattered because of the suspension of the works, it will be very much difficult to gather those scattered forces. If the development will be made at one stage, such problem will not come out.

In the meantime, there is not so big difference in the capital costs capitalized in 1982 between the alternatives A and B. There still remains the possibility that the alternative B will substitute for the alternative A, in the event the financial arrangement of such huge amount will be difficult and the peak load will not increase as estimated.

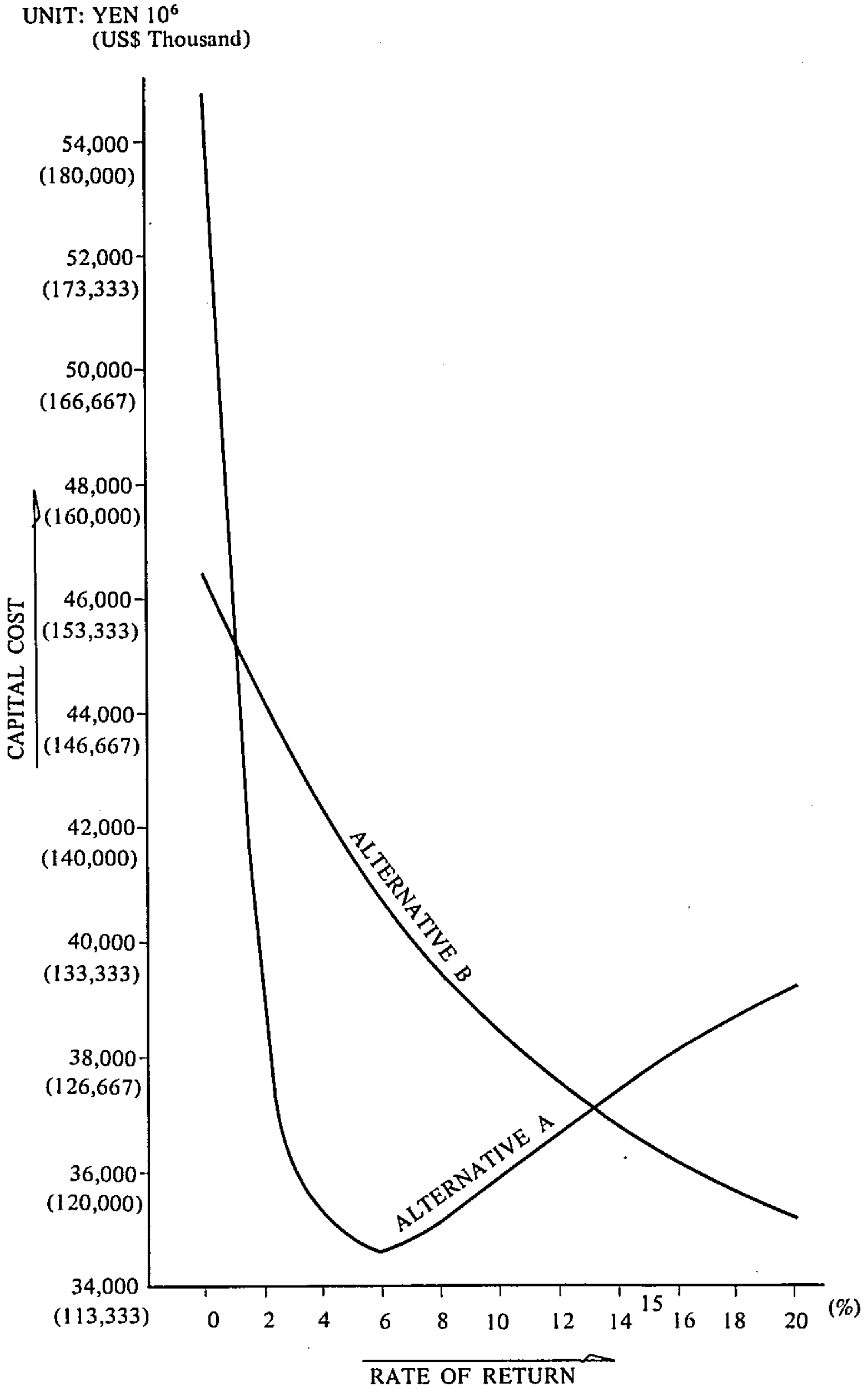
TABLE 4 Estimated Present Worth as of 1982 of Alternatives

Unit: 10^6 Yen
($ thousand)

Alternative	Rate of return	0%	2%	4%	6%	8%	10%	12%	14%	16%
Alternative A	Capital costs	46,000 (153,333)	46,000 (153,333)	46,000 (153,333)	46,000 (153,333)	46,000 (153,333)	46,000 (153,333)	46,000 (153,333)	46,000 (153,333)	46,000 (153,333)
	kW merit	△8,777 (29,257)	4,076 (13,587)	7,629 (25,430)	8,225 (27,417)	7,897 (26,323)	7,340 (24,467)	6,746 (22,487)	5,928 (19,760)	4,832 (16,107)
	Saving of fuel cost for thermal plants	0	2,488 (8,293)	3,099 (10,330)	3,120 (10,400)	2,961 (9,870)	2,769 (9,230)	2,575 (8,583)	2,312 (7,707)	1,955 (6,516)
	Balance	54,777 (182,590)	39,436 (131,453)	35,272 (117,573)	34,655 (115,516)	35,142 (117,140)	35,891 (119,636)	36,679 (122,263)	37,760 (125,866)	39,213 (130,710)
Alternative B		46,400 (154,667)	44,148 (147,160)	42,296 (140,987)	40,768 (135,893)	39,503 (131,677)	38,453 (128,177)	37,576 (125,253)	36,523 (121,743)	35,274 (117,580)

Note:
1. All the costs have been converted to the present worth in 1982, with the rate of return varied from 0% to 20%. (Completion of the alternative A will be in 1982 and the alternative B in 1991.)
2. Functional difference of the alternative A from the alternative B has been converted to the present worth.
3. △ ..... minus (-)

FIG. 12 ESTIMATED PRESENT WORTH AS OF 1982 OF ALTERNATIVES



SECTION 5.

PRELIMINARY DESIGN OF SAGULING HYDROELECTRIC POWER PROJECT

5. PRELIMINARY DESIGN OF SAGULING HYDROELECTRIC POWER PROJECT

5.1. Main Characteristics of Saguling Hydroelectric Power Project

(1)	Dam (Upper midstream site)	Type	Center core type rockfill dam
		Height	88 m
		Crest width	10 m
		Crest length	657 m
		Abutment width	406 m
		Dam slope on upstream side	1 : 2.5
		Dam slope on downstream side	1 : 2.0
		Design flood discharge	2,500 m^3/sec.
		Dam volume	3,000,000 m^3
		Excavation of dam foundation	950,000 m^3
		Spillway	
		Excavation	250,000 m^3
		Concreting	110,000 m^3
(2)	Intake	Type	Inclined type
		Dimension	width-10m, height-10m
		Gate	Steel roller gate
(3)	Pressure tunnel	Number of line	2
		Type	Circular pressure tunnel
		Internal diameter	5.8 m
		Length	4,807 m
		Concrete thickness	60 cm

	Acting internal pressure	At the inlet of the headrace 35 ton/m^2
	Water passing area	$f = 26.421\ m^2$
	Discharge	$Q = 100\ m^3/sec.$
	Velocity	$V = 3.785\ m/sec.$
	Gradient	$i = 1 : 241$
(4) Surge tank	Number	2 (each one for one conduit)
	Type	Restricted-orifice type
	Internal diameter	12 m
	Acting internal pressure	At the base 85 ton/m^2
	Height	80 m
	Port diameter	Dr = 3 m
	H. W.L.	EL. 680.1
	L.W.L.	EL. 607.1
	Top of tank	EL. 684.7
	Bottom of port (surface)	EL. 604.7
(5) Penstock	Number	2
	Type	Steel penstock
	Pipe length	1,202 m x 1 line, 44 m x 2 lines
	Internal diameter	4 m 2.8 m
	Pipe thickness	12 - 51 mm
	Upper part	Upper section 997 m long (EL. 598 - 403.5) Open type
	Lower part	Lower section 245 m long (EL. 403.5 - 285) Underground type
	Manifold	Starting from a place 30 m far from the entrance of the power house
	Maximum internal pressure at the end of penstock	P = 392+118+30 = 540 ton/m^2

(6) Power house	Type	Indoor type, reinforced concrete structure
	Dimensions	
	Aboveground portion	Width 30m, length 89m, height 15m
	Underground portion	1F-B2 width 30m, length 79m depth 8m B3-B6 width 30m, length 70m, depth 24m The width of main building is 20m on the mountain side out of the total width of 30m.
	Water turbine axis elevation	EL. 258 m
	Space	Width in the same direction as the route of penstock: from the center of main equipment to the mountain side .... 18 m from the center of main equipment to the river side .... 40 m Length: 125 m
	Approximate excavation	360,000 m^3
	Approximate elevation of slope	95 m
(7) Tailrace	Type	Tunnel type
	Internal diameter	5 m x 4 lines
	Discharge	50 m^3/sec. per line
	Length	36 m
(8) Switchyard	Area	Width 125 m x length 116 m (in parallel to the river) (at a right angle to the river)
	Attached building	Width 20 m x length 30 m

(9) Main equipments

1) Water turbine	Type	Vertical shaft, single runner, single discharge, vortex type Francis
	Maximum output	158 MW
	Effective head	362.2 m
	Discharge	50 m^3/sec.
	Revolution	333 rpm
	Draft head	–9.0 m
	Number of unit	4
2) Generator	Type	Vertical shaft revolving field, sub-umbrella, with air cooler.
	Output	170 MVA
	Voltage	11 - 20 kV
	Power factor	91.4%
	Frequency	50 Hz
	Revolution	333 rpm
	Number of unit	4
3) Main transformer	Type	Outdoor, special three-phase, oil-filling, fan cooling
	Capacity	170 MVA
	Voltage primary/ secondary	11 - 20/275 kV
	Frequency	50 Hz
	Number of unit	4

5.2. Dam

5.2.1. Hydrology and Climate

Hydrological observations of the River Tjitarum have been made from long time before, probably because of its importance as water resources in West Java, and many hydrological data are available.

Thirteen discharge gauging stations are confirmed on the River Tjitarum and the recording of the river flow commenced from the year of 1917. However, none of them has continuous records of the discharge measured for a long year.

At Saguling dam site, a gauging station was installed in 1970, and the readings of this gauging station are useful in comparing with those obtained from other stations.

Those gauging stations had suspended their recording from 1944 to 1951. Accordingly, the discharges during this period were estimated from the precipitation data. The discharge of Saguling dam site estimated on the above mentioned method is shown on TABLE 5:

In Indonesia, it is sufficient enough if the wind velocity of 20 m/sec., the maximum wind velocity recorded in the past at an other site, is considered in planning the project.

In Indonesia, any large damage given to civil structures owing to earthquakes has not been recorded yet. In designing the civil structures, 0.1 g is used as the possible maximum ground earthquake motion. This value was used for design of Djatiluhur dam.

5.2.2. Geology

The rocks of Saguling Project site have the following formations described in a descending order from the upper part to the lower part, according to the geological map, "Tjiandjur Djawa" issued by Geological Survey Institute of Indonesia;

TABLE 5 DISCHARGE AT SAGULING SITE

(m^3/sec.)

YEARS	DRY SEASON					RAINY SEASON							DRY SEASON	RAINY SEASON	YEAR
	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	MEAN	MEAN	MEAN
'19-'20	94.9	29.1	21.5	14.8	24.6	101.1	180.7	155.5	155.5	165.1	145.9	59.9	36.7	137.6	95.5
20-21	40.8	22.3	55.3	83.0	156.7	93.9	58.4	112.5	100.0	136.3	168.7	46.9	71.7	102.1	89.4
21-22	31.2	28.3	23.4	15.8	24.1	46.4	104.7	111.2	90.2	143.5	179.5	175.9	24.6	122.2	81.3
22-23	64.4	30.3	25.8	18.8	44.9	139.8	110.9	62.0	171.6	62.4	46.8	103.2	36.8	98.6	72.7
23-24	81.2	95.1	16.6	11.0	10.2	48.5	115.7	135.9	122.4	157.1	243.9	108.9	42.8	133.2	95.3
24-25	44.9	30.5	13.0	10.3	92.2	138.8	166.8	93.6	79.4	86.9	105.1	42.9	38.3	102.1	75.3
25-26	14.2	12.5	7.2	8.2	11.4	13.4	80.1	75.6	142.7	194.7	77.3	108.0	10.7	98.7	61.8
26-27	25.4	11.3	6.2	8.0	25.3	25.9	62.6	95.1	68.2	117.6	142.7	108.0	15.2	88.9	58.0
27-28	49.7	23.8	19.2	10.8	14.2	93.5	182.2	194.7	145.6	163.9	198.6	62.5	23.5	148.8	96.4
28-29	52.1	21.2	30.6	14.9	44.1	150.4	212.1	112.8	141.7	149.4	98.3	46.4	32.6	130.0	89.2
29-30	26.7	13.4	9.1	6.8	24.4	42.6	82.9	68.8	93.4	166.8	159.1	192.8	16.1	115.6	73.9
30-31	43.3	30.1	14.3	12.0	51.9	74.5	90.1	88.8	133.9	300.6	145.9	133.9	30.4	138.6	93.2
31-32	57.7	25.2	22.8	12.2	51.7	55.7	137.5	122.4	92.1	190.3	226.2	181.9	33.9	144.2	98.1
32-33	89.2	28.1	13.9	33.1	26.6	57.3	79.7	168.7	147.1	110.2	155.5	97.6	37.9	116.3	83.4
33-34	85.4	38.1	28.4	53.0	52.5	96.8	175.9	172.3	83.1	53.0	150.7	78.3	51.2	116.1	88.9
34-35	31.7	16.6	14.2	32.0	44.0	99.9	154.3	121.6	161.5	149.5	153.1	54.7	27.6	127.3	85.5
35-36	46.4	12.1	7.2	8.3	23.1	80.3	99.4	78.3	133.5	199.9	143.2	93.0	19.3	118.1	76.8
36-37	40.7	22.3	19.9	12.9	38.0	129.7	103.7	89.0	152.9	179.9	167.0	151.3	26.8	138.8	91.8
37-38	110.7	25.8	12.7	20.4	57.9	46.9	157.8	148.0	89.0	202.6	121.6	129.1	45.2	128.8	93.8
38-39	97.8	81.4	49.7	18.2	18.8	13.3	130.7	72.2	98.9	83.4	89.5	55.4	53.1	77.6	67.3
39-40	79.8	92.0	56.4	26.0	48.0	80.3	139.9	94.0	90.4	247.1	191.3	186.4	60.5	147.7	111.3
40-41	93.5	58.4	32.3	12.4	15.0	50.4	136.7	86.3	161.0	151.8	196.7	154.5	42.2	133.6	95.3
41-42	75.8	32.4	14.3	14.2	39.9	48.5	164.3	173.8	92.6	104.2	100.0	39.5	35.2	103.7	75.0
42-43	23.2	18.2	67.7	39.8	87.5	94.8	98.9	85.4	133.1	170.8	167.5	99.4	47.5	121.2	90.3
43-44	77.8	44.2	44.7	17.7	88.4	123.7	64.0	116.6	64.8	106.5	83.9	36.3	54.6	85.1	72.4
44-45	11.0	17.8	15.6	23.7	47.3	105.6	71.4	77.6	128.5	67.5	96.3	48.6	23.2	84.3	58.7
45-46	6.1	10.8	13.6	59.9	53.9	94.2	77.5	93.0	93.4	94.4	30.6	47.1	28.8	75.6	56.0
46-47	30.7	33.7	45.6	41.5	36.9	73.7	140.7	133.9	77.5	87.0	79.8	33.8	37.7	89.8	67.9
47-48	14.0	54.8	48.7	69.7	92.8	81.6	114.6	77.5	81.3	111.1	70.3	43.7	56.2	83.0	71.8
48-49	33.0	31.4	14.9	30.8	38.4	90.3	108.6	108.7	52.7	56.6	83.1	58.9	29.7	80.2	59.0
49-50	55.3	14.9	13.6	30.2	39.7	64.9	40.0	62.1	75.3	101.0	75.2	78.5	30.6	70.9	54.0
50-51	54.2	55.3	12.7	69.5	63.3	113.1	53.1	121.5	86.1	57.2	52.3	48.9	50.9	75.8	65.4
51-52	31.7	26.3	42.2	28.4	36.7	44.5	117.7	113.6	96.8	127.9	87.0	57.2	33.1	92.3	67.0
52-53	17.8	28.8	40.3	17.6	75.7	96.3	105.1	96.1	72.5	126.2	102.1	60.3	36.3	94.3	70.0
53-54	57.8	16.8	29.3	7.9	80.5	5.7	81.0	124.3	112.0	79.9	52.2	81.6	38.5	76.6	60.7
54-55	34.4	20.7	53.1	47.5	79.9	133.2	102.9	119.4	88.5	127.0	80.5	52.1	47.2	100.6	78.2
55-56	70.2	64.9	57.7	44.5	92.1	94.6	111.0	92.6	48.1	66.2	73.1	60.9	66.0	78.3	73.0
56-57	78.8	37.2	65.6	62.6	96.0	96.3	59.1	124.2	67.9	111.9	88.3	34.5	68.0	83.3	76.9
57-58	54.7	76.8	28.9	9.8	41.6	65.5	77.4	103.3	107.4	111.4	85.6	84.5	42.5	90.6	70.5
58-59	30.3	94.4	69.3	46.3	61.5	71.9	98.7	88.3	134.6	110.4	86.2	81.7	60.6	95.6	80.9
59-60	33.9	55.9	108.7	21.8	36.0	71.0	92.7	126.6	102.6	118.0	104.5	85.4	51.6	100.2	79.9
60-61	23.1	37.7	19.9	34.4	44.9	132.1	102.2	130.5	106.5	78.9	88.9	65.0	32.0	100.4	63.1
61-62	18.6	8.9	6.7	9.2	8.8	39.6	96.2	105.0	131.0	118.7	89.4	45.8	10.4	89.0	56.1
62-63	40.4	62.4	27.3	15.6	70.3	88.4	167.1	110.5	123.0	91.1	89.4	53.7	43.4	103.2	78.1
63-64	15.8	6.7	4.7	4.0	9.0	31.7	48.5	66.2	48.8	87.9	144.1	88.0	8.0	73.7	46.2
64-65	30.8	15.4	25.4	32.2	75.8	104.3	97.4	189.9	193.8	76.9	71.7	50.4	36.0	111.1	79.6
65-66	21.7	13.7	5.3	3.8	4.7	28.9	126.9	136.5	112.5	166.8	76.9	61.2	9.8	101.7	63.2
66-67	30.8	7.4	4.8	12.6	88.7	112.9	162.6	119.3	105.2	114.2	200.0	88.0	29.0	129.0	87.0
67-68	13.5	11.4	4.3	6.3	10.8	46.5	124.6	71.0	100.3	106.4	69.0	62.3	9.3	82.9	52.1
68-69	57.7	59.4	48.9	55.1	36.6	72.8	65.0	110.7	84.0	73.4	80.3	54.8	51.5	77.2	66.4
'69-'70	44.5	14.2	14.2	48.8	60.2	74.0	80.4	132.4	108.9	148.9	79.5	101.8	36.2	103.9	75.5
MEAN	46.8	33.7	28.4	26.4	49.0	78.0	110.0	111.2	107.5	125.7	115.6	81.9	36.9	104.3	76.1

