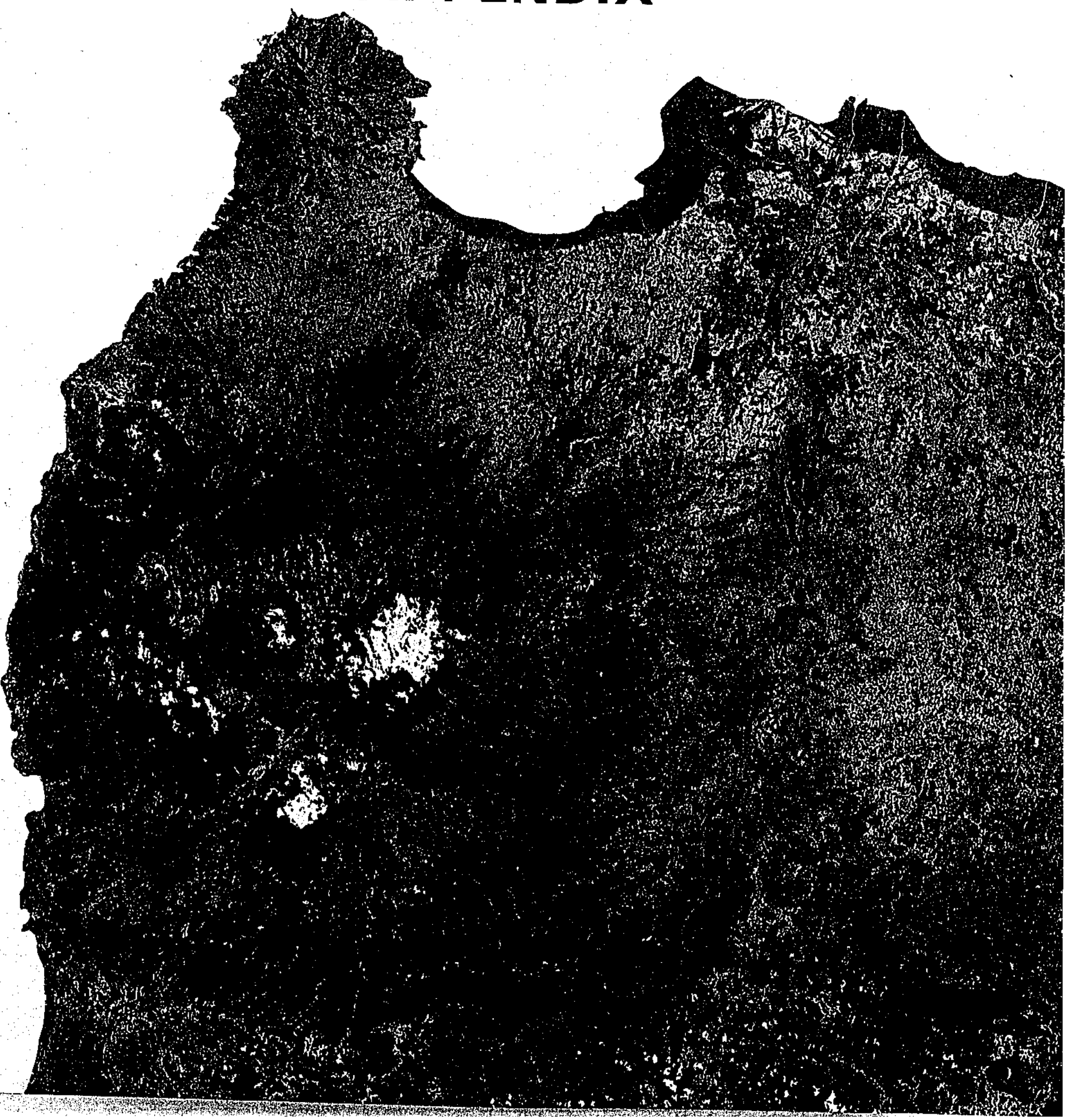
REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

MASTER PLAN STUDY ON NORTH BANTEN WATER RESOURCES DEVELOPMENT

APPENDIX



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JAPAN INTERNATIONAL COOPERATION AGENCY
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MASTER PLAN STUDY
ON
NORTH BANTEN
WATER RESOURCES DEVELOPMENT

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ABBREVIATIONS

(1) Local Terms

BAPPENAS	= Badan Perencanaan Pembangunan Nasional	: National Development Planning Agency
BIMAS	= Bimbingan Massal	: Mass Guidance for Self-sufficiency in Food
BKPM-D		: Investment Coordination Board of the Province of West Java
BPAM		: Provincial Water Management Unit
BPS	= Biro Pusat Statistik	: Central Bureau of Statistics
BULOG	= Badan Urusan Logistik	: National Food Logistics Agency
BUUD	= Badan Usaha Unit Desa	: Village Unit Executive Body
CIPTA KARYA		: Directorate General of Housing, Building, Planning and Urban Development
Danau		: Lake
Desa		: Village
DGWRD		: Directorate General of Water Resources Development
DIPERTA	= Dinas Pertanian Pakyat	: Ministry of Agriculture
DOLOG	= Depot Logistik	: Provincial Food Depot of BULOG
DPMA	= Direktorat Penyelidikan Masalah Air	: Directorate of Hydraulic Engineering
DPU	= Departmen Pekerjaan Umum	: Ministry of Public Works
DPUP	= Dinas Pekerjaan Umum	: Provincial Department Office of Public Works
DSE		: Directorate of Sanitary Engineering
Gunung		: Mountain
IKK	= Ibu Kota Kecamatan	: Sub-district town
INMAS	= Intensifikasi Massal	: Mass Intensification
Kabupaten		: Regency
Kampung		: Settlement
K-C-C area		: Kopo-Cikande-Carenang area
Kecamatan		: Sub-district
Kotamadya		: Municipality

KUD	= Koperasi Unit Desa	: Village Unit Cooperative
Lama		: Old
LEKNAS-LIPI		: National Institute of Economic and Social Research
Palawija		: Upland Crops
P3SA	= Proyek Perancang Pengembangan Sumber-Sumber Air	: Water Resources Development Planning Project Division
PDAM		: Regional Water Supply Enterprise
PELITA	= Pembangunan Lima Tahun	: Five Year Development
PLN	= Perusahan Listrik Nagara	: Public Cooperation of Electricity
PMA	= Penyelidikan Masalah Air	: Hydraulic Engineering (Sub-division)
PMG	= Pusat Meteorogi Dan Geofisika	: Meteological and Geophysical Center
PPA		: Nature Conservation and Wildlife Management
PPL	= Penyuluh Pertanian Lapangan	: Agricultural Field Extension Worker
PPM	= Penyuluh Pertanian Madya	: Agricultural Extension Officer
PPS	= Penyuluh Pertanian Spesialis	: Agricultural Extension Specialist
PROSIDA	= Proyek Irigasi IDA	: IDA Irrigation Project Division
P.T.	= Perusahaan Terbatas	: Private Estate Enterprise
REPELITA	= Rencana Pembangunan Lima Tahun	: Five Year Development Plan
Wilayah		: Region

(2) International or Foreign Organization

ADB	: Asian Development Bank
FAO	: Food and Agriculture Organization of the United Nations
IBRD	: International Bank for Reconstruction and Development
IDA	: International Development Association
JICA	: Japan International Cooperation Agency

UK	:	United Kingdom
UNESCO	:	United Nations Educational, Scientific, and Cultural Organization
US or USA	:	United States of America

(3) Others

B	:	Benefit
C	:	Cost
EIRR	:	Economic Internal Rate of Return
El.	:	Elevation above mean sea level
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
GRDP	:	Gross Regional Domestic Product
NPV	:	Net Present Value
O&M	:	Operation and Maintenance
PVC	:	Polyvinyl Chloride
TSP	:	Triple Super Phosphate

ABBREVIATIONS OF MEASUREMENT

Length

mm = millimeter
cm = centimeter
m = meter
km = kilometer

Area

cm^2 = square centimeter
m^2 = square meter
ha = hectare
km^2 = square kilometer

Volume

cm^3 = cubic centimeter
lit = liter
m^3 = cubic meter

Weight

mg = milligram
g = gram
kg = kilogram
ton = metric ton

Time

s = second
min = minute
h = hour
d = day
y = year

Electrical Measures

V = Volt
A = Ampere
W = Watt
kW = Kilowatt
MW = Megawatt
GW = Gigawatt

Other Measures

% = percent
PS = horsepower
° = degree
' = minute
" = second
°C = degree centigrade
10^3 = thousand
10^6 = million
10^9 = billion (milliard)
ppm = parts per million
pH = scale for acidity

Derived Measures

m^3/s = cubic meter per second
micromhos/cm = scale for electrical conductivity
kWh = kilowatt hour
MWh = Megawatt hour
GWh = Gigawatt hour
kWh/y = kilowatt hour per year
kVA = kilovolt ampere

Money

Rp = Rupiah
US$ = US dollar (US$1 = Rp 690)
¥ = Japanese Yen (¥100 = Rp 280)

APPENDIX A

SOCIO-ECONOMY

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1. GENERAL

1.1 National Background

Indonesia is located in a tropical zone which extends from 6° north latitude to 11° south latitude and from 95° to 141° east longitude. The total land area of the country is about 1.9 million km^2 comprising 13,667 islands. Of the numerious islands, Java is the fifth largest island and covers an area of 134,044 km^2 which occupies approximately 7% of the total area of Indonesia, and it is divided into three provinces, West Java, Central Java and East Java.

Indonesia has a population of 147 million according to the 1980 census corresponding to the density of 77 person/km^2. The growth in population was about 28 million compared with the 1971 census, i.e., the average growth rate was 2.37% per annum during the period from 1971 to 1980. This growth rate is high by 0.27% compared with that for the period from 1961 to 1971. The population projection, which was carried out in 1976 by the National Institute of Economic and Social Research (LEKNAS-LIPI), showed that the population of Indonesia in the year 2000 would reach between 210 and 260 million. Using the 1961 and 1980 censuses, if the average annual growth rate of 2.23% for the period from 1961 to 1980 may be applied to the forecast of population in the future, the population of Indonesia is expected to reach some 230 million by 2000.

As for population, Indonesia is at present ranked as the fifth largest country in the world after China, India, the Soviet Union and the United States, and in 1980 Java has a population of some 91 million corresponding to 62% of the total population of Indonesia. The ratio of the population in Java to the total population of Indonesia has decreased year by year owing to the promotion of transmigration policy by the Government, nevertheless, Java, with a population density of 690 person/km^2 in 1980, is still one of the most densely populated areas in the world.

The population of 10 years and over of age according to the 1980 census was 105.4 million, about 24 million more than that in the 1971 census. Among them, the labour force is 52.3 million corresponding to 49.6% of the population of 10 years and over of age. Comparing these figures with the 1971 figures, though the labour force increased by 10.5 million, on the contrary the participation rate of the labour force decreased from 51.3% to 49.6% due to the increase in the population of school attendance.

Percentage of workers employed in the agricultural sector such as agriculture, forestry, hunting and fishing, in Indonesia was about 55% of the number of the whole workers in 1980 or decreased by about 10% compared with the 1971 percentage. Share of the agricultural sector to the whole industry has a tendency to decrease. On the contrary, there is an observable tendency to increase in shares of manufacturing industries, trade and service sectors. Such a change in industrial structure is also seen in the difference between urban and rural on the growth in population, i.e., the average growth rates of population in the urban and rural areas in Indonesia is 2.8% and 1.8% per annum, respectively, during the period from 1971 to 1980. In view of the present socio-economic conditions in Indonesia, such the tendency is expected to continue for quite some time.

The Indonesian economy has achieved a remarkable development for the last decade based on REPELITA I, REPELITA II and REPELITA III. The per capita GDP in Indonesia in 1980 reached US$400 corresponding to seven times of that in 1971. Such a high growth is largely due to the expansion of the mining sector including petroleum production. The change in industrial structure is clearly appeared in share of GDP among industries; the share of agricultural sector to the total GDP decreased from 37% to 31% between 1975 and 1980, while the share of manufacturing industries sector increased from 11% to 14% during the same period.

Persons more than a half of the whole worker in Indonesia are engaged in the agricultural sector which is a basic industry of the country. However, most of the food crops have been being consumed in the country without being exported. Rice, the most important staple food, has been being imported at 2 million tons per annum on the average during the recent five years in spite of the increase in production of 3.8% yearly during the same period. To achieve self-sufficiency in rice in the near future, the expansion of productive capacity should be promoted mightily. In this context, the water resources development is regarded as one of the most important factor for increasing the rice production.

In Indonesia, the Third Five Year Development Plan (REPELITA III 1979/80 to 1983/84) is under execution at present and its major objectives are:

(1) to raise living standards, knowledge levels and welfare of people, and to strive for equitable distribution of them to the whole nation; and

(2) to establish a solid foundation for the next development stage.

During the period of PELITA III, the Government expects to achieve the average economic growth rate of 6.5% per annum, composing of 3.5% in agriculture, 4.0% in mining, 11.0% in manufacturing, 9.0% in construction, 10.0% in transportation and communication and 8.1% in other sectors. In view of the economic growth rate of nearly 10% in GDP from 1979 to 1980, the plan is regarded as being on the fair way to success.

At present, the agricultural sector is the lowest of all industrial sectors in terms of the economic growth rate and the per capita income. To expect the equitable distribution of the fruits of economic growth which is one of the major objectives of REPELITA III, the further economic growth is to be desired in the agricultural sector in which majority of the Indonesia people are engaged. On the other hand, the expansion of manufacturing industrial sector has the noticeable effects to raise GNP and to maintain the balance of international payments. The water resources development is an indispensable factor to the increase in agricultural production and to the expansion of manufacturing industries.

1.2 Regional Background

The Province of West Java covers an area of 46,300 km^2 occupying 35% of the total area of Java island and its administrative units are formed of 20 regencies (Kabupaten) which are further divided into four municipalities (Kotamadya) and 390 sub-districts (Kecamatan).

According to the 1980 census, the Province contains the population of 27.5 million corresponding to one third of the total population of Java island and its population density is 593 person/km^2. The population increased by 5.8 million between 1971 and 1980 with the average growth rate of 2.66% per annum. This growth rate is high by 0.57% compared with that for the period from 1961 to 1971. Based on the forecast of future population to be described in Section 3.6, the Province of West Java is expected to reach a population of some 44 million in 2000 with the average annual growth rate of 2.38% being equivalent to the rate for the period from 1961 to 1980.

The population of 10 years and over of age in the Province was 19.2 million in 1980 comprising 9.5 million of male and 9.7 million of female, and it corresponds to 70% of the total population. This total population increased by 4.8 million compared with that in 1971.

The labour force was 8.67 million in 1980, corresponding to 45% of the population of 10 years and over of age, and it consists of 6.14 million of male and 2.53 million of female. The percentage of employed persons in the Province was 97.7% of the total labour force in 1978, and the percentage of persons employed in the agricultural sector to these in all the industrial sectors decreased from 58.0% in 1971 to 56.5% in 1978. It seems that such a decrease in the share of agricultural sector is the recent trend in Indonesia. In 1980, the number of farm households in the Province was 3.25 million, corresponding to 53% of the total number of households.

The gross regional domestic product (GRDP) for the Province of West Java increased from Rp 1,501 billion in 1973 to Rp 2,595 billion in 1980 at the 1975 constant prices. This shows the average real growth rate of 8.1% per annum. The share in GRDP by main sector in 1980 was 29.8% for agriculture, 9.3% for mining and quarrying, 9.9% for manufacturing industries, 6.2% for construction, 4.8% for transportation and communication and 39.3% for trade, financing and other services. The share of agricultural sector reduced by 4.8% during the period from 1975 to 1980.

The per capita income for the Province in 1980 was Rp 206,000 at the current prices and Rp 95,000 at the 1975 constant prices. The average real growth rate of the per capita income was 5.6% per annum during the period from 1973 to 1980. This growth rate is higher than 4.0% for the whole of Indonesia.

The Province is the main rice bowl in the country, producing the dry paddy of 6.34 million tons in 1980 and covering 23% of the whole production in Indonesia. However, this production is slightly below the consumption in the Province at present. Therefore, the increase in rice production, through the expansion of irrigation area in the dry season and the improvement of irrigation system, is needed to realize the self-sufficiency in the Province.

2. ADMINISTRATION

The Study Area is situated in the northwest corner of the Province of West Java. The Study Area consists of three Kabupatens; Serang and some parts of both Lebak and Pandeglang, and it covers about 3,600 km^2 or 8% of the gross area of the Province comprising twenty (20) Kabupatens. Catchment areas of the Cibeureum and Ciberang rivers include a part of the Kabupaten of Bogor in their upper basins. However, the Study Area for socio-economy are limited to the Banten region except the Kabupaten of Bogor, judging from objectives of the socio-economic study in the present master plan.

The Kabupaten of Serang covers 1,876 km^2 occupying nearly half of the Study Area and comprises 26 Kecamatans. The town of Serang is the administrative center of the Kabupaten of Serang. The Kabupaten of Lebak within the Study Area covers 1,573 km^2 (44% of the total area of the Kabupaten of Lebak) and is divided into 10 Kecamatans. The Kabupaten of Lebak is administered from the town of Langkasbitung. The Kabupaten of Pandeglang within the Study Area covers 184 km^2 (5% of the total area of the Kabupaten of Pandeglang) comprising three Kecamatans and is administered from the town of Pandeglang.

Each Kecamatan has several Desas as an administrative substructure. Number of Desas in the Study Area is 477 in total including 330 in Serang, 113 in Lebak and 34 in Pandeglang. Most of the Study Area is the rural area and the urban area is below 10% of the total area. These figures are summarized in Table A-1.

3. POPULATION

3.1 Population Statistics

Population censuses in Indonesia were taken in the years 1961, 1971 and 1980 after the independence. Population figures for these years for the whole Indonesia, Java island, the Province of West Java, three Kabupatens of Serang, Lebak and Pandeglang, and the areas of these Kabupatens within the Study Area are given in Table A-2. According to the 1980 census, the Study Area contained the population of some 1,654,000, comprising population of 1,109,000 in Serang, 412,000 in Lebak and 133,000 in Pandeglang. The population in the Study Area was about 6% of that in the Province.

3.2 Population Density

Population in the Study Area is relatively dense in the northern part and coarse in the southern part. The population density for the Study Area was 455 person/km^2 in 1980. This figure is lower than those for the Province and the whole of Java island. Table A-2 shows that the population density in the Kabupaten of Serang was 591 person/km^2 in 1980, in Lebak 262 person/km^2 and in Pandeglang 719 person/km^2. Such a high density in the Kabupaten of Pandeglang is due to the fact that on Pandeglang the Study Area contains only three Kecamatans with the high population density relatively including the Kecamatan of Pandeglang. The population density in the whole area of the Kabupaten of Pandeglang was 264 person/km^2 as shown in Table A-2.

3.3 Growth in Population

The average growth rates of population per annum in the Study Area for the both periods of 1961 to 1971 and 1971 to 1980 are estimated to be 1.88% and 2.72% respectively, using a formula $P_n = P_1(1 + r)^{n-1}$. Where, P_1 and P_n mean the population in the first year and the n-th year, respectively, and r means an average growth rate of population per annum.

Comparing the average growth rate of the latter (1971 to 1980) with that of the former (1961 to 1971), the latter shows considerably higher rate than the former, that is, the growth rate is increasing in recent years. As shown in Table A-2, such a tendency to increase is also in evidence throughout the whole of Indonesia. It seems that the decrease in death rate due to the improvement of health services is one of the major factors. However, it is expected that in the future the population in the Study Area would not have so high growth rate as appeared for the period of 1971 to 1980 on account of the promotion of family planning program by the Government.

The population growth rate in the Study Area is close to that in the Province of West Java and just higher than that in the whole Indonesia. This rate, however, is very high compared with the growth rate of about 2.0% in the Java island.

3.4 Population Distribution

3.4.1 Population distribution by Kecamatan

The population distribution by Kecamatan within the Study Area is given in Table A-3. The Kecamatans of Serang, Rangkasbitung and Pandeglang, which contain each administrative centre of three Kabupatens, had the population of some 111,000, 104,000 and 49,000 in 1980, respectively. The Kecamatans of Cilegon and Pulomerak, which are the important industrial areas in the Study Area, had the population of some 51,000 and 90,000, respectively, in 1980. These five Kecamatans have the population of just over 400,000 in total or 24% of the total population in the Study Area, and nearly 40% of them inhabit in the urban area. Other than the above five Kecamatans, the urban areas are placed in the following three Kecamatans; Kramatwatu, Ciruas and Ciomas.

Table A-4 shows the population distribution ratio between urban and rural areas within eight Kecamatans in the recent years. As seen from the table, there was not very much change in the population distribution ratio between urban and rural of each Kecamatan during the period from 1977 to 1980. The population in the urban area is only 10% of the total population in the Study Area. In the Province of West Java, this figure is about 20%.

In the Study Area, the growth in population in Kecamatans with the urban area are generally speaking large. Especially, the population in the Kecamatans of Pulomerak and Cilegon showed the high average growth rate of over 4% per annum during the period of 1971 to 1980. Further, as for the population density, Cilegon as well as Serang and Pandeglang were over 1,200 person/km^2 in 1980. While, the population density for Cimarga, Mancang, Leuwidamar, Bojongmanik and Cileles was below 200 person/km^2 and the growth rate also was low. A disparity in the population distribution is seen among Kecamatans within the Study Area as shown in Table A-3.

3.4.2 Population distribution by age and sex groups

Table A-5 shows the population by age and sex groups in the Study Area, the Province of West Java and Indonesia. In the Study Area, the population under 15 years of age accounts for 45% of the whole, i.e. the average age is low compared with those of West Java and Indonesia. By contrast, the rate of population between 15 and 49 years is low, especially in the male group. This is probably due to that some of people are working away from home in other places to obtain their additional income. In the Study Area, the female inhabitants far outnumber the male.

3.5 Labour Force

3.5.1 Manpower

In the Study Area, the population of 10 years and over of age in 1980 was just over 1.10 million corresponding to 67% of the total population. According to the 1980 census, in the whole country the labour force participation rate was 67.8% of the total population of over 10 years for male and 32.0% for female. These rates in the Province of West Java were 64.7% for male and 26.0% for female. In the present study, number of the labour force in the Study Area are estimated using the labour force participation rates of West Java, because there are no available data of the rates for the Study Area.

The number of labour force in the Study Area are estimated at some 490,000 comprising 340,000 of male and 150,000 of female. This number corresponds to nearly 30% of total population, which is a little low compared with 32% (labour force of 870,000) for West Java and 35% (labour force of 52 million) for the whole country. These figures are summarized in Table A-6.

3.5.2 Employment

In the Study Area, more than 80% of the population in 1977 finds its occupation in the agricultural sector as shown in Table A-7. Though it seems that the share of agricultural sector is decreasing as a recent trend, the sector in the Study Area still has very high share in the whole industries as to the occupation, i.e. in 1980 number of farmer households occupied 69% of the total number of households. This percentage is extremely high compared with 53% for West Java as shown in Table A-8. It is therefore understood from such a fact that the development in the Study Area should be put the great emphasis on the agricultural sector.

3.6 Population Projections

Population projection for Indonesia to the year 2005 was carried out in 1976 using the 1961 and 1971 censuses and population statistics in other years till 1976 by LEKNAS-LIPI (Ref. 10). The projection was closely made assuming two conditions of the high and the low for each factor of fertility, migration and urbanization. As the results of forecast, it showed that in the year 2000 the population of Indonesia will reach between 210 and 260 million, and 235 million on the average. The average growth rates per annum for these population forecasted are 1.77%, 2.77% and 2.27%, respectively.

On the other hand, the average annual growth rates of the population in the past for the whole Indonesia, as shown in Table A-2, were 2.10% for the period of 1961 to 1971, 2.37% for the period of 1971 to 1980 and 2.23% for the period of 1961 to 1980. Among three kinds of growth rates mentioned above, the average growth rate of 2.23% for the period of 1961 to 1980 is close to the average rate of 2.27% in the forecast. Further, taking into consideration the effect of family planning for the future, the population in the Study Area in 2000 is, in the present study, estimated using the average growth rate from 1961 to 1980. The estimation is carried out by Kecamatan using each growth rate and the result of the 1980 census given in Table A-2, and the result is shown in Table A-10. For comparing, the future population for three Kabupatens (Lebak, Pandeglang and Serang), West Java, Java island and the whole Indonesia are estimated in the same manner as described above and these results are shown in Table A-9.

The total population within the Study Area is estimated to be some 2.63 million in 2000, including 1.78 million in the Kabupaten of Serang, 0.64 million in Lebak and 0.21 million in Pandeglang. The population for the Kecamatans of Serang, Langkasbitung, Pandeglang, Cilegon and Pulomerak in 2000 are estimated to be 208,000, 172,000, 82,000, 97,000 and 187,000, respectively. It is however expected that the population in Cilegon and Pulomerak will more increase in proportion to the development of the industrial area.

The population in the urban area for the future are estimated for eight Kecamatans, which contain the urban area, using the forecasted future population of each Kecamatan as shown in Table A-10 and the population distribution ratio between urban and rural as shown in Table A-4. Since there is not very much change in the ratio during the period from 1977 to 1980, a mean value for four years is applied to the estimation of population in the urban area. The result is shown in Table A-11.

In the Study Area, the population in the urban area is estimated to be 288,000, corresponding to 11% of the total population. The population in the urban area of the Kecamatan of Serang is estimated to be 144,000 according for 50% of the total population in the urban area within the Study Area.

4. AGRICULTURE AND INDUSTRY

4.1 Agriculture

Approximately 70% of the population in 1980 were engaged in the agricultural sector which was the mainstay of the Study Area. The most important crop is rice naturally. Other than rice, there are field crops such as cassava, peanuts, sweet potato, maize and soybeans. However, most of them are grown for self-use. The main estate crops are coconut, clove, coffee, pepper and so on. On the other hand, shrimp and fish called "Ikan Bandeng" are being produced in numerous fish ponds along the coast of the Banten Bay.

The arable lands in the Study Area are mostly cultivated mainly for paddy and perennial crops. Of the paddy fields which cover area of some 241,000 ha, about the area of 106,000 ha has irrigation facilities. The largest irrigation area is the Ciujung Irrigation Scheme commanding 24,000 ha. The rest areas have numerous small facilities of lower categories of irrigation. However, all of the existing facilities depend on the natural runoff of the river without storage facilities. Hence these facilities have been used mostly for the supplemental irrigation in the wet season. It is estimated that only one third or less of the irrigation area receives irrigation water in the dry season. The product of rice in the Study Area was about 0.4 million tons as dry paddy in 1981 corresponding to 8% of the rice products in the Province of West Java.

The Ciujung irrigation scheme was established about 70 years ago. By the hand of PROSIDA aided by IBRD, rehabilitation of the irrigation facilities and the construction of the tertiary canals were carried out under separate projects. Currently the improvement of the drainage is under way.

4.2 Industry

Cilegon/Merak region is the most industrial area in the Study Area. Notable factories in this region are P.T. Krakatau Steel Works and Suralaya thermal power station. The target of P.T. Krakatau Steel Works, founded in 1971, is to manufacture the steel products of some 1.5 million tons and to attract the secondary steel based industries to the region. The Suralaya power station is now under construction with a schedule of the final output of 3,100 MW. This figure indicates that the installed capacity would meet the projected demand in the Study Area without any additional installations.

The Government of Indonesia has been promoting the development of the industrial estate at Cilegon in coordination with P.T. Krakatau Steel Works. The industrial estate, which has an area of 550 ha, is expected to complete in the early stage for the development of the Study Area. The factories expected in the estate are of the fields such as chemical products, tinplate, machine tool, tyre factory, boiler, carbon black and workshop.

At present, the major manufacturing industries in the Study Area, except P.T. Krakatau Steel Works, are only a plywood factory at Anyer and a PVC resin factory near Merak. Others are small scale factories such as brick and tiles, bamboo and rotan products, and coconut products.

5. INFRASTRUCTURE

5.1 Transportation

5.1.1 Road

Transportation in the Study Area depends mainly on the road traffic by a national road and a number of provincial roads. The national road runs through the Study Area from Jakarta via Serang to Merak. This road as a main route to connect between Sumatra and Java is well maintained, and further the construction works of the by-pass road now are being carried out around Serang for increasing the traffic capacity. There are provincial roads to connect among Serang, Pandeglang and Rangkasbitung, to connect Rangkasbitung to Bogor and to connect Pandeglang to Labuan. These roads are asphalt paved and well maintained. Besides, there are many other smaller roads, and some of them are asphalt or metal paved. However, roads in the southern part of the Study Area are generally poor. Such a poor condition of the roads is one of the major factors restricting the development of this areas.

5.1.2 Railway

A railway with single line runs from Jakarta to Merak through the Study Area and connects at Merak with the ferry which runs between Java and Sumatra. There is a railway junction at Rangkasbitung, a major station on this line, and the other line from Rangkasbitung runs to Labuan on the west coast. These railways are at present the important facilities to transport daily passengers and cargoes to and from Jakarta, and it will be required in the near future to strengthen and modernize the facilities to promote the development of the region, especially in sectors of industry and tourism.

5.2 Water Supply

5.2.1 Urban water supply

The urban water supply system is administrated by the Regional Water Supply Enterprise (PDAM) in each Kabupaten. The water supply system of the town of Serang was started in 1885, and at present the connections of 200 (about 2.4% of households) are supplied by 14 old boreholes with yield of about 3.3 lit/s in total and a new borehole with yield of 2 lit/s at Cipare. However, most of the inhabitants have their own wells for the purpose of cooking, drinking, bathing and laundry. The river water is used for their washing and laundry in case the river is available near-by. The Sukacai and Citaman springs were lately completed for the new water supply system having the capacity more than present water demand.

The water supply system of the town of Pandeglang was commenced in 1938 using water of two springs; one is the Ciwasiat spring with yield of 9 lit/s and the other is the Ciraden spring with yield of 3.2 lit/s.

The water supply system of the town of Rangkasbitung was started in 1931 using water of the Ciwasiat spring in the Gunung Karang. This supply system however was abandoned in 1960, because the available capacity of spring water dropped to about 4 lit/s. Recently the No. 1 deepwell was dug at Malang Nengah 3 km northeast from the centre of town and 15 lit/s are supplied to the town. The No. 2 deepwell, 1 km distant from No. 1 deepwell, has also been dug and has been succeeded in getting a yield of 15 lit/s. In the same area, other three deep-wells having a yield of 40 lit/s in total are now under construction.

The town of Cilegon had no water supply system in the past. However, the town obtained the agreement of P.T. Krakatau Steel Works to receive water of 50 lit/s from the Krenceng treatment plant. The first stage construction (1982 to 1983) of 20 lit/s water supply system for 400 consumers has started and the next stage construction for 30 lit/s will follow after the first stage construction.

5.2.2 Rural water supply

The rural water supply system is administrated by the Provincial Water Management Unit (BPAM) and the Water User's Association under the control of the Directorate of Hygiene and Sanitation, Directorate General of Communicable Diseases Control.

In the rural area, there is no special water supply system, except hand operated pump facilities for each village. The recent status of the rural area in the Study Area is summarized as follows:

(1) The demand water for each 10 to 100 people is taken from one dug well (about 6 to 12 m in depth), and the served water is 8 to 70 lit/capita/d except limited in the dry season.

(2) Water of rivers and canals is used for their washing and laundry, and the groundwater taken out from their dug wells is used for their cooking and drinking.

(3) Water of many springs in the area around the Gunung Karang is used for the domestic and irrigation purposes.

5.2.3 Industrial water supply

The water supply source for P.T. Krakatau Steel Works, the biggest factory in the Study Area, is the river water taken from the Cidanau and pumped through a steel pipeline for 27 km to the Krenceng treatment plant near P.T. Krakatau Steel Works. A pumping station is located near the intake site and equipped with four units of pump, which is designed to have a capacity of 2.5 m^3/s by three units. A steel pipeline of 1,400 mm in diameter is designed to carry 2.5 m^3/s in the full flow condition. The treated water is partly pumped up to a elevated reservoir and partly fed directly by gravity to P.T. Krakatau Steel Works. At present, the water demand from P.T. Krakatau Steel Works is estimated to be about 0.98 m^3/s. About two thirds of the total demand is spent for the steel works, and one third is for the housing complex use.

The Suralaya thermal power station obtained the agreement of P.T. Krakatau Steel Works to receive the treated water of 0.05 m^3/s from the Krenceng treatment plant. It is scheduled that the construction of a transmission line with 250 mm diameter from the Krenceng treatment plant to the power station will be started on around October 1982 and be completed within one year.

There is at present no water demand in the Cilegon industrial estate. However, in the event of completion of the estate, the maximum daily water demand is estimated to be 0.69 m^3/s. Most of other small scale industries have their own shallow wells having yield of below 20 lit/min.

5.3 Electric Power Supply

The electric power supply in the Study Area is managed by PLN Wilayah which is organized for the regional distribution. In the Province of West Java, the power generation was about 1,440 GWh in 1980, and the power consumption was 1,153 GWh comprising 40% for household, 18% for commercial, 27% for industry and 15% for public.

At present, there is no hydroelectric power station in the Study Area. The requirement of power supply is estimated to be 58 GWh. PLN operates a 30 kV power transmission system, which links Rangkasbitung, Pandeglang and Serang. The power is distributed to the major towns with the high tension distribution lines of 20 kV and 6 kV. The power supply services are limited in major towns and their vicinities, but most of villages are not served.

Besides the above PLN utilities, P.T. Krakatau Steel Works have their own power plant of 400 MW, and most of other industries operate their own small or medium size generators. In the Study Area, Suralaya thermal power station is now under construction with a schedule of the final output of 2,800 MW. This figure indicates that the installed capacity would meet the projected demand in the Study Area without any additional installations, and also if P.T. Krakatau Steel Works' own power station has a excessive capacity, the power may be supplied for various purposes in the Study Area.

5.4 Tourism

The Study Area lies within easy driving distance of people who live in the metropolitan areas such as Jakarta, Bogor and Bandung. The Study Area may offer a wide diversity of tourism and recreational opportunities such as beach activities at the Anyer and Merak areas, and visits of natural reserve in the piedmont of the Gunung Karang and historical sites in the old Banten near the estuary of the Cibanten river. Tourism development of the Study Area can be expected in the context of West Java circuit and also on tour to Sumatra through the Study Area from the said metropolitan areas.