Quaternary	Pleistocene	Ql :	Lake deposits (Endapan danau)
		a :	andesites
Tertiary	Pleocene	Pb :	tuffaceous brecoias, lavas, sandstones, and conglomerates
		Mt :	pumicions tuffs, tuffaceous sandstones
	Miocene	Mts :	sandstones, siltstones
		Mtb :	breccias, sandstones
	Oligocene	Omc:	clays, marls, quartz sandstones
		Oml :	limestones

Among those rocks, Pb, Mt, Mts, Mtb, Omc, Oml and andesites will have an influence in designing of the structures of Saguling Hydroelectric Power Station, while the lake deposites have a little influence upon the stability of the hill side slope in the reservoir area.

The andesites, intruded into or covered by the tertiary formation, form vents, necks or lava flows and will be used for aggregates and rock materials in time of the construction works.

The general strike of the tertiary formations is NEE to SWW and their dip is 10^{o} to 30^{o} toward the SE direction. Accordingly, along the River Tjitarum, the upper formations exist on the upstream area of the river and the lower formations on the downstream area in conformity.

5.2.3. Dam Site and Type

It was proved by the reconnaissance survey that the four dam sites have the great potential for hydroelectric exploitation. Their locations are shown on FIG. 13.

At the upstream dam site, the span of the gorge is wide and landslides exist on the both banks. This site is inferior in its geological condition to other sites.

At the downstream dam site, a large cliff which may be a portion of Tjisaguling fault exists on the right bank just downstream of this dam site. It seems impossible that this cliff will be stabilized by the art of man. Accordingly, this site has been exempted from our study.

The lower midstream dam site is 228 m wide in its span at EL. 650 m. The dam volume will be the smallest among the proposed four sites. The rock bed on the right bank is exposed up to EL. 640, but the left bank does not expose any rock bed and is covered by the overburden.

The banks of the upper midstream site are about 342 m wide in the span at EL. 650 m. On the left bank, fresh and hard rock bed is exposed up to EL. 630 m and a weathered rock burden about 20 m thick covers the upper portion above EL. 630 m. The lower part of the right bank up to EL. 620 m exposes a rock bed and the upper part forms the same complicated contour as seen on FIGS. 13 and 14. But such part with the complicated contour is limited only to the upper part. The site investigations and office studies concluded that the upper midstream site is most promising at this stage.

Concrete arch dams, concrete gravity dams, and rockfill dams are common for dam types of high dams. The geology of the four sites is composed of tuffaceous breccias of younger geological age. Our site reconnaissance has found that they are not suitable for the abutment of the 88 m high arch dam construction. The foundation rocks on the base of concrete gravity dams are required to have sufficient shearing resistance. The foundation rocks of the sites are not hard enough in respect to the shearing resistance. Such considerations concerning the bearing capacity of the foundation rocks are not required for construction of rockfill dams. The foundation rocks of the sites provide adequate foundations for rockfill dams. We recommend, therefore, to adopt rockfill dam at this stage. FIG. 15 illustrates the proposed layout of the recommended upper midstream dam.

5.3. Waterway

5.3.1. Route of Waterway

Two alternatives have been studied for the waterway as shown on FIG. 16. The waterway A has been recommended, because the power house site Ⓓ is considered for adoption as mentioned below. The total length of the pressure tunnel from the intake to the surge tank is approximately 4,800 m. On the pressure tunnel route, an adit will be constructed at Tjisagu to reduce the construction period. On the right bank of the River Tjitarum downstream of the Saguling village develop cliffs which may be caused by Tjipanas fault. The tunnel route can not help passing through the cliff but it is not so serious problem.

5.3.2. Structures of Waterway

The layouts of the structures are proposed on the following figures.

Intake	FIG. 18
Pressure tunnel	FIGS. 17 and 19
Surge tank	FIGS. 17 and 19
Penstock	FIG. 17

5.4. Power House and Tailrace

There are two power house sites as shown on FIG. 16. Their alternative locations are four as per FIG. 20. The downstream site is located on a plain land sufficient enough for construction of the power house. There is the possibility that Tjipanas fault strikes inside this site but it can not be confirmed from the outside because of the overburden.

The area for the upstream site is narrower than the downstream one. But the bedrock is exposed over much of the site and Tjipanas fault and its related fault can be confirmed by eyes on the opposite side of the river.

Generally, the rockbeds on or around the power house sites are judged to have bearing capacity sufficient enough to support the loads of the power house. A difference in the tailrace levels between the upstream site and the downstream site is EL. 267 - EL. 252 = 15 m. The upstream site may cover the loss of head with the tailrace tunnels extended to the downstream site. At this stage where the geological condition of the downstream site is not disclosed, the upstream site, alternative Ⓓ, is adopted for our study in this report.

The dimensions of the power house, indoor type, will be as follows:

Width - about 30 m

Length - Substructure - 70 m

Superstructure - 90 m

Height - about 47 m

The layout of the power house is shown on FIG. 21.

The layour of the tailrace is shown on FIG. 22.

SECTION 6.

CONSTRUCTION SCHEDULE AND LOCAL MATERIALS FOR CONSTRUCTION

6. CONSTRUCTION SCHEDULE AND LOCAL MATERIALS FOR CONSTRUCTION

6.1. Construction Schedule

The construction work of the recommended scheme for Saguling Hydroelectric Power Project will be carried forward according to FIG. 23, assuming the necessary steps of planning, design, and construction are taken within the specified time. As an initial step, it is recommended that the engineering work will be carried out in the following schedule.

1) The engineering - intermediate stage will be started by mid 1973.

2) The engineering - detailed design and supervision of construction will be started by mid 1974, subsequent to the engineering - intermedate stage.

There still remains a possibility that the period of Saguling Hydroelectric Power Project Development will be shortened to 7 years, if all the necessary steps in the course of the development will proceed most efficiently and speedily.

6.2. Local Materials for Construction

6.2.1. Rockfill Materials for Dam

It is one of the important considerations whether rock and core materials of impermeability are available or not near the dam site. Andesites distributed on Mts. G. Masigit and G. Karang about 5.5 km far, south-west of the recommended dam site, or limestones forming Mts. Pr. Geoha and Pr. Sangiangtikoro about 6 km far, north-west of the dam site, will be quarry site for rockfill materials. After comparison of the material transportation routes, the former quarry site is recommendable.

The ground surface on or around the recommended dam site is covered with thick clayey weathered rocks. In any place around the dam site, the materials of impermeability are available. Accordingly, a place where the collection and transportation are easier shall be selected as core quarry site.

In this way, the plain place on the right bank upstream of the recommended dam site has been selected as core quarry site.

The physical property of the clayey weathered rocks existing around the dam site belongs to CH according to the standard classification method. They have no problem concerning the permeability but are characterised by the low efficiency of compaction and the small shearing force and large compressive force at the time of water saturation after compacted. These characteristics should be considered in the design and the construction, if the same materials will be used for Saguling dam.

As the core materials of small grain will be used, at least two kinds (layers) of filter materials will be used in order to adjust a large difference in grains between the outside rock and the core materials. Around the site, such deposits are not found. Those sands will be substituted by the powdered sands of the rock materials and the mixtures of ground powder of the rock and the core materials.

6.2.2. Aggregates for Concreting

Concrete aggregates necessary for construction of the dam, spillway, intake, tunnels, surgetanks and power house are not available from the river bed deposits near the dam site. The coarse and fine aggregates of good quality will be prepared by crushing the andesites and the limestones available at the two candidates for quarry site with aggregate plants.

6.2.3. Cements

Cements for concreting are locally available. There is no problem on the quality.

SECTION 7.

TRANSMISSION CONSIDERATIONS

7. TRANSMISSION CONSIDERATIONS

7.1. West Java System

The future load increase estimated by Chas. T. Main International, Inc. in its report entitled "West Java Power System Long Range Plan, August 1972" will be met by either development of only thermal plants (hereinafter referred to as Thermal Development Plan) or mixed development of Saguling Hydroelectric Power Project and thermal plants (hereinafter referred to as Mixed Hydro and Thermal Plan). Then both plans have been compared each other.
The result of the comparative study is summarized on FIG. 24.

1970's - before completion of Saguling Hydroelectric Power Project

(a) With the load increase in Jakarta, Bogor and Bandung and the new installation of Muara Karang Thermal Plant, a 150 kV transmission line will be required to be installed newly from Tjiwang to Bandung via Bogor in the latter half of 1970's.

(b) A 150 kV transmission line will be required to be newly installed between Bandung and Tjirebon, associated with the new installation of Tjirebon Thermal Plant (100 MW x 2 units).

1980's - at the commissioning of Saguling Hydroelectric Power Project

(a) In the Thermal Development Plan, a super-high voltage transmission line will be required to be newly installed, associated with the new installation of A thermal plant (150 MW x 2 units) in Jakarta and extension to Tjirebon Thermal Plant (150 MW x 2 units).

(b) In the Mixed Hydro and Thermal Plan, Saguling Hydroelectric Power Station will be developed instead of the above mentioned Jakarta thermal plant. With this hydroelectric power development, super-high voltage transmission lines for the sections of Saguling to Jakarta and Saguling to Bandung will be required to be newly installed.

1990's - prospect

(a) It is a basic problem of alternating current that the transmission capacity of long distance transmission lines is limited from a viewpoint of stability.

(b) Even at the time when the three Java systems will be interconnected, the power demand and supply balance in each district shall desirably be attempted to be kept, in order to avoid long distance transmission lines of large capacity as much as possible.

(c) It is, however, recommendable that power interconnections of adequate capacity among the localized districts shall be made, to reduce reserve generating capacity in the respective districts and make the best use of scale merit as a large interconnected power system.

(d) To enlarge the unit capacity of generating plants is economical, considering only scale merit, but the unit capacity shall be kept within 10% of 15% of the whole system generating capacity from a viewpoint of reliability of the power system operation.

(e) Saving of reserve generating capacity in a district will not be increased economically by interconnections among the districts, if its extent is beyond a certain limit.

(f) By mid 1970's, it is considered adequate that the interconnecting capacity among the districts shall be 100 MW to 150 MW.

(g) It is recommended that the all Java systems shall be interconnected, considering the above mentioned. As a part of the whole Java system planning, the applied voltage of super-high voltage transmission line between Jakarta and Bandung shall be determined.

7.2. Transmission and Substation Constructions associated with Saguling Hydroelectric Power Development

(a) The transmission capacity of the transmission lines associated with Saguling Hydroelectric Power Project will be at least more than 450 MW which is equivalent to the capacity of three units of the same power station, so that the peak supply capability of the transmission lines will be maintained even in case of shut-down of one circuit line route.

(b) On the basis of the considerations concerning the transmission capacity mentioned in the preceding (a) and the whole Java power system interconnection mentioned in the "1990's - prospect" as above, 150 kV is considered low for the voltage of the transmission lines.
400 kV is too high and 270 kV is considered adequate.

(c) A double-circuit transmission line is recommendable, to prevent the shut-down of power supply from Saguling Hydroelectric Power Station which will be caused by faults of the transmission lines, because the unit capacity of the same power station is large as compared with the total system capacity.

(d) Kinds of recommendable conductors will be 610 mm^2 single conductor or 330 mm^2 double conductor to protect against corona and radio interference.

(e) Capacities of Substations
Together with the development of Saguling Hydroelectric Power Project, each one substation with a capacity of 150 MW x 3 units will be required to be newly installed in Jakarta and Bandung.

SECTION 8.

ENGINEERING WORK

8. ENGINEERING WORK

It is recommended that the following engineering work will be carried out by the qualified consulting engineers experienced in this type of engineering work.

8.1. Engineering-intermediate stage

In order that this power station may be commissioned in 1982, it is necessary to carry out, successively in 1973, the site investigations itemized on TABLE 6 based upon the investigation plan illustrated on FIGS. 25, 26 and 27 and also the engineering work which will be required for preparation of the definite plan of the project.

8.2. Engineering-detailed design and construction supervision

After 1974, supplemental site investigations, detailed designing, preparation of tender specifications, assistance in tendering and construction supervision will be carried out in regular order.

TABLE 6. Site Investigations of Saguling Hydroelectric Power Project at Intermediate Stage

Item	Object	Quantity	Description
Aerographic survey	Rock material quarry	12.5 km^2	Preparating of aerographic maps at scale of 1/5000.
	Roads to be constructed or improved	21.0 km^2	- ditto -
Center line, route and cross sectional surveys	Dam site	3,000 m	Dam axis cross sectional survey
	Intake	320 m	Longitudinal survey
	Tunnel	6,520 m	"
	Penstock	2,620 m	"
	Tailrace	530 m	"
	Rock quarry	1,000 m	Traverse survey
	Core quarry	1,800 m	"
	Reservoir area		Longitudinal and cross-sectional survey of main stream
Seismic prospecting	Dam site	3,000 m	On the axial lines of the upper midstream site and the lower midstream site. 5 measuring lines x 600 m
	Intake	320 m	1 measuring line x 320 m
	Tunnel	6,520 m	On the center lines of the two tunnel routes
	Penstock	2,620 m	On the center lines of the two penstock routes
	Tailrace	530 m	On the center line of one tailrace route
	Rock quarry	1,000 m	100 m x 4 lines 300 m x 2 lines
	Core quarry	1,800 m	300 m x 6 lines

Item	Object	Quantity	Description
Drilling work	Dam site	500 m	50 m x 10 holes (the overburden on the left bank of the lower upstream site and the weathered zone on the upper flanks of the upper and lower midstream sites.)
	Tunnel	240 m	3 holes x 80 m
	Surge tank	150 m	2 holes x 75 m
	Power house	100 m	4 holes x 25 m
	Tailrace	100 m	2 holes x 50 m
	Outlet	200 m	2 holes x 100 m (Tjipanas fault)
	Core quarry	180 m	9 holes x 20 m
Test pit	Dam site	350 m	50 m x 7 tunnels
Soil test	Core quarry	one set	

SECTION 9.