6. GROSS REGIONAL DOMESTIC PRODUCT AND REGIONAL INCOME

6.1 Gross Regional Domestic Product

Table A-12 shows GRDP for the Banten region, comprising three Kabupatens of Serang, Lebak and Pandeglang, into comparison with GRDP for the Province of West Java and GDP of Indonesia. GRDP for the Banten region was about Rp 320 billion in 1980 at current prices. This amount corresponds to 3.7 times of that in 1973. For the same period, the growths in GRDP of West Java and GDP of Indonesia are 5.7 times and 6.5 times, respectively.

While, the real growth rate of GRDP for the Banten region was about 6.8% per annum on an average during the period of 1973 to 1980. This figure is close to 8.1% for West Java and 7.1% for the whole country for the same period. It means that the increases in prices in the Province of West Java and the whole country are higher than that in the Banten region.

Table A-13 shows the shares and the growth rates of GRDP by the industrial origin for the Banten region, West Java and Indonesia. In the Banten region, the share of agricultural sector, which occupies about a half of the total GRDP, decreased from 51.2% in 1975 to 40.4% in 1980. A decreasing tendency of the GRDP share for the agricultural sector coincides with that of the labour force share described in Section 3.5. It seems to be the general trend of Indonesia, judging from the share by the industrial origin for West Java and the entire country as shown in Table A-13.

Since 1975, the economic growth in the Banten region is very high, that is, the average annual growth rate of GRDP was 9.7% for the period of 1975 to 1980. Of the whole industries, the average annual growth rates of GRDP for the same period were 4.6% for the agricultural sector and 43.7% for the construction sector which had the highest growth.

6.2 Regional Income

The per capita income for the Banten region was about Rp 130,000 in 1980 at current prices as shown in Table A-14. This amount is about one half of that for the whole country and 63% of that for the Province of West Java. The average real growth rate of the per capita income for the Banten region was 4.5% per annum during the period of 1973 to 1980. This is close to 4.0% for the whole country and 5.6% for the Province. However, the per capita income in 1980 at the 1975 constant prices for the Banten region is 72% of that for the whole country and 77% of that for West Java. Such a low income for the Banten region is mainly caused by the fact that about 70% of all the workers are engaged in the agricultural sector of which the per capita income is relatively low among industries.

Table A-15 shows the per capita income by Kecamatan in the Study Area in 1977. As is obvious from the table, there is a disparity in the per capita income among Kecamatans. In general, the income in the urban area is higher than that in the rural area. The per capita income in the Kecamatan of Serang was about Rp 64,000, the highest among 39 Kecamatans. While, Cileles, Kopo, Cikande, Petir, Bojongmanik, Cikeusal and Kragilan belong to the low income Kecamatans. The income of these Kecamatans is nearly one-third of that of Serang. Among them, five Kecamatans are located in the K-C-C and its surrounding areas.

REFERENCES

1. STATISTICAL YEARBOOK OF INDONESIA 1980/1981, Biro Pusat Statistik, Jakarta

2. STATISTICAL POCKETBOOK OF INDONESIA 1980/81, Biro Pusat Statistik, Jakarta

3. PENDUDUK PROPINSI JAWA BARAT 1980, Kantor Statistik Propinsi Jawa Barat, Bandung

4. SENSUS PENDUDUK 1961, Seri SPI, Biro Pusat Statistik, Jakarta

5. PENDUDUK INDONESIA 1980 MENURUT PROPINSI DAN KABUPATEN/KOTAMADYA, Seri L No. 2, Biro Pusat Statistik, Jakarta

6. SENSUS PENDUDUK 1971, PENDUDUK DIPERINTJI MENURUT KETJAMATAN DILUAR JAWA DAN MADURA, Seri B No. 2, Biro Pusat Statistik, Jakarta

7. A BRIEF NOTE ON 1980 POPULATION CENSUS, Biro Pusat Statistik, Jakarta

8. PENDUDUK JAWA BARAT PER KECAMATAN 1975, 1976, 1977, 1978, 1979, 1980, Kantor Statistik Propinsi Jawa Barat, Bandung

9. PENDUDUK JAWA BARAT PER DESA 1975, 1976, 1977, 1978, 1979, 1980, Kantor Statistik Propinsi Jawa Barat, Bandung

10. PROJECTIONS OF POPULATION AND LABOUR FORCE FOR REGIONS OF INDONESIA 1970-2000, National Institute of Economic and Social Research, LEKNAS-LIPI, 1976

11. ULASAN SINGKAT HASIL SENSUS PENDUDUK 1980, Biro Pusat Statistik, Jakarta

12. PROPINSI TANI WILAYAH PEMBANGUNAN BANTEN 1977, Direktorat Agraria Propinsi Jawa Barat, Bandung

13. PENDAPATAN PER KAPITA WILAYAH PEMBANGUNAN BANTEN 1977, Direktorat Agraria Propinsi Jawa Barat, Bandung

14. NATIONAL INCOME OF INDONESIA 1975 - 1980, Biro Pusat Statistik, Jakarta

15. PRODUK DOMESTIK REGIONAL BRUTO TIAP WILAYAH PEMBANGUNAN PROPINSI JAWA BARAT 1973 - 1979, Kantor Statistik Propinsi Jawa Barat, Bandung

16. PRODUK DOMESTIK REGIONAL BRUTO PROPINSI JAWA BARAT 1973 - 1979, Kantor Statistik Propinsi Jawa Barat, Bandung

17. PRODUK DOMESTIK REGIONAL BRUTO MENURUT WILAYAH PEMBANGUNAN PROPINSI DT I JAWA BARAT 1975 - 1980, Kantor Statistik Propinsi Jawa Barat, Bandung

Table A-1 STUDY AREA

Kabupaten	Area (km^2)	Rate to Total Area (%)	Rate to Whole Kabupaten (%)	No. of Kecamatan	No. of Desa
Serang	1,876.00	52	100	26	330
Lebak	1,572.59	43	50	10	113
Pandeglang	184.43	5	7	3	34
Total	3,633.02	100	-	39	477

ɔle A-2 POPULATION IN STUDY AREA, WEST JAVA, JAVA AND INDONESIA IN 1961, 1971 AND 1980

Population Censuses			Average Growth Rate of Population per Annum (%)			Population Density per km^2 in 1980
Oct 31 1961	Sep 24 1971	Oct 31 1980	1961-1971	1971-1980	1961-1980	
97,085,348	119,208,229	147,490,298	2.10	2.37	2.23	77
63,059,575	76,086,327	91,269,528	1.91	2.02	1.97	690
17,614,555	21,623,529	27,453,525	2.09	2.66	2.36	593
427,802	546,364	682,868	2.50	2.48	2.49	219
440,213	572,628	694,759	2.69	2.15	2.43	264
720,169	859,467	1,109,186	1.80	2.84	2.30	591
1,588,184	1,978,459	2,486,813	2.24	2.54	2.39	326
270,749	333,003	411,825	2.11	2.36	2.23	262
86,353	102,730	132,593	1.77	2.84	2.28	719
1,077,271	1,295,200	1,653,604	1.88	2.72	2.28	455

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Table A-3 POPULATION DISTRIBUTION BY KECAMATAN IN STUDY AREA IN 1961, 1971 AND 1980

Kecamatan	Area (km2)	Population 1961	Population 1971	Population 1980	Average Growth Rate per Annum (%) 1961-1971	1971-1980	1961-1980	Population Density per km2 in 1980
Kabupaten Serang								
1. Anyer	95.56	23,355	27,836	37,947	1.79	3.47	2.59	394
2. Baros	39.35	18,253	21,326	25,119	1.58	1.82	1.69	638
3. Bojonegara	68.40	29,203	33,782	40,444	1.48	2.00	1.73	591
4. Carenang	54.93	31,771	34,521	40,666	0.84	1.82	1.31	740
5. Cikande	82.68	35,819	42,749	52,265	1.80	2.23	2.01	632
6. Cikeusal	98.93	41,120	48,003	60,620	1.58	2.60	2.06	613
7. Cilegon	42.19	27,775	34,402	51,200	2.18	4.47	3.27	1,214
8. Cinangka	128.41	24,088	29,674	36,992	2.13	2.45	2.28	288
9. Ciomas	50.54	15,363	18,269	22,431	1.77	2.28	2.01	444
10. Ciruas	37.62	24,821	28,855	32,970	1.53	1.48	1.51	876
11. Kasemen	60.56	22,901	30,573	42,326	2.96	3.64	3.29	699
12. Kopo	85.18	28,634	33,500	43,440	1.60	2.90	2.22	510
13. Kragilan	45.63	23,994	29,955	34,676	1.18	2.81	1.96	760
14. Kramatwatu	48.94	17,545	21,726	28,614	2.18	3.07	2.61	585
15. Mancak	94.01	17,579	20,241	25,654	1.43	2.64	2.01	273
16. Pabuaran	76.82	20,342	24,291	30,324	1.81	2.47	2.12	395
17. Padarincang	74.40	24,424	33,978	41,240	3.39	2.15	2.80	554
18. Pamarayan	73.44	29,058	32,974	41,085	1.29	2.45	1.84	559
19. Petir	94.77	39,208	41,542	53,957	0.59	2.92	1.69	569
20. Pontang	74.31	25,335	29,288	33,124	1.48	1.36	1.42	446
21. Pulomerak	92.80	44,600	58,655	89,628	2.81	4.77	3.74	966
22. Serang	90.65	61,476	79,675	111,278	3.34	3.74	3.17	1,228
23. Taktakan	61.49	19,069	21,732	28,131	1.33	2.88	2.07	457
24. Tirtayasa	90.64	37,490	40,461	49,251	0.77	2.18	1.45	543
25. Waringinkurung	65.86	14,765	17,193	20,969	1.55	2.21	1.86	318
26. Walantaka	47.89	22,181	27,266	34,798	2.11	2.72	2.40	727
Total (or Average)	1,876.00	720,169	859,467	1,109,186	1.80	2.84	2.30	591
Kabupaten Lebak								
1. Maja	106.51	28,205	34,211	42,767	1.97	2.48	2.22	402
2. Sajira	107.52	16,667	20,053	25,771	1.89	2.80	2.32	240
3. Cipanas	139.90	22,603	29,819	38,513	2.84	2.85	2.84	275
4. Rangkasbitung	223.00	64,013	78,685	103,690	2.11	3.08	2.57	465
5. Cimarga	221.91	22,658	27,589	32,384	2.01	1.78	1.90	146
6. Muncang	191.07	25,297	31,426	35,899	2.22	1.47	1.86	188
7. Leuwidamar	172.51	20,192	22,144	25,137	0.94	1.40	1.16	146
8. Warunggunung	98.39	35,266	41,801	51,984	1.73	2.42	2.06	528
9. Bojongmanik	162.33	19,213	24,785	28,117	2.61	1.40	2.02	173
10. Cileles	149.45	16,635	22,490	27,563	3.09	2.26	2.69	184
Total (or Average)	1,579.59	270,749	333,003	411,825	2.11	2.36	2.23	262
Kabupaten Pandeglang								
1. Cadasari	80.08	28,025	33,183	42,877	1.72	2.86	2.26	535
2. Pandeglang	35.90	29,726	35,550	48,654	1.82	3.51	2.63	1,355
3. Banjar	68.45	28,602	33,997	41,062	1.76	2.10	1.92	600
Total (or Average)	184.43	86,353	102,730	132,593	1.77	2.84	2.28	719

Source: Refs. 3, 4, 6 and 8

Table A-4 POPULATION DISTRIBUTION RATIO BETWEEN URBAN AND RURAL AREAS IN EIGHT KECAMATANS, 1977 - 1980

Kecamatan		Year				Mean
		1977	1978	1979	1980	
Pandeglang	Urban	28.2	28.0	25.2	27.5	27.2
	Rural	71.8	72.0	74.8	72.5	72.8
	Total	100.0	100.0	100.0	100.0	100.0
Rangkasbitung	Urban	24.6	23.9	24.9	24.9	24.6
	Rural	75.4	76.1	75.1	75.1	75.4
	Total	100.0	100.0	100.0	100.0	100.0
Serang	Urban	70.2	70.1	67.9	69.1	69.3
	Rural	29.8	29.9	32.1	30.9	30.7
	Total	100.0	100.0	100.0	100.0	100.0
Cilegon	Urban	29.2	29.1	29.1	32.7	30.0
	Rural	70.8	70.9	70.9	67.3	70.0
	Total	100.0	100.0	100.0	100.0	100.0
Pulomerak	Urban	17.2	17.2	15.8	17.3	16.9
	Rural	82.8	82.8	84.2	82.7	83.1
	Total	100.0	100.0	100.0	100.0	100.0
Kramatwatu	Urban	14.5	14.6	13.5	14.5	14.3
	Rural	85.5	85.4	86.5	85.5	85.7
	Total	100.0	100.0	100.0	100.0	100.0
Ciruas	Urban	15.1	15.0	14.8	16.8	15.4
	Rural	84.9	85.0	85.2	83.2	84.6
	Total	100.0	100.0	100.0	100.0	100.0
Ciomas	Urban	-	-	15.3	12.5	13.9
	Rural	-	-	84.7	87.5	86.1
	Total	-	-	100.0	100.0	100.0
Average of 8 Kecamatans	Urban	31.5	31.2	30.8	32.9	31.6
	Rural	68.5	68.8	69.2	67.1	68.4
	Total	100.0	100.0	100.0	100.0	100.0

Source: Refs. 3, 8 and 9

Table A-5 POPULATION DISTRIBUTION BY AGE AND SEX IN 1980

Age Group	Male		Female		Total	
	Number	%	Number	%	Number	%
(1) Indonesia						
0 - 4	10,555,575	14.4	10,163,963	13.7	20,719,538	14.1
5 - 9	10,817,738	14.8	10,410,441	14.1	21,228,179	14.4
10 - 14	9,403,612	12.8	8,765,011	11.8	18,168,623	12.3
15 - 24	13,433,455	18.4	15,027,980	20.3	28,461,435	19.3
25 - 49	20,973,173	28.6	21,408,258	28.9	42,381,431	28.8
50 and More	8,051,397	11.0	8,321,220	11.2	16,372,617	11.1
Total	73,234,950	100.0	74,096,873	100.0	147,331,823	100.0
(2) West Java						
0 - 4	2,081,578	15.2	2,021,354	14.7	4,102,932	15.0
5 - 9	2,099,242	15.4	2,029,619	14.7	4,128,861	15.0
10 - 14	1,741,377	12.7	1,602,200	11.6	3,343,577	12.2
15 - 24	2,317,126	17.0	2,738,921	19.9	5,056,047	18.4
25 - 49	3,951,788	28.9	3,973,987	28.8	7,925,775	28.9
50 and More	1,473,458	10.8	1,419,190	10.3	2,892,648	10.5
Total	13,664,569	100.0	13,785,271	100.0	27,449,840	100.0
(3) Study Area						
0 - 4	135,390	17.0	141,178	16.4	276,568	16.7
5 - 9	131,875	16.6	135,267	15.8	267,142	16.1
10 - 14	104,791	13.2	98,022	11.4	202,813	12.3
15 - 24	126,124	15.8	164,622	19.2	290,746	17.6
25 - 49	224,172	28.2	245,301	28.6	469,473	28.4
50 and More	73,422	9.2	73,440	8.6	146,862	8.9
Total	795,774	100.0	857,830	100.0	1,653,604	100.0

Source: Refs. 1 and 3

Table A-6 POPULATION OF 10 YEARS AND OVER OF AGE AND LABOUR FORCE IN STUDY AREA, WEST JAVA AND INDONESIA IN 1980

Items	Indonesia	West Java	Study Area
1. Population of 10 years and over of age			
Male	51,861,637	9,483,749	528,509
Female	53,522,469	9,734,298	581,385
Total	105,384,106	19,218,047	1,109,894
2. Labour force participation rate (%)			
Male	67.8	64.7	-
Female	32.0	26.0	-
3. Number of labour force			
Male	35,162,000	6,136,000	342,000/1
Female	17,127,000	2,531,000	151,000/1
Total	52,289,000	8,667,000	493,000

Remarks: /1 = These figures were estimated using the labour force participation rate for the West Java Province, because lack of available data for the Study Area.

Source: Refs. 3 and 11

Table A-7 PERCENTAGE OF EMPLOYED PERSONS BY INDUSTRIAL ORIGIN IN STUDY AREA, WEST JAVA AND INDONESIA

Industrial Origin	Indonesia			West Java		Study Area
	1971	1978	1980	1971	1978	1977
Agriculture	64.2	60.9	54.8	58.0	56.5	81.7
Manufacturing Industries	6.5	7.4	8.5	6.6	8.5	1.9
Trade	10.3	14.9	12.9	12.1	16.7	4.5
Services	10.0	12.3	15.1	10.4	11.9	3.7
Others	9.0	4.5	8.7	12.9	6.4	8.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Refs. 1, 6, 11 and 13

Table A-8 NUMBER OF FARM HOUSEHOLDS IN STUDY AREA, BANTEN REGION AND WEST JAVA IN 1980

Region	Number of Household		Ratio (%)
	Farmer (1)	Total (2)	(1)/(2) x 100
1. West Java	3,246,164	6,100,713	53.2
2. Banten			
Kabupaten Serang	150,568	231,022	65.2
Kabupaten Pandeglang	110,423	144,117	76.6
Kabupaten Lebak	122,423	145,394	84.2
Total	383,414	520,533	73.7
3. Study Area			
Kabupaten Serang	150,568	231,022	65.2
Kabupaten Pandeglang	17,043	24,414	69.8
Kabupaten Lebak	70,030	88,314	79.3
Total	237,641	343,750	69.1

Source: Ref. 3

Table A-9 POPULATION PROJECTIONS OF INDONESIA, JAVA, WEST JAVA AND BANTEN REGION

	Population (thousand)				Population Density (person/km²)			
	1990	1995	2000	2005	1990	1995	2000	2005
Indonesia /1 (high)	196,273	225,373	259,494	299,799	102	117	135	156
Indonesia /1 (low)	179,905	195,518	209,372	222,748	94	102	109	116
Indonesia /2	183,885	205,324	229,261	255,990	96	107	119	133
Java	110,930	122,296	134,826	148,640	839	925	1,020	1,124
West Java	34,666	38,954	43,773	49,188	749	841	945	1,062
Banten Region								
Lebak	873	988	1,117	1,263	280	317	358	405
Pandeglang	883	996	1,123	1,266	335	378	426	480
Serang	1,402	1,579	1,781	2,011	747	842	949	1,072
Total	3,158	3,563	4,021	4,540	414	467	527	595

Remarks: /1 = Based on Ref. 10
/2 = Estimates in the present study

Table A-10 POPULATION PROJECTIONS BY KECAMATAN IN STUDY AREA

Kecamatan	Population				Population Density (person/km^2)			
	1990	1995	2000	2005	1990	1995	2000	2005
Kabupaten Serang								
1. Anyer	49,038	55,727	63,327	71,963	513	583	663	753
2. Baros	29,702	32,298	35,121	38,191	755	821	893	971
3. Bojonegara	48,011	52,311	56,995	62,098	702	765	833	908
4. Carenang	46,319	49,433	52,757	56,304	843	900	960	1,025
5. Cikande	63,773	70,445	77,815	85,957	771	852	941	1,040
6. Cikeusal	74,331	82,309	91,144	100,926	751	832	921	1,020
7. Cilegon	70,634	82,963	97,444	114,452	1,674	1,966	2,310	2,713
8. Cinangka	46,346	51,876	58,066	64,994	361	404	452	506
9. Ciomas	27,370	30,234	33,397	36,891	542	598	661	730
10. Ciruas	38,301	41,281	44,493	47,956	1,018	1,097	1,183	1,275
11. Kasemen	58,518	68,799	80,886	95,097	966	1,136	1,336	1,570
12. Kopo	54,106	60,385	67,392	75,212	635	709	791	883
13. Kragilan	42,104	46,396	51,124	56,335	923	1,017	1,120	1,245
14. Kramatwatu	37,023	42,114	47,904	54,490	757	861	979	1,113
15. Mancak	31,303	34,578	38,195	42,191	333	368	406	449
16. Pabuaran	37,402	41,538	46,132	51,234	487	541	601	667
17. Padarincang	54,356	62,404	71,644	82,252	731	839	963	1,106
18. Pamarayan	49,302	54,008	59,163	64,810	671	735	806	882
19. Petir	63,801	69,378	75,442	82,036	673	732	796	866
20. Pontang	38,140	40,926	43,915	47,123	513	551	591	634
21. Pulomerak	129,392	155,467	186,796	224,440	1,394	1,675	2,013	2,419
22. Serang	152,035	177,710	207,720	242,798	1,677	1,960	2,291	2,678
23. Taktakan	34,528	38,252	42,379	46,950	562	622	689	764
24. Tirtayasa	56,877	61,122	65,683	70,586	628	674	725	779
25. Waringinkurung	25,214	27,646	30,315	33,241	383	420	460	505
26. Walantaka	44,114	49,665	55,918	62,958	921	1,037	1,168	1,315
Total	1,402,040	1,579,265	1,781,167	2,011,485	747	842	949	1,072
Kabupaten Lebak								
1. Maja	53,268	59,449	66,348	74,047	500	558	623	695
2. Sajira	32,414	36,353	40,770	45,724	301	338	379	425
3. Cipanas	50,960	58,619	67,429	77,564	364	419	482	554
4. Rangkasbitung	133,641	151,720	172,244	195,545	599	680	772	877
5. Cimarga	39,091	42,948	47,186	51,842	176	194	213	234
6. Muncang	43,164	47,330	51,899	56,908	226	248	272	298
7. Leuwidamar	28,210	29,884	31,658	33,538	164	173	184	194
8. Warunggunung	63,742	70,583	78,159	86,548	648	717	794	880
9. Bojongmanik	34,342	37,953	41,945	46,356	212	234	258	286
10. Cileles	35,942	41,044	46,869	53,522	240	275	314	358
Total	514,774	575,883	644,507	721,594	327	366	410	459
Kabupaten Pandeglang								
1. Cadasari	53,615	59,953	67,041	74,967	670	749	837	936
2. Pandeglang	63,076	71,818	81,772	93,106	1,757	2,001	2,278	2,593
3. Banjar	49,663	54,617	60,066	66,058	726	798	878	965
Total	166,354	186,388	208,879	234,131	902	1,011	1,133	1,269

Table A-11 POPULATION PROJECTIONS IN URBAN AREAS IN STUDY AREA

Kecamatan	Population			
	1990	1995	2000	2005
Pandeglang	17,157	19,534	22,242	25,325
Rangkasbitung	32,876	37,323	42,372	48,104
Serang	105,360	123,153	143,950	168,259
Cilegon	21,190	24,889	29,233	34,336
Pulomerak	21,867	26,274	31,569	37,930
Kramatwatu	5,294	6,022	6,850	7,792
Ciruas	5,898	6,357	6,852	7,385
Ciomas	3,804	4,203	4,642	5,128
Total	213,446	247,755	287,710	334,259

Table A-12 GDP OF INDONESIA AND GRDP OF WEST JAVA AND BANTEN REGION, 1973 - 1980

Unit: Rp 10^9

Region	GDP and GRDP								Average annual growth rate (%) 1973-1980
	1973	1974	1975	1976	1977	1978	1979	1980	
A. at current prices									
Indonesia	6,753.4 (-)	10,708.0 (158.6)/1	12,642.5 (118.1)	15,466.7 (122.3)	19,010.7 (122.9)	22,458.3 (118.1)	31,022.9 (138.1)	43,765.0 (141.1)	30.6
West Java	992.3 (-)	1,338.5 (134.9)	1,726.5 (129.0)	2,135.7 (123.7)	2,419.7 (113.3)	3,015.0 (124.6)	4,003.6 (132.8)	5,607.7 (140.1)	28.1
Banten /2	85.8 (-)	93.3 (108.7)	114.9 (123.2)	143.3 (124.7)	160.1 (111.7)	197.2 (123.2)	251.3 (117.5)	320.0 (127.4)	20.7
B. at 1975 constant prices									
Indonesia	11,231.2 (-)	12,144.2 (108.1)	12,642.5 (104.1)	13,513.1 (106.9)	14,697.1 (108.8)	15,711.7 (106.9)	16,550.8 (105.3)	18,148.1 (109.7)	7.1
West Java	1,501.4 (-)	1,610.5 (107.3)	1,726.5 (107.2)	1,913.1 (110.8)	2,010.8 (105.1)	2,261.2 (112.4)	2,324.2 (102.8)	2,595.5 (111.7)	8.1
Banten /2	114.6 (-)	109.9 (95.9)	114.9 (104.5)	136.1 (118.5)	140.7 (103.4)	164.2 (116.7)	161.9 (98.6)	182.1 (112.5)	6.8

Remarks: /1 = Figures in parentheses show growth rates to previous year (= 100).
/2 = Banten consists of three Kecamatans of Serang, Lebak and Pandeglang.

Source: Refs. 14 to 17

Table A-13 SHARE AND AVERAGE ANNUAL GROWTH RATES OF GDP AND GRDP BY INDUSTRIAL ORIGIN, 1975 AND 1980

Unit: %

Industrial Origin	Indonesia/1			West Java/2			Banten/2		
	Share		Average annual growth rate	*Share*		Average annual growth rate	*Share*		Average annual growth rate
	1975	1980	1975 - 1980	1975	1980	1975 - 1980	1975	1980	1975 - 1980
1. Agriculture	36.8	31.4	4.1	34.6	29.8	5.3	51.2	40.4	4.6
2. Mining and Quarrying	10.9	9.5	4.6	10.6	9.3	5.8	0.4	0.4	14.3
3. Manufacturing Industries	11.1	14.3	13.1	8.0	9.9	13.1	2.5	5.2	27.2
4. Electricity, Gas and Water Supply	0.5	0.7	13.6	0.5	0.7	16.2	0.2	0.2	9.8
5. Construction	4.8	5.7	11.5	3.3	6.2	23.1	2.7	10.5	43.7
6. Transportation and Communication	4.0	5.4	14.5	4.3	4.8	11.2	3.8	5.3	17.2
7. Trade, Financing and Other Services	31.9	33.0	8.2	38.7	39.3	8.8	39.2	37.9	8.9
8. Whole Industries	100.0	100.0	7.5	100.0	100.0	8.5	100.0	100.0	9.7

Remarks: /1 = At 1973 constant prices
/2 = At 1975 constant prices

Source: Refs. 14 and 17

Table A-14 NATIONAL AND REGIONAL INCOMES PER CAPITA, 1973 - 1980

Unit: Rp

Region	Income								Average annual growth rate (%) 1973 - 1980
	1973	1974	1975	1976	1977	1978	1979	1980	
A. at current prices									
Indonesia	46,073	70,987	82,286	99,758	118,793	136,554	183,046	253,372	27.6
	(-)	(154.1)/1	(115.9)	(121.2)	(119.1)	(115.0)	(134.0)	(138.4)	
West Java	42,969	56,607	71,308	86,137	95,295	115,932	150,299	206,111	25.1
	(-)	(131.7)	(126.0)	(120.8)	(110.6)	(121.7)	(129.6)	(137.1)	
Banten/2	40,678	43,242	52,045	63,458	69,313	83,452	103,970	129,783	18.0
	(-)	(106.3)	(120.4)	(121.9)	(109.2)	(120.4)	(124.6)	(124.8)	
B. at 1975 constant prices									
Indonesia	77,317	79,906	82,286	86,102	91,277	94,605	96,369	102,026	4.0
	(-)	(103.3)	(103.0)	(104.6)	(106.0)	(103.6)	(101.9)	(105.9)	
West Java	65,014	68,111	71,308	77,159	79,191	86,948	87,254	95,397	5.6
	(-)	(104.8)	(104.7)	(108.2)	(102.6)	(109.8)	(100.4)	(109.3)	
Banten/2	54,342	50,920	52,045	60,292	60,919	69,507	66,989	73,866	4.5
	(-)	(93.7)	(102.2)	(115.9)	(101.4)	(114.1)	(96.4)	(110.3)	

Remarks: /1 = Figures in parentheses show growth rates to previous year (= 100).
/2 = Banten consists of three Kabupatens of Serang, Lebak and Pandeglang.

Source: Refs. 14 to 17

Table A-15 PER CAPITA INCOME BY KECAMATAN IN STUDY AREA IN 1977

Kabupaten Lebak

	Kecamatan	Per Capita Income (Rp)
1.	Maja	26,232
2.	Sajira	29,229
3.	Cipanas	46,189
4.	Rangkasbitung	39,132
5.	Cimarga	27,398
6.	Muncang	28,177
7.	Leuwidamar	25,994
8.	Warunggunung	34,337
9.	Bojongmanik	23,953
10.	Cileles	17,678

Kabupaten Pandeglang

	Kecamatan	Per Capita Income (Rp)
1.	Cadasari	39,502
2.	Pandeglang	41,619
3.	Banjar	30,849

Source: Ref. 13

Kabupaten Serang

	Kecamatan	Per Capita Income (Rp)
1.	Anyer	35,277
2.	Baros	32,102
3.	Bojonegara	27,878
4.	Carenang	27,288
5.	Cikande	23,222
6.	Cikeusal	24,171
7.	Cilegon	37,603
8.	Cinangka	47,050
9.	Ciomas	47,671
10.	Ciruas	27,002
11.	Kasemen	49,095
12.	Kopo	22,353
13.	Kragilan	24,641
14.	Kramatwatu	33,241
15.	Mancak	36,610
16.	Pabuaran	32,712
17.	Padarincang	25,035
18.	Pamarayan	34,916
19.	Petir	23,888
20.	Pontang	29,303
21.	Pulomerak	32,145
22.	Serang	64,232
23.	Taktakan	49,500
24.	Tirtayasa	32,000
25.	Waringinkurung	35,919
26.	Walantaka	29,618

APPENDIX B
HYDROLOGY

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1. INTRODUCTION

This report is an Appendix summarizing hydrological aspects concerning "Master Plan Study on North Banten Water Resources Development". The major contents of the report are as follows:

(1) hydrological data;

(2) river flow;

(3) standard project flood; and

(4) water quality.

2. HYDROLOGICAL DATA

2.1 Hydrological Observation Stations

Location of hydrological observation stations in and around the Study Area is as shown in Fig. B-1. Rainfall observation was started brfore 1940. Today, there are about 100 rain gauging stations scattered over the Study Area. The majority of the observation apparatuses used are of accumulative type, with which observation is made once a day. But in recent years, automatic rain-gauges have been installed in nineteen observation stations. Meanwhile, measurement of water level is currently conducted at the seven observation stations as shown in Fig. B-1.

2.2 Rainfall

2.2.1 Rainfall data

The rain gauging stations located in the North Banten area belong either to PMG or P3SA. Among them, the major stations have been extracted and shown in Table B-1. As a result of checking the data-keeping situations in these stations, it has been found that the majority of stations are comparatively well replenished, making daily and monthly rainfall data available for the present study. For the upstream and downstream areas of the Ciujung river basin, two groups of rain gauging stations were set up in 1978, being spaced out at intervals of about 2 km. These gauging stations have been installed for the purpose of grasping the regional rainfall characteristics and rainfall patterns. But data have yet to be added and orderly arranged, because the observation period is too short.

2.2.2 Isohyetal map

From the monthly rainfall data collected on the major locations in and around the Study Area, the annual rainfall was integrated for the years between 1942 and 1980, and averaged to obtain the mean annual rainfall. Fig. B-2 shows the annual isohyetal map obtained from the mean annual rainfall of the respective major locations. In the Study Area, roughly parallel isohyetal lines were seen to be distributed from the north to the south. Rainfall distribution of approximately 1,500 mm is observed in the northern coastal area, while that of exceeding 5,000 mm is observed in the southern mountainous region. As for the central area, the seasonal wind blowing from the west is strongly influenced by the presence of the Gunung Karang, thereby brings relatively heavy rainfalls to its western slope, while on its eastern side, rainfall is relatively small. The basin along the Ciujung river that flows from the south to the north, whose area represents more than a half of the Study Area, shows relatively small rainfall in the central area. Meanwhile, the mean annual rainfall in Rangkasbitung, which is located at about the center of the Study Area, shows a mean annual rainfall of

2,240 mm, whereas that in Serang, located about 30 km to the north, shows 1,670 mm. And the data indicate a comparatively large difference of rainfall between the two areas. Fig. B-3 and Table B-2 show the monthly rainfall patterns at these major observation points.

2.3 Meteorological Data

As shown in Table B-3, meteorological observations are being made at five observation stations. Among them, the Serang Observation Station belongs to PMG, while the other four stations are run by P3SA. As for the starting period, Serang started observation in 1972, while the others in 1978. Fig. B-4 shows the mean monthly value of the evaporation, humidity and air temperature of the respective observation stations, which are compiled from data obtained at these stations. The study has revealed that changes of temperature throughout the year are relatively small, while seasonal changes of humidity and evaporation are remarkable.

2.4 Water Level and Discharge Measurement

2.4.1 Water level data

As shown in Table B-4, 10 water level gauging stations were installed in the Study Area. As the Curugbetung and Cileuksa gauging stations were closed down, there are eight gauging stations now working. And the Rangkasbitung, Sajira and Leuwidamar gauging stations located along the Ciujung river have lost their automatic water gauges because of the flood in November 1981. As a result, now three daily readings are being taken by using staff gauges at these stations. The station holding the longest observation record is the Rangkasbitung gauging station run by DPMA. The amount of missing data is comparatively small, and the data are filed and arranged in good order. Although P3SA has been improving its water level observation network and performing water level measurement since 1978, the period of observation is still too short and the accumulated data are still too insufficient to conduct the reliable hydrological analyses.

2.4.2 Discharge measurement and rating curve

The discharge measurement is being carried out at each gauging station. At the Kragilan and Rangkasbitung gauging stations, the rating curves are drawn up by DPMA based on the observed discharge. As for the other gauging stations managed by P3SA, the discharge measurement has been carried out since 1978 and its results are shown in Table B-5. Most of these observed data are useable to draw up the rating curves.

The discharge rating curve is derived from the relation between the water level and discharge of the river at the time of discharge measurement. Fig. B-5 shows the relation between water level and discharge obtained at the gauging stations and portrays the optimum curves asymptotic to the observed data.

In the case of the Sajira gauging station, it is very difficult to grasp clearly the relationship between discharge and water level and to prepare a rating curve from the presently available data, because the existing simple intake facility being located immediately downstream of the gauging station may affect the measurement results. The Sajira gauging station is recommended to be shifted to some suitable locations.

Rating curve formulae of the respective gauging stations are as follows:

(1)	Leuwidamar	$Q = 33.860\ (H-0.417)^2$;
(2)	Cileles	$Q = 15.854\ (H+0.087)^2$;
(3)	Kubang Baros	$Q = 15.054\ (H+0.296)^2$;
(4)	Serut	$Q = 15.054\ (H+0.296)^2$;
(5)	Sajira	Unable to compile for the reasons given in a later paragraph; and
(6)	Rangkasbitung and Kragilan	Compiled by reading values from the water discharge curve diagram (DPMA).