APPROXIMATELY ESTIMATED CAPITAL COSTS OF THE DEVELOPMENT

9. APPROXIMATELY ESTIMATED COSTS OF THE DEVELOPMENT

9.1. Capital Cost Estimates

The capital costs of the Saguling Hydroelectric Power Development are estimated to be:

Saguling Hydroelectric Power Project
Japanese Yen 46,000,000,000.- ($153,333,000.-)

Associated transmission and substation constructions
Japanese Yen 7,400,000,000.- ($24,667,000.-)

Total Japanese Yen 53,400,000,000.- ($178,000,000.-)

TABLE 7 is detailed breakdown of the estimated capital costs of the development.

9.2. Basis of Estimates

The estimates are based on present-day costs of offshore and local labour, materials, and equipment with escalation added as necessary to cover the rise in cost indices during the construction period. Items noted in the estimates are defined as follows:

9.2.1. Preliminary Work

1-1. Road construction and improvements - constructing and/or improving about 15 km of access roads and 15 km of construction roads at the site. It has been assumed that this work will be carried out by the local contractors.

1-2. Preliminary housing - preparing the camp site and housing accommodations required during the construction. It has been also assumed that this work will be done by the local contractors.

1-3. Power supply and communications for construction - installing temporarily power supply facilities and communications during the construction. It has been assumed that this work will be carried out partly by qualified contractors.

1-4. Temporary facilities - manufacture and delivery of materials and equipment necessary for temporary facilities, such as long-span bridge, which will be procured from abroad.

9.2.2. Civil Engineering Contract Work

Extension of unit prices, determined by an evaluation of labour, materials and construction plant equipment required to perform the work in accordance with the construction schedule, applied to estimated quantities computed from the layout studies of the structures and required for their construction. It has been assumed that the work will be executed by qualified contractors.

9.2.3. Electrical and Mechanical Equipment - manufacture and delivery of hydraulic equipment (including turbines, valves, gates), electrical equipment (including generators, transformers, switchgear) and mechanical equipment (including cranes, hoists and station service equipment).

9.2.4. Resettlement - an allowance to cover the cost of paying compensation for settled lands affected by the development.

9.2.5. Costs for engineering work -

a) Engineering - intermediate stage:
Engineering costs for site investigations and office studies which will be required for preparation of definite plan.

b) Engineering - detailed design and construction supervision:
Engineering costs for detailed design, preparation of tender specifications, tender evaluation and construction supervision.

9.2.6. PLN Administration - an allowance of 2.6% of the total estimated cost to cover the PLN administration cost of construction.

9.2.7. Contingencies and escalation during construction - an allowance of 15.6% of the total estimated cost.

9.2.8. Interest during the construction - for both offshore and local expenditures computed at the respective rates of 4 percent and 12 percent capitalized up to the time that the power station is commissioned.

9.2.9. Transmission and substations - manufacture, delivery, erection and commissioning of equipment and materials necessary for the recommended transmission and substation works described in Section 7.

9.3. Offshore and Local Currency Components

In appraising the local currency content of the estimated costs, local expenditure includes local labour and the cost of materials produced or manufactured in Indonesia. They do include cements, explosives, fuel, gasoline, and automobile oil.

9.4. Schedule of Expenditures (only for Saguling Hydroelectric Power Project)

The estimated schedule of yearly expenditures is as follows:

	Cash drawdown		Interest		Total	
Year	Offshore	Local	Offshore	Local	Offshore	Local
1973	175 (583)	97 (323)	4 (13)	6 (20)	179 (597)	103 (343)
1974	233 (777)	135 (450)	14 (47)	24 (80)	247 (823)	159 (530)
1975	233 (777)	466 (1,553)	24 (80)	70 (233)	257 (857)	536 (1,787)
1976	1,052 (3,507)	855 (2,850)	57 (190)	161 (537)	1,109 (3,697)	1,016 (3,387)
1977	1,618 (5,393)	771 (2,570)	116 (387)	255 (850)	1,734 (5,780)	1,026 (3,420)
1978	5,049 (16,830)	775 (2,583)	284 (947)	349 (1,163)	5,333 (17,777)	1,124 (3,747)
1979	8,742 (29,140)	1,694 (5,647)	597 (1,990)	525 (1,750)	9,339 (31,130)	2,219 (7,397)
1980	8,197 (27,323)	2,530 (8,433)	921 (3,070)	795 (2,650)	9,118 (30,393)	3,325 (11,083)
1981	5,508 (18,360)	1,603 (5,343)	1,176 (3,920)	889 (2,963)	6,684 (22,280)	2,492 (8,307)
Total	30,807 (102,690)	8,926 (29,753)	3,193 (10,643)	3,074 (10,247)	34,000 (113,333)	12,000 (40,000)

Unit: Yen 1 million
($ thousand)

TABLE 7. CAPITAL COST ESTIMATES

Unit: Yen 10^3
($ thousand)

Item	Offshore	Local	Total
1. Preliminary work	2,520,000 (8,400)	1,080,000 (3,600)	3,600,000 (12,000)
1-1. Road construction and improvements	-	900,000 (3,000)	900,000 (3,000)
1-2. Preliminary housing	-	120,000 (4,000)	120,000 (4,000)
1-3. Power supply and communications for construction	140,000 (467)	60,000 (200)	200,000 (667)
1-4. Temporary facilities	2,380,000 (7,933)	-	2,380,000 (7,933)
2. Civil engineering contract work	14,828,965 (49,430)	5,011,885 (16,706)	19,840,850 (66,136)
2-1. Dam	2,249,590 (7,498)	1,253,610 (4,179)	3,503,200 (11,677)
2-2. Spillway	1,373,625 (4,579)	593,875 (1,979)	1,967,500 (6,558)
2-3. Intake	312,050 (1,040)	111,150 (371)	423,200 (1,411)
2-4. Headrace	3,547,750 (11,826)	1,647,250 (5,491)	5,195,000 (17,317)
2-5. Surgetank	270,850 (903)	122,150 (407)	393,000 (1,310)
2-6. Penstock	5,300,250 (17,667.5)	545,250 (1,817.5)	5,845,500 (19,485)
2-7. Power house	1,274,135 (4,247)	527,415 (1,758)	1,801,550 (6,005)
2-8. Tailrace	360,715 (1,202)	151,185 (504)	511,900 (1,706)
2-9. Switchyard	140,000 (467)	60,000 (200)	200,000 (667)

Item	Offshore	Local	Total
3. Electrical and mechanical works	7,500,000 (25,000)	-	7,500,000 (25,000)
3-1. Electrical and mechanical	7,500,000 (25,000)	-	7,500,000 (25,000)
4. Re-settlement	-	580,000 (1,933)	580,000 (1,933)
5. Costs for engineering work	1,800,000 (6,000)	180,000 (600)	1,980,000 (6,600)
5-1. Engineering-intermediate stage	243,000 (810)	27,000 (90)	270,000 (900)
5-2. Engineering-detailed design and construction	1,557,000 (5,190)	153,000 (510)	1,710,000 (5,700)
6. PLN administration	-	870,000 (2,900)	870,000 (2,900)
7. Contingencies and escalation during construction	4,157,914 (13,860)	1,203,940 (4,013)	5,361,854 (17,873)
8. Interest during construction	3,193,121 (10,644)	3,074,175 (10,247)	6,267,296 (20,891)
Sub-total	34,000,000 (113,333)	12,000,000 (40,000)	46,000,000 (153,333)
9. Transmission and substation	4,042,800 (13,476)	1,431,200 (4,771)	5,474,000 (18,247)
9-1. Transmission lines	2,017,800 (6,726)	756,200 (2,521)	2,774,000 (9,247)
9-2. Substations	2,025,000 (6,750)	675,000 (2,250)	2,700,000 (9,000)
10. Contingencies and escalation during construction	630,677 (2,102)	223,267 (744)	853,944 (2,846)
11. Interest during construction	526,523 (1,755)	545,533 (1,819)	1,072,056 (3,574)
Sub-total	5,200,000 (17,333.5)	2,200,000 (7,333.5)	7,400,000 (24,667)
Grand Total	39,200,000 (130,667)	14,200,000 (47,333)	53,400,000 (178,000)

SECTION 10.

UPSTREAM AND DOWNSTREAM BENEFITS

10. UPSTREAM AND DOWNSTREAM BENEFITS

10.1. Effects upon Downstream Reservoir

The following seven alternatives are considered for operations of Djatiluhur reservoir and Saguling reservoir:

Alternative A : single operation of Djatiluhur reservoir (before commissioning of Saguling reservoir).

Storage capacity of Djatiluhur reservoir - 2,860 million m^3.

A-150 ..... Minimum discharge of Djatiluhur Hydroelectric Power Station 150 m^3/sec.

A-75 ...... Minimum discharge of Djatiluhur Hydroelectric Power Station 75 m^3/sec.

Alternative B : coordinated operation of Djatiluhur reservoir and Saguling reservoir (after commissioning of Saguling reservoir).

Storage capacity of Djatiluhur reservoir - 2,860 million m^3.

B-150 ..... Minimum discharge of Djatiluhur Hydroelectric Power Station 150 m^3/sec.

B-75 ...... Minimum discharge of Djatiluhur Hydroelectric Power Station 75 m^3/sec.

Alternative C : Separate operation of Djatiluhur reservoir and Saguling reservoir (after commissioning of Saguling reservoir)

Storage capacity of Djatiluhur reservoir - 2,860 million m^3.

C-150 ..... Minimum discharge of Djatiluhur Hydroelectric Power Station 150 m^3/sec.

C-75 ...... Minimum discharge of Djatiluhur Hydroelectric Power Station 75 m^3/sec.

Alternative B'-75 : Coordinated operation of Djatiluhur reservoir and Saguling reservoir (after commissioning of Saguling reservoir).

Storage capacity of Djatiluhur reservoir - 2,000 million m^3.

The effects upon Djatiluhur reservoir have been calculated with the hydrological data for fifty-one years from June, 1919 to May, 1970. The result of the calculation is summarized on TABLE 8.

TABLE 8 shows that the completion of Saguling reservoir will solve shortage in water supply for irrigation which is not avoidable only with the existing Djatiluhur reservoir and will increase only a little generated energy of Djatiluhur Hydroelectric Power Station.

10.2. Upstream Effects upon Forebays and Neighbourhood of Saguling Reservoir

If the reservoir will reach the high water level of EL. 650 m, the reservoir area will be about 58 km^2 and rice fields and houses existing now in the intended reservoir area will be submerged under the water. The compensation for resettlement will be necessary.

With completion of the reservoir a part of the road from Bandung to Malaka via Tjililin will be submerged and will be required to be relocated. The town which will be affected with completion of Saguling reservoir is Tjililin. But there will not be so serious effect upon the town, because it is located at EL. 665 m.

10.3. Necessity of Equalizing Reservoir

It is about 50 km distant from the outlet of Saguling Hydroelectric Power Station to Djatiluhur reservoir. In this section, the river flow varies time to time with operation of Saguling Hydroelectric Power Station. In the future, when the feasibilities of a hydroelectric power station downstream of Saguling Hydroelectric Power Station and Tjirata site will be studied, the necessity of equalizing reservoir should be studied.

TABLE 8 ALTERNATIVES OF OPERATION METHOD OF DJATILUHUR AND SAGULING RESERVOIRS

CASE NO.			A-150	A-75	B-150	B-75	C-150	C-75	B'-75
Dam			Djatiluhur only	Djatiluhur only	Djatiluhur+Saguling	Djatiluhur+Saguling	Djatiluhur+Saguling	Djatiluhur+Saguling	Djatiluhur+Saguling
Minimum discharge of Djatiluhur (m^3/sec.)			150	75	150	75	150	75	75
Operation	Djatiluhur storage		28.6 x 10^8 m^3	28.6 x 10^8 m^3	28.6 x 10^8 m^3	28.6 x 10^8 m^3	28.6 x 10^8 m^3	28.6 x 10^8 m^3	20.0 x 10^8 m^3
	Saguling operation		-	-	can supplement water supply for irrigation	can supplement water supply for irrigation	can not supplement water supply for irrigation	can not supplement water supply for irrigation	can supplement water supply for irrigation
Period of shortage for irrigation		Year	7 years	1 year	4 years	0	6 years	1 year	3 years
		Month	12 months	2 months	6 months	0	11 months	2 months	6 months
Water supply shortage for irrigation (m^3/sec.-M/51 years)			891.8	133.0	371.6	0	921.9	141.5	454.4
Djatiluhur	Generation impossible period	Year	22 years	8 years	22 years	5 years	20 years	5 years	0
		Month	94 months	38 months	104 months	27 months	96 months	22 months	0
	Average firm output (kW)		78,939	90,432	75,835	90,521	77,503	91,262	93,094
	Annual average generated energy (MWH/year)		691,819	793,230	664,864	794,111	679,444	800,647	816,827
	Average firm output during the most drought 5 years (kW)		24,901	43,547	14,169	35,166	18,389	41,558	60,133
	Spilled water (m^3/sec. -M/51 years)		2,291.8	5,082.5	1,967.1	4,749.7	1,991.6	4,749.7	4,749.7
Saguling	Generation impossible period	Year	-	-	0	0	0	0	0
		Month	-	-	0	0	0	0	0
	Average firm output (kW)		-	-	233,039	233,213	233,243	233,243	233,066
	Annual average generated energy (MWH/year)		-	-	2,039,880	2,041,277	2,041,570	2,041,570	2,040,104
	Average firm output during the most drought 5 years (kW)		-	-	176,983	176,432	172,151	172,151	177,084
	Spilled water (m^3/sec. -M/51 years)		-	-	229.0	229.0	229.0	229.0	229.0
Note					period during which firm discharge of Saguling can not be maintained 5 years (8 months)	can maintain firm discharge of Saguling	can maintain firm discharge of Saguling	can maintain firm discharge of Saguling	period during which firm discharge of Saguling can not be maintained 3 years (7 months)

* The minimum discharge enabling the power generation is assumed 5 m^3/sec. for both Djatiluhur and Saguling.

SECTION 11.

ECONOMIC CONSIDERATIONS

11. ECONOMIC CONSIDERATIONS

11.1. Power Costs of Saguling Hydroelectric Power Station

The Power costs of Saguling Hydroelectric Power Station have been calculated as follows:

a) Sent-out Power Cost (at sending end)

$$\frac{\text{Est. capital cost (excl. transmission and substation)} \times \text{Annual operating cost ratio of Saguling Power Station}}{\text{Potential energy} \times \text{Utility factor}}$$

$$= \frac{\text{Yen } 46{,}000 \times 10^6 \ (\$\ 153{,}333{,}000.- \ ) \times 0.0862}{2{,}042 \times 10^3 \text{ MWH} \times 0.98} = \text{Yen } 1.\underline{98} \ (6.6 \text{ mills})/\text{kWh}$$

b) Delivered Power Cost (at receiving end)

$$\frac{\begin{matrix}\text{Est. capital cost} \\ \text{(excl. transmission} \\ \text{and substation)}\end{matrix} \times \begin{matrix}\text{Annual operating} \\ \text{cost ratio of} \\ \text{Saguling Power Station}\end{matrix} + \begin{matrix}\text{Est. capital} \\ \text{cost for transmission} \\ \text{and substation}\end{matrix} \times \begin{matrix}\text{Annual operating cost} \\ \text{ratio of transmission} \\ \text{and substation}\end{matrix}}{\text{Potential energy} \times \text{Utility factor} \times (1 - \text{Transmission and substation loss})}$$

$$= \frac{(46{,}000 \times 0.0862 + 7{,}400 \times 0.0991) \times 10^6 \text{ Yen}}{2{,}042 \times 10^3 \text{ MWH} \times 0.98 \times (1 - 0.03)} \text{ or } \frac{\$153{,}333{,}000. \times 0.0862 + \$24{,}667{,}000. \times 0.0991}{2{,}042 \times 10^3 \text{ MWH} \times 0.98 \times (1 - 0.03)}$$

$$= \text{Yen } 2.\underline{42} \ (8.1 \text{ mills})/\text{kWh}$$

The estimated power costs of equivalent comparative thermal plants are as follows:

$$\frac{\text{Est. capital cost of thermal plant x Fixed cost ratio + Generated energy x Fuel cost unit price}}{\text{Generated energy (the same as Saguling Hydroelectric Power Station)}}$$

$$= \frac{\text{Yen } 66,000 \text{ (\$ } 220 \text{)/KW x } 600 \text{ MW x } 0.1058 + 1,941 \times 10^3 \text{ MWH x Yen } 1.\underline{52} \text{ (} 5.1 \text{ mills)/kWh}}{1,941 \times 10^3 \text{ MWH}}$$

$$= \frac{(4,190 + 2,950) \times \text{Yen } 10^6}{1,941 \times 10^3} \text{ or } \frac{\$13,967,000. + \$9,833,000.}{1,941 \times 10^3} = \text{Yen } 3.\underline{68} \text{ (} 12.3 \text{ mills)/kWh}$$

$$> \text{Yen } 2.\underline{42} \text{ (} 8.1 \text{ mills)/kWh}$$

Apparently, the delivered power cost of Saguling Hydroelectric Power Station is cheaper and more economical than that of comparative thermal plants.