3. RIVER FLOW

3.1 Discharge at Gauging Stations

3.1.1 Discharge at gauging stations

Among the P3SA's gauging stations presently operating in the Study Area, those are used to obtain the daily discharge. The discharge rating curve of each gauging station is shown in Fig. B-5. For reasons relating to the accuracy of discharge measurement, no discharge conversion from the water level was performed at the Sajira gauging station. Meanwhile, at the Kragilan and Rangkasbitung gauging stations belonging to DPMA, daily discharge data have already been put into fine order by using the discharge rating curves obtained from discharge measurement. Table B-6 shows the monthly mean discharge at these gauging stations. Further, as for the monthly mean flow of the Pamarayan weir which has already been put into fine order by DPUP in Serang are utilized. Considering the accuracy of discharge measurement and the period of water level data, data at the following gauging stations were used as the bases to estimate the mean monthly discharge.

River	Gauging Station	Supervisor
Ciujung	Kragilan	DPMA
Ciujung	Rangkasbitung	DPMA
Ciujung	Pamarayan	DPU
Ciujung	Cileles	P3SA
Cibanten	Serut	P3SA
Cisimeut	Leuwidamar	P3SA
Cidanau	Kubang Baros	P3SA

3.1.2 Correlation of monthly mean discharge

Rainfalls in the North Banten area bear strongly local characteristics, with rainfall in places located several km away being nil in some cases. Thus, the outflow of each gauging station bears different characteristics, uniquely of its own. Figure B-6 shows the results of studies made on the correlation, based on the use of the monthly mean discharges at major locations. Table B-7 shows a summary of the correlative coefficients.

From the viewpoint of Rangkasbitung, comparing the correlation with Kragilan and that with Pamarayan, the above results show the correlation with Kragilan to be excellent, while the correlation with Pamarayan is shown to be poorer as compared with that with Kopomaja.

Judging from this, the discharge data of Pamarayan seem to be unfit for use as data to estimate the missing measurement in the surrounding area. Furthermore, because the observation period of the Leuwidamar and Cileles gauging stations is too short, it will be necessary to make studies after additional data will have been collected by these stations in the future.

3.2 Discharge at Dam Sites

3.2.1 Mean annual catchment rainfall and catchment loss

Annual rainfall in the North Banten area measures about 1,500 mm in the northern coastal area, while exceeds 5,000 mm in the southern mountainous zones. Consequently, the outflow will change in accordance with changes in the rainfall amount. The followings show the results of calculations made on the annual amount of rainfall at each dam site and gauging station obtained from Fig. B-2.

Dam Site	Mean Annual Rainfall (mm)
Karian	4,282
Pasir Kopo	3,971
Bojongmanik	3,558
Cilawang	3,761
Rangkasbitung Gauging Station	3,350
Pamarayan Weir	3,301
Cibanten	2,357
Cidanau	3,146
Anyer	2,571

As the rainfall loss in the concerned catchment basin is generally set to about 1,200 mm, this figure is used in the present study.

3.2.2 Discharge at dam sites

As for the monthly mean discharge at each dam site, judgement concerning the use of data is made based on such factors as the accuracy of the discharge rating curve and the length of the gauging period. In consideration of the comparatively short observation period of the gauging stations located in the Ciujung river basin and the low accuracy of discharge measurement at the Sajira gauging station, it will be advisable to use the discharge data at the Rangkasbitung gauging station run by DPMA whose observation period is comparatively long and which misses minimal measurement data. However, rainfall distribution in the upper Ciujung river basin is not uniform, being comparatively dense in the Ciberang river basin. Because of this, calculation of the discharge at each dam site along the Ciujung river should be made, based on the discharge at Rangkasbitung and by taking into account the catchment area of each dam site together with the previously-calculated mean annual rainfall and runoff loss for the concerned basin. Similarly, in calculating the monthly mean discharge at the Cilawang dam site, the monthly mean discharge at Rangkasbitung is used, whose data up to 1982 are found to be arranged in good order. Meanwhile, at the Cibanten and Cidanau dam sites, the monthly mean discharge obtained from data of the gauging station set up in the same river system is used, though the observation period is relatively short. As for the Anyer dam site, due to the absence of water level measurement data in the basin, the monthly mean discharge is estimated by using the discharge data in the

Cibanten dam site whose rainfall distribution is much the same as that of the Anyer dam site. The monthly mean discharge at each dam site is listed in Table B-8.

3.3 Probable Monthly Mean Discharge and Annual Runoff

For the assessment of the probable monthly mean discharge, the Thomas Plot Method is used. Probable rainfall is obtained by plotting the relation between the probability of exceedance F(x) and sample value (x) on a logarithmic probability paper, and by drawing a straight line that passes through the respective points in an averaging manner. The probable monthly mean discharge at each dam site is listed in Table B-9.

4. STANDARD PROJECT FLOOD

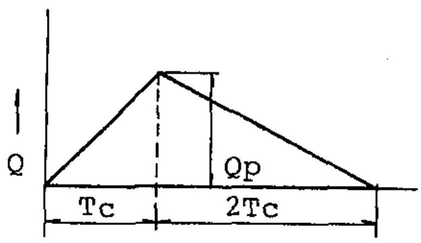
4.1 Calculation Method of Discharge

In the present study, the following calculation method of discharge is adopted. The peak flow is obtained from the Rational formula and, at the same time, a triangle hydrograph which uses the peak flow as the vertex is employed. The basic concept underlying the standard triangle hydrograph is shown below.

Rational Formula and Triangle Hydrograph

Qp: Peak discharge

Tc: Time of concentration



Peak Discharge

$$Qp = \frac{1}{3.6} \cdot f \cdot r \cdot A$$

where, QP: Peak discharge (m^3/s)

f: Runoff coefficient

r: Rainfall intensity (mm/hr)

A: Catchment area (km^2)

4.2 Characteristics of the Basins

4.2.1 Time of concentration

The time of concentration is calculated from the horizontal length and height difference of the catchment basin, using the Rziha's formula shown below.

$$Tc = \frac{L}{w} \text{ (hr)}$$

$$w = 72\left(\frac{H}{L}\right)^{0.6} \text{ (km/hr)}$$

where, Tc: Time of concentration (hr)

w: Propagation velocity of flow (km/hr)

L: Horizontal length of catchment basin (km)

H: Height difference of catchment basin (km)

Table B-10 shows the calculated time of concentration at each dam site.

4.2.2 Runoff coefficient

In the present study, f = 0.7 is adopted as the runoff coefficient, in consideration of such factors as the soil-cover, geology and topography.

4.2.3 Rainfall intensity

In the Study Area, short-term rainfall data is not available because the observation period is too short. Therefore, in the present study, the Mononobe's formula derived from the daily rainfall data is used.

$$r = \frac{R24}{24} \left(\frac{24}{T}\right)^{2/3}$$

where, r: Rainfall intensity

T: Rainfall duration

R24: Daily rainfall

To grasp the rainfall characteristics in the Study Area, the time-rainfall data for the rainfall in November 1981, measured at the gauging stations within the Study Area, are put into order and then the relationship between the duration and the cumulative percentage is plotted. Figure B-7 shows the plotted results. Based on these results, the exponent n of the formula below is examined when the Mononobe's formula is applied.

$$\frac{Rt}{R24} = \left(\frac{T}{24}\right)^{n}$$

where, Rt: Cumulative rainfall (mm)

R24: Daily rainfall (mm/d)

n: Exponent

As a result of the examination, it is found that "1/3" is adequate for the exponent n to represent the rainfall results. Therefore, the Mononobe's formula is adopted to obtain the rainfall intensity.

4.3 Standard Project Flood

4.3.1 Available gauging stations and annual maximum daily rainfall

As regards the annual maximum daily rainfall data of gauging stations distributed in the Study Area, data of gauging stations for comparatively long observation period and properly arranged data are extracted and summarized. The summarized results are shown in Table B-11.

4.3.2 Probable daily catchment rainfall

Probability calculations are conducted by using the annual maximum daily rainfall data of the available gauging stations within the Study Area. It is decided that the Thomas Plotting, which permits relatively simple calculation, will be used for probability calculations. Table B-12 shows the results of probable daily rainfall calculations made at the respective gauging stations. Meanwhile, for the assessment of the daily catchment rainfall, the Thiessen Polygon method is used. Table B-13 shows the area percentages of the respective gauging stations' occupation in relation to the respective catchment basins. The percentages are obtained from Fig. B-8. The probable daily catchment rainfall is obtained from the governing area and the probable rainfall of each gauging station as shown in Table B-14.

4.3.3 Standard project flood distribution

The standard project flood distribution is obtained by applying the characteristics of each catchment basin to the Rational formula as the runoff calculation method. Discharge calculation is conducted independently for each tributary, while for the main stem of the Ciujung river downstream from Rangkasbitung, flow calculation is conducted by superposing runoff hydrographs of the respective tributaries in the upstream area. Point rainfall is converted into mean catchment rainfall, using the basin area as shown in Fig. B-9 and the conversion ratio diagram. Table B-15 shows the conversion ratio in each catchment basin. Table B-16 shows the results of standard project flood calculations made at the major points of each tributary in the upstream area. Meanwhile, Fig. B-10 shows a flood hydrograph of the Ciujung river at Rangkasbitung following the confluence of the respective tributaries, which is prepared by taking into account the time of concentration in the catchment basins of the upstream-side tributaries. The standard project flood distribution of the Ciujung river basin is summarized in Table B-17. The standard project flood distribution of the river channels is set as shown in Fig. B-11. Extracted from Fig. B-11, the standard project flood at the major points within the catchment basin is obtained as below.

River	Site	Standard Project Flood 1/50 Probability (m^3/s)	 1/10 Probability (m^3/s)
Ciberang	Karian	740	600
Cisimeut	Pasir Kopo	850	610
Upper Ciujung	Bojongmanik	590	450
Ciujung	Rangkasbitung	1,800	1,400
Ciujung	Pamarayan weir	1,800	1,400
Ciujung	Kragilan	2,000	1,600

4.4 Spillway Design Flood

As for the spillway design flood, the peak discharge is calculated by using the Rational formula as the basis. The maximum daily rainfall of existing data of 340 mm is used as the rainfall intensity to be used in the Rational formula. This rainfall is observed at the Sampan Peundeuy gauging station located in the upper Ciujung basin in August 1921. Consequently, the spillway design flood at each dam site located along the Ciujung river is set to the values listed below. The values are obtained by adding a 20% allowance to the results of flood calculations.

Dam Site	Catchment Area (km^2)	Spillway Design Flood (m^3/s)	Specific Discharge ($m^3/s/km^2$)
Karian	288	1,600	5.56
Pasir Kopo	172	1,700	9.88
Bojongmanik	159	1,200	7.55
Cilawang	93	780	8.39

5. WATER QUALITY

For water quality test, water was sampled at 12 places as shown in Fig. B-12, and 19 samples were taken during the two seasons in 1982, i.e. dry season sample in August and wet season sample in December. The analysis of water is conducted by the Water Quality Laboratory, DPMA. The results of water quality analyses on the 19 samples taken at 12 sites are shown in Tables B-18 and B-19. In both dry and wet seasons, the water has no problem for agricultural use. When it comes to drinking water, however, if strict judgement is made, the water is not adequate to the used as it is. If the raw water is purified, it can be used as drinking water.

Salinity survey was carried out along the downstream reaches of the Ciujung river in December 1982. At Tirtayasa located about 5 km from the river-mouth in the lower reaches of the Ciujung river, salinity of about 1,000 ppm was detected. At Kragilan located about 18 km from the river-mouth, the salinity was very small. Estimating from this, the saline water intrusion is considered to be terminated near the Kragilan bridge. Thus, if water is taken from the upstream reaches of the Kragilan bridge where the effect of saline water intrusion is small, relatively good water will be utilized.

6. RECOMMENDATION

6.1 Improvement of Gauging Stations

6.1.1 Sajira gauging station

As for the Sajira gauging station, its discharge observation accuracy is greatly influenced by a simple intake facility in the immediate downstream, hence the area free from similar effects should be selected. As a candidate point, if examined taking into consideration the completion of Karian dam in the future, the neighborhood of Sabagi village downstream from the Karian dam site and above the confluence of the Cisimeut river is considered appropriate.

6.1.2 Leuwidamar gauging station

The automatic water level recorder was washed away in November 1981. At present, a staff-gauge is being used for reading and recording. It is desirable to install the automatic water level recorder at the same point as this staff-gauge.

6.2 Installation of New Water-level Recorder

In the Gadeg area of the Cibeureum river which plays an important role in the development of K-C-C and Cicinta areas, it is desirable to install a water-level recorder.

Table B-1 EXISTING CONDITION OF MONTHLY RAINFALL DATA

STATION NO.	STATION NAME	1942	1943	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1 a	HANDEULEM	△	△	△	△																																			
2 a	TOPPERSHUOJE										△	△	○	△		△	△		△																					
3	ANJER KIDUL	○	○	△	△	△					○	○	○	○	○																									
3 b	CINANGKA																																	○	○	○	○			
4	PADARINCANG		○	○	△																										△	○	○	△	○	△	○			
4 a	CITASUK																△	△																						
5	MENES	○	○	△	△	○	△				△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		△	○	○	○	○	○	○	○	○	△
6	LABUHAN	○	○	△	△							○	○	○	○	△	△	○	○	○	○	○	△	○	△	○	○	○	○		△	△	○	○	○	○	○			
7	PAGELARAN	△	○	○	△						○	△	○	○	○	△	○	△	○	△								△	○	△	○	○	○	△			△	△		△
7 a	PASIRWARINGIN																○	○	○	○	○	○	△	○	○	△	○	○	○	△	○	△	○		○	○	○	△		△
8	MAJAU								△	△																														
9	BOJONG DATAR										○	○					△		○						○						○	○	○	○	○	○	○			
10	SANGIANG-DAMAR											△	○	○	○	△	○	△		△	○	○		○		△	○		○	○	○	○	△	○	○	○	○	△		△
10 a	BOJONG	○	○	○							○	○	△	○	△			△	△	○	△									○	○	△	○	○	○	○	○	○	○	△
10 b	KADUMLATI											△	△	○	○	△								○		△	△													
11 b	RANGKAS	○	○	○	○	△				○	○	△	○	○	△			△	○	○	△	△	○	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△
12	CIBALIUNG	○	○	△	△	△					○	△	○	○	△	○	○	○		△	△	△							△	△	△	○	○	△	○	○	○			
13	CIMANGGU	○	○	○	△						○	○	○	○	△	△	△			△			△	△									△		○	○	△			
14	CILEGON	△	○	○							○		△	○	△	○	○	○	△	○	○	△	○	△	△	△		△					△				△	△	○	△
14 a	BAJANEGARA	△	○	○	△						○	○	○	○	○		○	△	△	○	○	○	○	○	△	△				△			△	○	△	△	△	△	△	
14 c	KRAMATWATU	△	○	○	△																																			
14 d	CILEGON B.P.M.D																△	○	△	△																			○	
17	GUNUNGKUPAK																							○	○	△	△	○	○	○	○	△	○							
18	CIOMAS	○	○	○	△							△	○	○	○	○	△	○	○	○	○	○	○	○	△	△				△		△	○	△	△	○	△		△	△
19	PABUARAN	○	○	○	△																										△	○	△	○		△	△		△	△
20 a	G. KARANG	○	○	△	△												△	△	△												△									
21	MANDALAWANGI	○	○	○	○	○					○	○	○	○	○	△	△	○	○	○	○	△	○	○	○	○	○			○	△	△		○	○	○	○	○	△	△
22	CIMANUK	○	○	○	△	○	△			△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△			△	△	△	○			○	△	○	○	△	△
23	SERANG		○	△	△				△	○	○	○	○	○	○	○		○	○	○	○	△	△	○			○	△				△		○	○	○	○	○	○	△
23 a	SERANG(IRR)	△	○	○	△				△												○	△	△	○			○	△				△		○	○	○	△	○	○	
23 b	CIMOENG	○	○	△	○																																			
23 c	KRAMATWETAN	△	○	○	△				△	○	○	○	○	○	○	△	△	○	○	○	○	○	○	○	△	△	○	○	○	○	△	△	○		○	△		○	○	△
23 d	SOEKALILA	○	○	△									○	○	○	○	○	○	○	△																				
23 e	SINGAMERTA(K.P)	○	○	○	△								△	○						△	○	○		△			○		○	△	○	○	○	△	○					
23 f	CIRUAS										○	○	○	○	○	○	○	△	○	○	○	○	○	○	△	△	○			△	○	○	○							
23 g	KALENPENTUNG										○	○	○	○	○	○	○	○	○		○	○	○	○	△	△	○				△	○	○					△	△	
24	BAROS	○	○	△	△						○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△		○	○	○	○	△		○	○	○	○	△
24 a	NJAPAH																○	△	○	○	○	○	○	○	△	△	○				△	○	○					○	○	△
24 b	PETIR																																	○	○	○	○			
26	PANDEGLANG	○	○	○			△			△	○	○	○	○	○	△	△	△	△	△	△	△	○	○	△		△	○	○	○	○	○	○	△	○	△	○	○	○	△
26 a	CIKAREO																○	△	○	○	△			○							○	△	△	△						
26 b	CILELES	○	△	△	△						△	△	○	△	△	○	○	△	○		△	△	○	△	△							△	○	△		△	○			
26 c	WARUNGGUNUNG	○	○	○	△						○	△	○	○	○	○	○	○	○	○	○	○	○	○	△			△	△	△	○	○	△	△	○	△	○	○	○	△
27	G. KENCANG	○	○	△	△						△	○	○	○	○	○	△	△	○	△	○	△	○	△	△	△	△		△	△	△	○	○	○	○	△	○	○		△
28	MUNJUL	○	○	○	○						○	○	○	○	○	○	△	○	△	○	○	△	○	△							△									
29	G.KENDENG	○	○	○	△						○	○	○	○																							△			
30	CIKEUSIK	△	△								○	○	○	○	○	△	△	○	○	○	△		○	△	△			○	○	△										
31	MALINGPING	○	○	○	△					△	○	△	○	○	○	○	○	○	○	○	○	○	○	○	△			○		△	○	○	△	△	○	△	○	○	○	△
31 a	KANDANGSAPI	○	○	○	△																																△			
31 b	CILANGKAHAN				△																															○	○			
31 c	CIPUCANGPARE											△	○	○	△	○	○	○	○	○	○	○	○	○	△			○				○	△	○	○	△	○	○	○	△
32	TANARA											○	○	△																										
32 a	JEUNGJING	○	○	○	○	○			○	○	○	○	○	○	○	○	○	○	△	○	○	○	△	○	△	△	○			△	○	○	△							
32 b	KEMAJUNGAN	○	○	△	△						○	△	○	△																										
32 c	RAGASILIR											○	○	○	○	○	○	○	△	○	○	○	○	○	△	△	○			△	○	○	○					△	○	
33	PARIGI / CIKANDE	△	△	○							○	○	○	○	○	△	○	○	○	○	△	○	△	○	○	△	○	○	○	○		△	○	○	○	○	○			
35	PAMARAYAN	△	○	○	△				○	○	○	○	○	○	○	○	○	△	○	○	○	○	△	○	○	○	○		○	△	○		○				△	△	○	△
36 a	MAJA																										○	○	○	△	△	○								
37	RANGKASBITUNG	○	○	△	○	○	△				○	○	○	○	○	○	○	○	○	○	○	○	○	○	△				△		○	○	○	○	○	○	○	○	○	
37 b	CIKADU										○	○	○	○	○	○	○	○	○	△		○	○	○	△		○				○	○	○	○	○	○	△	△		
37 c	CIMARGA					○						○																					○				△			
37 e	CIMARGA	△	△								△		○	△	○	○	○	△	△												△	△	○	○	○	△	△	△	○	△
37 f	CISALAK BARU										○	○	△	○		○	△	△	○	○	○	○	○	○	○	○	△	○	○	○	○	○	○	○	○	△	△	○	○	△
37 g	JINIHNIH											○	○	○	△	○	△	△	○	△		○	○	○	△															
37 h	PANANCANGAN											○	○	○	○	○	△		○	△	○	○	○	○	△	○	△		○	△	△	○	△							
38	LEUWIDAMAR	○	○	○	○		△				○	○	○	△	○	○	○	△	○	△									○			△					△			
38 a	SAMPANG PEUNDEUY																△	△	○	○	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	△
38 b	WANTI				△																															△				
38 c	CIKOPEK(PASIR KOPPO)																○	○	○		○	△	△	○	○	△	○													
38 d	GUNUNG RUNGGAL											○	○	○	○	○	△	△	○	○	○	△					△	○	○	△	○						△			
38 e	BANTAR JAYA																													○		△	○	○		○	○			
39	CICARUNGEUN		○	○	△																																			
40	BOJONGMANIK	○	○	○	△	△					△	○	○	○	△		△	△			△			○	△	○					△		○	△	△	○	△	○	○	△
41	PASIR AJUNAN																○	○	○	○	○	○	△	△	○	△														
42 a	SAJIRA	○	○	△	○	○					○	○	○	△	○	△	△	△	△	○	△			○	○						△	○	○				△	○	△	△
43	MUNCANG	○	○	○	△	○					○	△																			△		○				○			
43 a	PANGGARANGAN	○	○	○						○	○	△	○	○	○	○		○	△	○	○	○	△	○	△	△	△	○	○	○	△	○	○	○	○	○	○	○	○	△
43 b	CILAKI											○	○	○	○	○	○	○	○	○	△	○	○	○	△		○		△	△		○	△	○	○	○	○	○	○	
44	CIPANAS	○	○	△	△						○	○	○	○	○	△	○	○	○	○	○	△	△	△	△	△	△			△					○	△	△	△	△	
44 a	BANJAR IRIGASI											○	○		○	△				○	△	○	○	○	△		○		△	△		○		○	○	○	○	○		△
45	LEBAKPARAY																												△											
45 a	CIROTAN																																				○			
48	CIKOTOK	○	○	△	○	△				△	○	△	○	○	○	○	○	○	○	○	△	△	○	○	○		○					△	○			○	○			
46 c	CIKOTOK																△	△	△	○							○			○	○	○	○	○	○					
46 e	PENJAWUNGAN																○	○	○		○	○	○	○						○	○	△	○	△						

Remarks: ○ Available Data

△ Partially Available Data

Table B-2 AVERAGE MONTHLY RAINFALL

Station Name	Station No.		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean Max/Min
Cipanas	44	Ave.	442	384	448	472	398	266	227	262	249	310	319	337	4309
		Max.	1058	612	858	743	975	729	527	849	595	658	481	636	6245
		Min.	161	195	145	140	100	22	21	0	33	52	222	82	2886
			(26)	(25)	(24)	(25)	(24)	(24)	(20)	(24)	(24)	(25)	(23)	(22)	(15)
Cileles	26b	Ave.	336	310	340	235	242	105	98	140	174	202	263	291	2599
		Max.	612	568	1037	593	607	247	283	405	543	401	585	526	3210
		Min.	137	38	37	28	45	0	0	0	0	36	94	66	1799
			(18)	(19)	(19)	(21)	(19)	(22)	(19)	(17)	(17)	(17)	(16)	(15)	(8)
Rangkasbitung	37	Ave.	322	219	228	216	180	113	126	124	142	162	182	187	2242
		Max.	654	338	319	483	457	226	304	450	298	423	434	336	2996
		Min.	99	75	40	105	21	12	2	0	2	31	52	45	1603
			(29)	(29)	(29)	(29)	(30)	(30)	(29)	(29)	(29)	(28)	(28)	(27)	(26)
Pamarayan	35	Ave.	276	227	204	183	184	113	104	87	105	163	176	194	2014
		Max.	619	385	368	376	413	262	293	279	322	375	290	510	2489
		Min.	12	35	28	49	39	0	1	0	0	25	33	15	843
			(29)	(28)	(28)	(27)	(27)	(29)	(29)	(28)	(29)	(29)	(27)	(26)	(24)
Jeungjing	32a	Ave.	328	261	215	121	74	66	53	50	48	61	98	138	1407
		Max.	782	609	885	323	225	270	198	172	229	191	257	397	2141
		Min.	75	54	53	0	0	0	0	0	0	0	0	12	1121
			(28)	(28)	(28)	(28)	(26)	(25)	(27)	(25)	(27)	(26)	(27)	(25)	(22)
Pandeglang	26	Ave.	327	241	244	244	207	126	119	123	162	206	265	259	2619
		Max.	586	447	502	491	586	382	259	312	378	472	466	583	3685
		Min.	92	105	81	77	74	13	0	0	0	59	127	103	1652
			(27)	(30)	(30)	(29)	(29)	(30)	(31)	(29)	(31)	(31)	(30)	(30)	(19)
Serang	23	Ave.	281	201	196	121	130	74	76	69	73	96	155	182	1672
		Max.	522	349	403	229	354	194	238	256	219	196	355	482	2033
		Min.	65	42	90	51	39	0	0	0	0	9	18	32	1029
			(23)	(23)	(23)	(24)	(23)	(23)	(22)	(23)	(23)	(22)	(21)	(22)	(18)
Cilegon	14	Ave.	264	194	168	107	109	66	76	46	32	42	99	145	1376
		Max.	535	460	492	225	269	250	295	155	157	122	402	458	2152
		Min.	22	13	1	0	4	0	0	0	0	0	7	4	123
			(20)	(21)	(20)	(19)	(20)	(21)	(21)	(20)	(19)	(20)	(21)	(21)	(12)
Soekadana/ Cilomas	18	Ave.	360	292	276	218	172	106	113	119	116	190	255	274	2511
		Max.	651	599	626	491	385	234	310	459	338	377	583	905	3601
		Min.	103	100	86	68	52	0	0	0	0	0	22	65	1674
			(24)	(24)	(26)	(26)	(26)	(24)	(25)	(24)	(22)	(23)	(23)	(21)	(17)

Remarks: (1) Average for 1942 - 1976
(2) ( ) shows available Nos. of years

Table B-3 LIST OF METEOROLOGICAL STATIONS

Station	Installed by	Period of Observation Date
Serang	PMG	1972 - 1978
Padarincang	P3SA	1978 - 1981
Cikadu	P3SA	1978 - 1981
Cadasari	P3SA	1978 - 1981
Cileles	P3SA	1978 - 1981

Table B-4 WATER LEVEL RECORDERS AND STAFF GAUGES

River	Location	Catchment Area (km^2)	Type	Installed by	Date	Water Level Data
Cidanau	Curugbetung	200	R	T.A.	1915	1924, 1932, 1936
Cidanau	Kubang Baros	200	R	P3SA	1980	1980 - 1982
Ciberang	Cileuksa	58	R	T.A.	1929	1929, 1934
Ciberang	Sajira	233	R/S	P3SA	1978	1978 - 1981
Cisimeut	Leuwidamar	183	R	P3SA	1979	1980 - 1981
Ciujung	Rangkasbitung	1,383	R/S	DPMA	1969/70	1972 - 1982
Ciujung	Pamarayan weir	1,451	S	DPU	—	1975 - 1981
Ciujung	Kragilan	1,812	S&R	DPMA	1969	1970, 1972 - 1975, 1978 - 1979
Ciujung	Cileles	216	R/S	P3SA	1978	1978 - 1982
Cibanten	Serut	77	R	P3SA	1977	1977 - 1982

Remark: R = Automatic recorder
S = Daily normal gauge

Table B-5 (1/3) DISCHARGE MEASUREMENT RECORD

Ciujung River, Cileles Station			
No.	Date	Discharge m^3/s	Water Level m
1	06/10/1978	2.20	0.58
2	27/10/1978	18.19	1.08
3	14/11/1978	6.97	0.81
4	29/12/1978	36.29	-
5	29/03/1979	-	-
6	27/04/1979	13.59	-
7	25/05/1979	3.48	-
8	25/06/1979	1.73	0.30
9	24/07/1979	2.26	0.32
10	16/08/1979	1.18	0.24
11	26/09/1979	3.62	0.43
12	25/10/1979	3.29	0.40
13	29/11/1979	9.06	0.60
14	29/12/1979	8.15	0.54
15	28/01/1980	9.66	0.86
16	27/08/1980	2.72	0.33
17	18/09/1980	18.26	-
18	14/10/1980	12.25	0.63
19	24/12/1980	60.43	1.89
20	18/02/1981	22.32	0.89
21	28/03/1981	14.20	0.74
22	14/06/1981	8.91	0.56
23	09/09/1981	16.21	0.79
24	20/12/1981	8.80	0.57
25	18/02/1982	9.93	0.61
26	04/06/1982	2.19	0.33

Cisimeut River, Leuwidamar Station			
No.	Date	Discharge m^3/s	Water Level m
1	23/07/1978	3.89	-
2	04/10/1978	4.33	-
3	25/11/1978	3.50	-
4	28/12/1978	27.79	-
5	25/02/1979	15.70	-
6	24/03/1979	17.52	-
7	26/04/1979	17.52	-
8	23/05/1979	5.57	-
9	22/06/1979	2.67	-
10	26/07/1979	3.31	-
11	22/08/1979	2.77	-
12	25/09/1979	12.87	-
13	23/10/1979	9.35	-
14	27/11/1979	12.89	-
15	05/01/1980	18.24	0.95
16	05/01/1980	18.24	0.95
17	26/08/1980	4.76	0.85
18	18/09/1980	20.66	1.18
19	15/10/1980	15.99	1.10
20	01/12/1980	6.67	0.94
21	21/12/1980	23.62	1.23
22	16/01/1981	28.96	1.36
23	19/02/1981	24.69	1.28
24	11/09/1981	21.53	1.21
25	20/11/1981	21.02	1.20
26	19/12/1981	8.54	0.99
27	23/01/1982	20.45	1.19
28	17/02/1982	13.31	1.06
29	12/03/1982	10.94	1.03
30	21/04/1982	10.78	1.03
31	04/06/1982	5.49	0.93

Table B-5 (2/3) DISCHARGE MEASUREMENT RECORD

Ciberang River, Sajira Station			
No.	Date	Discharge m^3/s	Water Level m
1	24/07/1978	8.77	0.65
2	03/10/1978	8.00	0.56
3	24/10/1978	13.57	1.16
4	22/11/1978	8.99	0.96
5	05/12/1978	10.42	-
6	09/01/1979	7.21	-
7	16/02/1979	20.12	1.62
8	26/03/1979	20.82	1.66
9	24/04/1979	20.84	1.67
10	22/05/1979	7.89	0.36
11	21/06/1979	5.97	0.29
12	25/07/1979	6.66	0.30
13	14/08/1979	8.52	0.42
14	25/09/1979	11.88	1.01
15	20/10/1979	5.65	1.06
16	26/11/1979	19.72	1.04
17	26/12/1979	16.52	0.90
18	26/08/1980	7.77	0.30
19	17/09/1980	34.32	1.07
20	16/10/1980	13.11	0.98
21	01/12/1980	14.49	0.49
22	20/12/1980	33.64	1.14
23	19/02/1981	14.04	0.50
24	30/03/1981	20.51	0.62
25	09/05/1981	25.29	0.66
26	21/10/1981	11.42	0.98
27	20/11/1981	14.03	0.50
28	23/01/1982	36.37	0.85
29	17/02/1982	20.29	0.59
30	12/03/1982	10.42	0.32

Cibanten River, Serut Station			
No.	Date	Discharge m^3/s	Water Level m
1	23/10/1978	2.19	0.46
2	30/10/1978	1.27	0.35
3	24/11/1978	0.81	0.26
4	31/12/1978	3.01	-
5	19/01/1979	10.42	-
6	17/02/1979	4.13	0.48
7	28/03/1979	1.62	0.41
8	25/04/1979	2.86	0.50
9	26/05/1979	1.10	0.30
10	23/06/1979	0.70	0.27
11	25/07/1979	0.59	0.26
12	15/08/1979	0.62	0.41
13	24/09/1979	0.35	0.23
14	22/10/1979	0.49	0.22
15	22/11/1979	0.97	0.35
16	28/12/1979	1.77	0.40
17	26/01/1980	2.80	0.51
18	28/08/1980	0.44	0.21
19	22/09/1980	0.76	0.30
20	17/10/1980	0.79	0.32
21	28/11/1980	1.09	0.35
22	19/12/1980	1.44	0.38
23	16/01/1981	3.11	0.56
24	29/03/1981	1.65	0.40
25	08/05/1981	0.24	0.32
26	13/06/1981	1.26	0.37
27	10/09/1981	1.61	0.41
28	20/10/1981	1.02	0.34
29	19/11/1981	3.02	0.52
30	20/12/1981	1.26	0.38
31	22/01/1982	5.67	0.71
32	19/02/1982	2.27	0.48
33	11/03/1982	2.22	0.46
34	21/04/1982	2.49	0.44
35	03/06/1982	1.79	0.40

Table B-5 (3/3) DISCHARGE MEASUREMENT RECORD

Cidanau River, Peusar Station			
No.	Date	Discharge m^3/s	Water Level s
1	22/09/1979	1.36	-
2	22/10/1979	2.36	0.10
3	22/11/1979	9.93	0.50
4	28/12/1979	6.32	0.38
5	28/08/1980	3.34	0.19
6	22/09/1980	5.94	0.36
7	17/10/1980	13.96	0.59
8	28/11/1980	16.37	0.76
9	19/12/1980	8.34	0.39
10	27/03/1981	15.27	0.70
11	08/05/1981	13.33	0.63
12	13/06/1981	5.12	0.30
13	10/09/1981	13.41	0.65
14	20/10/1981	4.89	0.31
15	18/12/1981	6.59	0.37
16	11/03/1982	19.75	0.89
17	21/04/1982	15.98	0.75
18	03/06/1982	5.06	0.27

Cibeureum River, Gadeg Station			
No.	Date	Discharge m^3/s	Water Level m
1	17/09/1980	5.52	0.48
2	16/10/1980	8.65	0.68
3	27/11/1980	7.48	0.60
4	20/12/1980	4.34	0.30
5	12/06/1981	5.05	0.32
6	11/09/1981	10.61	0.83
7	21/10/1981	1.55	0.00
8	20/11/1981	3.24	0.12
9	19/12/1981	0.91	0.00