11.2. Cost-benefit of Saguling Hydroelectric Power Station

The cost-benefit of Saguling Hydroelectric Power Station has been calculated as per TABLE 9.

TABLE 9. Cost-benefit of Saguling Hydroelectric Power Station

Item			Unit	Quantity	Remarks
(1)	Sent-out (at sending end)	Maximum output	MW	600	
(2)		Potential energy	10^3 MWH	2,042	Average generated energy for 51 years from 1919 to 1970.
(3)		Output in drought periods	MW	600	
(4)		Sent-out energy	10^3 MWH	2,001	Utility factor 98% (Record in Japan)
(5)	Delivered (at receiving end)	Available output	MW	582	(3) x (1 – loss factor) = (3) x 0.97
(6)		Available energy	10^3 MWH	1,941	(4) x (1 – loss factor) = (4) x 0.97
(7)		70% LF energy	"	3,569	(5) x 8,760 hrs x 0.7
(8)		Delivered energy	"	1,628	(7) – (6)
(9)	Capital cost	Saguling plant	10^6 Yen ($thousand)	46,000 ($153,333)	
(10)		Associated transmission and substation	"	7,400 ($24,667)	

	Item		Unit	Quantity	Remarks
(11)	Annual cost	Generation	10^6 Yen ($thousand)	3,965 ($ 13,217)	Annual cost ratio 8.62%
(12)		Transmission and substation	"	733 ($ 2,443)	Annual cost ratio 9.91%
(13)		Total (C)	"	4,698 ($15,660)	
(14)	Worth	kW	"	4,770 ($15,900)	(5) x Yen 8,196.-/kW ($ 27.32)
(15)		kWh	"	2,950 ($ 9,833)	(6) x Yen 1.52/kWh (5.1 mills)
(16)		Total (B)	"	7,720 ($25,733)	
(17)	B - C		10^6 Yen ($thousand)	3,022 ($10,073)	
(18)	B/C			1.64	
(19)	Excl. capital cost for transmission and substation B - C		10^6 Yen ($thousand)	3,755 ($12,517)	(16) – (11)
(20)	Excl. capital cost for transmission and substation B/C			1.95	(16) ÷ (11)

11.3. Sequence of Electric Power Developments

11.3.1. Combined Demand Forecasts of West Java System and Central Java System

The demand forecast used for scheduling is the total of the demand forecasts for the West Java Power System and the Central Java Power System developed by Chas. T. Main International, Inc. in its reports entitled "West Java Power System Long Range Plan" and "Central Java Long Range Plan for Power System Development" as referred to in Section 3. It is summarized on TABLE 10.

TABLE 10. Combined Demand Forecasts of West Java System and Central Java System

Year	West Java	Central Java	Total	Additional Requirements
1981	910 MW	309 MW	1,219 MW	-
1982	1,010	309	1,319	100 MW
1983	1,110	309	1,419	100
1984	1,260	409	1,669	250
1985	1,410	409	1,819	150
1986	1,560	509	2,069	250
1987	1,710	509	2,219	150
1988	1,860	509	2,369	150
1989	2,010	609	2,619	250
1990	2,160	609	2,769	150
1991	2,310	609	2,919	150

11.3.2. Power Developments by All Thermal Additions and Mixed Hydro-Thermal Additions

A suggested sequence of power development, in case Saguling Hydroelectric Power Project is put for operation in the power system, is summarized on TABLE 11.

TABLE 11. Power Developments by All Thermal Additions and Mixed Hydro-Thermal Additions

Year	Developments by All Thermal Additions		Developments by Mixed Hydro-Thermal Additions including Saguling Power Station		
	Yearly Thermal Addition	Accumulative after 1981	Effective output of Saguling Power Station	Necessary Thermal Additions	Yearly Thermal Addition
1981	-	-	-	-	-
1982	100 MW	100 MW	382 MW	-	-
1983	100	200	399	-	-
1984	250	450	417	33 MW	33 MW
1985	150	600	434	166	133
1986	250	850	454	396	230
1987	150	1,000	477	523	127
1988	150	1,150	505	645	122
1989	250	1,400	535	865	220
1990	150	1,550	564	986	121
1991	150	1,700	582	1,118	132

Note: The yearly effective output of Saguling Hydroelectric Power Station means the kW-kWh balanced output at the system load factor of 60%, including transmission loss.

11.3.3. Economic Comparisons between Developments by All Thermal Additions and Mixed Hydro-Thermal Additions

The yearly operating costs of the developments by all thermal additions and the developments by mixed hydro-thermal developments, capitalized in 1982, have been compared for the duration of life of Saguling Hydroelectric Station, 50 years. Its result is summarized on TABLE 12.

TABLE 12. Economic Comparisons between Developments by All Thermal Additions and Mixed Hydro-Thermal Additions

Year		All Thermal Additions	Mixed Saguling Hydro and Thermal Additions		Difference
			Saguling	Thermal	
1982		100 MW	582 MW	-	100 MW
1983		100	-	-	100
1984		250	-	100 MW	150
1985		150	-	100	50
1986		250	-	200	50
1987		150	-	150	-
1988		150	-	150	-
1989		250	-	150	100
1990		150	-	150	-
1991		150	-	118	32
Total		1,700	582	1,118	-
Present worth in 1982 Unit: Yen 10^6 ($ thousand)	Rate of return 5%	223,442 ($744,807)	164,426 ($548,087)		59,016 ($196,720)
	Rate of return 10%	106,484 ($354,947)	98,901 ($329,670)		7,583 ($ 25,277)

It can be concluded that the mixed hydro-thermal addition developments are more profitable than all thermal additions.

The above mentioned power costs have been calculated by the standard capital costs and service life of thermal power plants with a similar capacity now in use by the Japanese power utilities.

As an alternative, we have recalculated the power costs of Saguling Hydroelectric Power Station and equivalent comparative thermal plants on the following assumptions;

a) Comparative thermal plants

i)	Estimated capital cost	Yen 45,000. - ($150. -)/kW
ii)	Service life	30 years
iii)	Fuel cost	Yen 7,230. - ($24.10)/ton

b) Saguling Hydroelectric Power Station

Voltage of associated transmission lines 380 kV

The comparison of the both power costs is summarized below. It shows that the delivered power cost of Saguling Hydroelectric Power Station associated with 380 kV transmission lines is still cheaper than that of the comparative thermal plants calculated on the above mentioned assumptions.

	Estimated original power costs	Estimated alternative power costs
Comparative thermal plants:		
Estimated capital cost	Yen 66,000. -($220. -)/kW	Yen 45,000. -($150. -)/kW
Service life	20 years	30 years
Fuel cost	Yen 5,130. -($17.10)/ton	Yen 7,230. -($24.10)/ton
Fixed annual cost ratio	10.58%	9.25%
Estimated power cost	Yen 3.69 (12.3 mills)/kWh	Yen 3.30 (11.0 mills)/kWh

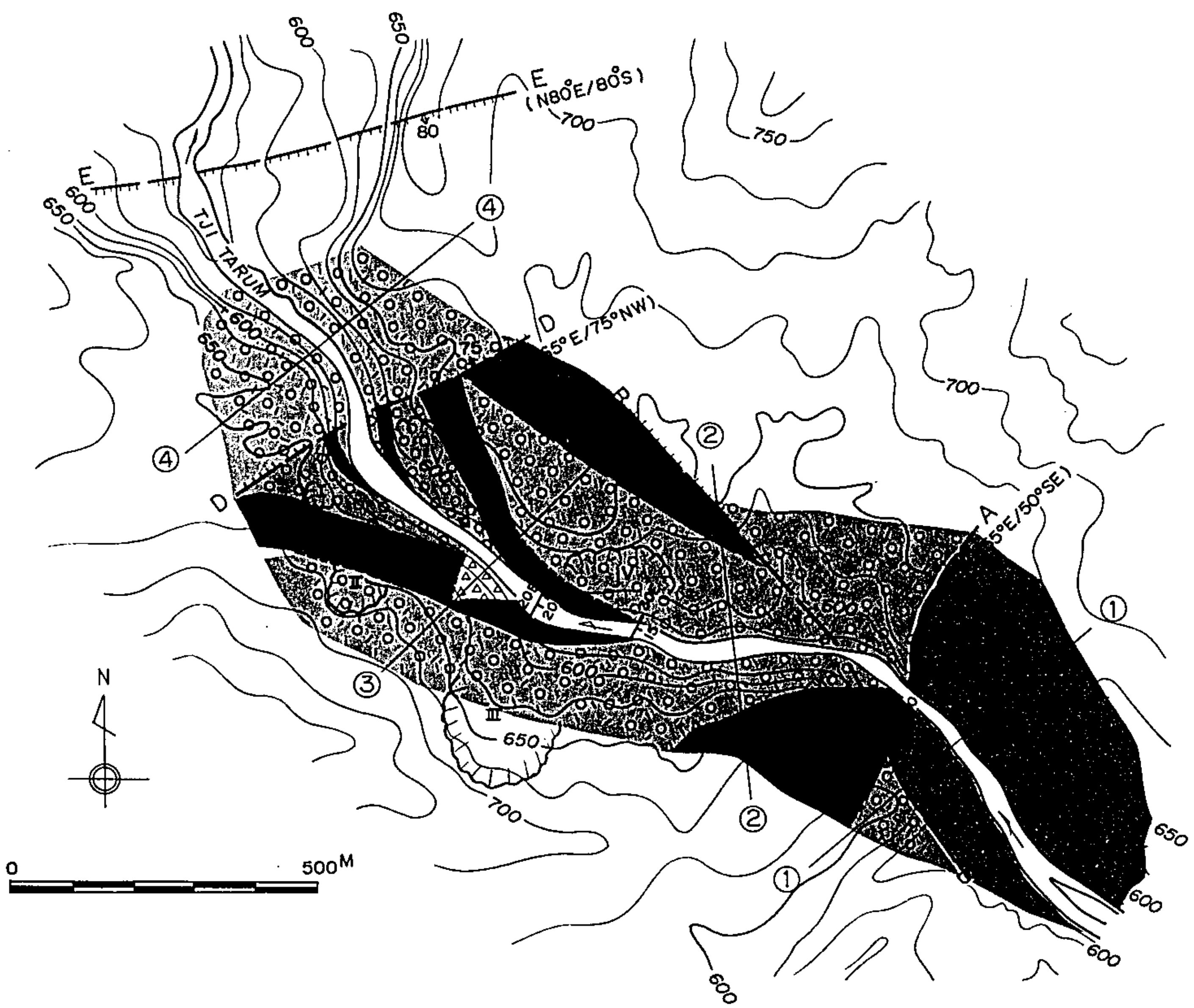
	Estimated original power costs	Estimated alternative power costs
Saguling Hydroelectric Power Station:		
Transmission voltage	270 kV	380 kV
Estimated power cost		
Sent-out (at sending end)	Yen 1.98 (6.6 mills)/kWh	Yen 1.98 (6.6 mills)/kWh
Delivered (at receiving end)	Yen 2.43 (8.1 mills)/kWh	Yen 2.61 (8.7 mills)/kWh
B/C:		
Including Transmission & substation	1.64	1.43
Excluding transmission & substation	1.95	1.70

GEOLOGICAL MAP OF PROPOSED LOCATION

S = 1/10,000

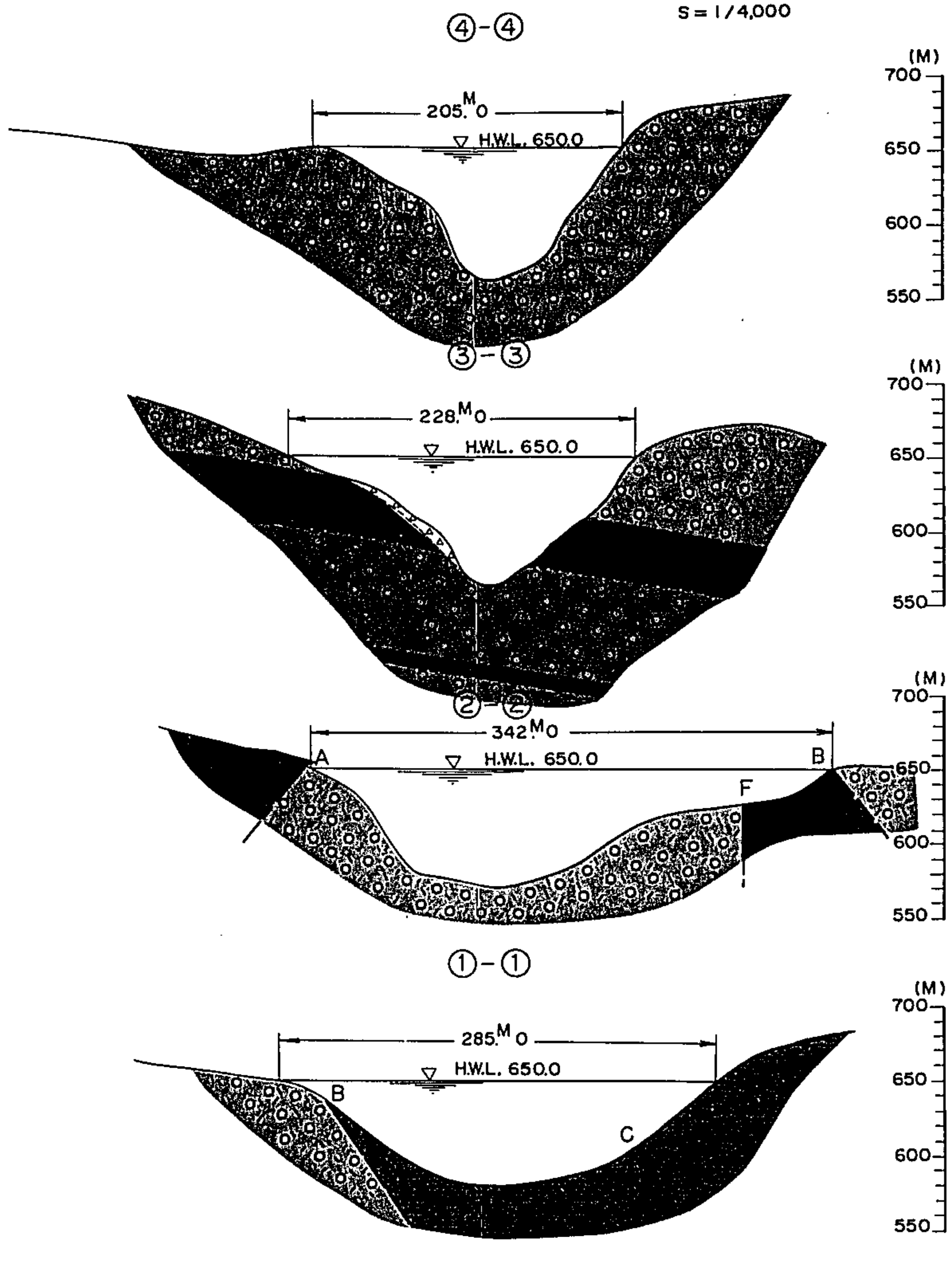
LEGEND

- TALUS DEPOSITES
- ALTERNATION OF SANDSTONES AND SHALES
- ALTERNATION OF SANDSTONES AND CONGLOMERATES
- VOLCANIC CONGLOMERATES AND TUFF-BRECCIAS
- TUFF- BRECCIAS WITH MUDSTONES
- LIMESTONE- BRECCIAS
- CONGLOMERATES WITH MUDSTONES
- 15 / 30E STRIKES AND DIPS OF BEDDING PLANE
- B B FAULT LINES (B, C, D AND F ARE ASSUMED FAULTS)