Table B-6 (1/2) RECORDED MONTHLY MEAN DISCHARGE

Unit: m^3/s

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Annual Runoff (10^6 m^3)
(1) Kragilan Station (Catchment Area = 1,812 km^2)														
1969	-	-	-	-	-	-	-	-	-	40.6	38.2	40.3	39.7	1,252
1970	74.8	204.0	132.0	150.0	195.0	122.0	40.0	18.4	41.0	48.1	119.0	226.0	114.2	3,601
1971	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1972	378.0	210.0	240.0	112.0	168.0	24.4	12.3	19.1	7.8	9.1	32.3	59.1	106.0	3,343
1973	197.0	144.0	166.0	184.0	190.0	112.0	39.8	61.1	128.0	124.0	136.0	136.0	134.8	4,251
1974	279.0	196.0	216.0	145.0	155.0	60.8	96.8	111.0	242.0	103.0	108.0	79.7	149.4	4,712
1975	84.0	194.0	124.0	150.0	134.0	32.8	56.1	80.8	146.0	74.8	91.3	193.0	113.4	3,576
1976	398.4	121.0	144.0	80.6	37.0	19.6	10.2	10.9	4.5	26.3	64.5	28.6	78.8	2,485
1977	186.1	146.0	198.3	150.4	125.2	78.7	15.0	5.0	5.1	5.0	11.5	38.4	80.4	2,536
1978	190.7	91.5	163.4	111.5	64.5	49.0	51.3	65.9	85.8	92.5	117.0	93.6	98.1	3,094
1979	237.0	154.0	150.0	188.0	62.8	29.8	28.5	14.4	21.1	21.3	93.4	-	90.9	2,867
1980	290.2	147.3	79.2	98.2	84.4	24.0	29.5	90.7	63.3	47.6	87.9	123.3	97.1	3,062
1981	275.5	166.6	149.6	103.6	119.1	-	120.5	60.1	88.7	114.0	145.3	131.5	134.1	4,229
1982	303.2	103.0	43.5	103.5	-	-	-	-	-	-	-	118.2	134.3	4,235
Average	241.2	156.5	150.5	131.4	121.4	55.3	45.5	48.9	75.8	58.9	87.0	105.6	105.5	3,326
(2) Rangkasbitung Station (Catchment Area = 1,383 km^2)														
1972	260.0	141.0	187.0	80.0	105.0	24.2	13.5	20.9	6.2	9.3	34.1	62.2	78.7	2,482
1973	166.0	111.0	157.0	173.0	189.0	106.0	48.5	63.6	125.0	109.0	101.0	131.0	121.7	3,838
1974	189.0	143.0	150.0	115.0	128.0	58.2	65.6	91.0	178.0	96.1	80.0	88.2	115.3	3,635
1975	103.0	162.0	106.0	55.4	70.7	42.4	62.0	90.8	135.0	74.8	127.0	173.0	100.2	3,160
1976	274.0	101.0	123.0	94.9	58.4	37.7	23.4	24.3	15.0	43.9	76.0	50.4	77.3	2,438
1977	189.4	111.0	156.0	145.0	126.6	75.1	29.8	15.7	15.5	(29.0)	28.0	46.5	80.6	2,542
1978	183.0	89.4	139.0	108.0	(68.0)	68.7	61.1	83.5	73.9	77.1	94.6	89.0	94.6	2,983
1979	133.0	151.0	121.0	165.0	63.6	41.0	44.6	26.6	32.7	33.1	96.7	31.0	82.4	2,599
1980	183.2	127.8	66.2	100.2	91.5	45.1	51.2	88.1	89.3	69.7	96.0	124.9	94.4	2,977
1981	200.0	127.4	132.9	106.7	123.2	149.7	127.8	90.1	108.2	103.3	(120.9)	(111.8)	125.2	3,948
1982	235.2	87.7	45.2	84.5	59.8	25.8	21.5	8.9	6.0	17.3	84.8	103.4	65.0	2,050
Average	192.4	122.9	125.8	111.6	98.5	61.3	86.4	54.9	71.4	60.2	85.4	92.0	94.1	2,969
(3) Pamarayan Weir Station (Catchment Area = 1,451 km^2)														
1975	90.1	75.4	67.8	162.6	148.8	88.7	122.8	178.8	370.0	120.6	157.0	489.5	172.7	5,446
1976	959.0	376.5	268.9	114.9	70.2	45.1	21.5	21.9	15.0	38.3	72.7	54.5	171.5	5,408
1977	157.3	110.1	164.6	191.6	129.7	83.7	31.9	14.4	15.2	13.0	24.8	29.5	80.5	2,539
1978	158.1	83.3	151.4	97.6	77.0	51.7	41.9	76.3	81.0	29.2	-	72.4	83.6	2,636
1979	124.9	-	102.7	151.2	21.9	28.0	41.9	18.8	37.7	30.9	-	53.6	61.1	1,927
1980	287.1	196.4	58.5	76.3	121.5	100.2	78.8	95.0	93.5	77.0	61.7	148.5	116.2	3,665
1981	165.1	218.7	195.1	169.4	207.4	204.4	150.2	146.4	163.4	130.4	199.5	133.8	173.8	5,481
1982	429.3	181.0	59.2	96.6	135.2	83.5	31.3	18.4	-	-	-	-	-	-
Average	296.4	177.3	133.5	132.5	114.0	85.7	65.0	71.3	110.8	62.8	103.1	140.3	122.8	3,872

Remarks: ( ) adapted from Kragilan

Table B-6 (2/2) RECORDED MONTHLY MEAN DISCHARGE

Unit: m^3/s

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Annual Runoff (10^6 m^3)
(4) Kopomaja Station (Catchment Area = 304 km^2)														
1969	-	-	-	-	-	-	-	-	-	-	21.5	12.4	-	-
1970	22.7	36.4	22.5	20.8	39.6	19.2	7.5	7.2	18.3	7.5	28.8	14.3	20.4	643
1971	21.3	49.2	24.5	28.7	16.5	18.3	13.4	14.2	6.3	26.7	14.0	19.3	21.0	662
1972	61.9	31.5	48.5	27.3	32.6	9.7	2.3	7.7	1.6	4.7	12.4	25.9	22.2	700
1973	27.8	47.6	30.9	51.2	32.9	23.6	15.4	17.6	42.7	27.3	18.8	23.4	29.9	943
1974	49.2	32.3	23.3	29.4	35.3	17.0	15.5	22.9	55.7	24.9	20.4	11.3	28.1	886
1975	24.9	32.8	20.3	32.7	37.9	15.7	14.9	25.5	32.7	21.4	22.3	14.8	24.7	779
1976	83.1	29.0	28.8	25.2	19.1	10.6	4.3	8.6	6.1	19.7	22.4	11.9	22.4	706
1977	51.0	34.0	33.4	45.5	42.8	22.2	11.9	4.4	7.6	7.6	15.0	25.4	25.1	792
1978	37.4	18.2	32.9	20.4	12.5	13.1	12.9	14.5	26.2	21.6	18.2	20.2	20.7	653
1979	35.8	24.4	26.8	32.3	15.3	15.4	17.4	14.5	11.4	18.0	47.6	17.8	23.1	729
1980	47.2	31.0	19.0	24.1	33.8	-	-	16.5	28.1	19.1	27.4	22.9	26.9	848
1981	44.1	25.3	36.9	39.8	-	-	-	-	-	-	22.5	39.2	34.6	1,091
1982	55.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Average	43.2	32.6	29.0	31.5	28.9	16.5	11.6	14.0	21.6	18.1	22.4	19.9	23.1	786
(5) Cileles Station (Catchment Area = 216 km^2)														
1978	-	-	-	-	4.5	4.0	3.3	-	3.5	7.2	7.2	10.6	5.8	183
1979	-	-	-	-	(5.4)	4.2	4.7	2.2	-	3.2	12.0	9.0	5.8	183
1980	31.1	(12.4)	-	-	-	-	-	-	-	-	-	17.8	20.4	643
1981	28.7	19.1	12.2	-	-	-	-	-	6.4	(9.7)	(32.0)	-	18.0	568
1982	35.2	-	-	-	-	-	-	-	-	-	-	-	-	-
Average	31.7	15.8	12.2	-	5.0	4.1	4.0	2.2	5.0	6.7	17.1	12.5	12.5	394
(6) Serut Station (Catchment Area = 77 km^2)														
1977	-	-	-	-	-	-	0.9	0.6	0.7	0.2	0.2	1.2	-	-
1978	4.8	3.2	2.7	2.6	1.4	1.6	1.3	1.3	1.7	1.9	1.5	(4.9)	2.4	76
1979	-	4.5	3.7	3.3	1.5	1.1	1.3	-	-	(0.6)	1.8	1.9	2.2	69
1980	(3.5)	4.5	1.6	1.4	1.0	0.7	0.4	1.8	2.0	1.2	1.7	2.5	1.9	60
1981	7.6	8.0	5.9	1.5	2.0	1.3	2.8	1.6	(3.1)	3.6	4.2	(2.3)	3.7	117
1982	7.0	2.9	-	-	-	-	-	-	-	-	-	-	-	-
Average	5.7	4.6	3.5	2.2	1.5	1.2	1.3	1.3	1.9	1.5	1.9	2.6	2.6	82
(7) Leuwidamar Station (Catchment Area = 183 km^2)														
1980	19.6	14.7	6.8	21.0	17.8	11.2	10.2	13.5	-	-	-	23.4	15.4	486
1981	(39.1)	(29.0)	(78.0)	-	-	-	-	-	-	-	-	-	-	-
Average	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(8) Kubang Baros Station (Catchment Area = 200 km^2)														
Curugbetung														
1924	17.9	11.8	28.0	16.7	14.9	8.2	3.7	2.3	3.4	11.1	21.4	20.9	13.4	423
1932	21.5	24.1	15.6	21.9	18.8	9.4	6.4	3.4	5.2	5.0	5.7	29.5	13.9	438
1936	17.7	16.5	15.5	21.0	16.0	6.1	3.7	4.4	6.5	6.0	18.1	11.4	11.9	375
Kubang Baros														
1980	8.1	10.5	13.1	7.6	(9.6)	6.7	6.2	12.2	24.5	(6.1)	-	65.6	15.5	489
1981	57.3	27.7	12.7	(27.2)	6.6	10.9	12.5	8.3	8.0	23.8	39.6	25.4	21.7	684
1982	22.1	5.5	-	-	-	-	-	-	-	-	-	-	-	-
Average	24.1	16.0	17.0	19.0	13.2	8.3	6.5	6.1	9.5	10.4	21.2	30.6	15.3	482

Table B-7 CORRELATIVE COEFFICIENTS OF MONTHLY MEAN DISCHARGE

	Cileles	Leuwidamar	Kopomaja	Rangkasbitung	Pamarayan
Kragilan	0.961 (19)	0.515 (19)	0.829 (126)	0.949 (118)	0.764 (83)
Pamarayan	0.881 (18)	0.474 (9)	0.722 (74)	0.745 (85)	
Rangkasbitung	0.930 (19)	0.686 (9)	0.839 (110)		
Kopomaja	0.851 (19)	0.372 (7)			
Leuwidamar	(2)				
Cileles					

Remarks: Figures in parentheses denote the number of data.

Table B-8 (1/2) ESTIMATED MONTHLY MEAN DISCHARGE

Unit: m^3/s

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Annual Runoff (10^6 m^3)
(1) Karian Dam Site (Catchment Area = 288 km^2)														
1972	77.6	42.1	55.8	23.9	31.3	7.2	4.0	6.2	1.9	2.8	10.2	18.6	23.5	741
1973	49.6	33.1	46.9	51.6	56.4	31.6	14.5	19.0	37.3	32.5	30.1	39.1	36.3	1,145
1974	56.4	42.7	44.8	34.3	38.2	17.4	19.6	27.2	53.1	28.7	23.9	26.3	34.4	1,085
1975	30.7	48.4	31.6	16.5	21.1	12.7	18.5	27.1	10.4	22.3	37.9	51.6	29.9	943
1976	81.8	30.1	36.7	28.3	17.4	11.3	7.0	7.3	4.5	13.1	22.7	15.0	23.1	729
1977	56.5	33.1	46.6	43.3	37.8	22.4	8.9	4.7	4.6	8.7	8.4	13.9	24.1	760
1978	54.6	26.7	41.5	32.3	(20.3)	20.5	18.2	24.9	22.1	23.0	28.2	26.6	28.2	889
1979	39.7	45.1	36.1	49.3	19.0	12.2	13.3	7.9	9.8	9.9	28.9	9.3	24.6	776
1980	54.7	38.2	19.8	29.9	27.3	13.5	15.3	26.3	26.7	20.8	28.7	37.3	28.2	889
1981	59.7	38.0	39.7	31.9	36.8	44.7	38.2	26.9	32.3	30.8	(36.1)	(33.4)	37.4	1,180
1982	70.2	26.2	13.5	25.2	17.9	7.7	6.4	2.7	1.8	5.2	25.3	30.9	19.4	612
Average	57.4	36.7	37.6	33.3	29.4	18.3	14.9	16.4	18.6	18.0	25.5	27.5	28.1	886
(2) Pasir Kopo Dam Site (Catchment Area = 172 km^2)														
1972	41.7	22.6	30.0	12.8	16.8	3.9	2.2	3.4	1.0	1.5	5.5	10.0	12.6	397
1973	26.6	17.8	25.2	27.7	30.3	17.0	7.8	10.2	20.0	17.5	16.2	21.0	19.8	629
1974	30.3	22.9	24.0	18.4	20.5	9.3	10.5	14.6	28.5	15.4	12.8	14.1	18.4	580
1975	16.5	26.0	17.0	8.9	11.3	6.8	9.9	14.6	21.6	12.0	20.4	27.7	16.1	508
1976	43.9	16.2	19.7	15.2	9.4	6.0	3.8	3.9	2.4	7.0	12.2	8.1	12.3	388
1977	30.4	17.8	25.0	23.2	20.3	12.0	4.8	2.5	2.5	(4.7)	4.5	7.5	12.9	407
1978	29.3	14.3	22.3	17.3	(10.9)	11.0	9.8	13.4	11.9	12.4	15.2	14.3	15.2	479
1979	21.3	24.2	19.4	26.5	10.2	6.6	7.2	4.3	5.2	5.3	15.5	5.0	12.6	397
1980	29.4	20.5	10.6	16.1	14.7	7.2	8.2	14.1	14.3	11.2	15.4	20.0	15.1	476
1981	32.1	20.4	21.3	17.1	19.8	24.0	20.5	14.4	17.3	16.6	(19.4)	17.9	20.1	634
1982	37.7	14.1	7.3	13.5	9.6	4.1	3.5	1.4	1.0	2.8	13.6	16.6	10.4	328
Average	30.8	19.7	20.2	17.9	15.8	9.8	8.0	8.8	11.4	9.7	13.7	14.7	15.0	474
(3) Bojongmanik Dam Site (Catchment Area = 159 km^2)														
1972	32.8	17.8	23.6	10.1	13.2	3.1	1.7	2.6	0.8	1.2	4.3	7.8	9.9	312
1973	20.9	14.0	19.8	21.8	23.8	13.4	6.1	8.0	15.8	13.7	12.7	16.5	15.5	489
1974	23.8	18.0	18.9	14.5	16.1	7.3	8.3	11.5	22.4	12.1	10.1	11.1	14.5	457
1975	13.0	20.4	13.4	7.0	8.9	5.4	7.8	11.5	17.0	9.4	16.0	21.8	12.6	397
1976	34.6	12.7	15.5	12.0	7.4	4.8	3.0	3.1	1.9	5.5	9.6	6.4	9.7	306
1977	23.9	14.0	19.7	18.3	16.0	9.5	3.8	2.0	2.0	(3.7)	3.5	5.9	10.2	322
1978	23.1	11.3	17.5	13.6	(8.6)	8.7	7.7	10.5	9.3	9.7	11.9	11.2	11.9	375
1979	16.8	19.0	15.3	20.8	8.0	5.2	5.6	3.4	4.1	4.2	12.2	3.9	9.9	312
1980	23.1	16.1	8.4	12.6	11.5	5.7	6.5	11.1	11.3	8.8	12.1	15.8	11.9	375
1981	25.2	16.1	16.8	13.5	15.5	18.9	16.1	11.4	13.6	13.0	(15.2)	(14.1)	15.8	498
1982	29.7	11.1	5.7	10.7	7.5	3.3	2.7	1.1	0.8	2.2	10.7	13.0	8.2	259
Average	24.3	15.5	15.9	14.1	12.4	7.6	6.3	6.9	9.0	7.6	10.8	11.6	11.8	373

Table B-8 (2/2) ESTIMATED MONTHLY MEAN DISCHARGE

Unit: m^3/s

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Annual Runoff (10^6 m^3)
(4) Pamarayan Weir (Catchment Area = 1,451 km^2)														
1972	266.4	144.5	191.6	82.0	107.6	24.8	13.8	21.4	6.4	9.5	34.9	63.7	80.6	2,542
1973	170.1	113.7	160.9	177.3	193.6	108.6	49.7	65.2	128.1	111.7	103.5	134.2	126.4	3,986
1974	193.6	146.5	153.7	117.8	131.1	59.6	67.2	93.2	182.4	98.5	82.0	90.4	118.0	3,721
1975	105.5	166.0	108.6	56.8	72.4	43.4	63.5	93.0	138.3	76.6	130.1	177.3	102.6	3,236
1976	280.7	103.5	126.0	97.2	59.8	38.6	24.0	24.9	15.4	45.0	77.9	51.6	78.7	2,482
1977	194.1	113.7	159.8	148.6	129.7	76.9	30.5	16.1	15.9	(29.7)	28.7	47.6	82.6	2,605
1978	187.5	91.6	142.4	110.7	(69.7)	70.4	62.6	85.6	75.7	79.0	96.9	91.2	96.9	3,056
1979	136.3	154.7	124.0	169.1	65.2	42.0	45.7	27.3	33.5	33.9	99.1	31.8	80.2	2,529
1980	187.7	130.9	67.8	102.7	93.8	46.2	52.5	90.3	91.5	71.4	98.4	128.0	96.8	3,053
1981	204.9	130.5	136.2	109.3	126.2	153.4	130.9	92.3	110.9	105.8	(123.9)	(114.6)	128.2	4,043
1982	241.0	89.9	46.3	86.6	61.3	26.4	22.0	9.1	6.2	17.7	86.9	105.9	66.6	2,100
Average	197.1	126.0	128.8	114.4	100.9	62.8	51.1	56.2	73.1	61.7	87.5	94.2	96.1	3,032
(5) Cilawang Dam Site (Catchment Area = 93 km^2)														
1972	20.8	11.3	15.0	6.4	8.4	1.9	1.1	1.7	0.5	0.7	2.7	5.0	6.8	215
1973	13.3	8.9	12.6	13.9	15.1	8.5	3.9	5.1	10.0	8.7	8.1	10.5	9.9	312
1974	15.1	11.5	12.0	9.2	10.3	4.7	5.3	7.3	14.3	7.7	6.4	7.1	9.2	290
1975	8.3	13.0	8.5	4.4	5.7	3.4	5.0	7.3	10.8	6.0	10.2	13.9	8.0	252
1976	22.0	8.1	9.9	7.6	4.7	3.0	1.9	2.0	1.2	3.5	6.1	4.0	6.2	196
1977	15.2	8.9	12.5	11.6	10.1	6.0	2.4	1.3	1.2	(2.3)	2.2	3.7	6.5	205
1978	14.7	7.2	11.1	8.7	(5.5)	5.5	4.9	6.7	5.9	6.2	7.6	7.1	7.6	240
1979	10.7	12.1	9.7	13.2	5.1	3.3	3.6	2.1	2.6	2.7	7.8	2.5	6.3	199
1980	14.7	10.2	5.3	8.0	7.3	3.6	4.1	7.1	7.2	5.6	7.7	10.0	7.6	240
1981	16.0	10.2	10.7	8.6	9.9	12.0	10.2	7.2	8.7	8.3	(9.7)	(9.0)	10.0	315
1982	18.8	7.0	3.6	6.8	4.8	2.1	1.7	0.7	0.5	1.4	6.8	8.3	5.2	164
Average	15.4	9.9	10.1	8.9	7.9	4.9	4.0	4.4	5.7	4.8	6.8	7.4	7.6	239
(6) Cibanten Dam Site (Catchment Area = 76 km^2)														
1977	-	-	-	-	-	-	0.9	0.6	0.7	0.2	0.2	1.2	0.6	19
1978	4.7	3.2	2.7	2.6	1.4	1.6	1.3	1.3	1.7	1.9	1.5	(4.8)	2.4	76
1979	-	4.4	3.7	3.3	1.5	1.1	1.3	-	-	(0.6)	1.8	1.9	2.2	69
1980	(3.5)	4.4	1.6	1.4	1.0	0.7	0.4	1.8	2.0	1.2	1.7	2.5	1.9	60
1981	7.5	7.9	5.8	1.5	2.0	1.3	2.8	1.6	(3.1)	3.6	4.2	(2.3)	3.6	114
1982	6.9	2.9	-	-	-	-	-	-	-	-	-	-	4.9	155
Average	5.7	4.6	3.5	2.2	1.5	1.2	1.3	1.3	1.9	1.5	1.9	2.5	2.6	82
(7) Cidanau Dam Site (Catchment Area = 216 km^2)														
1924	19.3	12.7	30.2	18.0	16.1	8.9	4.0	2.5	3.7	12.0	23.1	22.6	14.4	454
1932	23.2	26.0	16.9	23.7	20.3	10.2	6.9	3.7	5.6	5.4	6.2	31.9	15.0	473
1936	19.1	17.8	16.7	22.7	17.3	6.6	4.0	4.8	7.0	6.5	19.6	12.3	12.9	407
1980	8.8	11.3	14.2	8.2	(10.4)	7.2	6.7	13.2	26.5	(6.6)	-	70.9	16.7	527
1981	61.9	29.9	13.7	(29.4)	7.1	11.8	13.5	9.0	8.6	25.7	42.8	27.4	23.4	738
1982	23.9	5.9	-	-	-	-	-	-	-	-	-	-	14.9	470
Average	26.0	17.3	18.3	20.4	14.2	8.9	7.0	6.6	10.3	11.2	22.9	33.0	16.2	512

Table B-9 PROBABLE MONTHLY MEAN DISCHARGE

Unit: m^3/s

Station	Return Period (Year)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Runoff (10^6 m^3)
Pamarayan	1/3	165.7	111.2	99.2	92.2	77.5	40.7	31.3	28.1	22.5	32.9	64.1	64.9	2,668
	1/5	145.1	100.6	82.3	78.6	64.4	31.0	23.1	18.9	12.3	22.5	51.8	50.5	2,406
	1/10	125.8	90.4	67.4	66.3	52.9	23.2	16.7	12.3	6.4	15.0	41.2	38.7	2,157
Rangkasbitung	1/3	161.7	108.6	96.8	89.9	75.6	39.7	30.6	27.5	21.9	32.1	62.6	63.3	2,620
	1/5	141.6	98.2	80.4	76.7	62.9	30.3	22.6	18.4	12.0	22.0	50.6	49.3	2,368
	1/10	122.8	88.2	65.8	64.7	51.6	22.7	16.3	12.0	6.2	14.7	40.3	37.8	2,129
Karian	1/3	48.3	32.4	28.9	26.8	22.6	11.9	9.1	8.2	6.0	9.6	18.7	18.9	782
	1/5	42.2	29.3	24.0	22.9	18.8	9.0	6.7	5.5	3.3	6.6	15.1	14.7	706
	1/10	36.6	26.3	19.7	19.3	15.4	6.8	4.9	3.6	1.8	4.4	12.0	11.3	637
Pasir Kopo	1/3	25.9	17.4	15.5	14.4	12.1	6.4	4.9	4.4	3.5	5.2	10.0	10.2	416
	1/5	22.7	15.7	12.9	12.3	10.1	4.9	3.7	2.9	1.9	3.5	8.1	7.9	375
	1/10	19.7	14.1	10.6	10.4	8.3	3.6	2.7	1.9	1.0	2.4	6.5	6.1	337
Bojongmanik	1/3	20.4	13.7	12.2	11.4	9.5	5.1	3.9	3.5	2.8	4.1	7.9	8.0	328
	1/5	17.9	12.4	10.2	9.7	7.9	3.9	2.9	2.3	1.5	2.8	6.4	6.2	296
	1/10	15.5	11.1	8.3	8.2	6.5	2.9	2.1	1.5	0.8	1.9	5.1	4.8	265
Cilawang	1/3	13.0	8.7	7.6	7.2	6.1	3.2	2.5	2.2	1.8	2.6	5.0	5.1	211
	1/5	11.4	7.9	6.4	6.1	5.1	2.4	1.8	1.5	1.0	1.7	4.0	4.0	189
	1/10	9.9	7.1	5.2	5.2	4.2	1.8	1.3	1.0	0.5	1.2	3.2	3.0	170
Cidanau	1/3	15.8	10.9	14.9	14.4	10.5	7.6	4.8	3.8	5.3	6.6	11.6	19.6	451
	1/5	11.5	7.9	12.8	11.2	8.4	6.7	3.7	2.6	3.6	4.7	7.4	14.0	410
	1/10	8.2	5.7	10.8	8.6	6.5	5.8	2.8	1.8	2.4	3.3	4.6	9.7	369
Cibanten	1/3	4.4	3.4	2.2	1.6	1.2	0.9	0.7	0.9	1.1	0.5	0.7	1.7	47
	1/5	3.6	2.8	1.6	1.3	1.0	0.8	0.5	0.7	0.8	0.3	0.4	1.3	32
	1/10	2.9	2.3	1.2	1.0	0.9	0.6	0.3	0.5	0.6	0.2	0.2	1.0	22

Table B-10 TIME OF CONCENTRATION

River System	Point	Catchment Area (km^2)	Time of Concentration (hr)
Ciberang	Karian Dam	288	9
Ciberang	Confluence to Ciujung	331	12
Cisimeut	Pasir Kopo Dam	172	4
Cisimeut	Confluence to Ciberang	458	10
Ciujung	Bojongmanik Dam	159	6
Ciujung	Confluence with Ciberang	594	19
Cibanten	Cibanten Dam Site	76	1
Cibanten	Old Banten	183	3
Cidanau	Cidanau Dam Site	216	3
Cibeureum	Cilawang Dam Site	93	4
Cibeureum	Gadeg Weir Site	117	5
Cibeureum	Confluence to Cidurian	255	12

Table B-11 (1/5) DAILY MAXIMUM RAINFALL

Unit: mm/d

Year	Menes (5)		Labuan (6)		Rangkas (11b)		Bajanegara (14a)		Ciomas (18)		Mandalawangi (21)	
	Month	RF	Month	RF	Month	RF	Month	RF	Month	RF	Month	RF
1942	11	117	12	190	4	200	12	63	3	163	5	245
1943	2	120	2	188	1	325	11	111	1	132	1	256
1944	2	99	2	130	4	125	5	60	12	128	12	203
1945	2	112	2	127	12	134	8	84	5	71	2	364
1946	12	114			11	132					11	475
1947	2	107										
1948												
1949												
1950					5	170						
1951	12	148	6	93	1	100	2	76			2	115
1952	5	151	2	148	5	107	3	82	8	105	10	130
1953	3	165	3	199	5	175	12	67	3	100	3	116
1954	1	178	11	238	7	179	7	83	1	139	12	135
1955	2	164	2	156	7	131	7	177	7	100	7	175
1956	7	159	12	127					12	159	12	130
1957	12	220	12	159			3	91	1	98	1	154
1958	2	125	2	176	2	163	7	129	2	195	2	230
1959	5	150	11	121	3	145	2	84	3	125	12	117
1960	12	150	1	168	2	127	1	103	8	114	4	172
1961	12	141	5	163	3	168	5	61	1	100	4	140
1962	11	100	3	92	1	145	2	93	10	128	11	206
1963	4	131	3	118	1	152	1	75	1	100	2	105
1964	11	100	3	106	10	118	11	80	4	98	4	90
1965	3	137	12	100	12	76	2	145	1/2	125	2/12	75
1966	12	115	12	150	1/12	60	3	64	1	175	1	145
1967	12	107	3	175	2	86					1	110
1968	12	286	12	275	5	114						
1969	11	177	12	195	12	100						
1970					12	127	5	90	3	150	5	76
1971	3	121	1	83	10	256					11	89
1972	1	122	2	305	1	210			4	76	1	120
1973	11	206	6	330	6	180	2	100	2	110		
1974	1	210	10	185	2	240	2	95	7	72	4	150
1975	12	250	12	150			1/2	85	2	60	1	150
1976	12	200	12	360	12	191	1	75	3	99	11	136

Remarks: RF = Rainfall
The numbers in parentheses mean the station numbers.

Table B-11 (2/5) DAILY MAXIMUM RAINFALL

Unit: mm/d

Year	Cimanuk (22)		Kramatwetan (23c)		Baros (24)		Pandeglang (26)		Cileles (26b)		Warunggunung (26c)	
	Month	RF	Month	RF	Month	RF	Month	RF	Month	RF	Month	RF
1942	10	185	12	74	1	110	8	88	5	131	5	76
1943	1	271	1	120	1/7	107	1	130	2	173	1	139
1944	2	107	9	58	1	92	4	71	10	110	3	133
1945	2	208	2	92	9	80			3	155	5	128
1946	1	305										
1947	2	153					4	64				
1948												
1949			5	76								
1950	12	87	12	94			9	113				
1951	9	85	2	59	3	84	4	161	1	50	8	116
1952	7	95	3	69	1	68	1	91	12	117	2	90
1953	1/2	105	5	65	1	65	3	75	2	109	10	73
1954	11	117	11	61	10	84	11	89	1	105	7	90
1955	2	161	6	67	7	128	10	106	11	135	7	165
1956	12	146	6	72	1	86	9	95	12	135	8	132
1957	12	107	1	83	2	78	12	89	5	95	2	167
1958	2	350	1	93	2	150	2	200	3	156	2	153
1959	12	120	3	134	1	82	5	90	1	225	10	85
1960	11	122	2	74	7	70	10	94			12	84
1961	4	140	5	74	5	82	1	87	5	126	5	93
1962	11	100	4	74	10	57	9	91			6	108
1963	2	89	7	75	1	70	5	143	11	240	10	130
1964	10	85	8	74	10	39	10	100	1	75	2	101
1965	1	97	1	75	1	27	2	74	10	58	10	80
1966	1	95	7	74	3	47						
1967			12	82	1	50	5	102				
1968			5	90			6	137				
1969	5	90	5	115			5	90			3	116
1970			12	82	5	76	7	97			4	100
1971	1	92	3	63	3	75	1	96			1	110
1972	5	138	2	58	12	92	3	90	3	150	3	82
1973			1	73	5	75	9	104	9	209	9	86
1974					9	73	12	115	4	100	12	86
1975	12	120	6	59			4	86			7	67
1976	1	197	1	118	1	65	1	71	5	34	12	93

Remarks: RF = Rainfall
The numbers in parentheses mean the station numbers.

Table B-11 (3/5) DAILY MAXIMUM RAINFALL

Unit: mm/d

Year	G. Kencang (27)		Malingping (31)		Jeungjing (32a)		Parigi (33)		Pamarayan (35)		Rangkasbitung (37)	
	Month	RF	Month	RF	Month	RF	Month	RF	Month	RF	Month	RF
1942	1	92	4	101	8	90	10	53	11	76	3	75
1943	1	116	2	85	1	80	1	75	2	105	2	105
1944	2	104	5	100	1	116	3	76	4	72	4	100
1945	3	113	3	57	3	96			9	95	5	72
1946			11	114	12	78					1	97
1947											1	69
1948												
1949					11	150			3	127		
1950			12	86	2	75			3	104		
1951	6	112	4	93	2	71	12	127	8	104	8	198
1952	10	111	3	110	12	63	11	83	1	107	10	65
1953	2	130	11	79	6	62	5	80	11	63	2	63
1954	1	126	1	94	4	67	11	96	8	85	1	75
1955	11	124	8	134	3	67	12	171	9	92	10	84
1956	10	138	7	246	9	52	12	79	12	166	4	103
1957	5	110	12	126	1	124	8	62	12	75	7	86
1958	12	139	10	114	1	73	2	82	2	109	4	112
1959	2	115	7	86	1	70	5	87	3	131	10	80
1960	8	139	1	140	1	76	1	110	4	76	4	140
1961	3	129	1	110	1	55	12	65	5	104	3	75
1962	4	171	1	94	2	55	2	91	4	98	8	96
1963	12	78	12	100	2	75	1	85	1	82	2	99
1964	1	125	6	109	11	90	2	67	7	85	1	85
1965	1	82	3	84	4	100	11	75	1	114	1	118
1966	1	170			3	73	6	87	9	130		
1967	3	70					2	130	2	115		
1968			7	139			2	65				
1969	12	108					2	100	11	50	5	58
1970	4	108	3	110	2	87	11	146	4	103		
1971	3	150	2	170	5	87			10	99	12	94
1972	1	130	2	109	3	79	4	75			3	86
1973	1	150	9	156	11	144	2	89	1	90	10	61
1974	3	135	1	117			1/9	135			1	100
1975	12	135					12	82			1	62
1976	3	165	11	134			11	90			1	150

Remarks: RF = Rainfall
The numbers in parentheses mean the station numbers.

Table B-11 (4/5) DAILY MAXIMUM RAINFALL

Unit: mm/d

Year	Panggarangan (43a)		Cipanas (44)		Serang (23)		Cisalak Baru (37f)		Sangiang Damar (10)		Cipucangpare (31c)	
	Month	RF	Month	RF	Month	RF	Month	RF	Month	RF	Month	RF
1942	9	81	11	85								
1943	1	145	2	145	1	88						
1944	11	76	10	110	1	82						
1945			4	121	3	67						
1946												
1947												
1948												
1949					6	53						
1950	11	95			4	62						
1951	4	110	8	128	9	51	7	120				
1952	11	175	9	104	8	88	1	89	5	118	3	108
1953	5	136	3	147	1	99	12	65	5	192	3/5	76
1954	1	147	5	140	12	93	1	80	6	90	1	165
1955	7	107	11	135	6	110			11	199	4	180
1956	8	160	12	125	1	115	8	160	10	113	7	134
1957			10/11	105			3	97	6	151	1	86
1958	4	229	6	175	12	141	3	77	10	170	2	182
1959	11	92	5	185	3	92	1	70			1	106
1960	6	142	7	145	1	109	12	88	1	114	1	185
1961	4	120	3	141	5	122	5	92	3	448	1	156
1962	3	110	4	177	4	79	4	79	11	121	4	91
1963	3	77	11	91	1	107	2	120			2	90
1964	2	300	6	161	3	80	11	98	11	120	6	116
1965	12	86	6	145	2	86	10	80			3	70
1966	10	120	1	90			4	87	4	200		
1967	1	100	4	147			2	73	2	183		
1968	1	60					7	77			2	65
1969	5	100					6	86	12	115		
1970	11	127	3	125			5	110	4	130		
1971	3	125					10	117	10	140		
1972	1	92			1	108	2	87	1	169	10	145
1973	11	121					11	169	5	150	11	150
1974	1/12	109			12	107	7	94	9	170	12	160
1975	3	122	4	120	12	144	1	81	12	168	1	80
1976	11	135	3	122	1	96	1	119	3	137	11	185

Remarks: RF = Rainfall
The numbers in parentheses mean the station numbers.