GEOLOGICAL SECTION OF EACH SITE

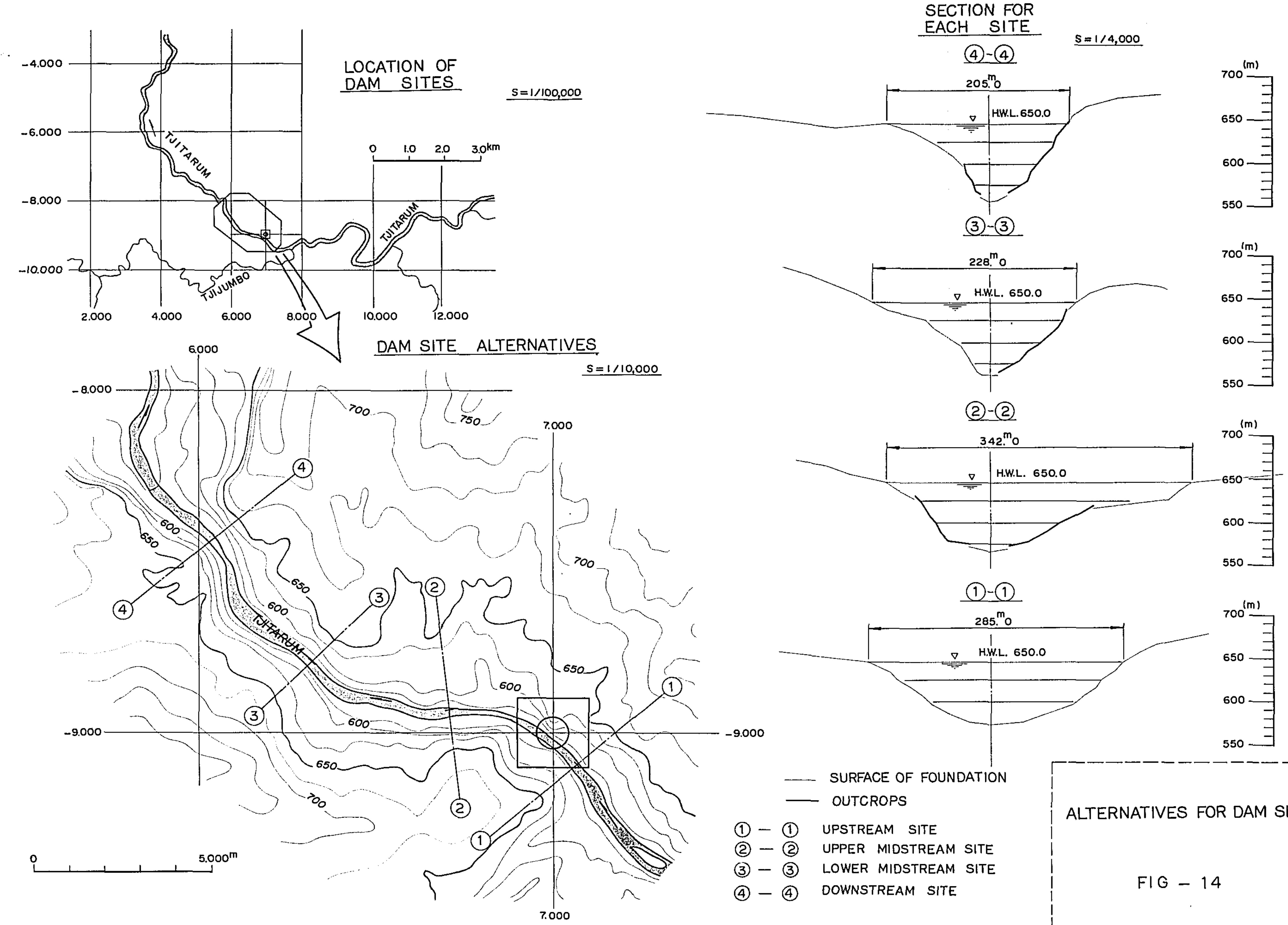
S = 1/4,000



①—① UPSTREAM SITE
②—② UPPER MIDSTREAM SITE
③—③ LOWER MIDSTREAM SITE
④—④ DOWNSTREAM SITE

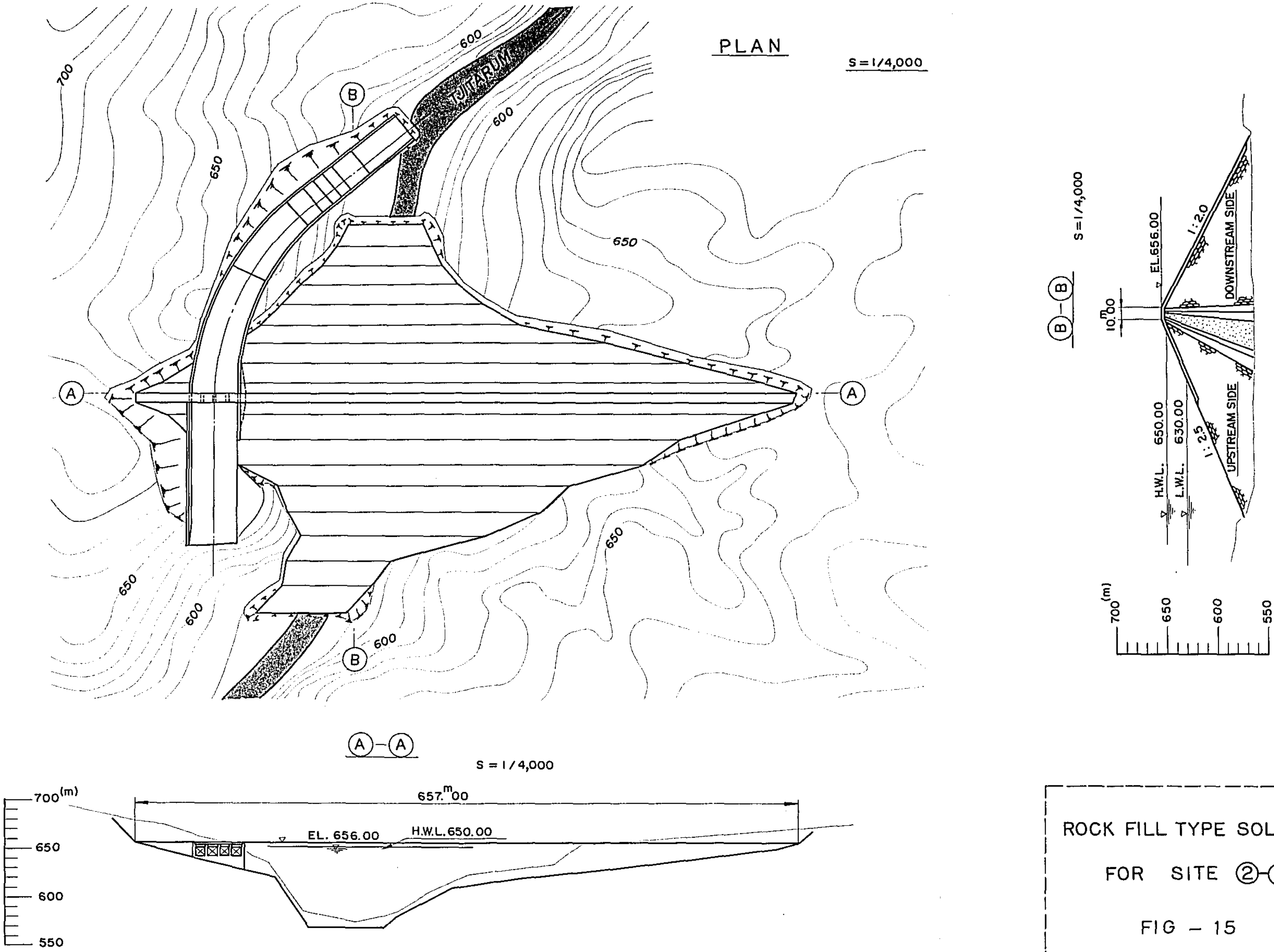
GEOLOGICAL MAP AND SECTION OF DAMSITE

FIG – 13



ALTERNATIVES FOR DAM SITES

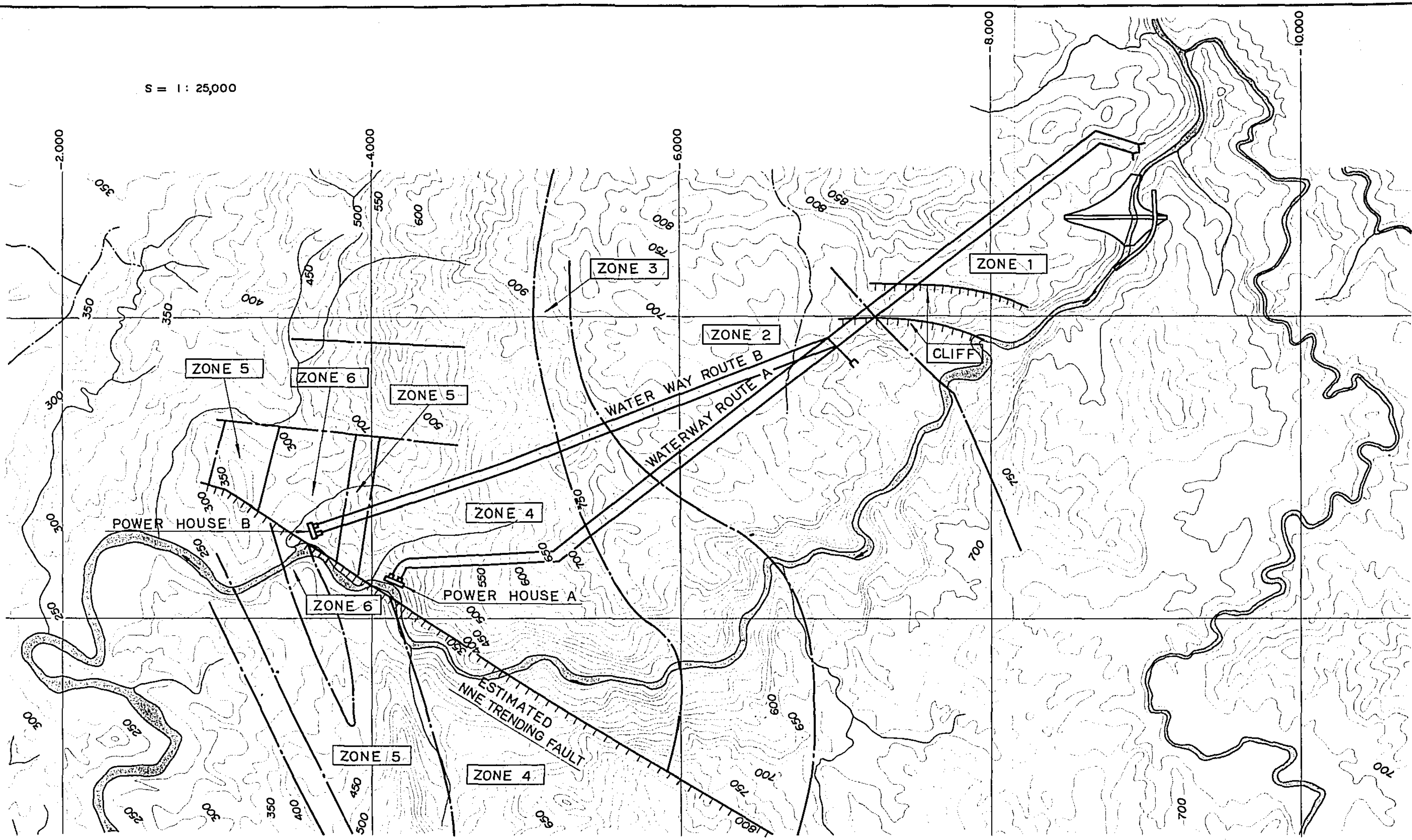
FIG – 14



ROCK FILL TYPE SOLUTION

FOR SITE ②-②

FIG – 15



LEGEND

WATERWAY ROUTE

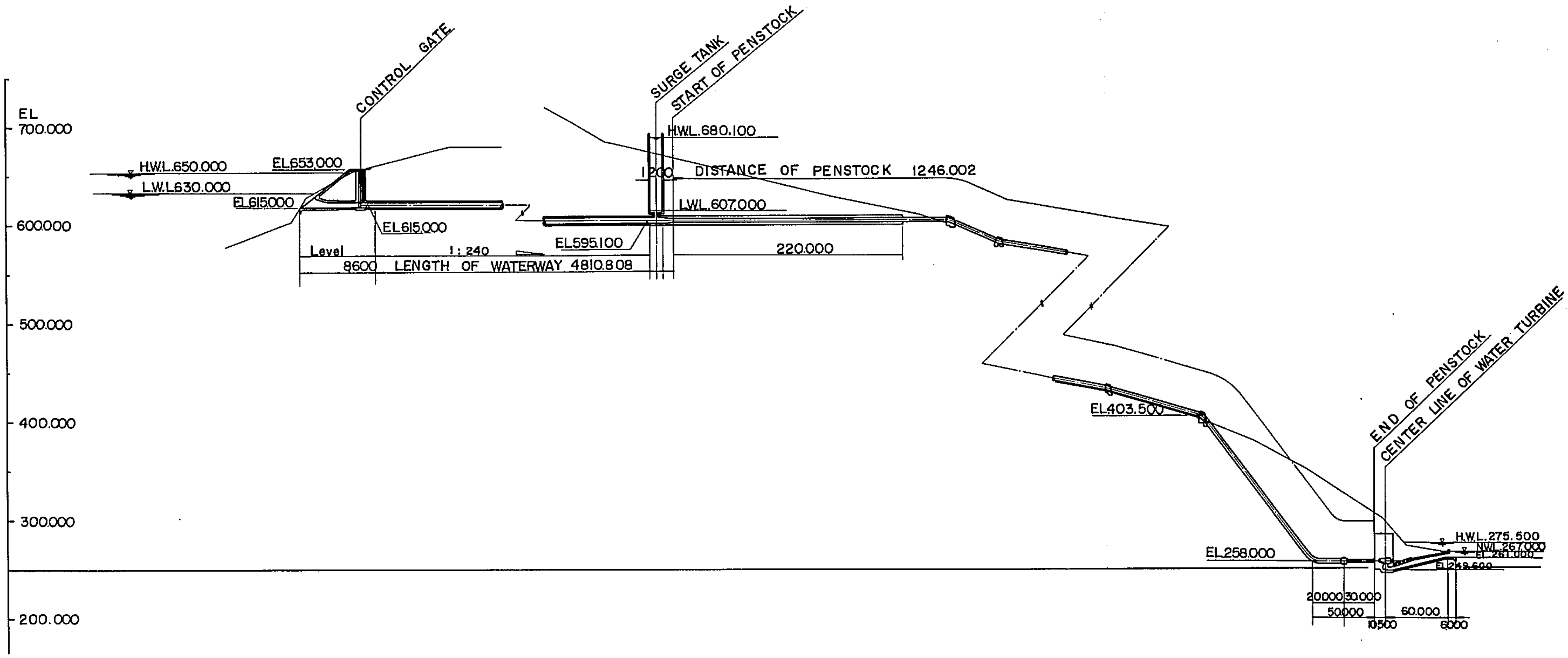
FAULT OR CRIFF

STRATIFICATION

ZONE 1 : TUFFACEOUS BRECCIA LAVA SANDSTONE CONGLOMERATE
ZONE 2 : PUMICEOUS TUFF TUFFACEOUS SANDSTONE
ZONE 3 : BRECCIA, SANDSTONE
ZONE 4 : SANDSTONE, SILTSTONE
ZONE 5 : LIME STONE
ZONE 6 : CLAY MARL QUARTZ SANDSTONE
AFTER PETA GEOLOGI LEMBAR TJIANDJUR DJAWA

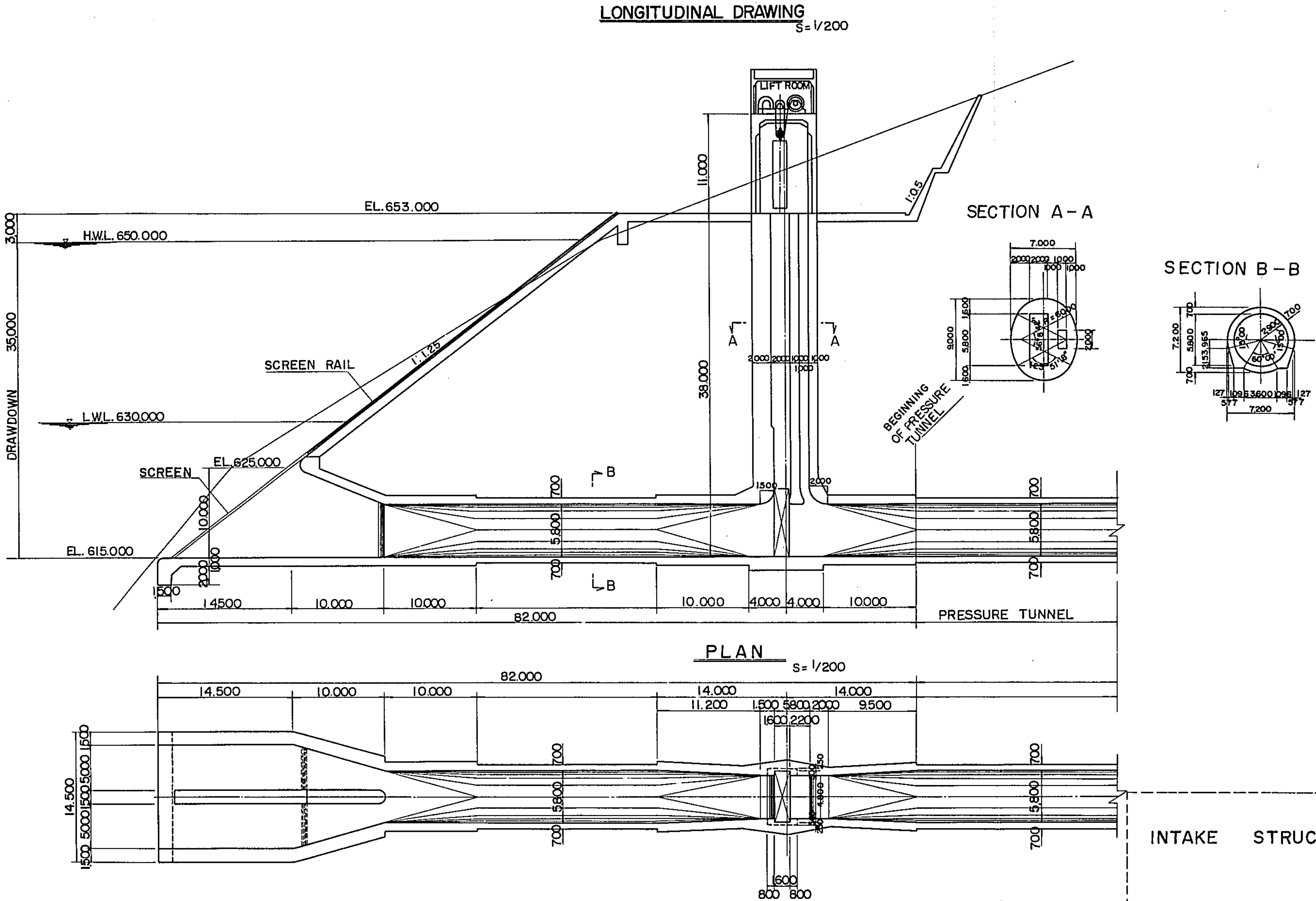
POWER HOUSE SITE AND WATERWAY ROUTE ALTERNATIVES