Table B-11 (5/5) DAILY MAXIMUM RAINFALL

Unit: mm

Year	Cilaki (43b)		Ciruas (23f)		Maja (36a)		Pasirwaringin (7a)		Sampang Peundeuy (38a)	
	Month	RF	Month	RF	Month	RF	Month	RF	Month	RF
1942										
1943										
1944										
1945										
1946										
1947										
1948										
1949										
1950										
1951			6	60	8	89				
1952	4	70	6	84	5	85				
1953	3	116	5	90	3	73	3	164	2	100
1954	5	73	12	61	5	105	12	143	8	152
1955	1	70	11	115	2	86	11	183	11	110
1956	4	70	12	75	12	96	12	155	11	110
1957	5	67	1	93	3	87	12	207	1	86
1958	2	61	2	96	8	69	2	198	3	160
1959	5	64	5	124	1	60	12	140	5	129
1960	8	173	2	116	3	65	1	150	8	168
1961	2	165	11	162	11	85	4	189	3	95
1962	4	179	12	125	4	108	3	115	10	110
1963	12	70	1	117	11	97	1	98	1/9	110
1964	4	111	4	99	12	75	11	223	5	120
1965	1	128	1	40	5	106	12	198	3	100
1966			2/3	45	3	72	3	142	12	117
1967	5	99	4	45			5	161	2	93
1968					4	75	12	221	12	101
1969	9	63			9	105	11	154	4	90
1970	2	55			4	68	4	145	4	151
1971			10	95	10	100	2	150	10	110
1972	12	31	1	97	4	80	1	170	1	137
1973	9	114	2	125			4	245	11	160
1974	1	86							4	105
1975	2	114					12	230	7	137
1976	6	65					12	245	1	103

Remarks: RF = Rainfall
The numbers in parentheses mean the station numbers.

Table B-12 PROBABLE DAILY RAINFALL BY THOMAS METHOD

Unit: mm/d

Rainfall Gauging Station		Return Period					
		1/200	1/100	1/50	1/25	1/10	1/50
No. 5	Menes	317	294	271	248	215	188
No. 6	Labuan	448	406	364	323	267	224
No. 11b	Rangkas	390	354	319	283	236	199
No. 14a	Bajanegara	205	189	173	157	135	118
No. 18	Ciomas	256	237	217	197	170	148
No. 21	Mandalawangi	479	428	378	329	266	218
No. 22	Cimanuk	369	333	298	263	217	181
No. 23c	Kramatwetan	141	133	125	117	105	95
No. 24	Baros	192	175	158	142	119	102
No. 26	Pandeglang	188	176	164	152	135	121
No. 26b	Cileles	445	390	337	287	224	177
No. 26c	Warunggunung	207	193	179	165	145	129
No. 27	Gunung Kencang	221	208	195	181	162	146
No. 31	Malingping	233	216	200	183	160	141
No. 32a	Jeungjing	170	158	146	134	117	103
No. 33	Parigi	183	170	158	145	127	112
No. 35	Pamarayan	190	178	165	153	135	120
No. 37	Rangkasbitung	193	179	165	151	131	114
No. 43a	Panggarangan	290	266	242	217	185	158
No. 44	Cipanas	230	218	205	191	172	156
No. 23	Serang	197	182	168	153	133	116
No. 37f	Cisalak Baru	178	167	156	144	128	115
No. 10	Sangiang Damar	353	325	297	269	231	200
No. 31c	Cipucangpare	316	287	259	231	193	163
No. 43b	Cilaki	268	240	212	185	150	123
No. 23f	Ciruas	256	231	206	181	149	124
No. 36a	Maja	138	132	125	118	108	99
No. 7a	Pasirwaringin	330	309	289	267	237	212
No. 38a	Sampang Peundeuy	203	192	181	170	154	140

Table B-13 (1/2) COEFFICIENT OF THIESSEN POLYGON

Rainfall Station No.	Karian Dam	Cibeu-reum	Pasir Kopo Dam	Cisi-meut	Bojong-manik	Upper Ciujung	Rangkas-bitung	Kragi-lan
44	0.649	0.579					0.137	
43b	0.254	0.226	0.913	0.633	0.483	0.130	0.328	
31					0.003	0.001	0.001	
27					0.244	0.094	0.039	
38a			0.087	0.251	0.255	0.157	0.153	
26b					0.015	0.253	0.105	
22						0.104	0.043	
21						0.010	0.004	
18						0.005	0.002	0.033
26						0.102	0.042	0.081
26c						0.126	0.052	0.094
37				0.043		0.018	0.022	0.050
37f	0.077	0.177		0.073			0.068	0.060
36a	0.020	0.018					0.004	0.043
35								0.259
24								0.232
23								
23f								0.007
23c								0.089
33								0.052
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table B-13 (2/2) COEFFICIENT OF THIESSEN POLYGON

Rainfall Station No.	Cibanten Dam	Old Banten	Cidanau Dam	Kari Anyer Dam	Cilawang Dam	Gadeg Weir	Confluence of Cidurian
44					0.919	0.807	0.393
43f							
31							
27							
38a							
26b							
22							
21			0.336				
18	0.878	0.423	0.664	1.000			
26							
26c							
37							
37f							0.018
36a					0.081	0.193	0.520
35							0.003
24	0.122	0.053					
23		0.524					
23f							
23c							
33							0.066
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table B-14 PROBABLE DAILY RAINFALL

Unit: mm/d

River & Point		Return Period					
		1/10	1/25	1/30	1/50	1/100	1/200
Ciberang	Karian Dam	161.9	184.6	189.0	201.2	217.6	233.8
Ciberang	Confluence to Ciujung	158.2	180.2	184.5	196.3	312.0	227.7
Cisimeut	Pasir Kopo Dam	150.2	183.6	190.3	209.2	235.4	262.2
Cisimeut	Confluence to Ciberang	148.5	176.8	182.4	198.1	219.7	241.7
Upper Ciujung	Bojongmanik Dam	155.0	181.8	187.0	201.8	222.0	242.3
Upper Ciujung	Rangkasbitung	176.2	211.4	218.3	238.1	265.4	293.4
Ciujung	Rangkasbitung	162.3	191.9	197.8	214.2	236.8	259.8
Ciujung	Kragilan	128.6	147.2	150.8	160.7	173.8	186.9
Cibeureum	Cilawang Dam	167.0	185.4	188.8	198.2	210.7	222.7
Cibeureum	Gadeg Weir	159.7	177.1	180.4	189.3	201.1	212.4
Cibeureum	Confluence to Cidurian	134.7	149.1	151.8	159.2	168.9	178.2
Cibanten	Cibanten Dam	164.0	190.6	195.7	210.0	229.2	248.2
Cibanten	Old Banten	133.2	152.2	155.7	165.8	179.2	192.4
Cidanau	Cidanau Dam	164.0	190.6	195.7	210.0	229.2	248.2
Kari Anyer	Anyer Dam	170.2	197.4	202.6	217.2	236.7	256.1

Table B-15 CONVERSION RATIO OF EACH CATCHMENT AREA

River	Point	Catchment Area (km^2)	Conversion Ratio
Cisimeut	Pasir Kopo Dam	172	0.88
Cisimeut	Confluence to Ciberang	458	0.75
Ciberang	Karian Dam	288	0.82
Ciberang	Confluence to Ciujung	331	0.80
Ciujung	Bojongmanik Dam	159	0.89
Ciujung	Confluence to Ciberang	594	0.76
Ciujung	Rangkasbitung	1,383	0.61
Ciujung	Pamarayan Weir	1,451	0.60
Ciujung	Kragilan Bridge	1,812	0.60
Cibanten	Cibanten Dam	76	0.93
Cibanten	Old Banten	183	0.88
Cidanau	Cidanau Dam	216	0.86
Cidanau	Bridge	222	0.85
Cibeureum	Cilawang Dam	93	0.92
Cibeureum	Confluence to Cidurian	255	0.82
Kari Anyer	Anyer Dam	37	0.96
Kari Anyer	Bridge	50	0.95

Table B-16 (1/3) ESTIMATION OF FLOOD DISCHARGE

River Name	Point	W (year)	A (km^2)	Tc (hr)	R (mm)	x (%)	r (mm/hr)	f (%)	Qp (m^3/s)	q (Qp/A) ($m^3/s/km^2$)
Ciberang	Karian Dam	1/10	288	9	161.9	0.82	10.6	0.7	600	2.1
		1/25	288	9	184.6	0.82	12.1	0.7	680	2.4
		1/50	288	9	201.2	0.82	13.2	0.7	740	2.6
	Rangkasbitung	1/10	331	12	158.2	0.80	8.4	0.7	550	1.7
		1/25	331	12	180.2	0.80	9.5	0.7	620	1.9
		1/50	331	12	196.3	0.80	10.4	0.7	670	2.0
Cisimeut	Pasir Kopo	1/10	172	4	150.2	0.88	16.5	0.7	560	3.3
		1/25	172	4	183.6	0.88	20.2	0.7	680	4.0
		1/50	172	4	209.2	0.88	23.0	0.7	770	4.5
	Rangkasbitung	1/10	458	10	148.5	0.75	8.3	0.7	740	1.6
		1/25	458	10	176.8	0.75	9.9	0.7	890	1.9
		1/50	458	10	198.1	0.75	11.1	0.7	990	2.2
Upper Ciujung	Bojongmanik Dam	1/10	159	6	155.0	0.89	14.5	0.7	450	2.8
		1/25	159	6	181.8	0.89	17.0	0.7	530	3.3
		1/50	159	6	201.8	0.89	18.9	0.7	590	3.7
	Rangkasbitung	1/10	594	19	176.2	0.76	6.5	0.7	760	1.3
		1/25	594	19	211.4	0.76	7.8	0.7	910	1.5
		1/50	594	19	238.1	0.76	8.8	0.7	1,100	1.9

Remarks:
W = Return period (Year)
A = Catchment area (km^2)
Tc = Time of concentration (hr)
R = Probable daily rainfall (mm)
x = Conversion ratio (%)
r = Rainfall intensity (mm/hr)
f = Runoff coefficient (%)
Qp = Discharge (m^3/s)
q = Specific discharge ($m^3/s/km^2$)

Table B-16 (2/3) ESTIMATION OF FLOOD DISCHARGE

River Name	Point	W (year)	A (km^2)	Tc (hr)	R (mm)	x (%)	r (mm/hr)	f (%)	Qp (m^3/s)	q (Qp/A) ($m^3/s/km^2$)
Ciberang	Rangkasbitung	1/10	331	12	158.2	0.61	6.4	0.7	420	1.3
		1/25	331	12	180.2	0.61	7.3	0.7	470	1.4
		1/50	331	12	196.3	0.61	7.9	0.7	510	1.5
Cisimeut	Rangkasbitung	1/10	458	10	148.5	0.61	6.8	0.7	610	1.3
		1/25	458	10	176.8	0.61	8.1	0.7	730	1.6
		1/50	458	10	198.1	0.61	9.0	0.7	810	1.8
Upper Ciujung	Rangkasbitung	1/10	594	19	176.2	0.61	5.2	0.7	610	1.0
		1/25	594	19	211.4	0.61	6.3	0.7	730	1.2
		1/50	594	19	238.1	0.61	7.1	0.7	820	1.4
Ciujung	Rangkasbitung	1/10	1,383	-	-	-	-	-	1,400	1.0
		1/25	1,383	-	-	-	-	-	1,600	1.2
		1/50	1,383	-	-	-	-	-	1,800	1.3

Remarks:
W = Return period (Year)
A = Catchment area (km^2)
Tc = Time of concentration (hr)
R = Probable daily rainfall (mm)
x = Conversion ratio (%)
r = Rainfall intensity (mm/hr)
f = Runoff coefficient (%)
Qp = Discharge (m^3/s)
q = Specific discharge ($m^3/s/km^2$)

Table B-16 (3/3) ESTIMATION OF FLOOD DISCHARGE

River Name	Point	W (year)	A (km^2)	Tc (hr)	R (mm)	x (%)	r (mm/hr)	f (%)	Qp (m^3/s)	q (Qp/A) ($m^3/s/km^2$)
Cibanten	Cibanten Dam Site	1/10	76	1	164.0	0.93	56.9	0.7	790	10.4
		1/25	76	1	190.6	0.93	66.1	0.7	910	12.0
		1/50	76	1	210.0	0.93	72.8	0.7	1,000	13.2
	Old Banten	1/10	183	3	133.2	0.88	22.2	0.7	700	3.8
		1/25	183	3	152.2	0.88	25.4	0.7	800	4.4
		1/50	183	3	165.8	0.88	27.6	0.7	870	4.8
Cidanau	Cidanau Dam Site	1/10	216	3	210.5	0.86	35.1	0.7	1,300	6.0
		1/25	216	3	251.7	0.86	41.9	0.7	1,600	7.4
		1/50	216	3	282.5	0.86	47.1	0.7	1,700	7.9
Kari Anyer	Anyer Dam Site	1/10	37	1	170.2	0.96	59.0	0.7	410	11.1
		1/25	37	1	197.4	0.96	68.4	0.7	480	13.0
		1/50	37	1	217.2	0.96	75.3	0.7	520	14.1
Cibeureum	Cilawang Dam Site	1/10	93	4	167.0	0.92	23.0	0.7	390	4.2
		1/25	93	4	185.4	0.92	25.5	0.7	430	4.6
		1/50	93	4	198.2	0.92	27.3	0.7	460	4.9
	Gadeg Weir	1/10	117	5	159.7	0.91	18.9	0.7	400	3.4
		1/25	117	5	177.1	0.91	21.0	0.7	440	3.8
		1/50	117	5	189.3	0.91	22.4	0.7	470	4.0
	Confluence to Cidurian	1/10	255	12	134.7	0.82	8.9	0.7	360	1.4
		1/25	255	12	149.1	0.82	9.9	0.7	410	1.6
		1/50	255	12	159.2	0.82	10.5	0.7	430	1.7

Remarks: W = Return period (Year)
A = Catchment area (km^2)
Tc = Time of concentration (hr)
R = Probable daily rainfall (mm)
x = Conversion ratio (%)
r = Rainfall intensity (mm/hr)
f = Runoff coefficient (%)
Qp = Discharge (m^3/s)
q = Specific discharge ($m^3/s/km^2$)

Table B-17 CIUJUNG RIVER PROBABLE FLOOD CALCULATION RESULT

River	Study Point	Catchment Area	Return Period					
			1 in 10 year		1 in 25 year		1 in 50 year	
		(km^2)	Q (m^3/s)	q ($m^3/s/km^2$)	Q (m^3/s)	q ($m^3/s/km^2$)	Q (m^3/s)	q ($m^3/s/km^2$)
Cisimeut	Pasir Kopo Dam Site	172	610	3.5	750	4.4	850	4.9
	Cilaki R. Confluence	221	(670)	(3.0)	(820)	(3.7)	(930)	(4.2)
	Ciberang R. Confluence	458	740	1.6	880	1.9	990	2.2
Ciberang	Karian Dam Site	288	600	2.1	680	2.4	740	2.6
	Cisimeut R. Confluence	305	(580)	(1.9)	(640)	(2.1)	(700)	(2.3)
	Ciujung R. Confluence	789	1100	1.4	1200	1.5	1400	1.8
Upper Ciujung	Bojongmanik Dam Site	159	450	2.8	530	3.3	590	3.7
	Cipeutuj R. Confluence	237	(560)	(2.4)	(650)	(2.7)	(740)	(3.1)
	Cipanas R. Confluence	384	(690)	(1.8)	(800)	(2.1)	(910)	(2.4)
	Ciberang R. Confluence	594	760	1.3	910	1.5	1100	1.8
Ciujung	Rangkasbitung	1383	1400	1.0	1600	1.2	1800	1.3
	Pamarayan Weir	1451	1400		1600		1800	
	Kragilan	1812	(1600)	(0.9)	1800	(1.0)	(2000)	(1.1)

Remarks: Q; Discharge
q; Specific Discharge

Table B-18 (1/2) RESULT ON WATER QUALITY ANALYSIS OF DRY SEASON SAMPLES

Substances		Units	Sampling Site			
			1	2	3	4
PHYSICAL						
Temperature		°C	-	-	-	-
Colour		Unit PtCo	10 K	10 K	10 K	10 K
Odour		-	-	-	-	-
Taste		-	-	-	-	-
Turbidity		ppm SiO_2	29.5	33.0	25.5	18.5
Dissolved Solid		ppm	48	50	84	76
Conductivity		micromho/cm	95	60	125	110
CHEMICAL						
pH		-	6.75	6.70	6.65	6.70
Calcium	(Ca)	ppm	8.82	4.17	16.27	11.86
Magnesium	(Mg)	ppm	3.28	1.22	1.46	1.95
Hardness		d°	2.00	0.87	2.60	2.11
Sodium	(Na)	ppm	4.06	4.57	4.34	4.72
Potasium	(K)	ppm	1.64	1.81	2.15	1.54
Nickel	(Ni)	ppm	ud	ud	ud	ud
Iron	(Fe)	ppm	0.80	1.10	0.71	0.19
Mangan	(Mn)	ppm	ud	ud	ud	ud
Copper	(Cu)	ppm	ud	ud	ud	ud
Zinc	(Zn)	ppm	ud	ud	ud	ud
Chrom Hexavalen	(Cr)	ppm	ud	ud	ud	ud
Cadmium	(Cd)	ppm	ud	ud	ud	ud
Mercury	(Hg)	ppm	-	-	-	-
Lead	(Pb)	ppm	ud	ud	ud	ud
Cyanide	(CN)	ppm	-	-	-	-
Sulfide	(S)	ppm	-	-	-	-
Fluoride	(F)	ppm	ud	ud	ud	ud
Chloride	(Cl)	ppm	4.81	4.65	4.90	4.73
Sulfate	(SO_4)	ppm	3.90	4.50	3.20	2.40
Ammonia	(NH_4-N)	ppm	0.40	0.46	0.40	0.62
Nitrate	(NO_3-N)	ppm	0.80	0.90	0.80	0.80
Nitrite	(NO_2-N)	ppm	ud	ud	ud	ud
Bicarbonate	(HCO_3)	ppm	41.5	23.2	58.0	48.8
Detergent	(MBAS)	ppm	-	-	-	-
Phenolic Substances		ppm	-	-	-	-
Grease and Oil		ppm	-	-	-	-
Boron	(B)	ppm	ud	ud	ud	ud
Permanganate Number		ppm $KMnO_4$	10.98	13.75	16.13	8.34
Phosphate	(PO_4)	ppm	-	-	-	-
Free Carbon Dioxyde	(CO_2)	ppm	-	-	-	-
CO_2 Aggressive		ppm	-	-	-	-
Silica	(SiO_2)	ppm	-	-	-	-
% Na		-	19.4	35.7	16.1	21.0
S.A.R.		-	0.30	0.51	0.28	0.34
R.S.C.		-	0	0.07	0.02	0.05
Faecal Coli		MPN/100 ml.	-	-	-	-

Remarks: ud = Undetected, K = Koloid

Sampling site = No. 1; Karian (Ciberang river), No. 2; Gadeg (Cibeureum river), No. 3; Cileles (Upper Ciujung river), No. 4; Leuwidamar (Cisimeut river)

Table B-18 (2/2) RESULT ON WATER QUALITY ANALYSIS OF DRY SEASON SAMPLES

Substances		Units	Sampling Site		
			5	6	7
PHYSICAL					
Temperature		°C	-	-	-
Colour		Unit PtCo	10 K	10 K	10 K
Odour		-	-	-	-
Taste		-	-	-	-
Turbidity		ppm SiO_2	31.5	23.0	28.0
Dissolved Solid		ppm	102	88.0	94.0
Conductivity		micromho/cm	165	125	130
CHEMICAL					
pH		-	6.81	6.78	6.64
Calcium	(Ca)	ppm	11.06	12.67	12.42
Magnesium	(Mg)	ppm	4.26	1.58	2.55
Hardness		d°	2.51	2.14	2.33
Sodium	(Na)	ppm	13.40	8.54	7.94
Potasium	(K)	ppm	3.56	2.60	2.45
Nickel	(Ni)	ppm	ud	ud	ud
Iron	(Fe)	ppm	1.49	1.08	0.81
Mangan	(Mn)	ppm	ud	ud	ud
Copper	(Cu)	ppm	ud	ud	ud
Zinc	(Zn)	ppm	ud	ud	ud
Chrom Hexavalen	(Cr)	ppm	ud	ud	ud
Cadmium	(Cd)	ppm	ud	ud	ud
Mercury	(Hg)	ppm	-	-	-
Lead	(Pb)	ppm	ud	ud	ud
Cyanide	(CN)	ppm	-	-	-
Sulfide	(S)	ppm	-	-	-
Fluoride	(F)	ppm	ud	0.07	ud
Chloride	(Cl)	ppm	5.81	5.48	6.14
Sulfate	(SO_4)	ppm	4.20	6.10	4.80
Ammonia	(NH_4-N)	ppm	0.30	0.30	0.34
Nitrate	(NO_3-N)	ppm	0.65	0.85	0.90
Nitrite	(NO_2-N)	ppm	ud	ud	ud
Bicarbonate	(HCO_3)	ppm	79.3	53.1	58.0
Detergent	(MBAS)	ppm	-	-	-
Phenolic Substances		ppm	-	-	-
Grease and Oil		ppm	-	-	-
Boron	(B)	ppm	ud	ud	ud
Permanganate Number		ppm $KMnO_4$	14.16	6.89	10.88
Phosphate	(PO_4)	ppm	-	-	-
Free Carbon Dioxyde	(CO_2)	ppm	-	-	-
CO_2 Aggressive		ppm	-	-	-
Silica	(SiO_2)	ppm	-	-	-
% Na		-	36.94	30.83	28.23
S.A.R.		-	0.87	0.60	0.55
R.S.C.		-	0.40	0.16	0.12
Faecal Coli		MPN/100 ml.	-	-	-

Remarks: ud = Undetected, K = Koloid

Sampling site = No. 5; Serut (Cibanten river), No. 6; Pamarayan (Ciujung river), No. 7; Rangkasbitung (Ciujung river)

Table B-19 (1/3) RESULT ON WATER QUALITY ANALYSIS OF WET SEASON SAMPLES

Substances		Units	Sampling Site			
			1	2	3	4
PHYSICAL						
Temperature		°C	-	-	-	-
Colour		Unit PtCo	50	10	15	15
Odour		-	-	-	-	-
Taste		-	-	-	-	-
Turbidity		ppm SiO_2	150.0	7.5	7.0	7.50
Dissolved Solid		ppm	42	66	122	75
Conductivity		micromho/cm	65	85	200	110
CHEMICAL						
pH		-	6.67	6.85	7.07	7.61
Calcium	(Ca)	ppm	5.59	5.59	20.76	11.98
Magnesium	(Mg)	ppm	1.58	1.58	5.72	1.95
Hardness		d°	1.14	1.14	4.23	2.06
Sodium	(Na)	ppm	3.71	5.68	6.38	4.92
Potasium	(K)	ppm	2.03	2.27	2.05	1.32
Nickel	(Ni)	ppm	ud	ud	ud	ud
Iron	(Fe)	ppm	2.07	0.32	0.08	0.23
Mangan	(Mn)	ppm	0.01	0.01	0.01	0.01
Copper	(Cu)	ppm	ud	ud	ud	ud
Zinc	(Zn)	ppm	ud	0.01	ud	0.01
Chrom Hexavalen	(Cr)	ppm	ud	ud	ud	ud
Cadmium	(Cd)	ppm	ud	ud	ud	ud
Mercury	(Hg)	ppm	-	-	-	-
Lead	(Pb)	ppm	ud	ud	ud	ud
Cyanide	(CN)	ppm	-	-	-	-
Sulfide	(S)	ppm	-	-	-	-
Fluoride	(F)	ppm	ud	ud	ud	ud
Chloride	(Cl)	ppm	4.71	2.83	5.65	3.77
Sulfate	(SO_4)	ppm	4.76	5.56	8.73	10.70
Ammonia	(NH_4)	ppm	0.45	0.17	0.07	0.07
Nitrate	(NO_3)	ppm	0.20	0.25	0.30	0.15
Nitrite	(NO_2)	ppm	ud	ud	ud	ud
Bicarbonate	(HCO_3)	ppm	26.23	33.60	93.94	40.26
Detergent		ppm	-	-	-	-
Phenolic Substances		ppm	-	-	-	-
Grease and Oil		ppm	-	-	-	-
Boron	(B)	ppm	0.07	0.05	0.05	0.10
Permanganate Number		ppm $KMnO_4$	19.15	10.52	15.80	10.31
CO_2 Aggressive		ppm	-	-	-	-
% Na		-	25.81	34.72	15.22	21.43
S.A.R.		-	0.36	0.56	0.32	0.34
R.S.C.		-	0.02	0.14	0.03	0.00
E. Coli		MPN/100 ml.	-	-	-	-

Remarks: ud = Undetectable

Sampling site = No. 1; Karian (Ciberang river), No. 2; Gadeg (Cibeureum river), No. 3; Cileles (Upper Ciujung river), No. 4; Leuwidamar (Cisimeut river)

Table B-19 (2/3) RESULT ON WATER QUALITY ANALYSIS OF WET SEASON SAMPLES

Substances		Units	Sampling Site 5	6	7	8
PHYSICAL						
Temperature		°C	-	-	-	-
Colour		Unit PtCo	40	15	20	30
Odour		-	-	-	-	-
Taste		-	-	-	-	-
Turbidity		ppm SiO_2	51.0	22.5	85.0	35.0
Dissolved Solid		ppm	144	68	76	82
Conductivity		micromho/cm	185	105	125	140
CHEMICAL						
pH		-	7.06	6.69	6.95	6.85
Calcium	(Ca)	ppm	11.18	7.19	11.98	14.37
Magnesium	(Mg)	ppm	4.62	4.13	4.62	1.70
Hardness		d°	2.63	1.95	2.75	2.40
Sodium	(Na)	ppm	14.20	5.62	4.92	6.25
Potasium	(K)	ppm	4.40	2.28	2.03	2.28
Nickel	(Ni)	ppm	ud	ud	ud	ud
Iron	(Fe)	ppm	2.32	0.54	0.51	0.75
Mangan	(Mn)	ppm	0.01	0.01	0.02	0.01
Copper	(Cu)	ppm	ud	ud	ud	ud
Zinc	(Zn)	ppm	0.01	0.01	0.01	0.01
Chrom Hexavalen	(Cr)	ppm	ud	ud	ud	ud
Cadmium	(Cd)	ppm	ud	ud	ud	ud
Mercury	(Hg)	ppm	-	-	-	-
Lead	(Pb)	ppm	ud	ud	ud	ud
Cyanide	(CN)	ppm	-	-	-	-
Sulfide	(S)	ppm	-	-	-	-
Fluoride	(F)	ppm	ud	ud	ud	ud
Chloride	(Cl)	ppm	5.65	4.71	4.71	4.71
Sulfate	(SO_4)	ppm	8.33	6.35	6.33	10.32
Ammonia	(NH_4)	ppm	0.25	0.28	0.12	0.22
Nitrate	(NO_3)	ppm	0.30	0.25	0.15	0.35
Nitrite	(NO_2)	ppm	ud	ud	ud	ud
Bicarbonate	(HCO_3)	ppm	85.40	41.48	57.95	52.46
Detergent		ppm	-	-	-	-
Phenolic Substances		ppm	-	-	-	-
Grease and Oil		ppm	-	-	-	-
Boron	(B)	ppm	0.05	0.10	0.15	0.07
Permanganate Number		ppm $KMnO_4$	14.13	12.01	16.91	20.07
CO_2 Aggressive		ppm	-	-	-	-
% Na		-	37.13	24.00	16.94	22.67
S.A.R.		-	0.90	0.41	0.30	0.41
R.S.C.		-	0.46	0.00	0.00	0.00
E. Coli		MPN/100 ml.	-	-	-	-

Remarks: ud = Undetectable

Sampling site = No. 5; Serut (Cibanten river), No. 6; Pamarayan (Ciujung river), No. 7; Rangkasbitung (Ciujung river), No. 8; Kragilan (Ciujung river)

Table B-19 (3/3) RESULT ON WATER QUALITY ANALYSIS OF WET SEASON SAMPLES

Substances		Units	Sampling Site			
			9	10	11	12
PHYSICAL						
Temperature		°C	-	-	-	-
Colour		Unit PtCo	15	70	25	15
Odour		-	-	-	-	-
Taste		-	-	-	-	-
Turbidity		ppm SiO_2	26.0	370.0	50.0	90.0
Dissolved Solid		ppm	56	186	93	85
Conductivity		micromho/cm	70	250	135	130
CHEMICAL						
pH		-	6.92	6.55	6.92	6.74
Calcium	(Ca)	ppm	5.59	15.17	15.17	12.77
Magnesium	(Mg)	ppm	1.58	5.72	1.70	2.68
Hardness		d°	1.14	3.43	2.52	2.40
Sodium	(Na)	ppm	3.82	19.30	6.09	5.73
Potasium	(K)	ppm	1.30	4.49	2.50	2.44
Nickel	(Ni)	ppm	ud	ud	ud	ud
Iron	(Fe)	ppm	0.31	4.38	0.93	0.68
Mangan	(Mn)	ppm	0.01	0.04	0.02	0.01
Copper	(Cu)	ppm	ud	ud	ud	ud
Zinc	(Zn)	ppm	0.02	0.01	0.02	0.01
Chrom Hexavalen	(Cr)	ppm	ud	ud	ud	ud
Cadmium	(Cd)	ppm	ud	ud	ud	ud
Mercury	(Hg)	ppm	-	-	-	-
Lead	(Pb)	ppm	ud	ud	ud	ud
Cyanide	(CN)	ppm	-	-	-	-
Sulfide	(S)	ppm	-	-	-	-
Fluoride	(F)	ppm	ud	ud	ud	ud
Chloride	(Cl)	ppm	3.77	12.24	5.65	4.71
Sulfate	(SO_4)	ppm	3.97	9.52	5.95	7.14
Ammonia	(NH_4)	ppm	0.06	0.55	0.23	0.19
Nitrate	(NO_3)	ppm	0.17	0.20	0.18	0.25
Nitrite	(NO_2)	ppm	ud	ud	ud	ud
Bicarbonate	(HCO_3)	ppm	26.23	96.38	58.56	51.85
Detergent		ppm	-	-	-	-
Phenolic Substances		ppm	-	-	-	-
Grease and Oil		ppm	-	-	-	-
Boron	(B)	ppm	0.05	0.10	0.12	0.08
Permanganate Number		ppm $KMnO_4$	9.29	70.22	12.64	10.24
CO_2 Aggressive		ppm	-	-	-	-
% Na		-	27.81	38.36	21.95	21.37
S.A.R.		-	0.38	1.08	0.40	0.38
R.S.C.		-	0.02	0.35	0.06	0.00
E. Coli		MPN/100 ml.	-	-	-	-

Remarks: ud = Undetectable

Sampling site = No. 9; Sajira (Ciberang river), No. 10; Cinangka (Cidanau river), No. 11; Bedeng (Left-bank Primary Irrigation Canal), No. 12; Pos (Right-bank Primary Irrigation Canal)

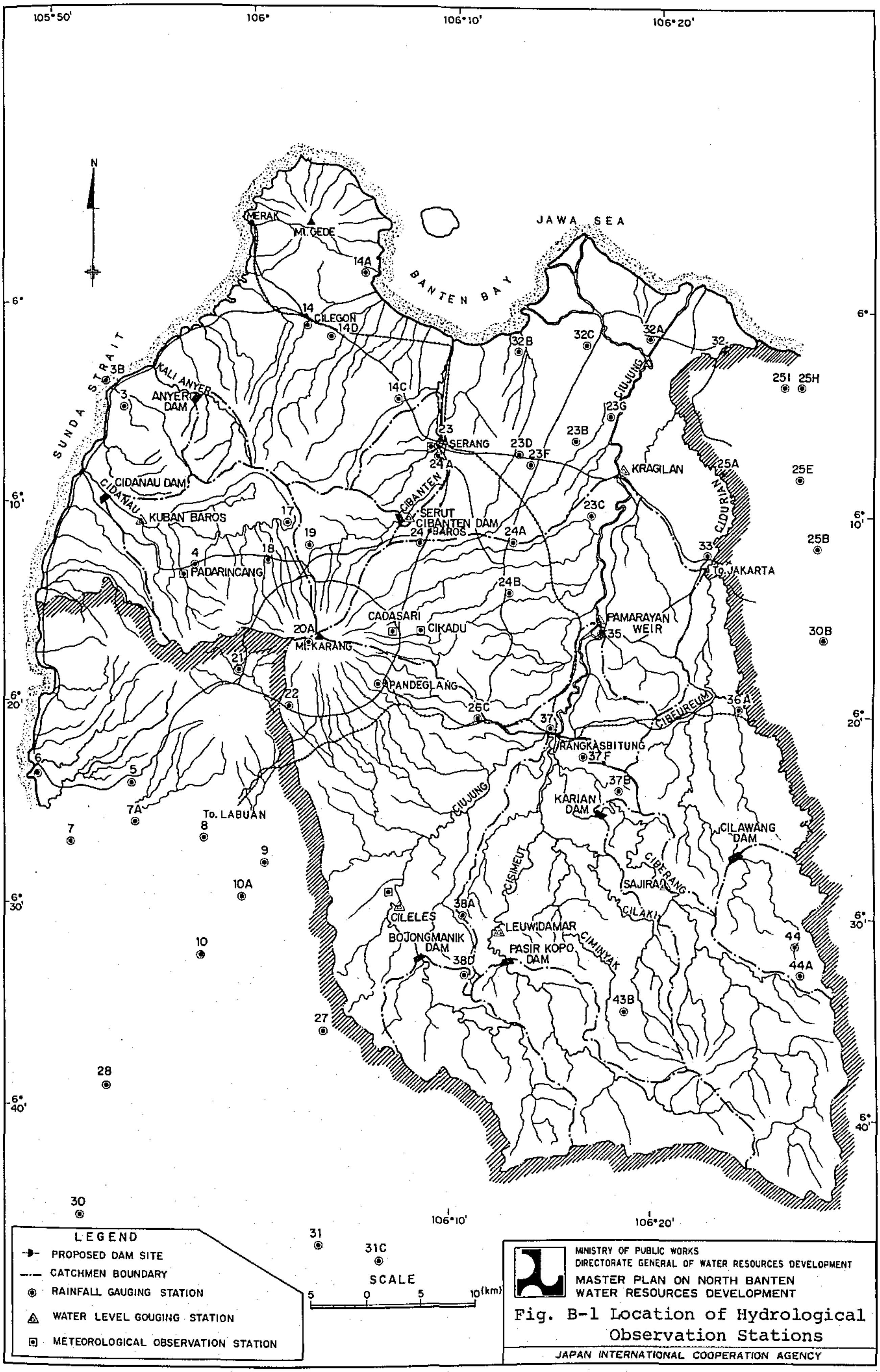


Fig. B-1 Location of Hydrological Observation Stations

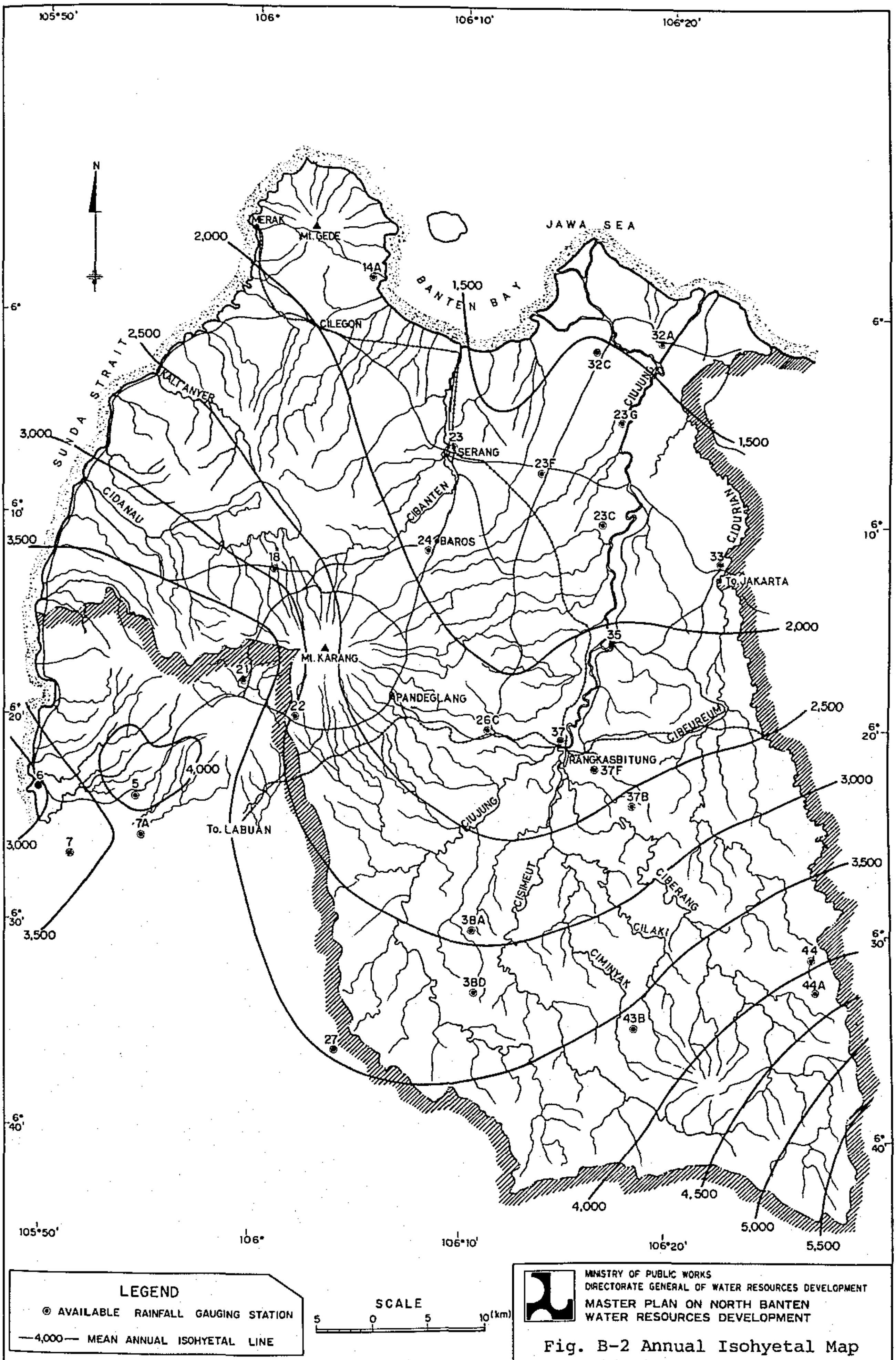


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Fig. B-2 Annual Isohyetal Map

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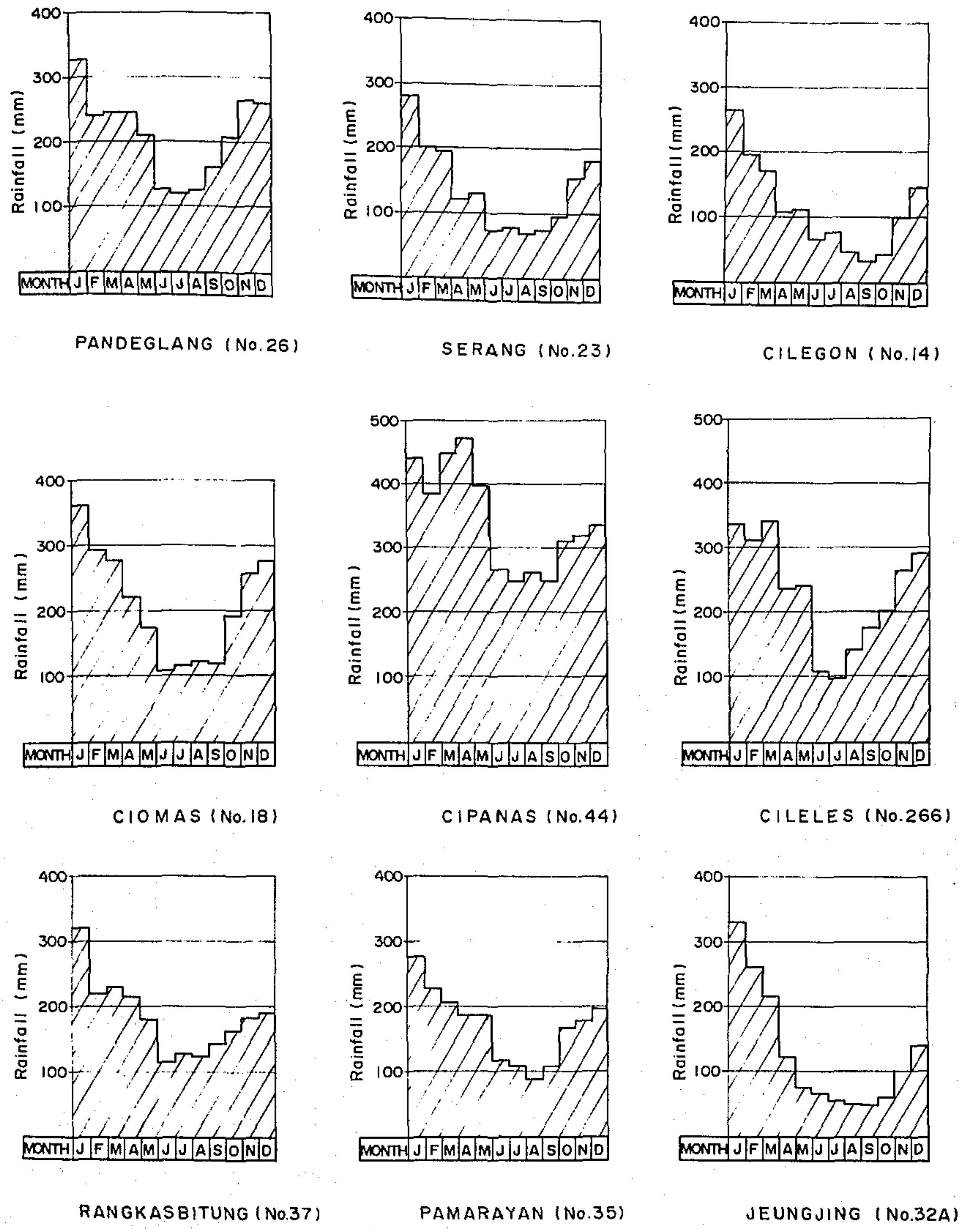

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Fig. B-3 Annual Pattern of Average Monthly Rainfall

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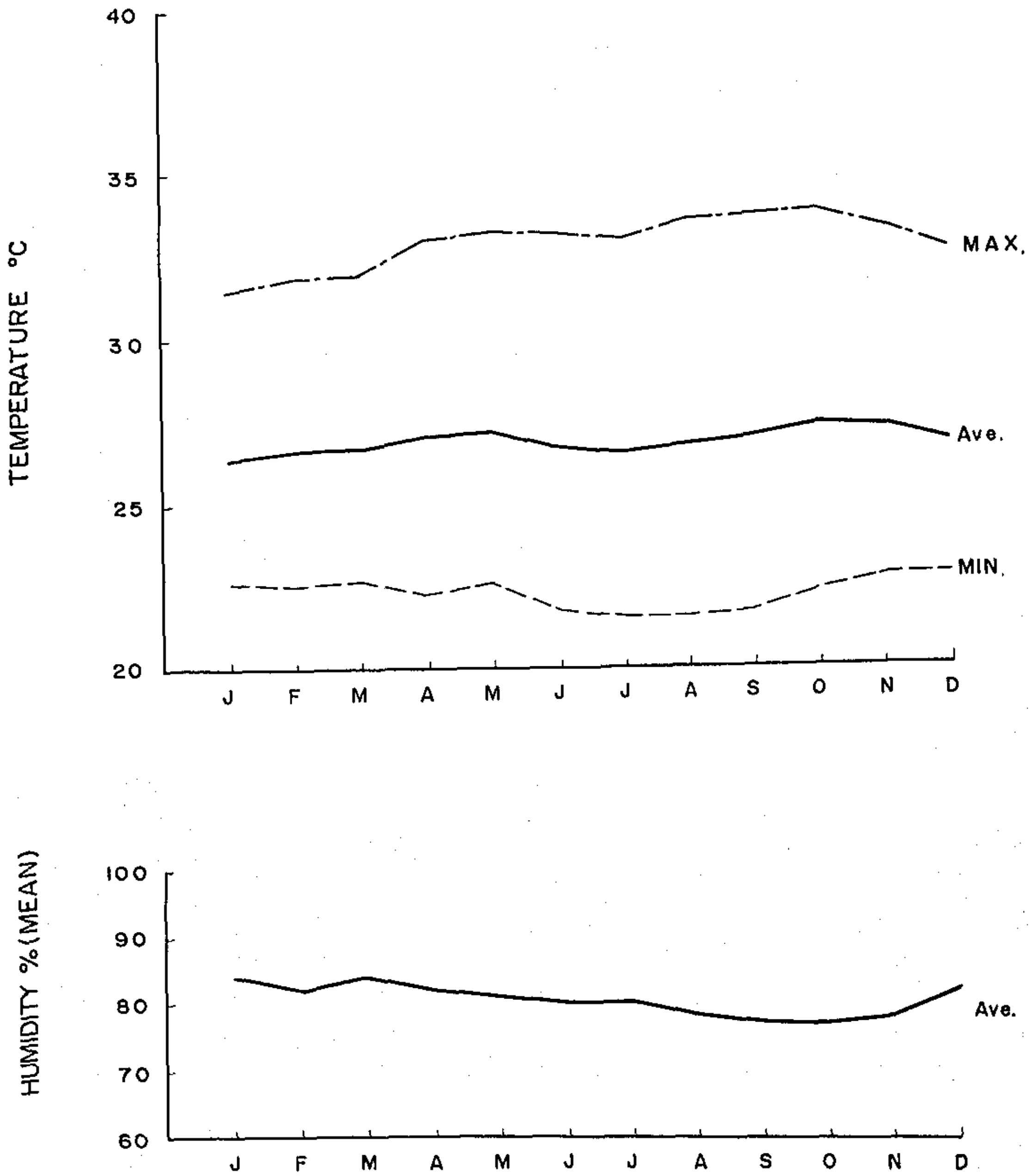

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Fig. B-4 (1/3) Monthly Mean Meteorological Data

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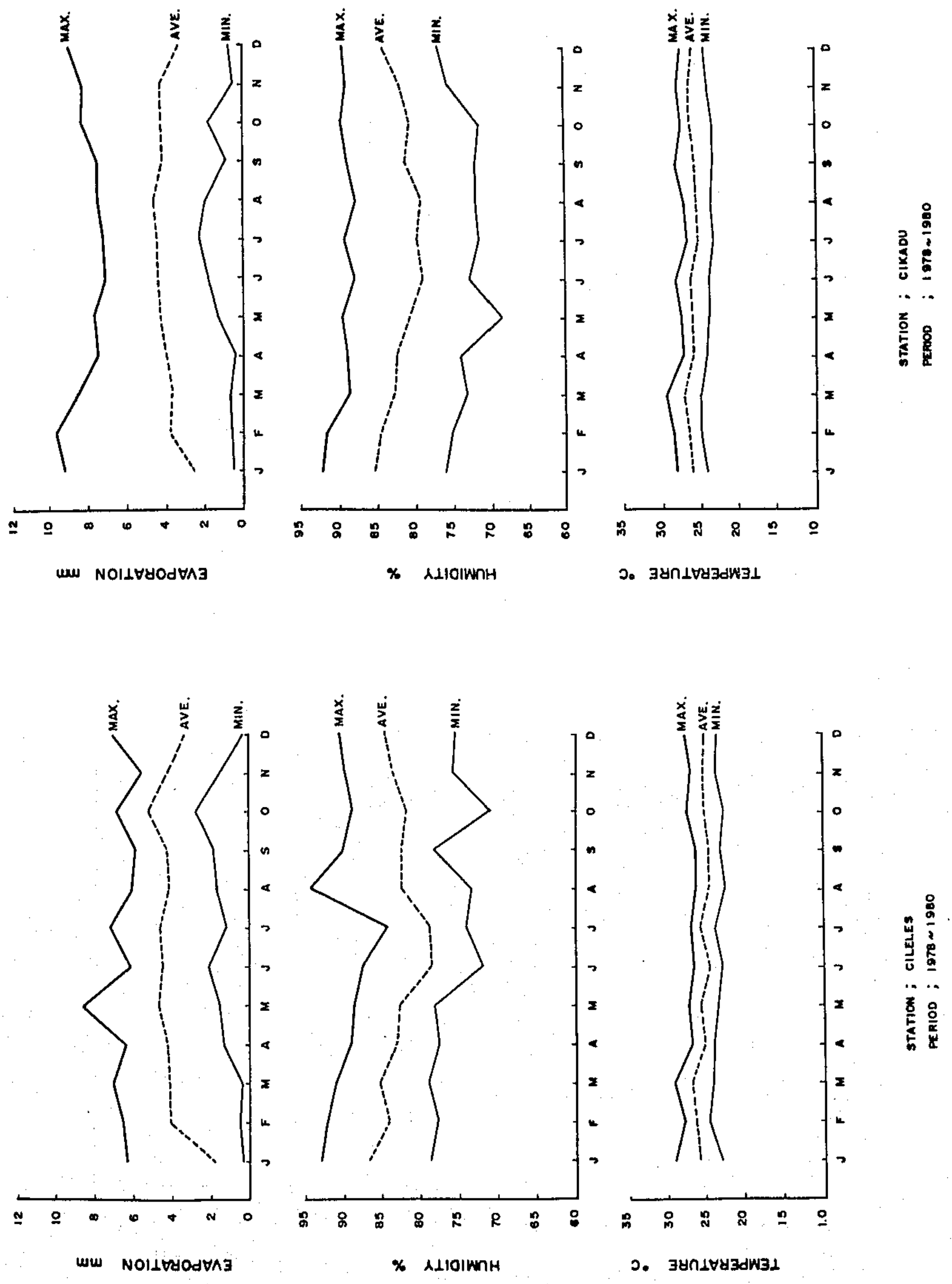

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Fig. B-4 (2/3) Monthly Mean Meteorological Data

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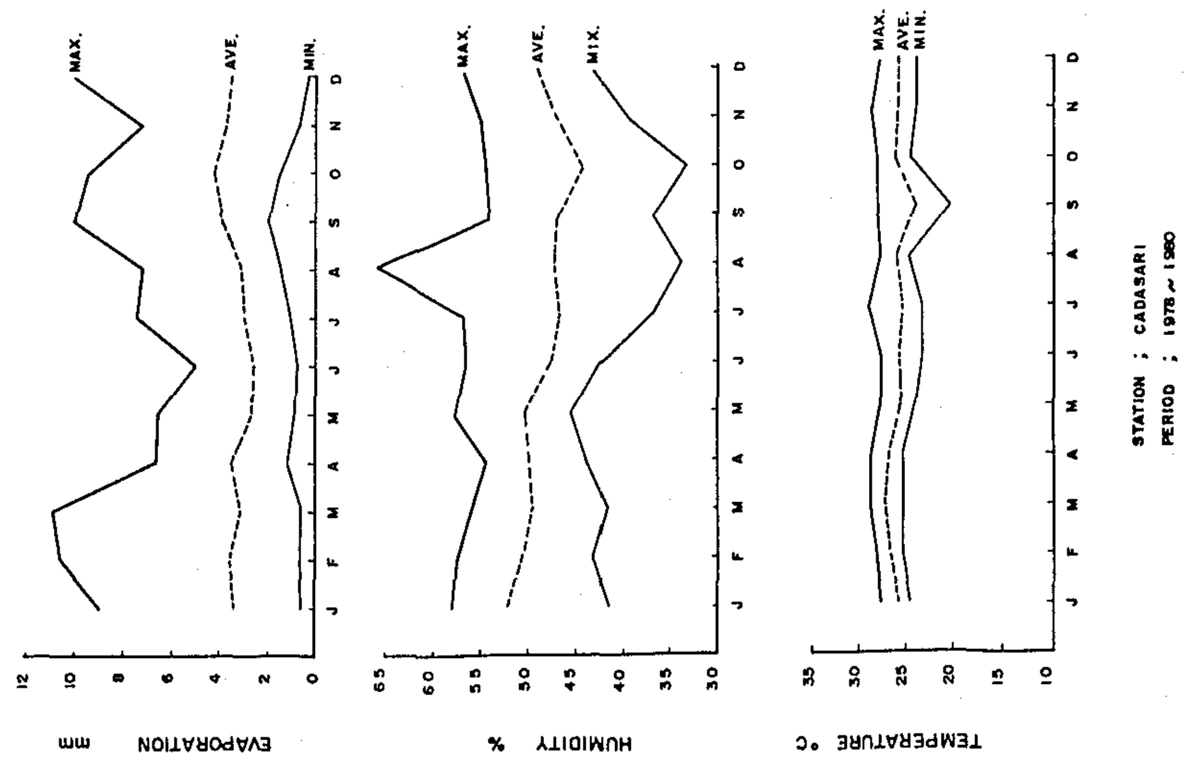

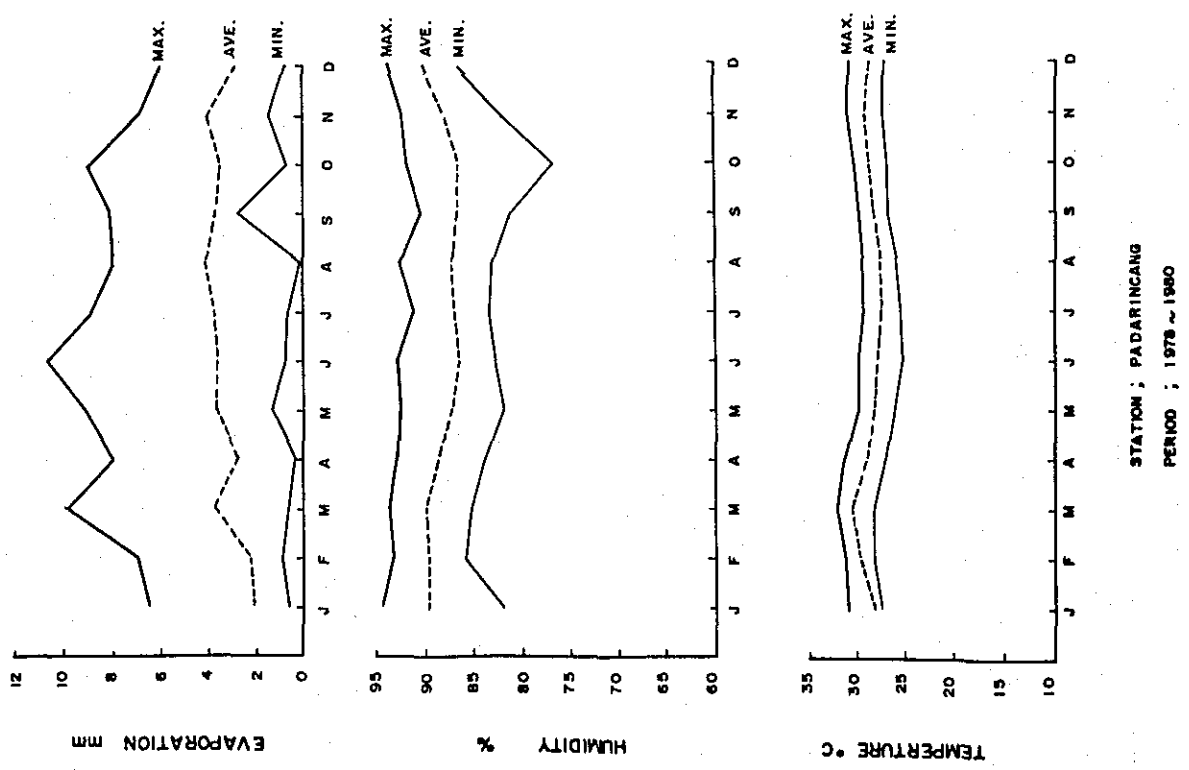

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Fig. B-4 (3/3) Monthly Mean Meteorological Data

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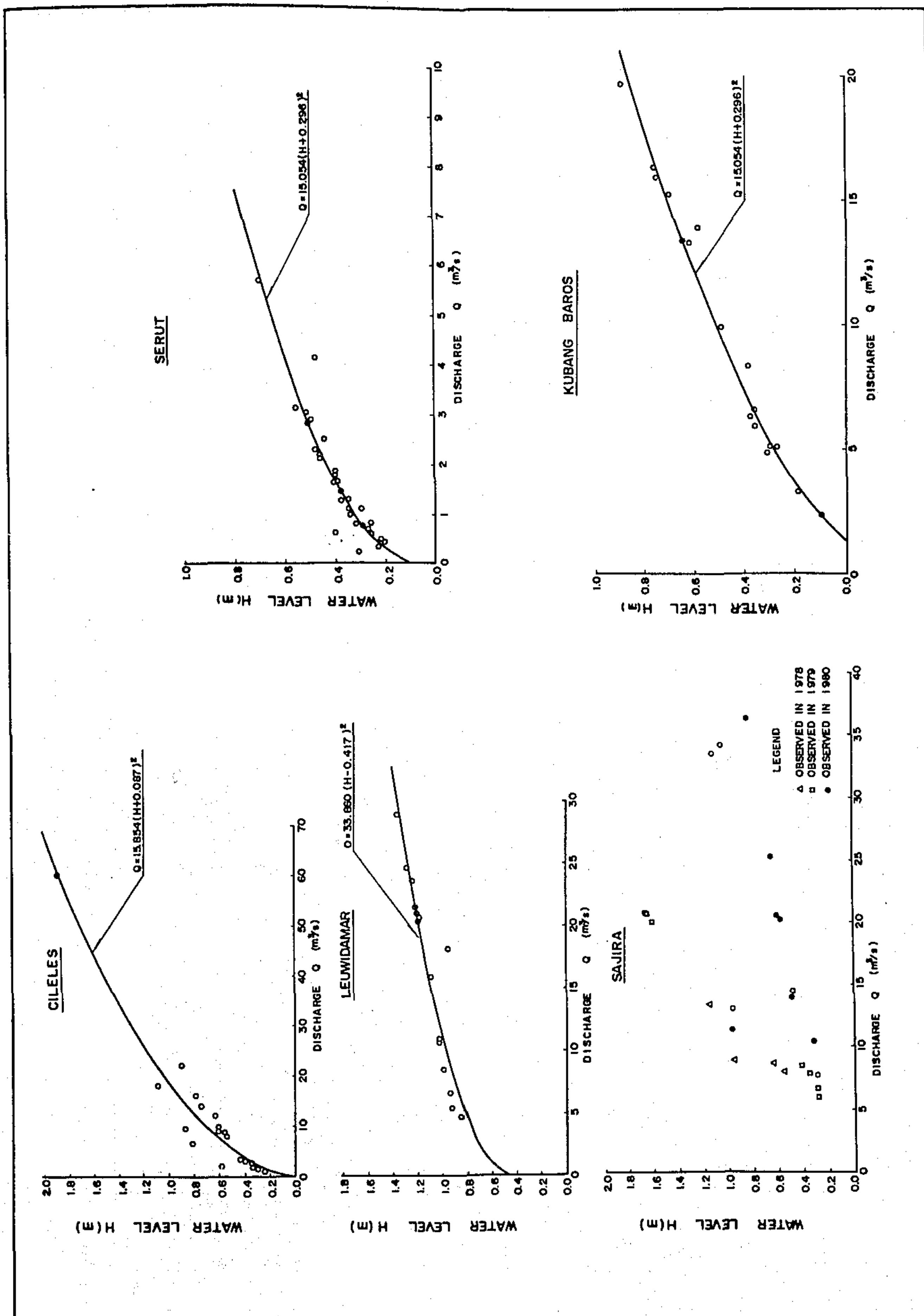

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Fig. B-5 Discharge Rating Curves

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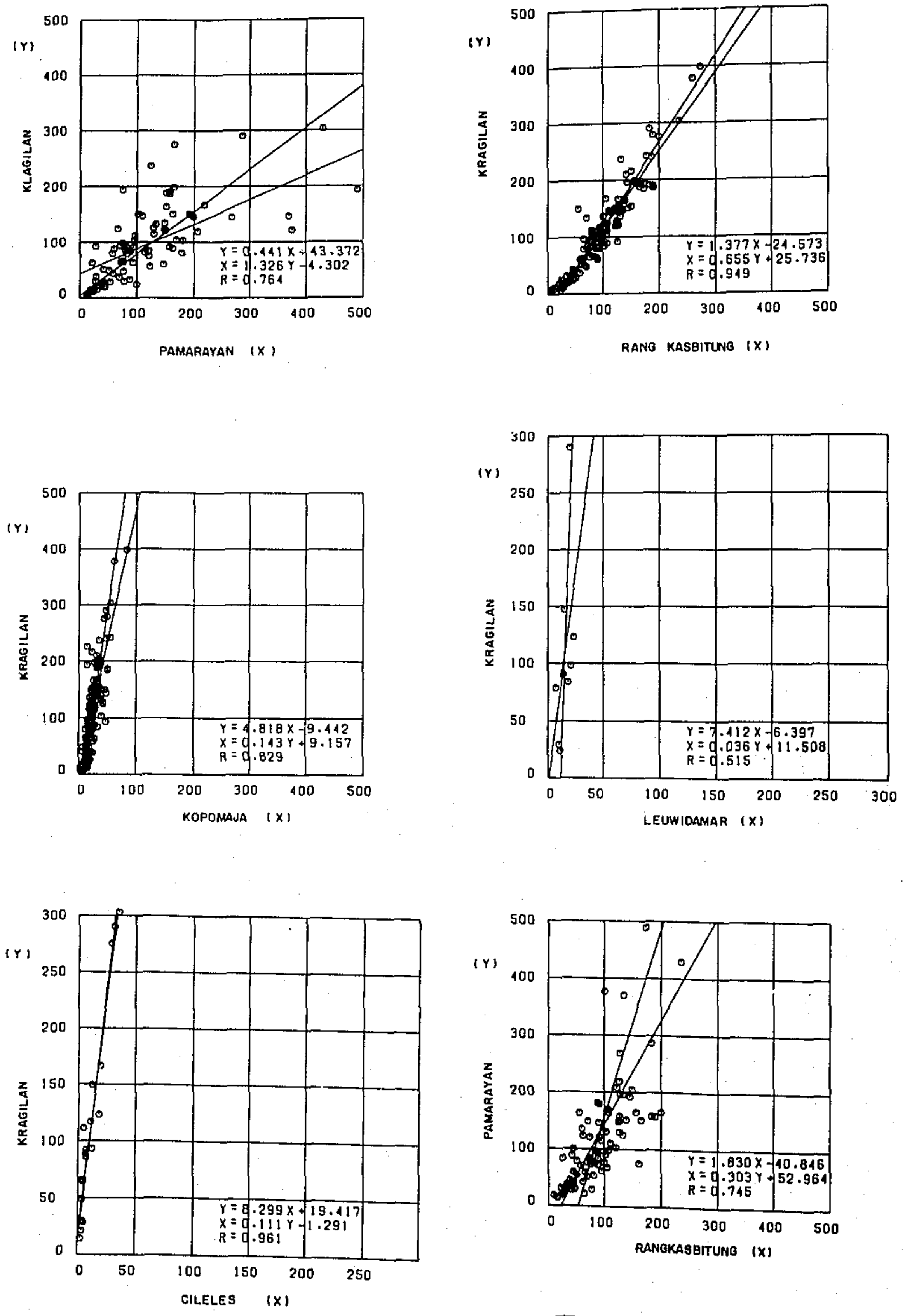

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Fig. B-6 (1/3) Correlation of Monthly Mean Discharge

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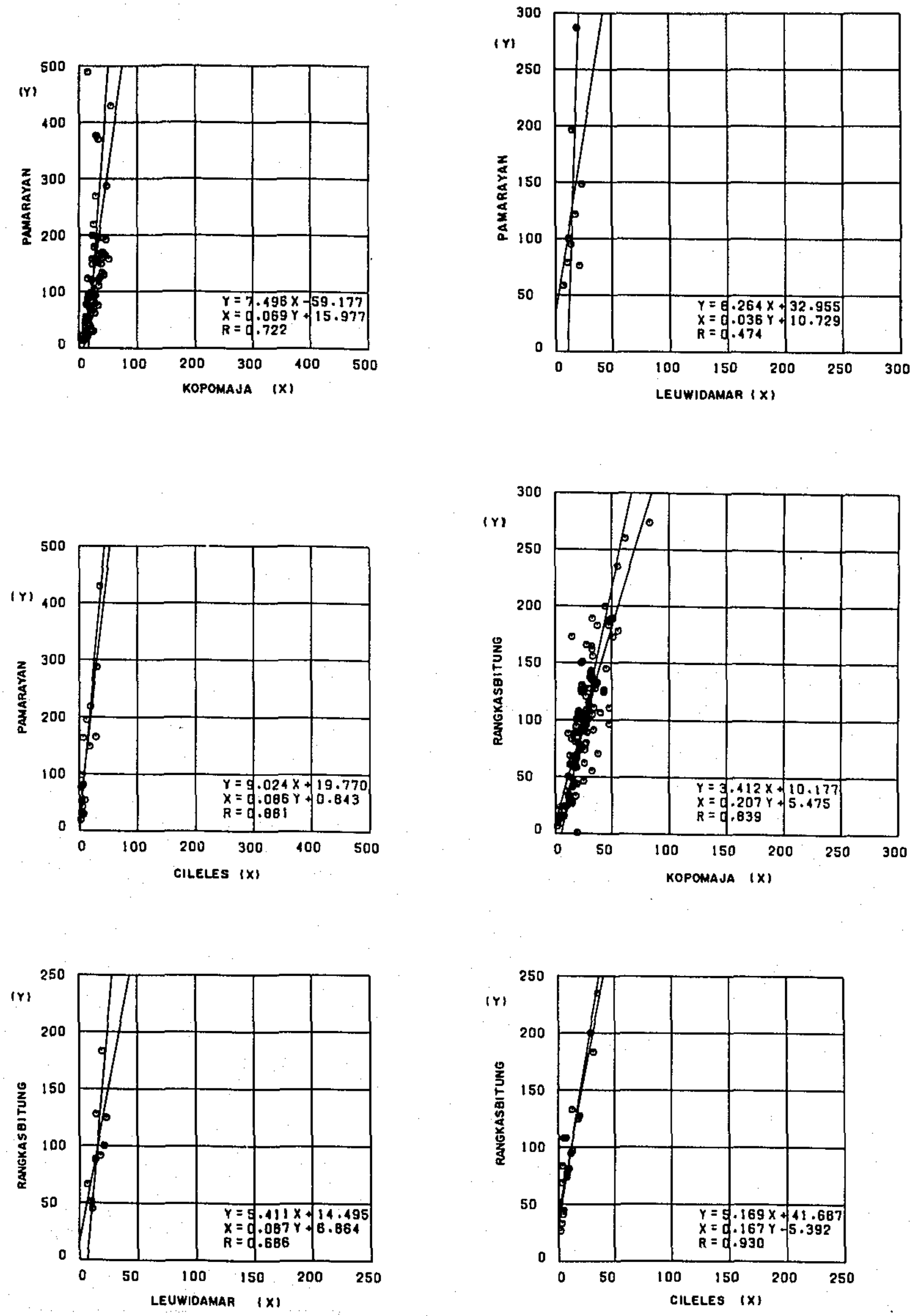

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Fig. B-6 (2/3) Correlation of Monthly Mean Discharge

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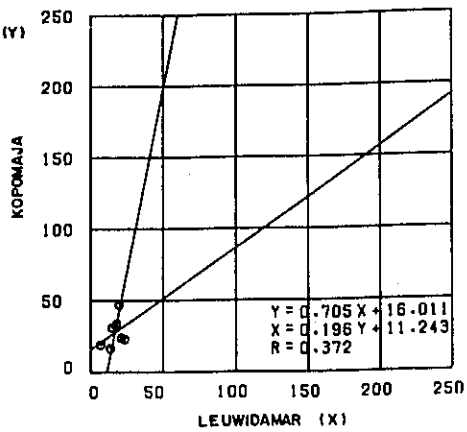