FIG – 16



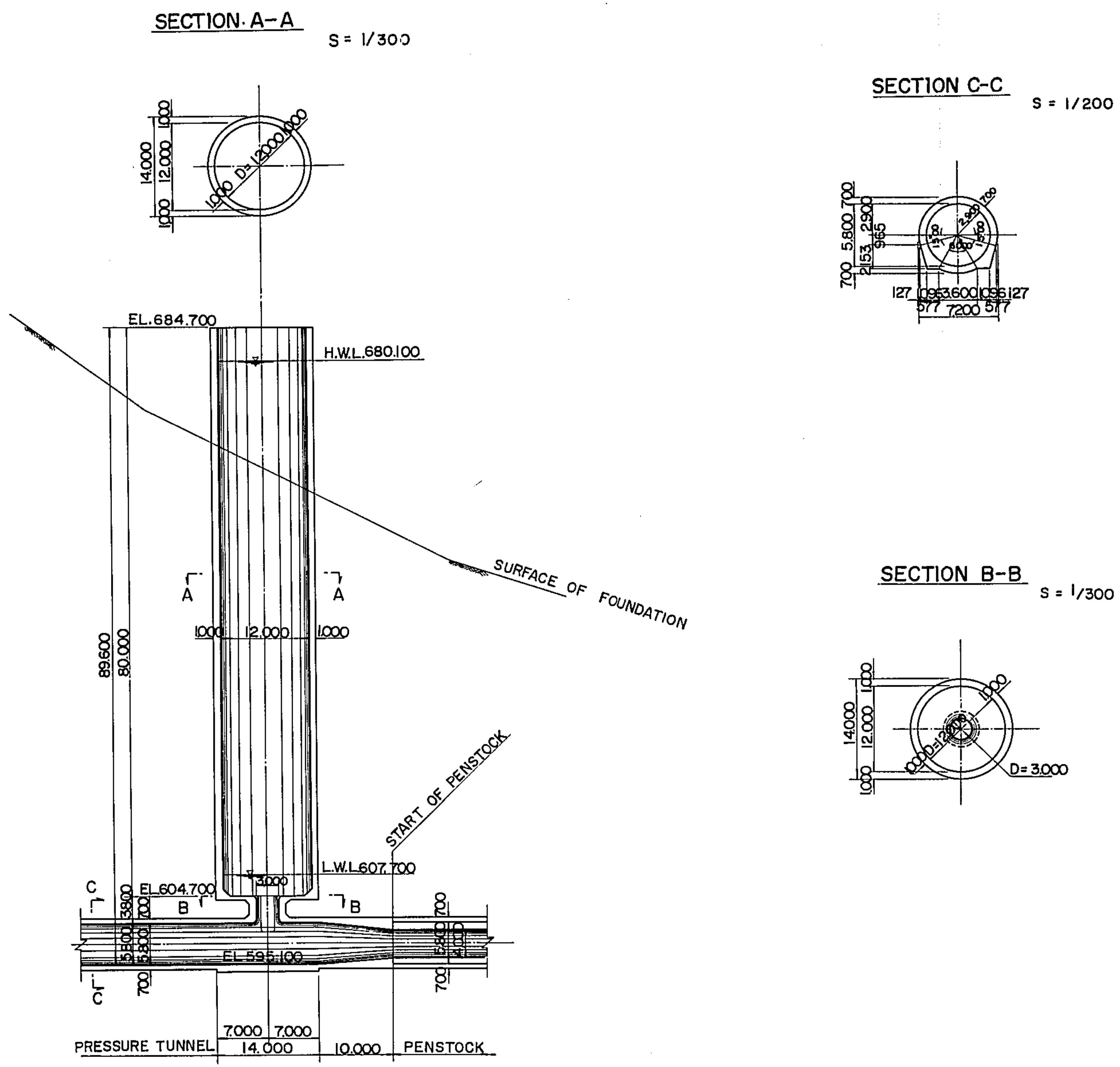
LONGITUDINAL SECTION OF WATERWAY

FIG — 17



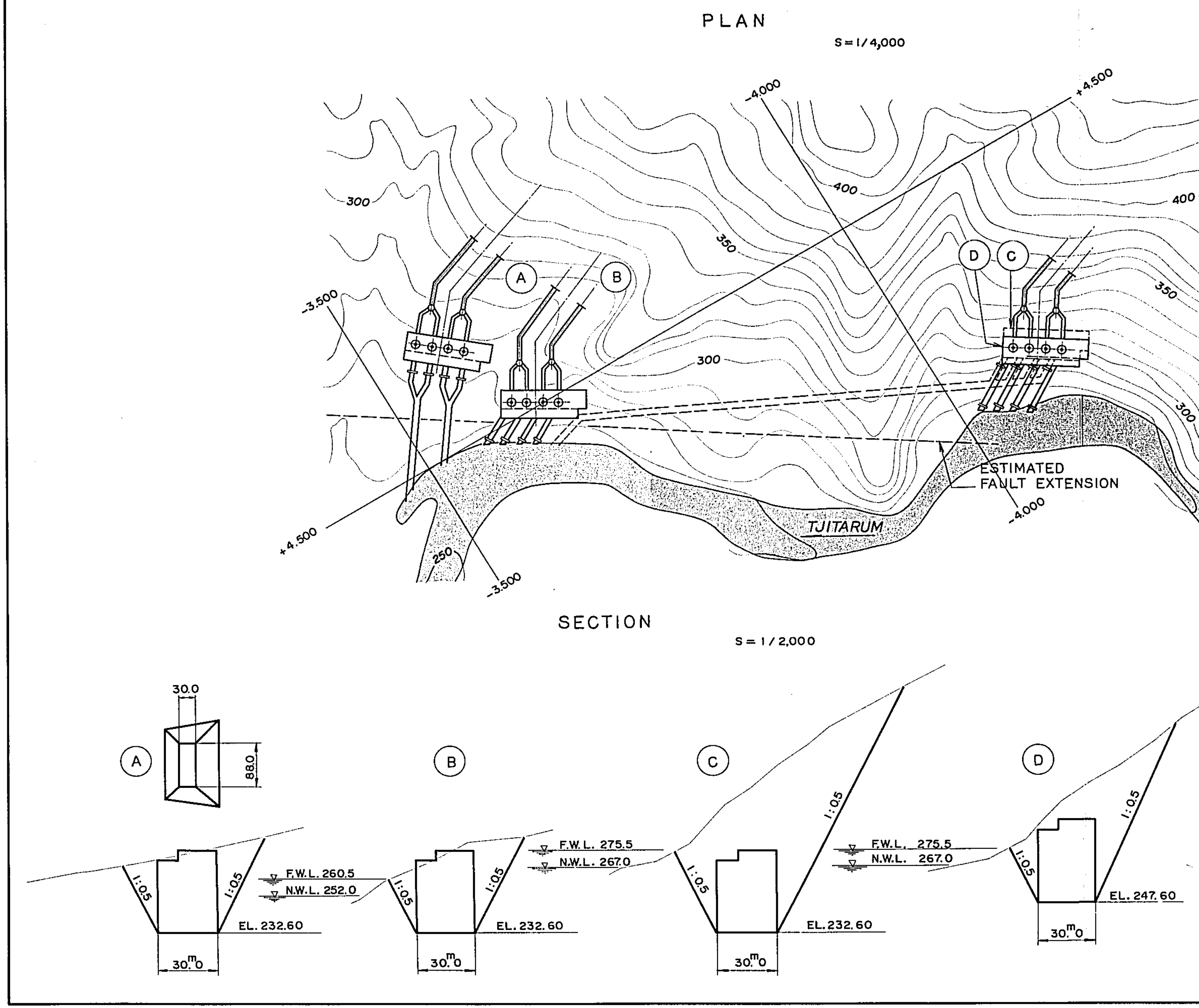
INTAKE STRUCTURE

FIG — 18



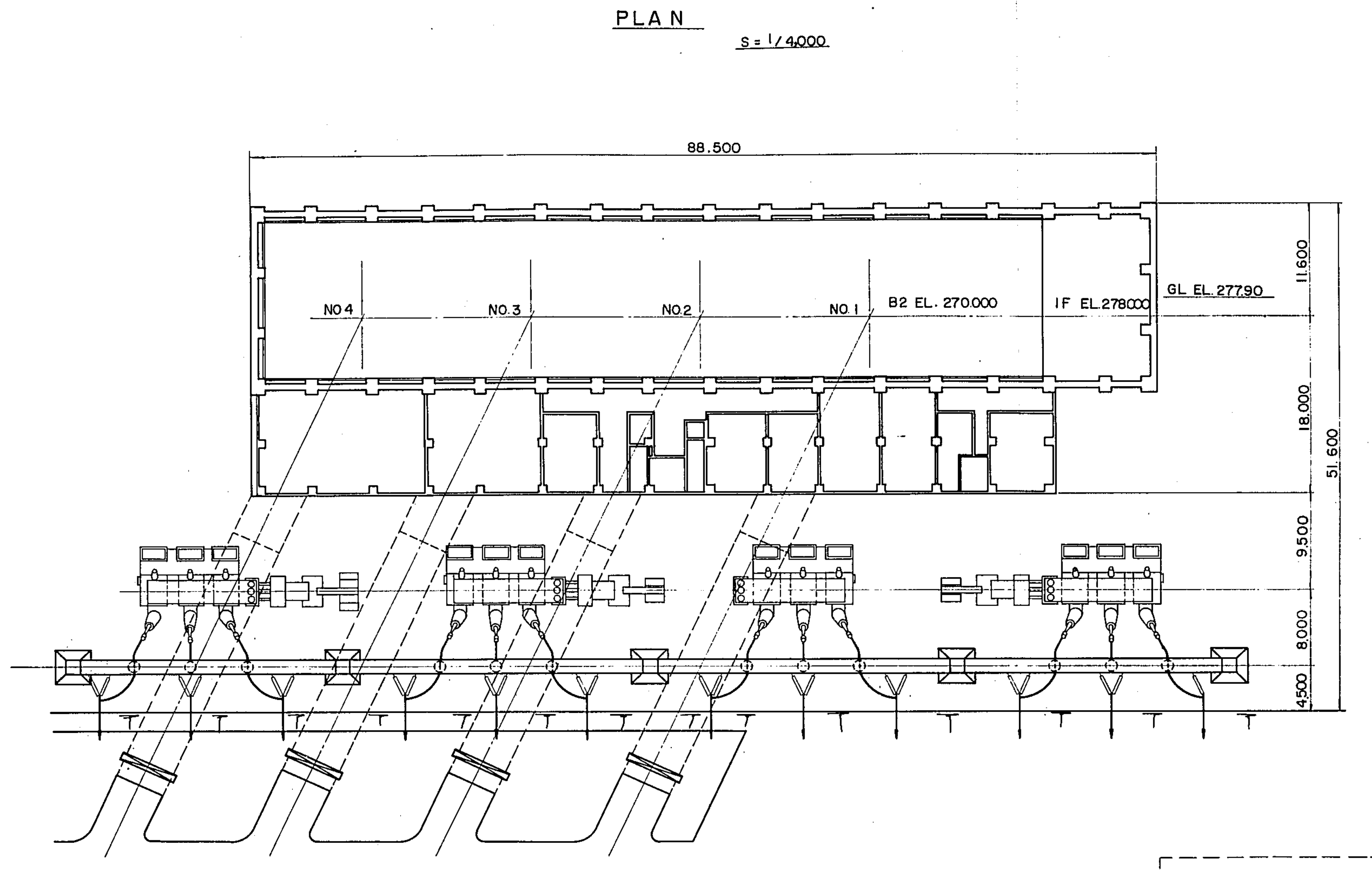
SURGE TANK

FIG - 19



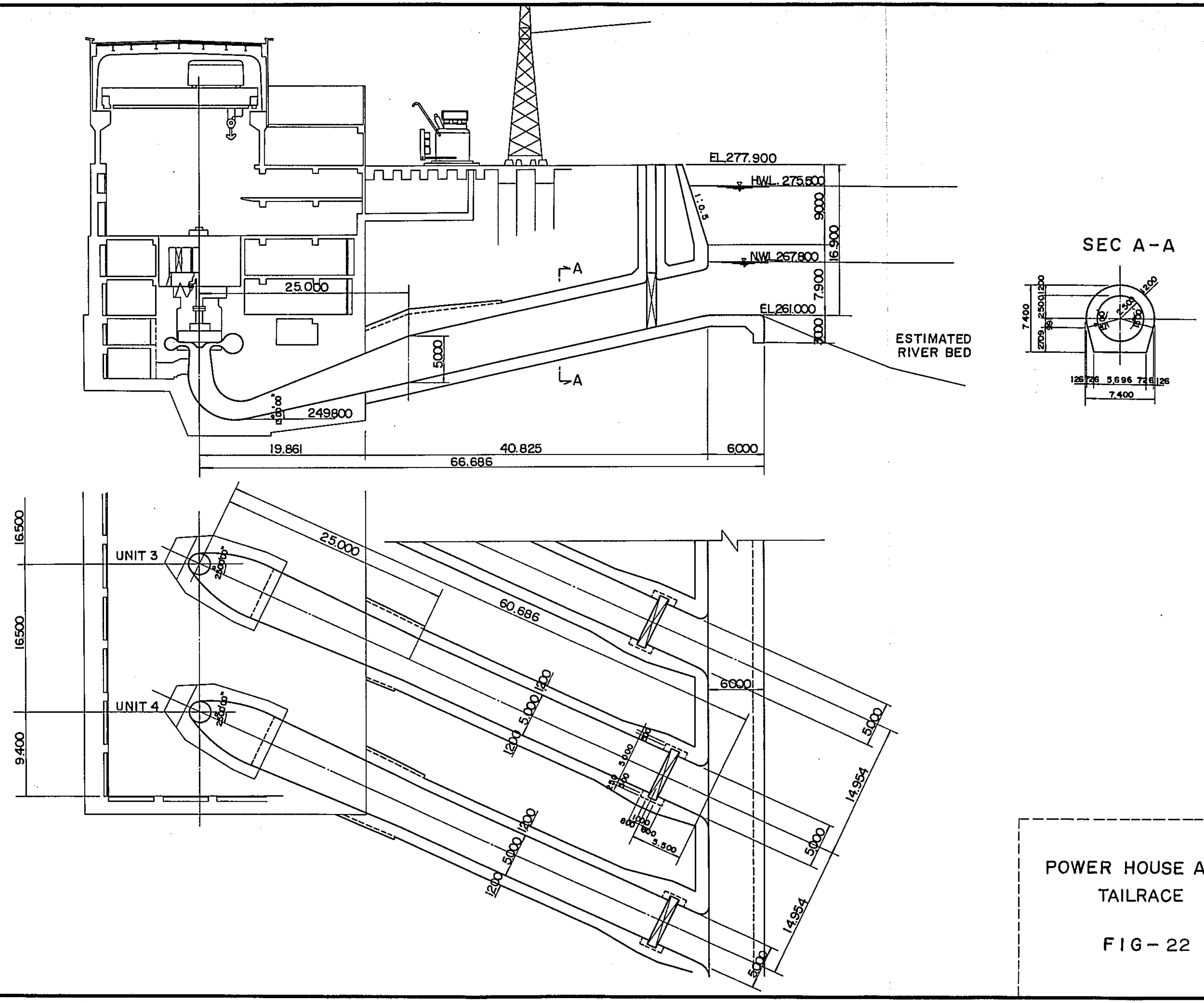
ALTERNATIVES FOR
POWER HOUSE LOCATION

FIG – 20



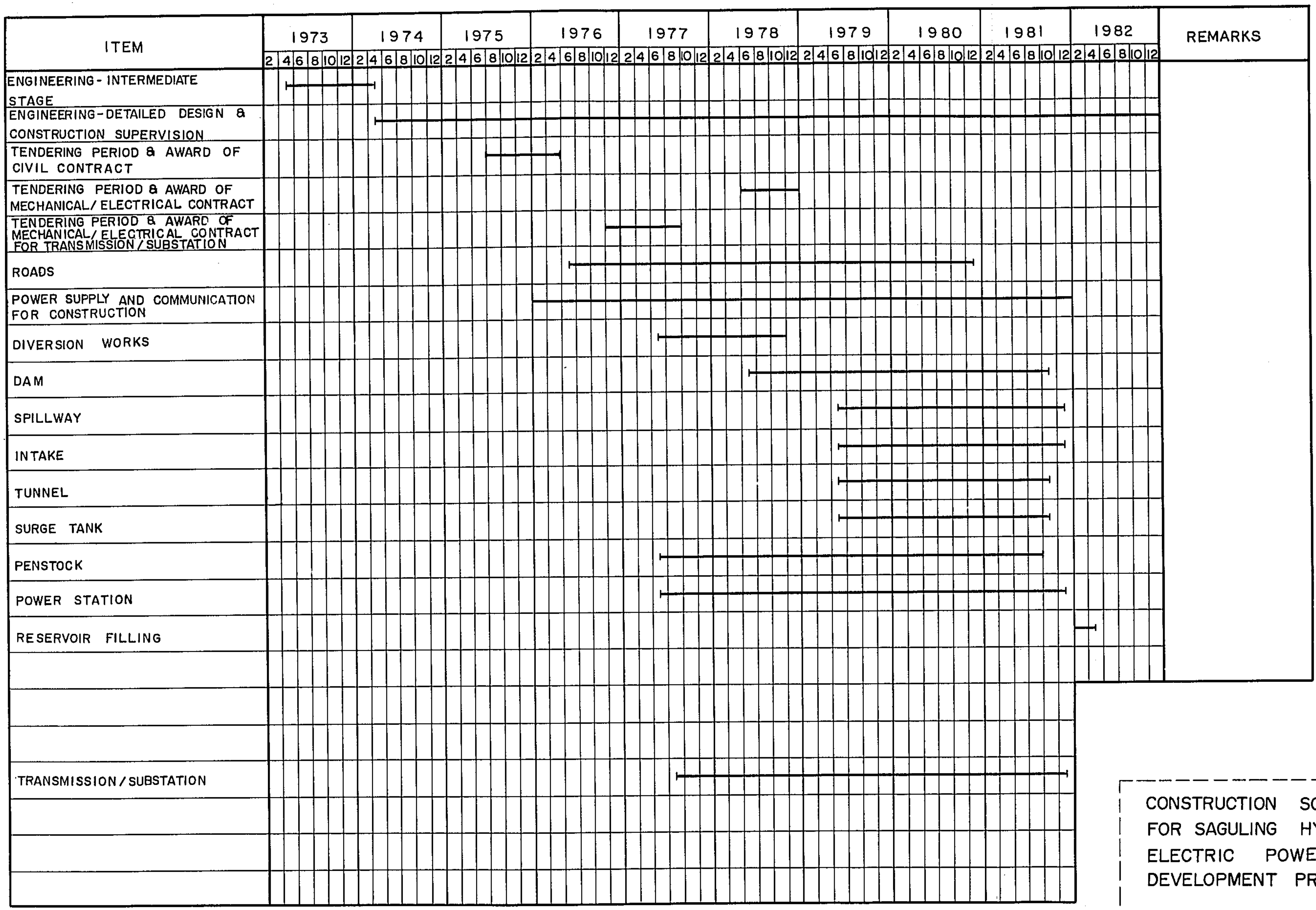
LAYOUT OF POWER HOUSE

FIG. — 21



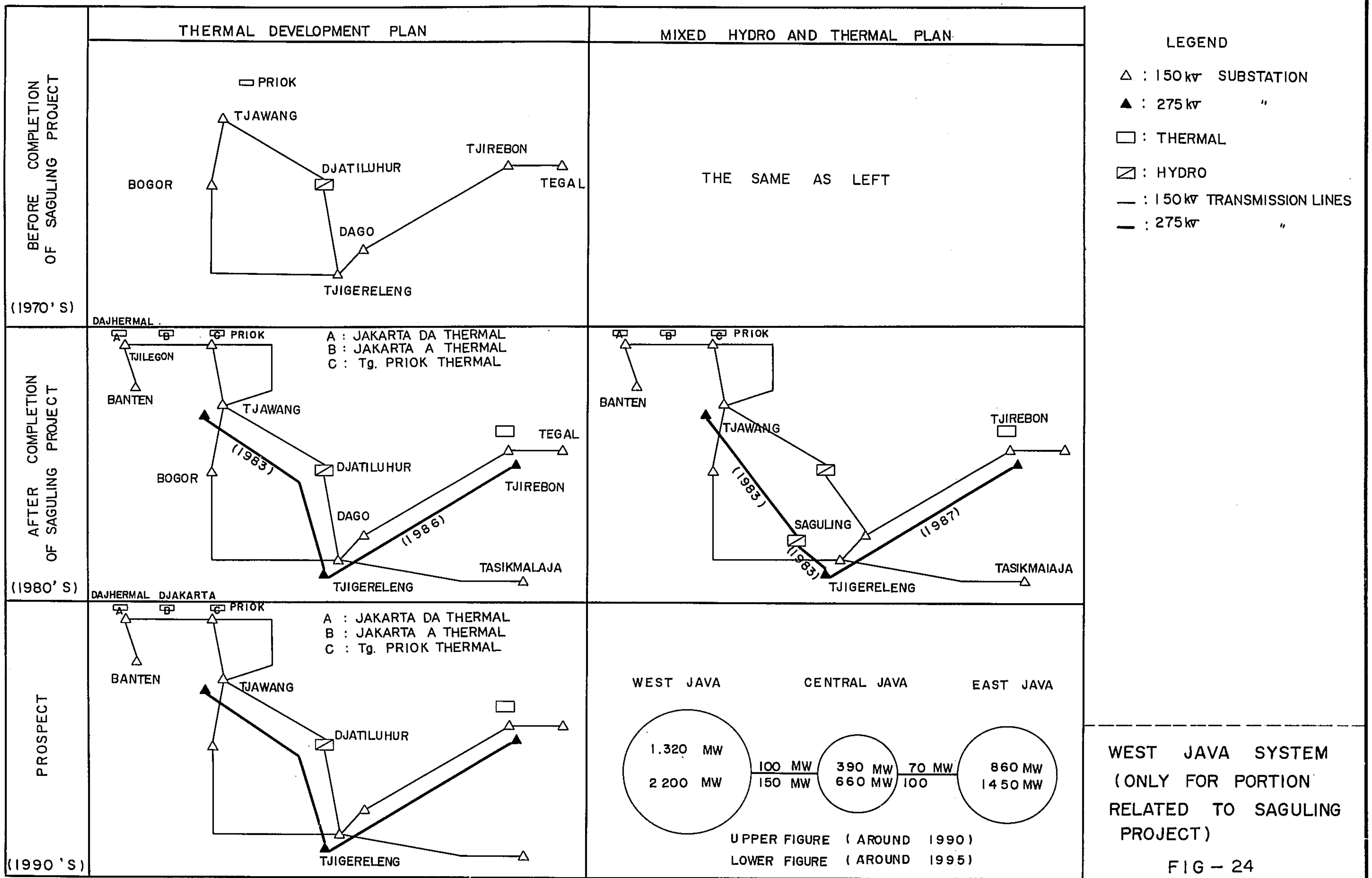
POWER HOUSE AND TAILRACE

FIG-22



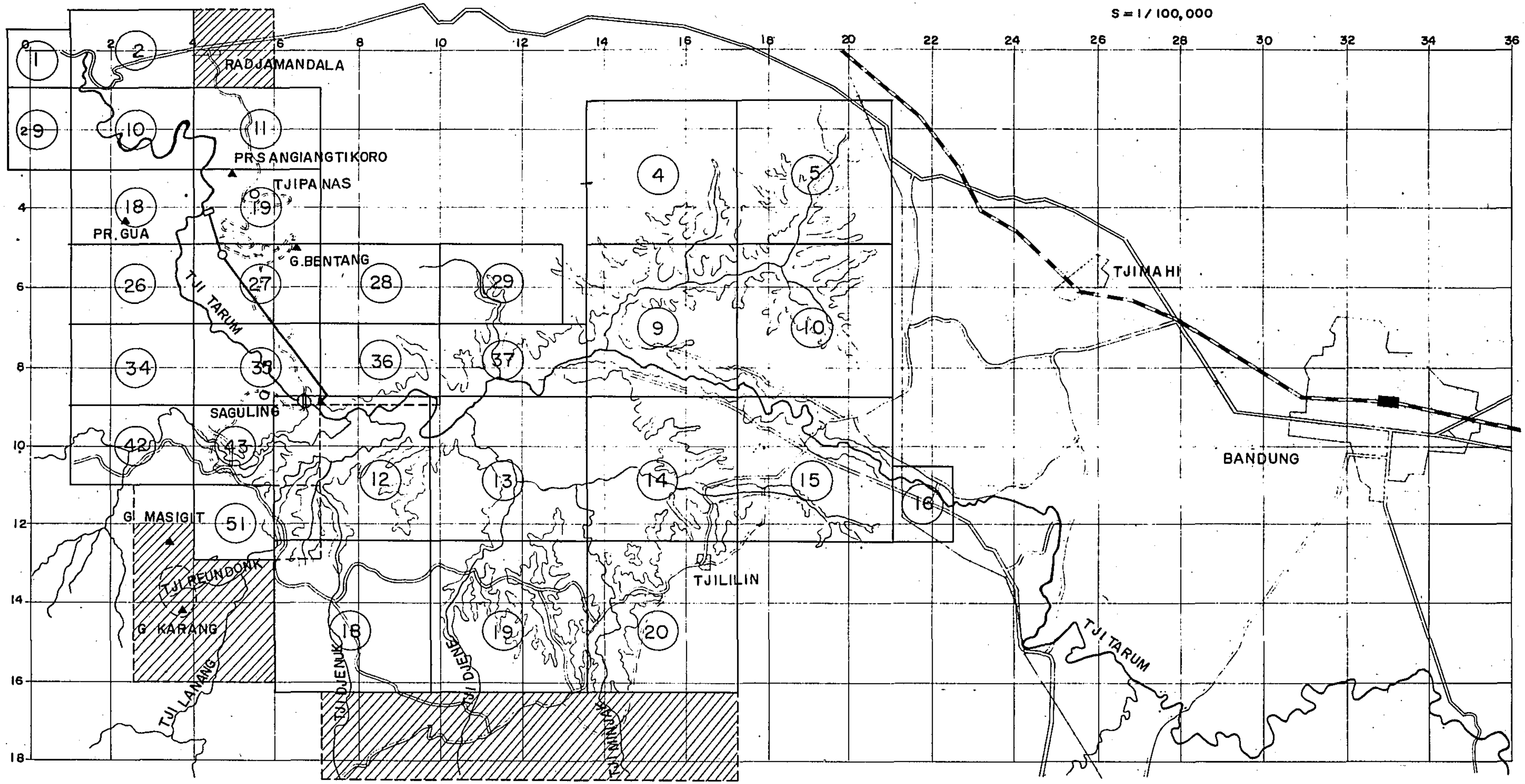
CONSTRUCTION SCHEDULE FOR SAGULING HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

FIG - 23



WEST JAVA SYSTEM (ONLY FOR PORTION RELATED TO SAGULING PROJECT)

FIG – 24



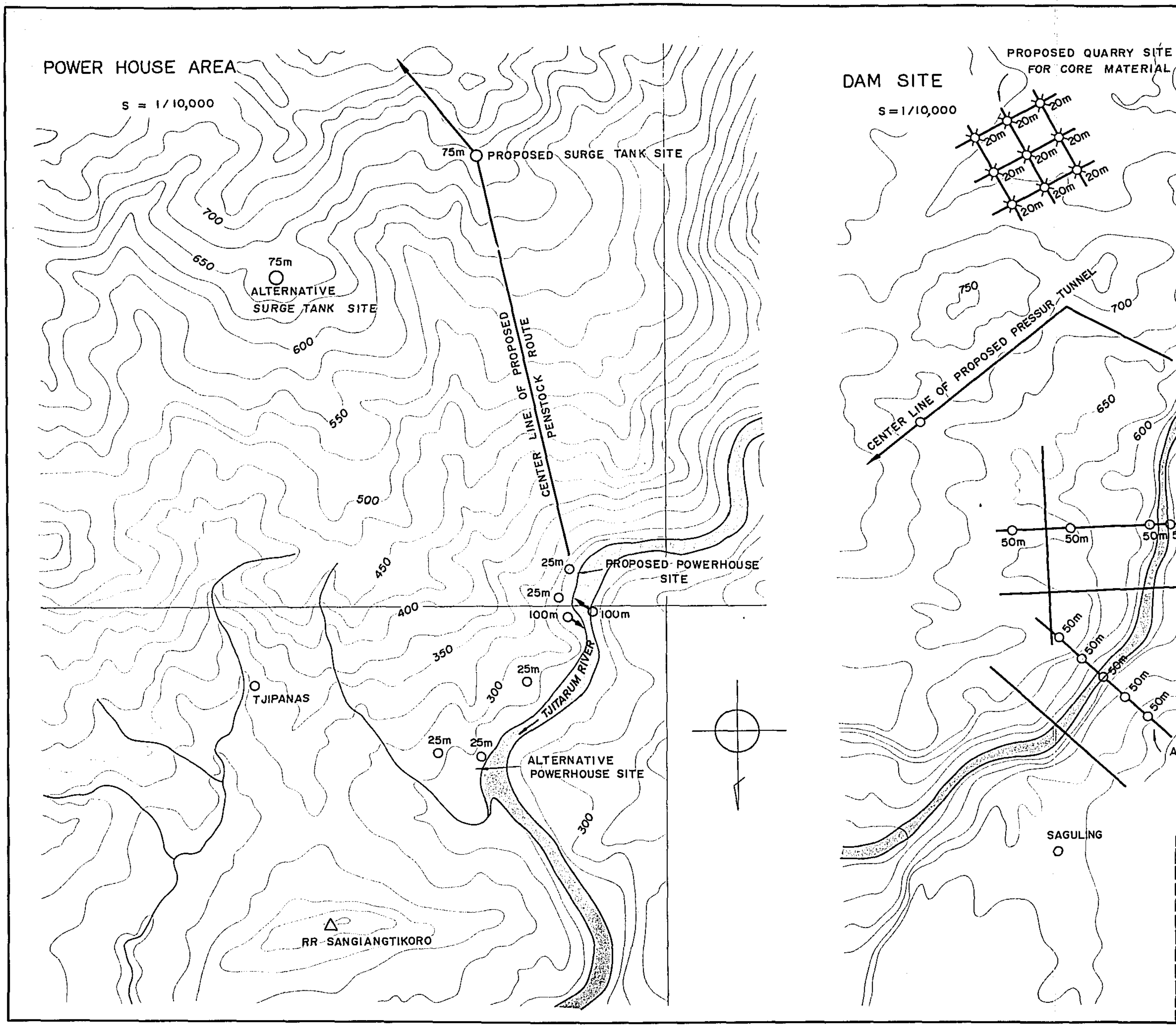
(10) PORTION ALREADY MAPPED AT 1:5000 SCALE AND 2.50m INTERVALS