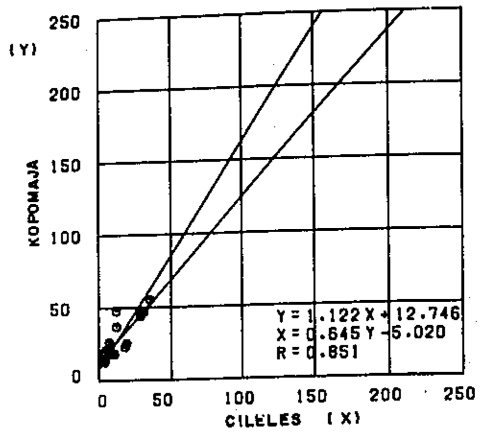

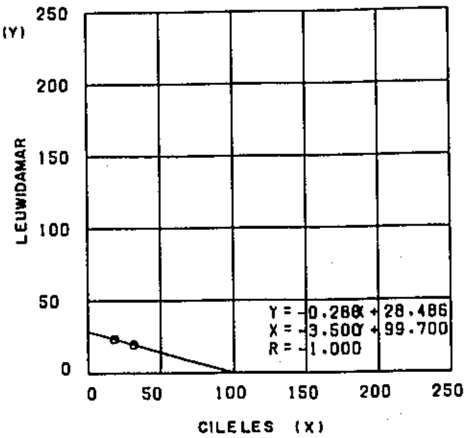

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Fig. B-6 (3/3) Correlation of Monthly Mean Discharge

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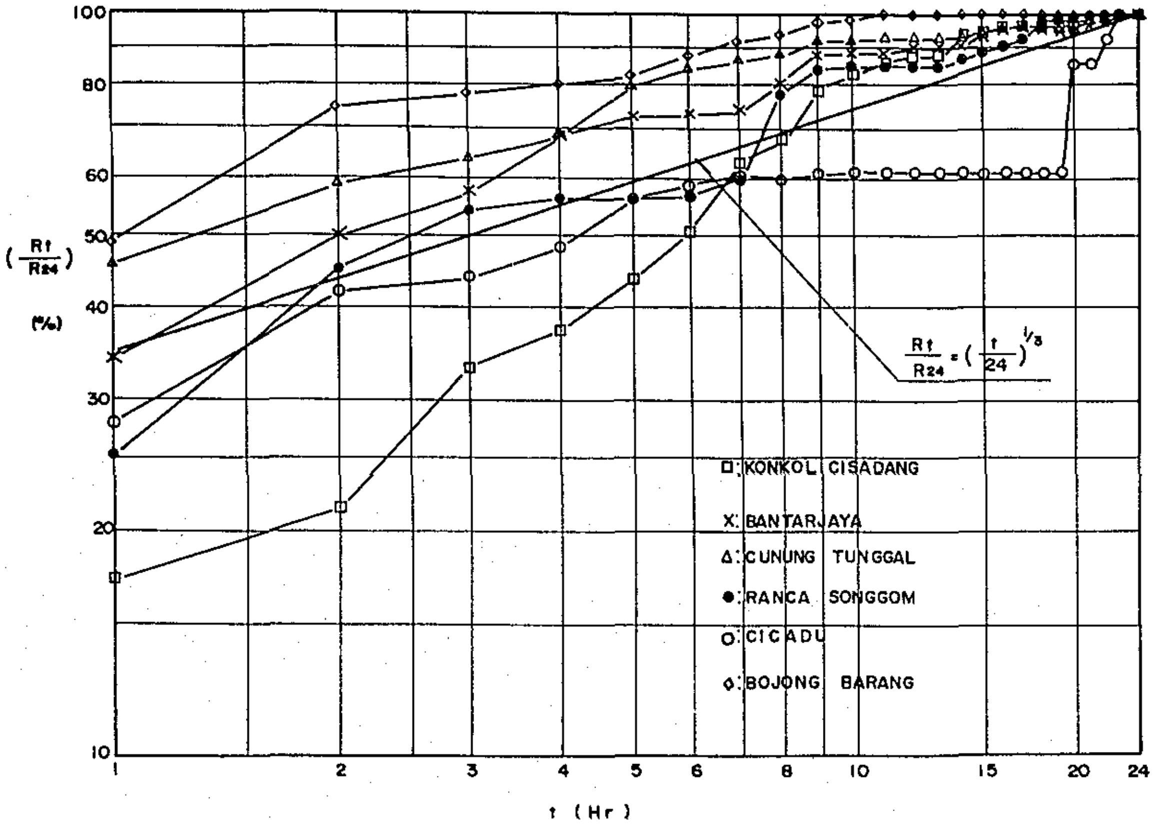

REMARKS Rt : CUMULATED HOURLY RAINFALL
R24 : DAILY RAINFALL
t : RAINFALL DURATION

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Fib. B-7 Rainfall Intensity of Mononobe Method and Actual Rainfall

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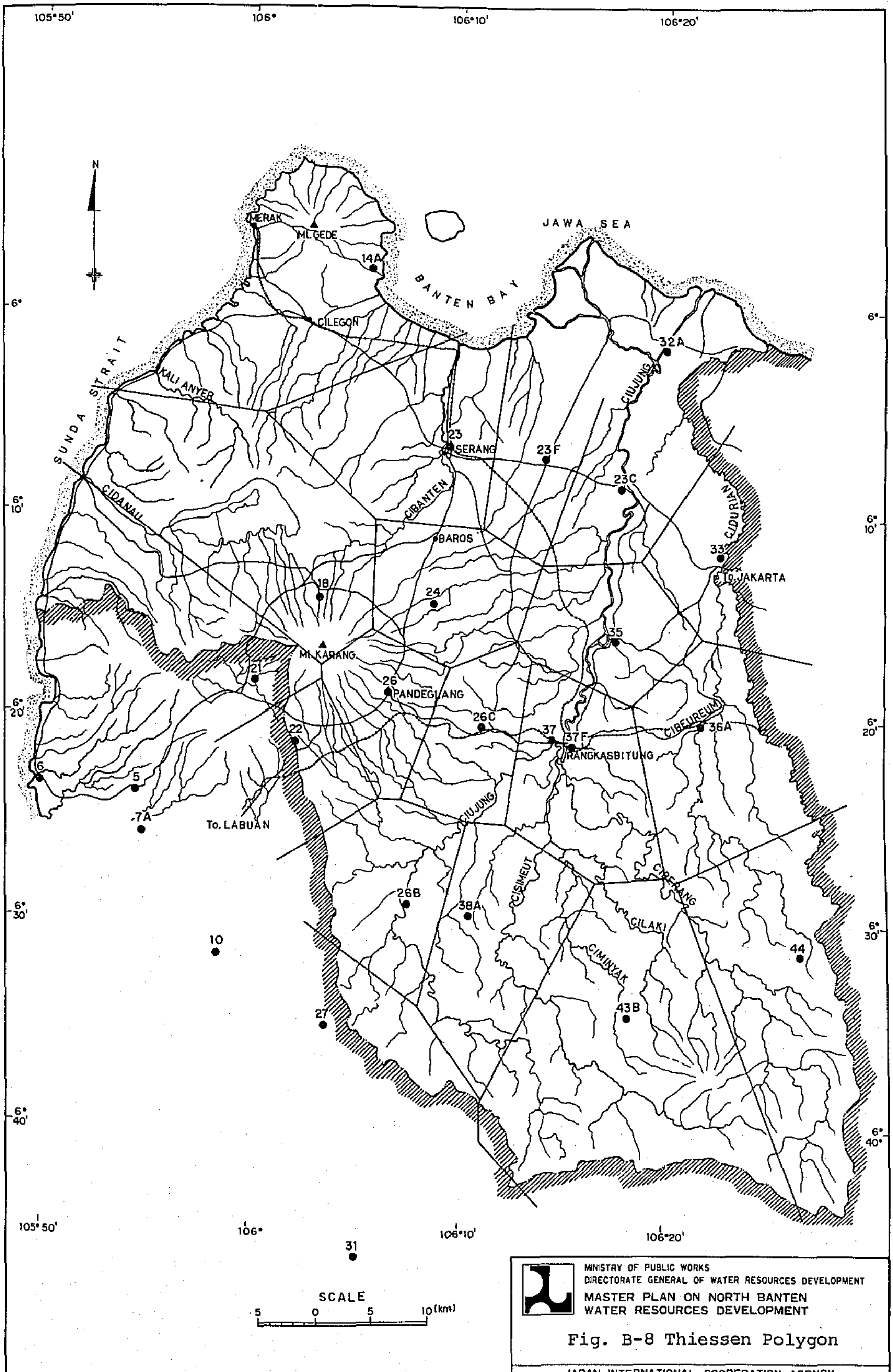

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Fig. B-8 Thiessen Polygon

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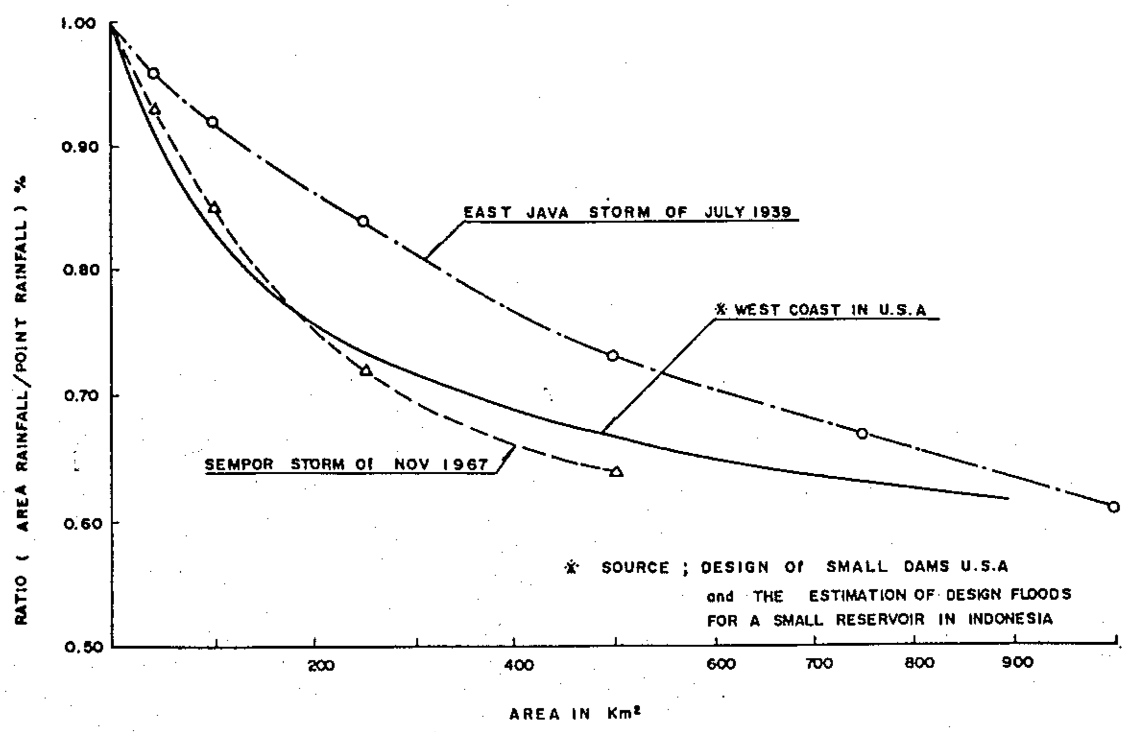

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Fig. B-9 Conversion Ratio from Point Rainfall to Area Rainfall

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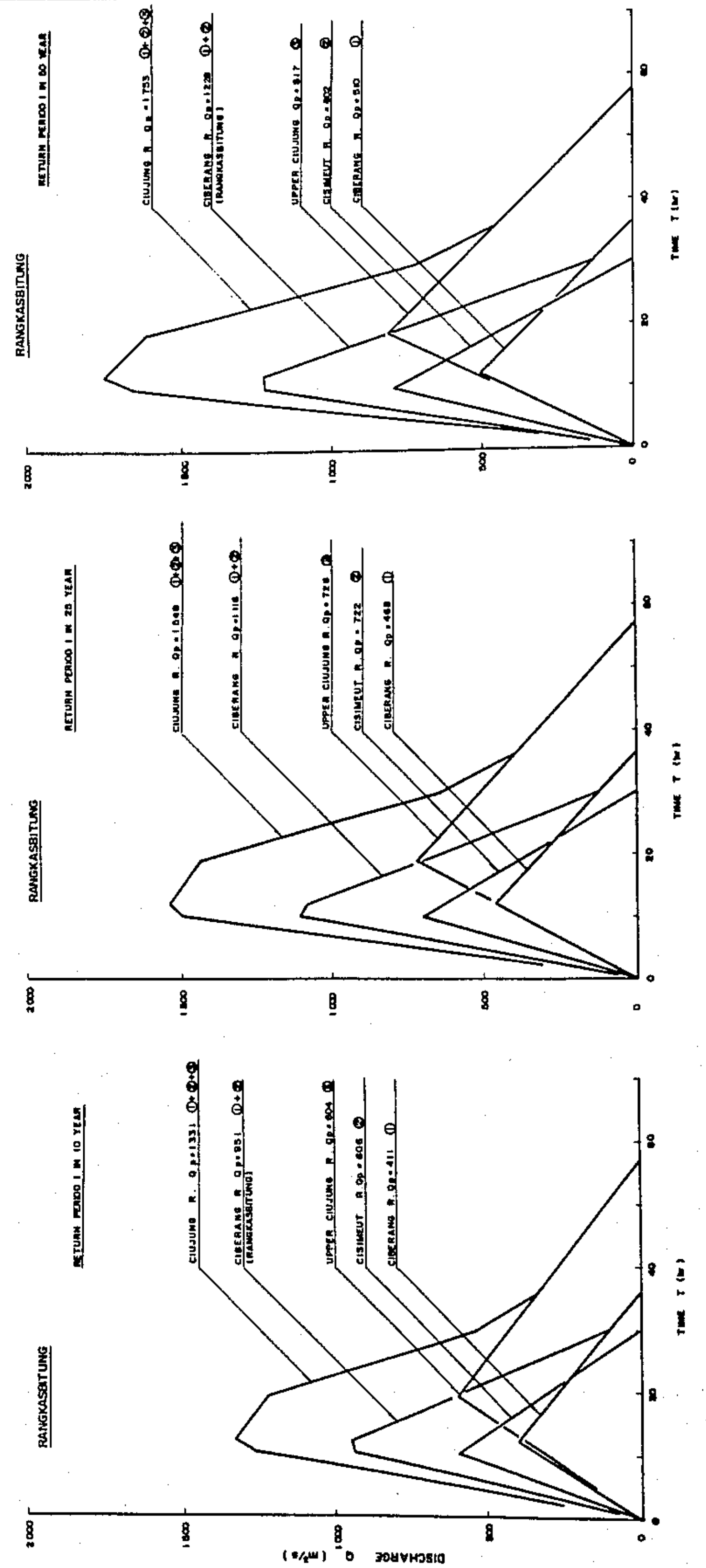

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Fig. B-10 Probable Flood Hydrograph

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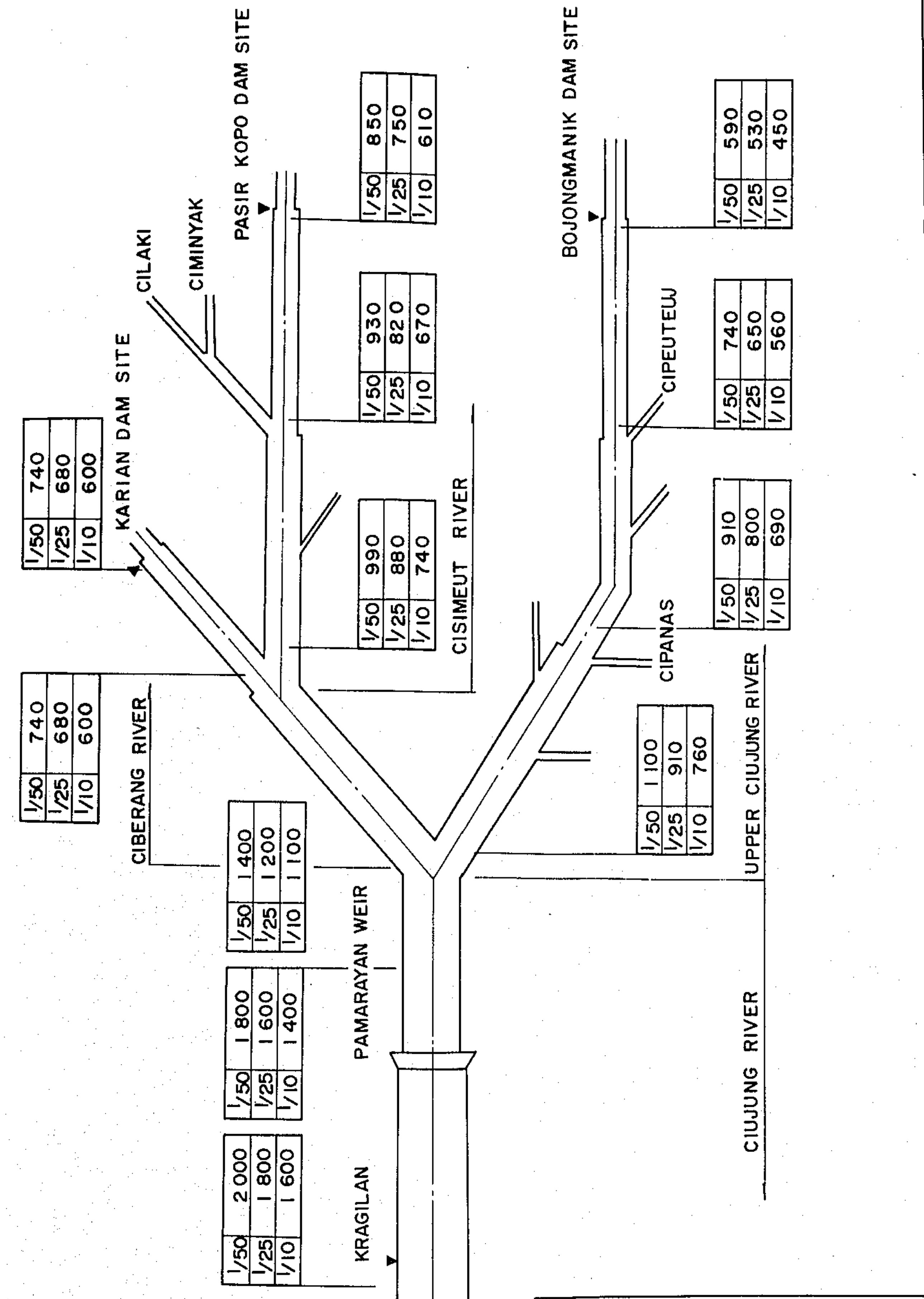

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Fig. B-11 Standard Project Flood Distribution of Ciujung River System

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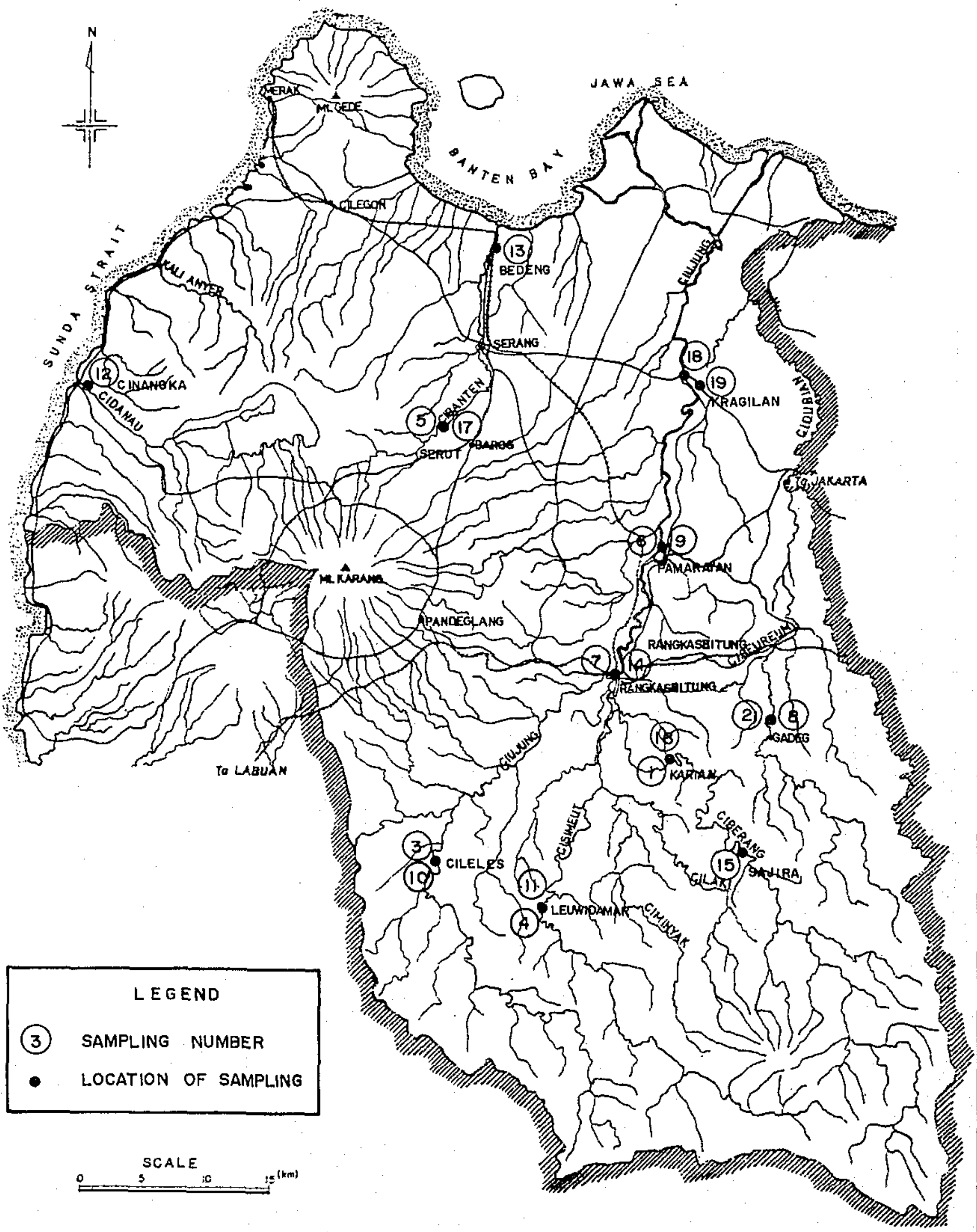

Remarks:

1 - 7 Dry Season Sample
8 - 19 Wet Season Sample

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Fig. B-12 Location Map of Water Sampling

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APPENDIX C
GROUNDWATER

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1. INTRODUCTION

The main purpose of the groundwater investigation is to clarify the possibilities of groundwater development in the Study Area. This report presents the results of the study including hydrogeology, present condition of groundwater use and groundwater development potential. During the past several years, many reports have been prepared about the groundwater availabilities in the Banten Area (Refs. 1 to 3). The data on existing dug wells and monitoring results were provided by P3SA. Hydrogeological data such as geological logs, well structure, borehole logging, water quality and pumping tests were collected from P2AT, CIPTA KARYA and "Geological Survey of Indonesia".

2. HYDROGEOLOGY

The topography of the Study Area is divided into alluvial plains, low terraces, gently sloping to undulating hills and mountain areas. According to the general geological map prepared by R.W. Van Bemmelen in 1945, as shown in Fig. C-1, the alluvial plains nearby the Banten Bay are formed of recent alluvium. In general, alluvial plains having rather deep deposits have the possibility to develop wells yielding adequate groundwater for the domestic and industrial water supply. However, groundwater pumped up from the recent alluvium in the Study Area is of low quality by suffering from sea water intrusion.

Low terraces and gently sloping to undulating hills are underlain by tuffaceous sedimentary rocks of Miocene to Pleistocene. The water holding capacity of such rocks is very small and the rocks form aquicludes. Due to this low permeability, the surface runoff may mostly flow downward over the ground surface.

In the mountain areas, there are many volcanoes which constitute the most remarkable features of geology in the Study Area. The areas are formed of volcanic breccias and andesite lavas of Pliocene and overlying Quaternary andesites. Although these mountain areas are covered with considerable thickness of soils, the areas are highly dissected where slopes is more than 15% resulting in remarkable development of radial drainage patterns. The surface runoff infiltrates into the permeable layers of soils on the slopes and gushes out from the foot of mountain as spring throughout the year.

3. PRESENT CONDITION OF GROUNDWATER

3.1 Shallow Wells

Shallow wells are broadly used for the domestic purpose in the Study Area. Most of these shallow wells are composed of large cylindrical hole type with a diameter of 60 to 120 cm and a depth of 2 to 17 m. Some shallow wells are of pipe type and have a hand pump or an electric pump installation.

Water levels in about 150 shallow wells were measured in January and September 1979 and in January and March 1982 by P3SA. The results are given in Fig. C-2 showing the contour lines of water-level and the direction of water movement. The depth to water table in the Study Area varies from less than 1 m to more than 12 m below the ground surface in January 1982. This fact means that yields of the shallow wells are not sufficient for the domestic use in the dry season. The electrical conductivity of groundwater from the shallow wells varies between 145 and 5,000 micromhos/cm in January 1982. As seen in an isoconductivity line of the Study Area as portrayed in Fig. C-3, groundwater in the unconfined aquifer has a good quality in the foot of the Gunung Karang, while the unconfined aquifer in the alluvial plains is not potable due to the sea water intrusion.

3.2 Deep Wells

Many deep wells have been dug since 1885 in the coastal plain occupying the northern part of the Study Area. But the detailed data of these wells are not available.

At present, 15 deep wells are under operation in and around Serang. All the boreholes are drilled in the alluvial sediments and tuffaceous sandstone with pumice, ranging from 50 to 200 m in depth. Several aquifers are recognized in the strata of fine to medium sand within 5 m in thickness. The maximum yields of these aquifers are expected to be 3 lit/s.

According to the preliminary study of groundwater resources in Cilegon located 20 km to the west of Serang, the result of pumping test shows that the discharge rate ranges from 2 to 3 lit/s.

In Cikande located 20 km to the east of Serang, three boreholes, No. 1 to No. 3 as shown in Table C-1 and Fig. C-4, were drilled by P2AT for the development of domestic water supply. These wells are 80 m in depth, 100 mm in diameter and 1 to 3 lit/s in discharge rate, but reliable yield is estimated to be less than 1 lit/s. As the aquifers are affected by the sea water intrusion, the electrical conductivity shows such high values as 1,200 to 1,900 micromhos/cm. From this, it is pointed out that the water quality is unsuitable for drinking.

In Warung Gunung, P2AT carried out the systematic groundwater development program in 1981 to estimate groundwater potential by digging three boreholes, No. 4 to No. 6, to the depth of 58 m each at Jagabaya, Curugpanjang and Warung Gunung. The location and summarized data of these wells are shown in Fig. C-4 and Table C-1, respectively. The results of the pumping test indicate that the maximum yield of groundwater reduces to 0.8 lit/s, while the electrical conductivity becomes low ranging from 140 to 400 micromhos/cm. The water quality is good for the domestic use.

In Rangkasbitung, deep well groundwater yielding 35 lit/s in total is used for urban water supply and other deep wells yielding 40 lit/s in total are now under development. The existing deep tube well, No. 7, exploits the groundwater in the Pliocene aquifers of sands, gravelly sands alternating with clays and limestone. The well is 150 m in depth and screened by slotted steel pipes with a diameter of 150 mm. The total screen length is 25.5 m. A thickness of each aquifer is estimated to be 2 to 10 m as a result of well logging. The location and summarized data of the well are shown in Fig. C-5 and Table C-1. The existing tube well has become lower in water level year by year and there is a possibility of drying up of the well in the near future. Further, there is no potentiality for development of new springs and deep wells in and around Rangkasbitung.

3.3 Springs

Most of 200 springs in the Study Area are perennial and gushing on similar elevation between El. 200 and 300 m at the foot of the Gunung Karang. The location and summarized data of main springs are shown in Fig. C-6 and Table C-2, respectively. The yield of springs is more than 100 lit/s in the surrounding area of the Gunung Kqrang, while it becomes less than 10 lit/s on the foot slopes of the Gunungs Parakasa and Pulasari depending on the catchment area.

The discharge of each spring has seasonal variation and small springs dry up in the dry season. As for the water quality, the electrical conductivity ranges from 140 to 300 micromhos/cm and both contents of carbon dioxide and bicarbonate are rather high. The water temperature is fairly constant at the level of 24 to 25°C throughout the year. But the hot springs located on the northern slope of the Gunung Parakasa have a temperature of 58°C.

The spring water in the Study Area is fully used for the domestic and irrigation purposes. The details of spring water use are described in Appendix I.

4. GROUNDWATER POTENTIAL

4.1 Unconfined Aquifer

As shown in Fig. C-7, the unconfined aquifer which distributes in the alluvial plains nearby the Banten Bay and in the foot of the Gunung Karang has groundwater potentialities to some extent. The unconfined aquifer is categorized into two classes on the basis of its physical and chemical characteristics as below.

Item	Unit	Class 1	Class 2
Water table depth	m	0.5 - 12.4	0.4 - 3.0
Well depth	m	2 - 16	2 - 8
Water depth in a well	m	0.2 - 11.0	1.3 - 5.0
Electrical conductivity	micromhos/cm	145 - 500	545 - 5,500
Permeability coefficient	cm/s	2×10^{-3} - 2×10^{-4}	1×10^{-3} - 5×10^{-4}
Water temperature	°C	26 - 27	28 - 29
Location		Mountain foot	Coastal plain

The unconfined aquifer categorized into Class 1 is thin in general, consisting of fine to coarse tuff or pumice tuff derived from volcanic activities. The groundwater yield is relatively small, although the water quality is good. Groundwater potential in this unconfined aquifer directly depends on the thickness of aquifers and precipitation in the catchment area. Hence, there is no potential to meet the domestic demand in the future.

The unconfined aquifer categorized into Class 2 is also thin, consisting of fine to coarse deposits of alluvium. The groundwater yield is small and its quality is not potable caused by sea water intrusion.

4.2 Confined Aquifer

The confined aquifer is found in the alluvial plains and gently sloping to undulating hills as shown in Fig. C-7. The confined aquifer is categorized into four classes on the basis of its characteristics including water quality as shown in Table C-3 as follows:

(1) The confined aquifer of Class 1 is moderate in groundwater yield, good in quality and high in water level. The distribution of this confined aquifer is limited in the middle reaches of the Ciujung river. Hence, the groundwater development potential is not expected to large extent.

(2) The confined aquifer categorized into Class 2 is small in groundwater yield, good in quality and high in water table. This confined aquifer distributes in the low terrace facing the area of Class 1 confined aquifer beyond the middle reaches of the Ciujung river. There are three tube wells drilled to the depth of 58 m in this area. Judging from the fact that the profiles, No. 4 to No. 6 as shown in Fig. C-5, and topography, deep drilling is required for getting high yield of groundwater.

(3) The confined aquifer categorized into Class 3 is small in groundwater yield, good to fairly good in quality and low in water table, distributing on flat and low terraces surrounding Serang and Cilegon as shown in Fig. C-7. The confined aquifer of this Class consists of clay, sand and gravel intercalated with pumice tuff. Though the detailed data are not available, the groundwater may be affected by sea water intrusion if the well is drilled near the sea shore.

(4) The confined aquifer categorized in Class 4 is small in groundwater yield, poor in quality and high in water table, distributing in Cikande located 20 km east to Serang. It comprises alluvial deposits of fine to coarse sand which are intercalated with clay and tuff as an aquiclude. Because of sea water intrusion, the further development of the groundwater is not expected in the area of Class 4.

4.3 Spring

Although the existing springs have already been fully used for the domestic and irrigation purposes, development potential is expected to some extent in the Study Area.

Springs in the Study Area are categorized into two classes on the basis of the spring water yield, water quality as shown in Table C-4 and recharge area as follows:

(1) The spring categorized in Class 1 is moderate to large in yield, good in quality and large in recharge area. Springs gushing from the northern and southern foots of the Gunung Karang belong to this class. As the mountain area is blessed with natural recharge depending on thick tephra and heavy rainfall, the spring water yield is large and its discharge is perennial.

(2) The spring categorized in Class 2 is small to moderate in spring water yield, good to fairly good in quality and small in recharge area. The spring of this class exists in the foots of the Gunungs Parakasa and Pulasari. The hydrogeological condition is very similar to that of the Class 1 spring. However, the discharge is less than that of the Class 1 spring because of small recharge area.

At present, these springs play an very important roles in the domestic and irrigation water supply. Therefore, soil conservation and watershed management are required for maintaining spring water yield within the limited recharge area.

5. GROUNDWATER DEVELOPMENT

At present, the water sources for most municipalities in the Study Area are springs and/or deep wells. The policy of obtaining water sources from springs and/or deep wells is recommendable so long as stable and sufficient yields are available.

The development of water supply system for the town of Serang is now being proceeded according to the master plan. The Sukacai and Citaman springs, yielding 303 lit/s in total, can serve the town water supply system of Serang with sufficient water and satisfy the future water demand in the 2000's.

For the town of Pandeglang, the Karang Tanjung spring yielding 195 lit/s has recently been found and started water supply. However, it is required to develop springs as additional water resources to cope with the future urban water demand in Pandeglang. In the surroundings of the town, there is high development potential and the formulation of water resources development plan depending upon springs and deep wells is recommendable.

In the towns of Rangkasbitung and Cilegon, there is a possibility of drying up of the existing deep wells. As the surrounding areas of these two towns have no potentiality for development of new springs and deep wells, it is required that the water supply system to meet the urban water demand in the future depends on the surface water of the Ciujung river which is planned to be regulated by reservoirs.

REFERENCES

1. SERANG WATER SUPPLY PROJECT D. GEN. CIPTA KARYA, 1978, DHV Consulting Engineers

2. LAPORAN AKHIR STUDI PERENCANAAN TEKNIK PEMAFAATAN AIR TANAH DAERAH BANTEN, 1982, NUSA Consultants

3. BANTEN WATER RESOURCES DEVELOPMENT RECONNAISSANCE STUDY, 1979, Binnie and Partners

4. 15 CITIES WATER SUPPLY PROJECT BASIC DESIGN FOR A WATER SUPPLY SYSTEM OF PANDEGLANG, 1980, IWACO B.V.

5. 15 CITIES WATER SUPPLY PROJECT BASIC DESIGN FOR A WATER SUPPLY SYSTEM OF RANGKASBITUNG, 1981, IWACO B.V.