PORTION PROPOSED AT 1:5000 SCALE AND 5.0m INTERVALS

NUMBERS INSIDE CIRCLES SHOW NUMBERS GIVEN BY PLN UNIT SURVEY FOR AREA ALREADY MAPPED

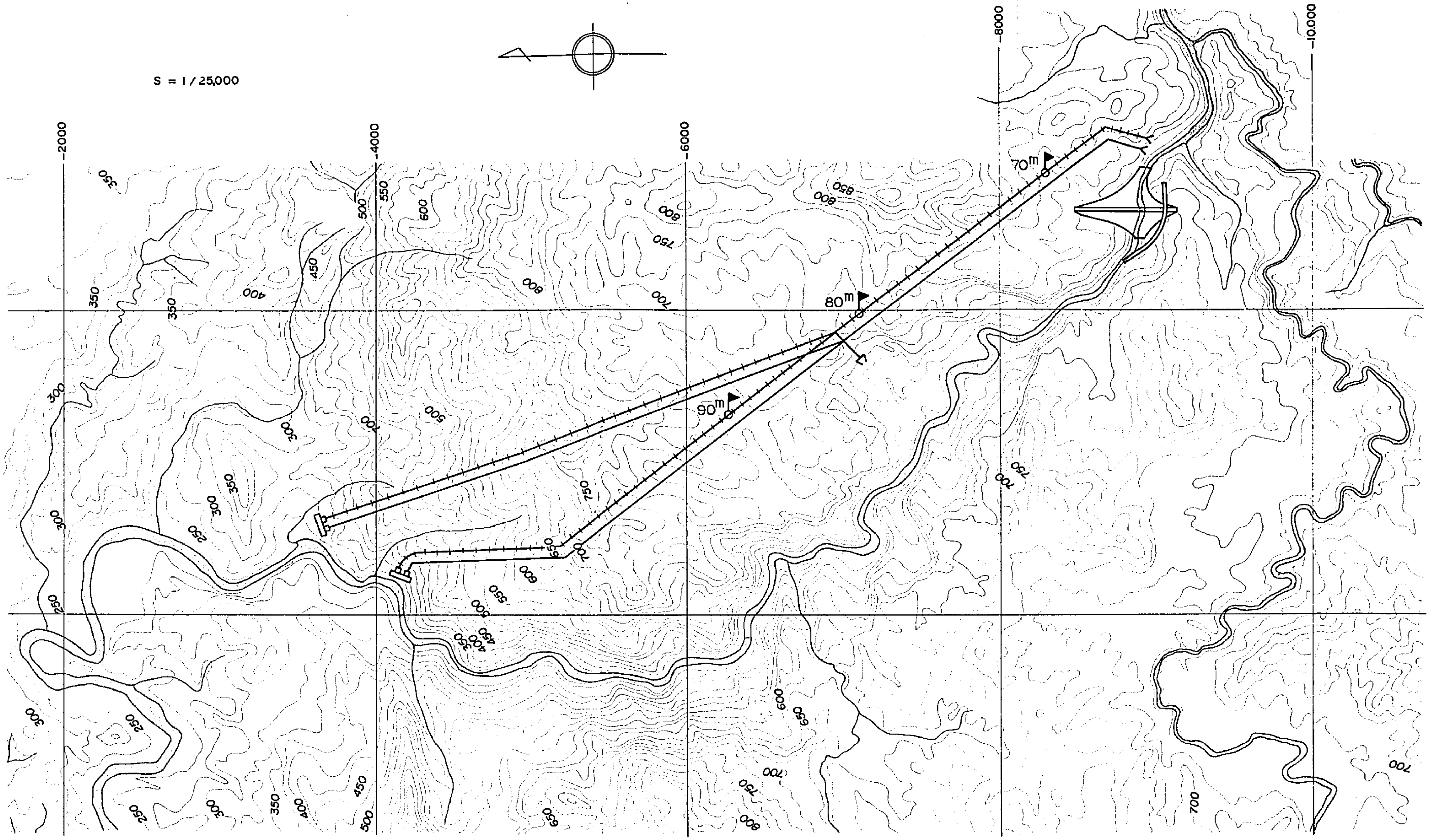
AEROGRAPHIC MAPPING

FIG. — 25



SEISMIC PROSPECTING AND BORING TEST ARRANGEMENTS (DAM SITE AND POWER HOUSE AREA)

FIG—26

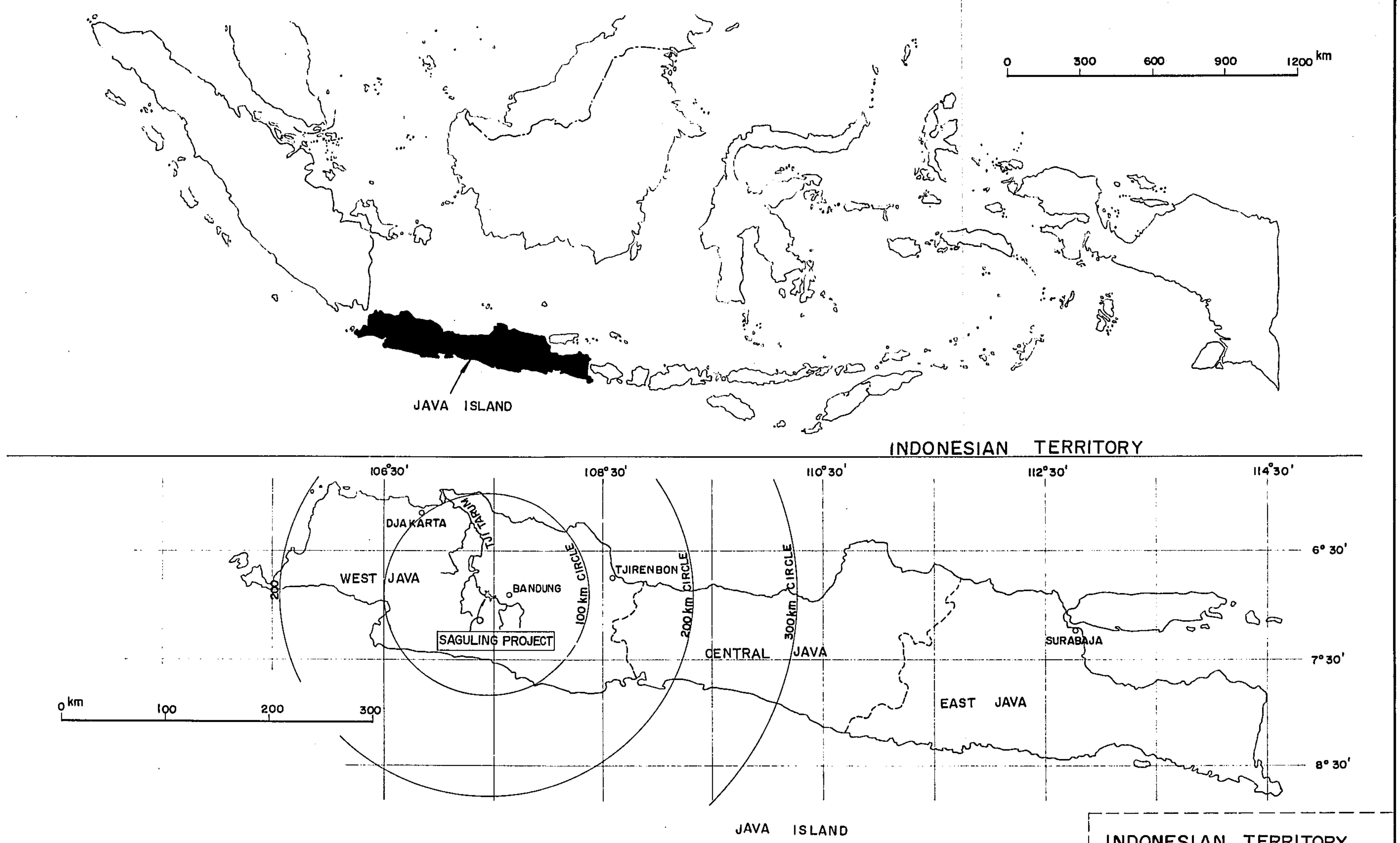


LEGEND

- ROUTE FOR PROPOSED WATERWAY
- LINE OF SEISMIC PROSPECTING
- LOCATION OF TEST BORING

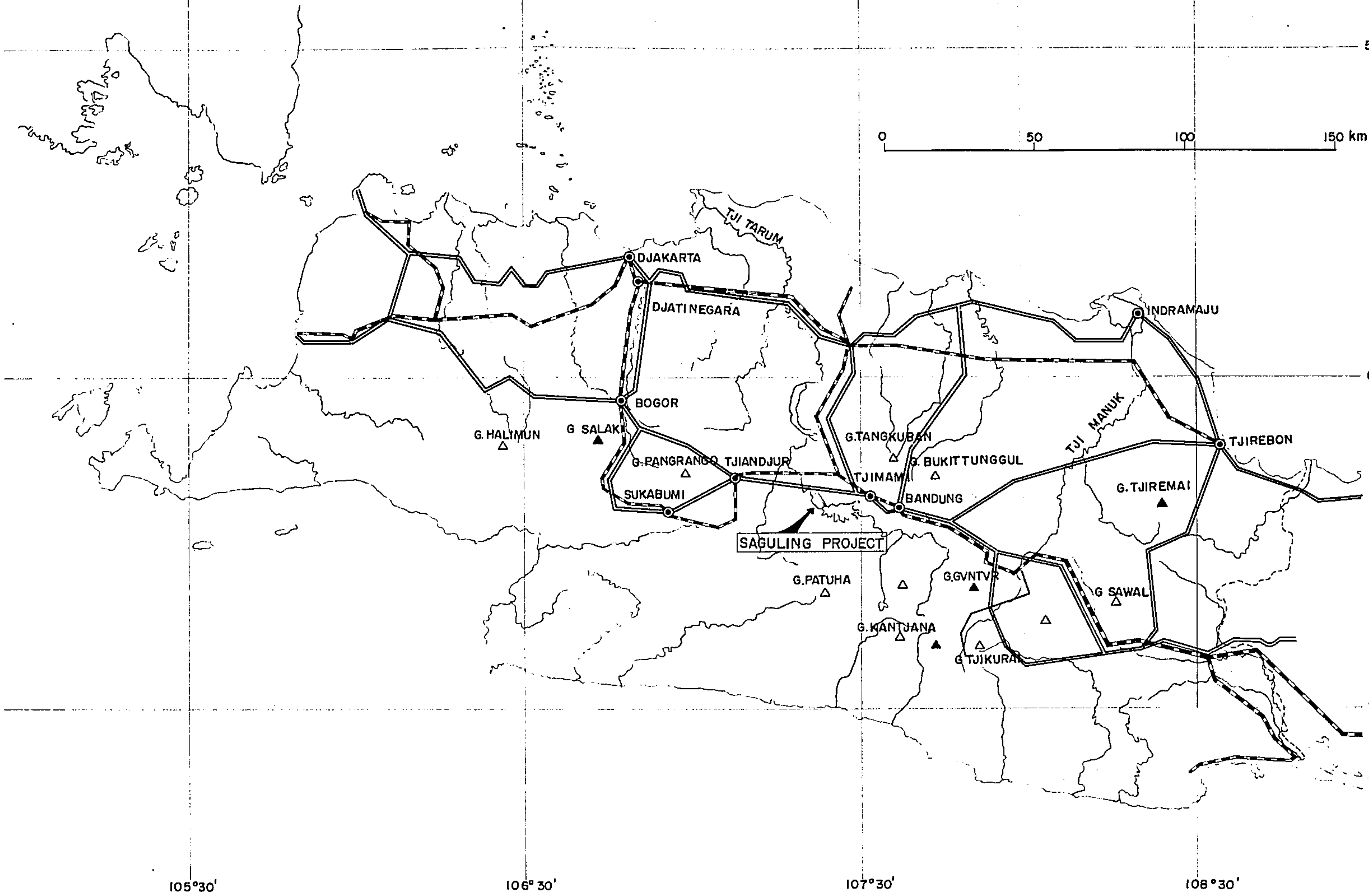
SEISMIC PROSPECTING AND BORING TEST ARRANGEMENT (WATERWAY)

FIG – 27



INDONESIAN TERRITORY
JAVA ISLAND
AND SPOT OF THE PROJECT

PLATE- I

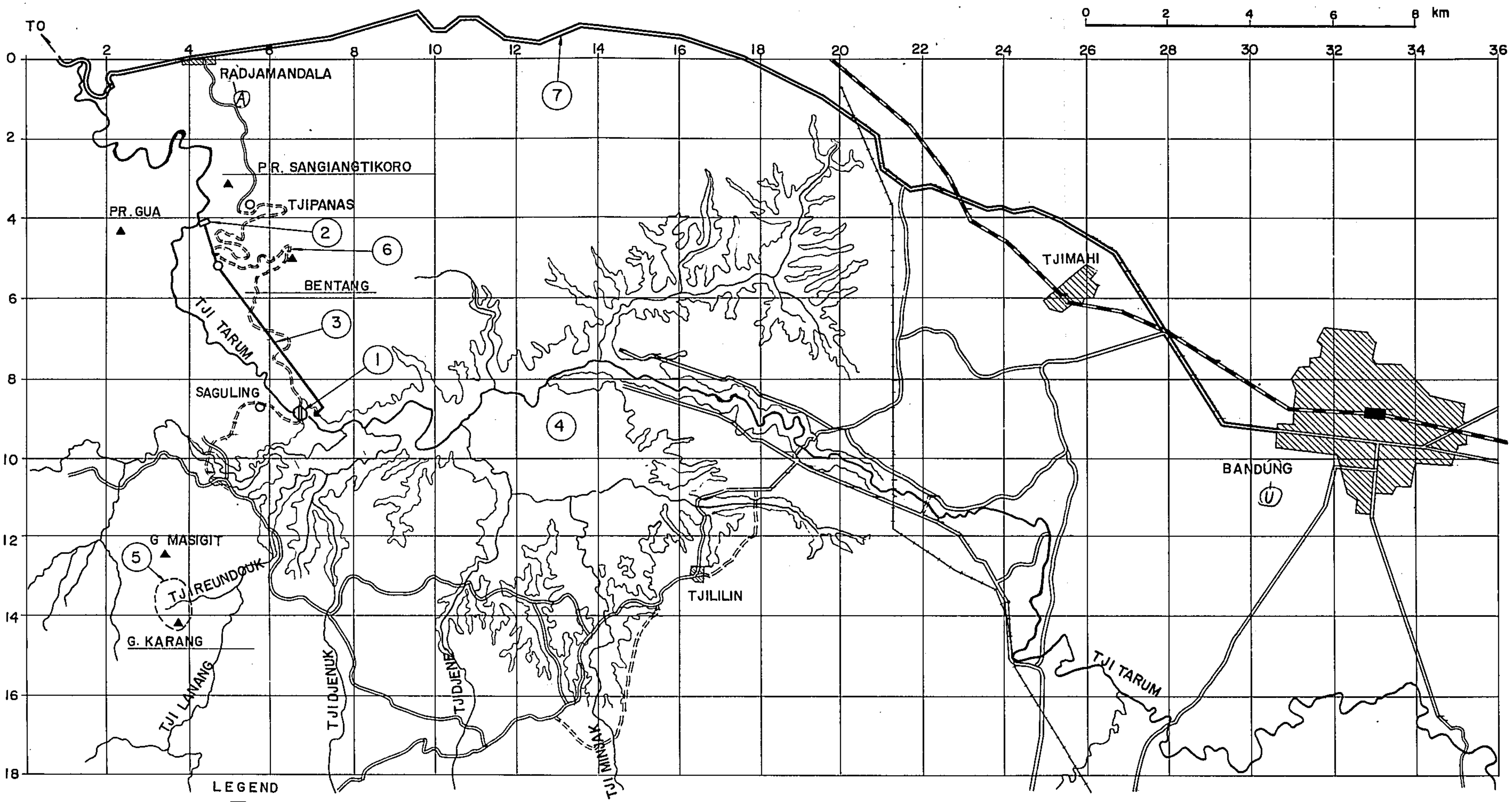


LEGEND

- ⊙ CITY
- ROAD
- RAILWAY
- △ MOUNTAIN
- ▲ VOLCANIC MOUNTAIN

WEST JAVA AREA

PLATE - 2



LEGEND

CITY OR TOWN

VILLAGE

MOUNTAIN OR HILL

RAIL WAY

MAIN ROAD

EXISTING ROAD

NEW ROAD

EXISTING TRANSMISSION LINE

(1) DAM

(2) POWER HOUSE

(3) PRESSURE TUNNEL

(4) RESERVOIR

(5) QUARRY SITE

(6) NEW ROAD (DAM - POWERHOUSE)

(7) MAIN ROAD (DJAKRTA - BOGOR - BANDUNG)

GENERAL PLAN OF THE PROJECT

PLATE- 3