6. FINAL REPORT FEASIBILITY STUDY DAN MASTER PLAN AIR MINUM KOTA RANGKASBITUNG, 1979, Widya Pertiwi Engineering

7. PEMBORAN 4 BUAH SHALLOW-BOREHOLES/WELL DI KABUPATEN LEBAK DAN BOGOR ZONE, JAWA BARAT, 1981, ITA

8. PEMBORAN 1 BUAH SHALLOW-BOREHOLES/WELL DI KABUPATEN LEBAK DAN BOGOR ZONE, JAWA BARAT, 1981, ITA

9. LAPORAN PEKERJAAN PENGEBORAN EKSPLORASI DI RANGKASBITUNG, 1979, PHONENIX YASASARANA

10. LAPORAN PENGUKURAN SUMUR GEOHIDROLOGI, Feb. 1979, P3SA

11. LAPORAN PERJALANAN DINAS PENGUKURAN TINGGI MUKA AIR TANAH, Dec. 1981, P3SA

12. LAPORAN PENGUKURAN TINGGI MUKA AIR TANAH DI DAERAH BANTEN, Jan. 1982, P3SA

13. LAPORAN PENGUKURAN TINGGI MUKA AIR TANAH DI DAERAH BANTEN, Mar. 1982, P3SA

14. TABEL BEDA TINGGI AIR SUMUR GALI, Jan. 1979 to Sept. 1979, P3SA

15. DATA-DATA PENGUKURAN MUKA AIR SUMUR DAERAH BANTEN, Sept. 1979, P3SA

16. PEKERJAAN PENGUKURAN SUMUR-SUMUR OBSERVASI DI DAERAH K. CIUJUNG-K. CISADANE JAWA BARAT, 1980, EXSA International Co., LTD.

17. LAPORAN: PELASANAAN PEKERJAAN PEMBUATAN SUMUR-SUMUR EXPLORASI DI DAERAH JAWA BARAT, 1979, CITY CIPTA

18. REPORT ON CORE-DRILLING IN MERAK HARBOUR IN THE FRAMEWORK OF THE IRON & STEEL PROJECT, WEST JAWA, 1963, Joedo D. Flifas

19. HYDROGEOLOGY REPORT OF THE PROJECTED IRON AND STEEL MILL IN CILEGON, 1960, Achmad Subiarto

20. IKHTISAR LAPORAN AKHIR (EXECUTIVE SUMMARY) STUDI PERENCANAAN TEKNIK PEMANFAATAN AIR TANAH DAERAH BANTEN, 1982, NUSA Consultants

21. GEOLOGICAL MAP OF THE BOGOR QUADRANGLE JAVA, 1974, GSI

22. LAPORAN DENYELIDIKAN PENDUGAAN GEOLISTRIK DALAM RANGKA EXPLORASI AIR TANAH DI DAERAH CIWUNG-CISADANE, JAWA BARAT, 1979, GEODATA

23. HYDROGEOLOGICAL MAP OF INDONESIA SHEET XI JEMBER (JAWA) 1:250,000, 1981, GSI

Table C-1 SUMMARIZED DATA OF TUBE WELLS

Location	Date	Diameter (mm)	Depth (m)	Water Level (m)	Drawdown (m)	Quantity (lit/s)	Specific Yield (lit/s/m)	Total Screen Length (m)	Transmissivity (m^2/d)	Electrical Conductivity (micromhos/cm)	Cl (ppm)
Cikande											
1. Bakung	02/1980	200 150	0 - 36 36 - 95	11.54	12.67	3.5	0.276	24	18.48	1,904	174.2
2. Julang	10/1980	150 100	0 - 27 27 - 80	5.25	8.05	3.0	0.372	26	31.68	1,295	25.5
3. Gorda	04/1980	150 100	0 - 24 24 - 80.5	5.5	8.51	1.25	0.147	20	19.80	1,235	32.0
Warung Gunung											
4. Jagabaya	03/1981	100	0 - 58	1.53	34.11	0.18	0.005	18	0.228	393	18.2
5. Curugpanjang	04/1981	100	0 - 58	20.60	7.28	0.83	0.114	18	2.19	140	8.09
6. Warung Gunung	03/1981	100	0 - 58	5.32	20.8	0.5	0.024	29	1.13	472	34.4
Rangkasbitung											
7. Rangkasbitung	10/1978	200 150	0 - 36 36 - 155	0	9.2	22.5	2.44	25.5	178.2	400	28.8

Source: No. 1 - 6 = P2AT
No. 7 = CIPTA KARYA

Table C-2 SUMMARIZED DATA OF MAJOR SPRINGS

No.	Name	Elevation (m)	Discharge (lit/s)	Electrical Conductivity (micromhos/cm)	Temperature (°C)	Remarks
1	Cibanten	310	296 - 376	160	24	Irrigation & domestic use
2	Cibulakan (A)	305	91 - 133	140	25	Irrigation & domestic use
3	Sukacai	220	115	250	25	Irrigation & town water supply for Serang
4	Citaman	150	215	300	25	Irrigation & town water supply for Serang
5	Cibulakan (B)	30	29	600	32	Irrigation
6	Ciwasiat	240	6.5 - 9	340	25	Town water supply for Pandeglang
7	Ciraden	290	3 - 8	200	25	Town water supply for Pandeglang
8	Cubulakan (C)	350	30	160	24	Irrigation & domestic use
9	Cibulakan (D)	240	20 - 25	200	25	Irrigation & domestic use
10	Karang Tanjung	152	195	180	25	Irrigation & town water supply for Pandeglang
11	Cikoneng II	125	50 - 100	290	28	Irrigation & fish pond
12	Cileweng	250	10	185	25	Irrigation
13	Cigewok	200	10	160	25	Irrigation & fish pond
14	Cisompok	225	10	225	-	Irrigation & domestic use
15	Citomo	225	10	225	-	Irrigation & domestic use
16	Toyo Metro	10	15	-	-	Irrigation & domestic use
17	Batukuwung	100	20	1,100	58	Hot spring

Source: DPU & CIPTA KARYA

Table C-3 QUALITY OF GROUNDWATER

	Unit	Cikande			Warung Gunung			Rangkasbitung	
		Bakung (1)	Julang (2)	Gorda (3)	Jagabaya (4)	Curug-Panjang (5)	Warung Gunung (6)	Well A (7)	Well B (8)
Temperature	°C	-	28.5	27.5	-	-	-	-	-
pH		7.8	7.7	7.8	7.0	6.4	6.4	7.5	7.0
Electrical Conductivity	micromhos /cm	1,904	1,295	1,235	393	140	472	440	400
Colour		5	4	5	15	10	15	10	10
Turbidity		-	2.1	-	6	4	4	4	-
Hardness ($CaCO_3$)	ppm	512.7	430.9	417.6	-	-	-	-	-
Iron (Fe)	ppm	0.55	0.5	negative	0.15	0.10	0.10	0.40	0.40
Manganese (Mn)	ppm	0.11	-	-	0.40	0.25	0.20	trace	0.40
Copper (Cu)	ppm	-	-	-	-	-	-	-	-
Chloride (Cl)	ppm	174.2	25.5	32.0	18.2	8.09	34.4	23.8	28.8
Nitrite (NO_2)	ppm	trace	-	-	-	-	-	trace	-
Nitrate (NO_3)	ppm	negative	-	-	-	-	-	0.2	-
Fluoride (F)	ppm	-	-	-	-	-	-	-	-
Sulphate (SO_4)	ppm	90	-	-	6.4	5.6	6.6	3.1	3.8
Dissolved Oxygen (O_2)	ppm	-	-	-	-	-	-	-	-
Carbon Dioxide (CO_2)	ppm	5.2	11.3	7.6	55	32	55	31	28
Calcium (Ca)	ppm	85.5	29.8	29.8	50.7	19.9	65.9	46.8	47.8
Bicarbonate (HCO_3)	ppm	512.7	430.9	417.6	253	142	321	580	322

Source: (1) = Ref. 16
(2) = Ref. 16
(3) = Ref. 16
(4) = Ref. 7
(5) = Ref. 7
(6) = Ref. 7
(7) = Ref. 5
(8) = Ref. 6

Table C-4 QUALITY OF SPRING WATER

	Unit	Cibanten (1)	Sukacai (2)	Cibanten (3)	Cubulakan (4)	Karang Tanjung (5)
Temperature	°C	25.2	24.5	24.5	24.5	-
pH		6.7	6.6	6.7	6.8	7.3
Electrical Conductivity	micromhos/cm	325	400	280	210	140
Colour		0	25	20	20	10
Turbidity		0	8	6	4	-
Hardness ($CaCO_3$)	ppm	80	110	68	40	-
Iron (Fe)	ppm	0.02	0.06	0.07	0.04	0
Manganese (Mn)	ppm	0.0	0.2	0.2	0.1	0
Copper (Cu)	ppm	0.1	0.13	0.11	0.1	-
Chloride (Cl)	ppm	2.5	2.5	2.5	2.5	6.92
Nitrite (NO_2)	ppm	0.02	0.04	0.04	0.04	-
Nitrate (NO_3)	ppm	3.96	4.4	4.84	4.4	-
Fluoride (F)	ppm	0.4	0.3	0.3	0.28	-
Sulphate (SO_4)	ppm	0.0	2.0	2.0	2.0	1.9
Dissolved Oxygen (O_2)	ppm	6.0	6.0	6.0	7.0	-
Carbon Dioxide (CO_2)	ppm	80	70	64	48	8.8
Calcium (Ca)	ppm	-	-	-	-	15.4
Bicarbonate (HCO_3)	ppm	-	-	-	-	103

Source: (1) = Ref. 1
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(4) = Ref. 1
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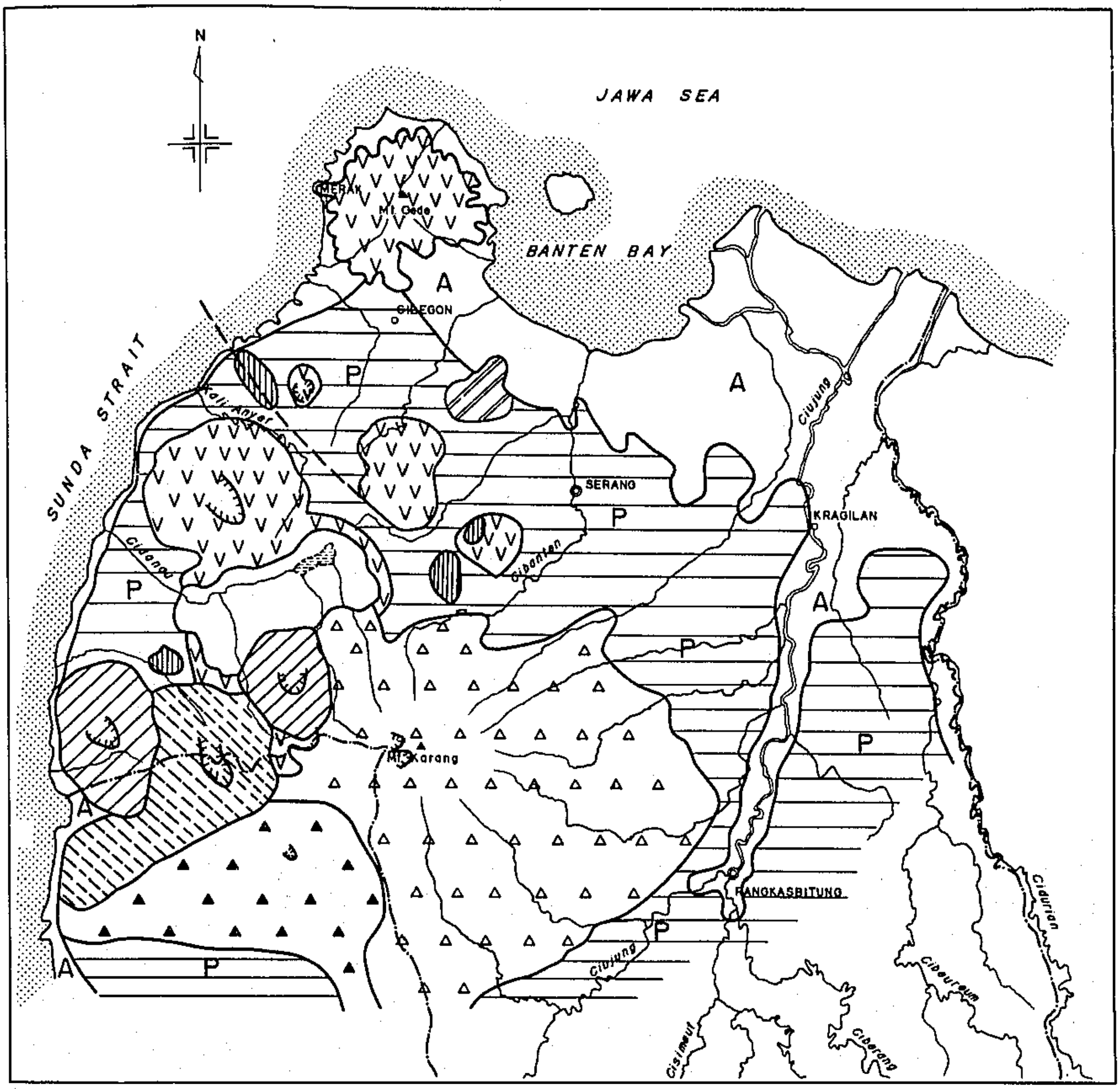

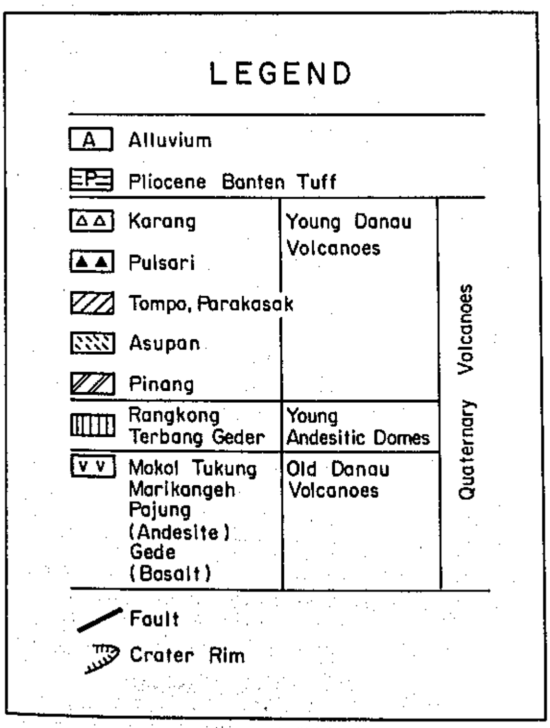

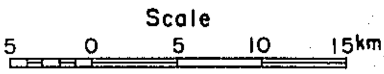

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Fig. C-1 General Geological Map

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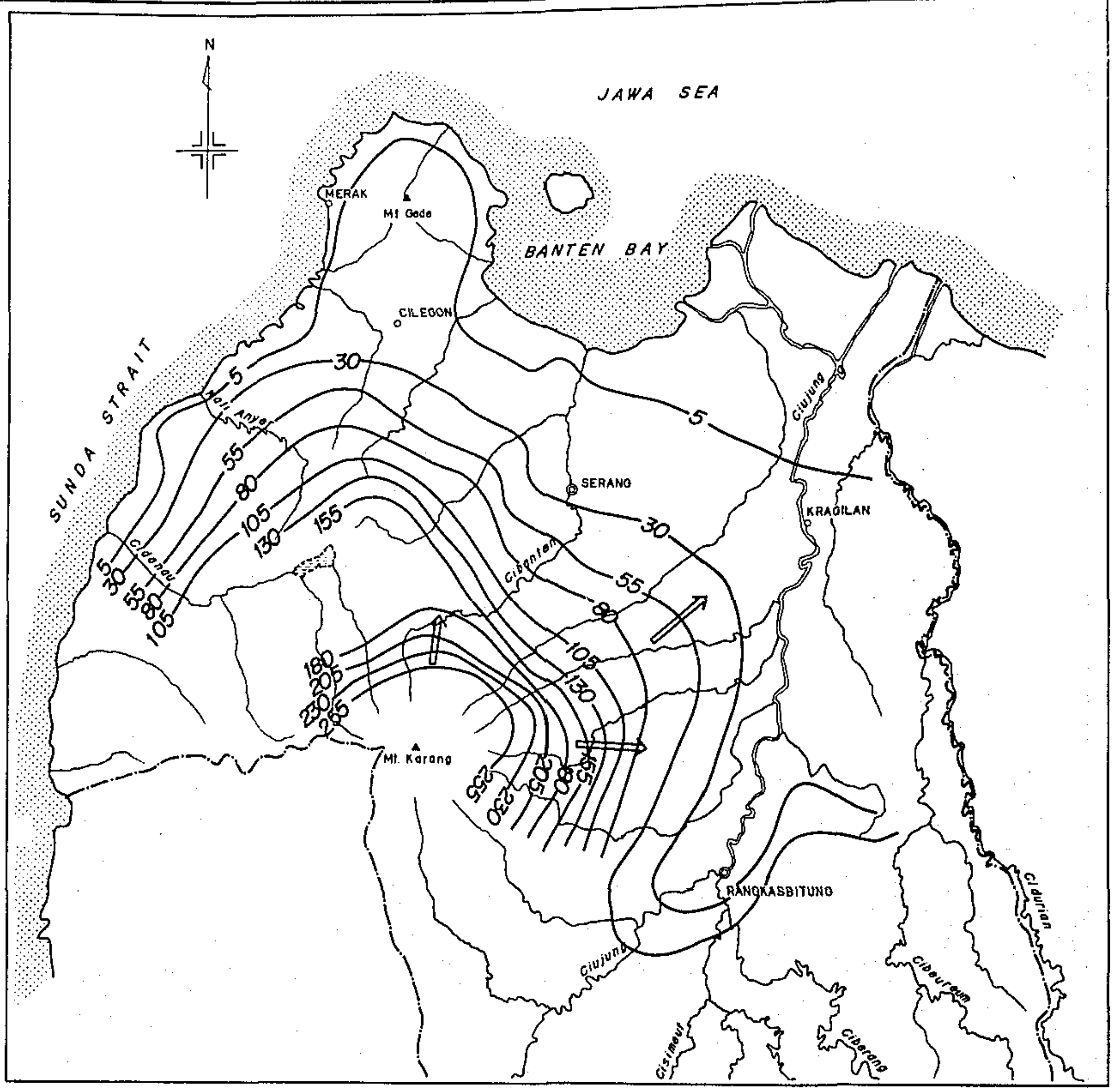

LEGEND

55 Water-table Elevation

Flow Direction of Ground Water

(After P3SA, JAN 1982)

Scale

5 0 5 10 15km

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Fig. C-2 Approximate Elevation of Water Table

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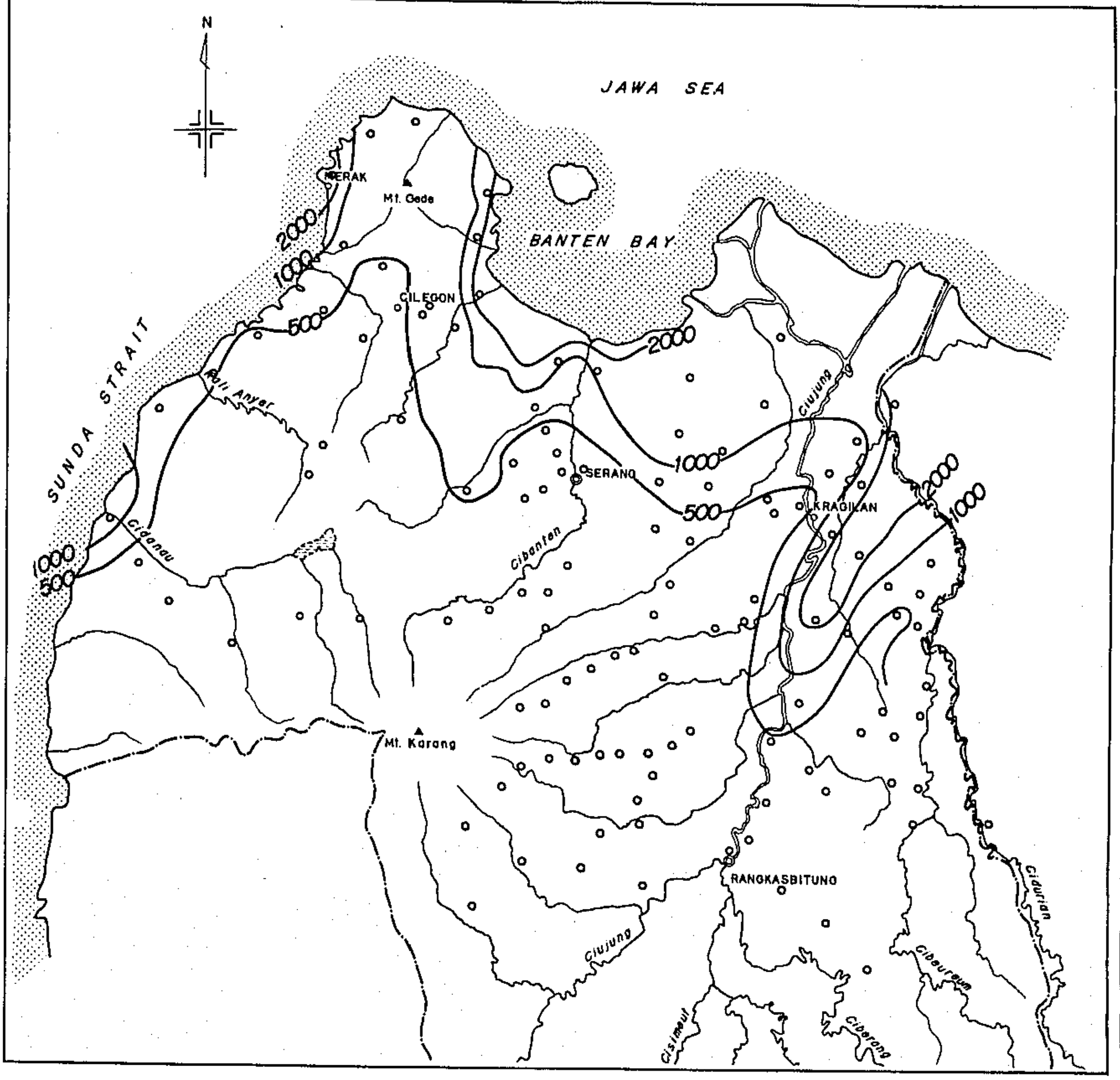

LEGEND

2000 Isoconductivity Line Value in micro S/cm

o Shallow Well for Monitoring

(After P3SA, JAN 1982)

Scale 5 0 5 10 15 km

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Fig. C-3 Electrical Conductivity Contour Map

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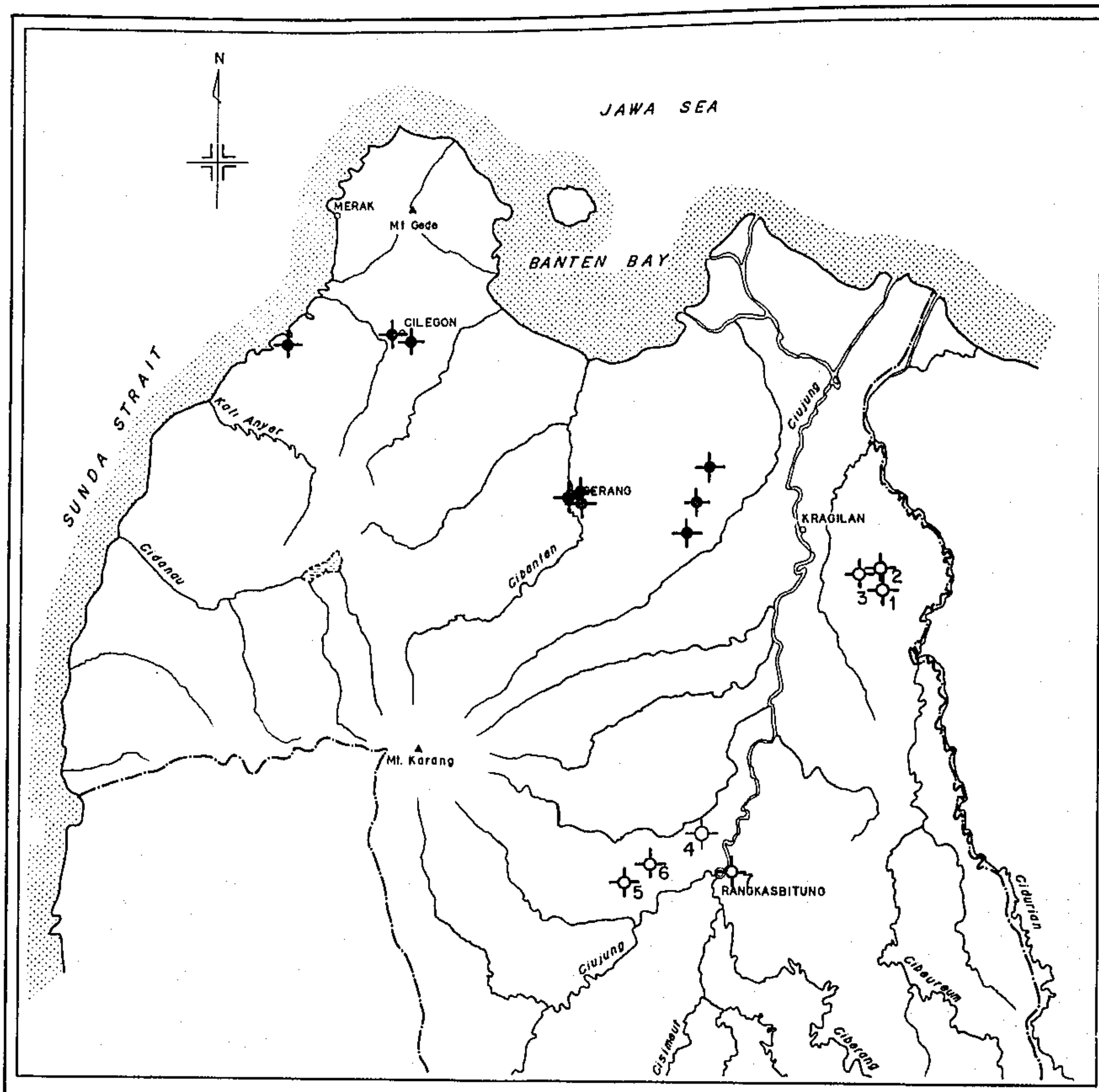

LEGEND

- Tube Well followed with detailed geologic and hydrologic data
- Tube Well without detailed data

Scale
5 0 5 10 15km

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Fig. C-4 Distribution of Tube Well

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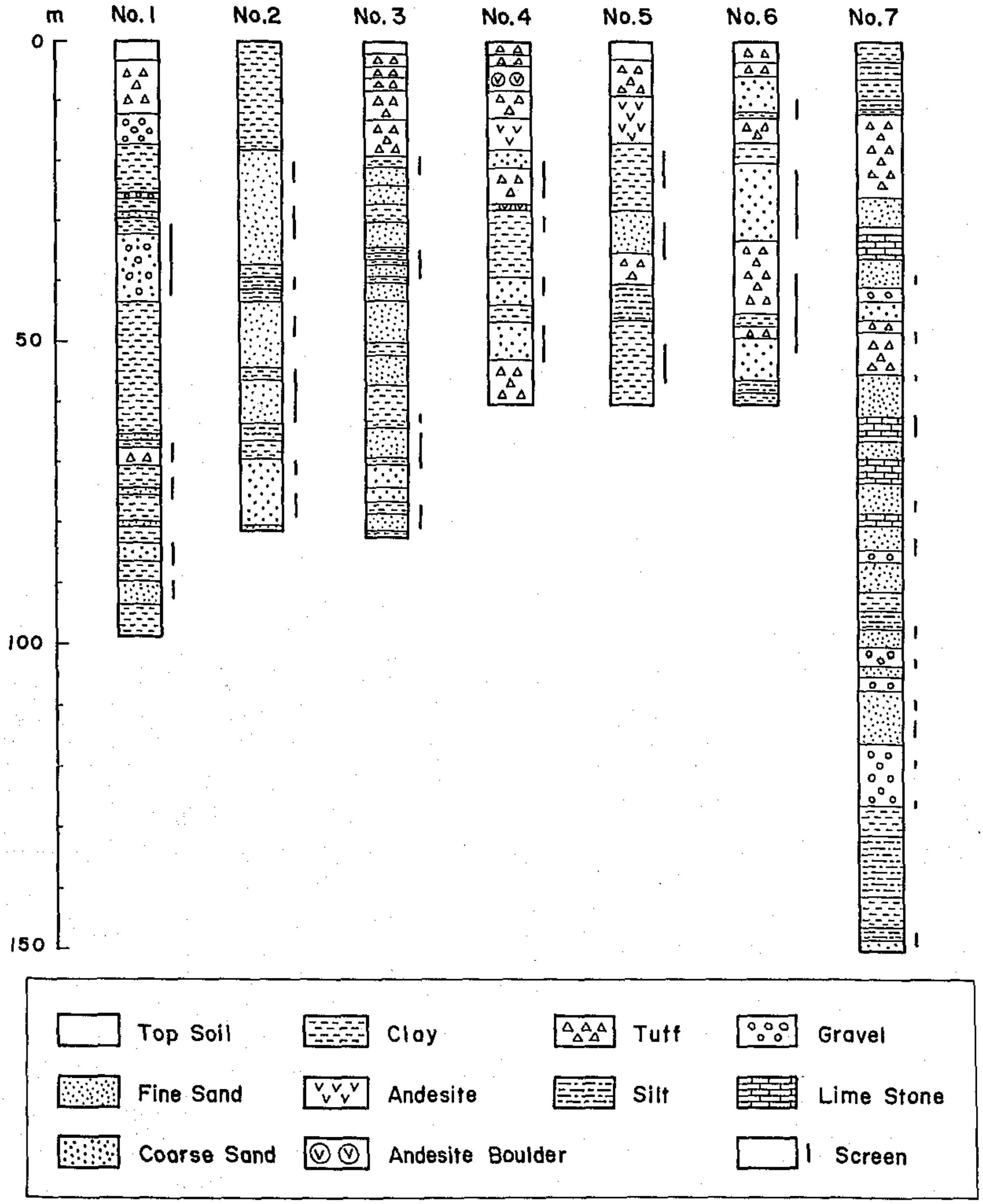

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Fig. C-5 Tube Well Logs

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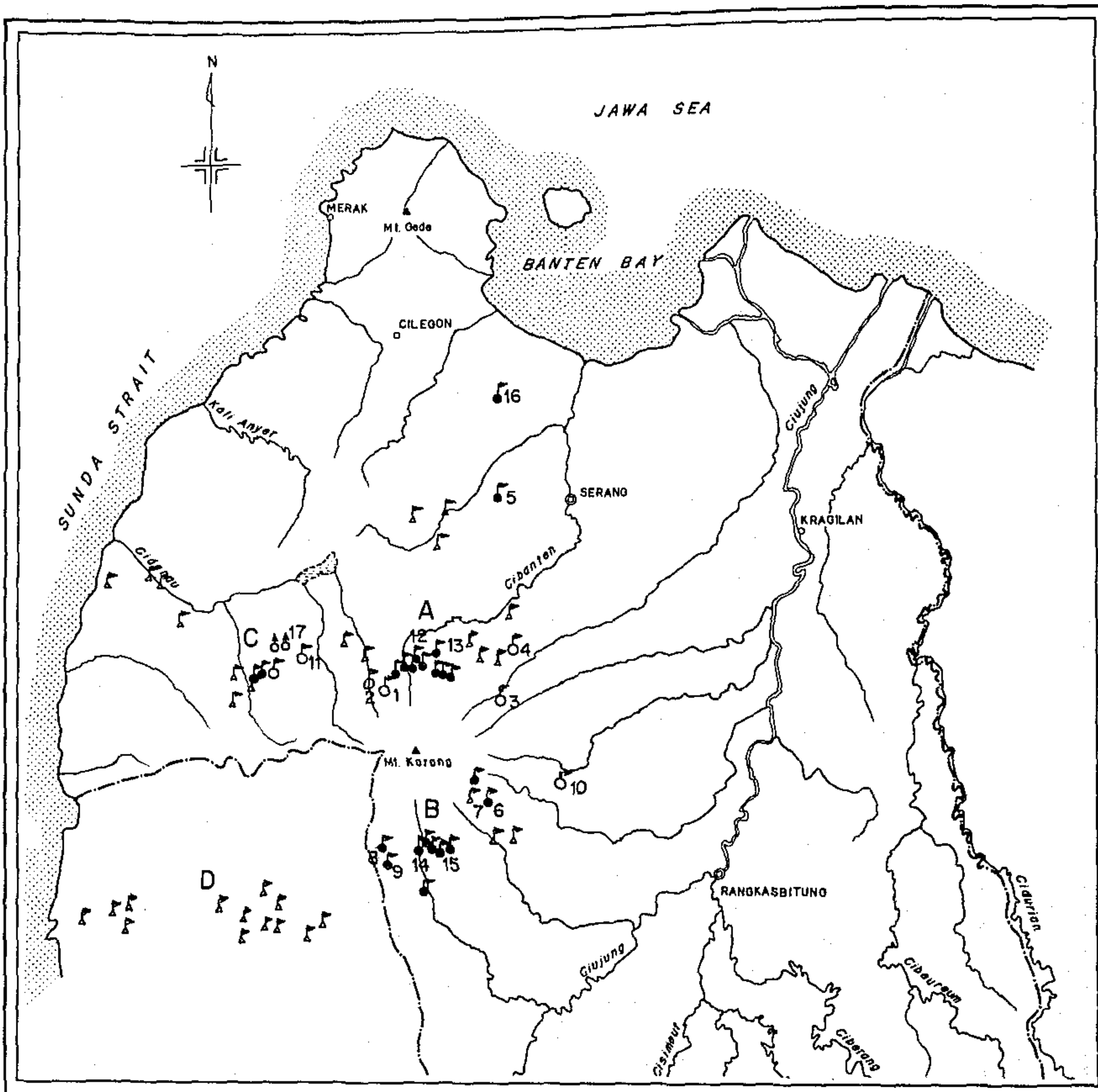

LEGEND

- Spring (more than 100ℓ/sec)
- Spring (10ℓ/sec – 100ℓ/sec)
- Spring (less than 10ℓ/sec)
- Hot Spring

A: Northen Karang Spring Group
B: Southeast Karang Spring Group
C: G. Parakasa Spring Group
D: G. Pulasari Spring Group

Scale
5 0 5 10 15 km

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Fig. C-6 Spring Location

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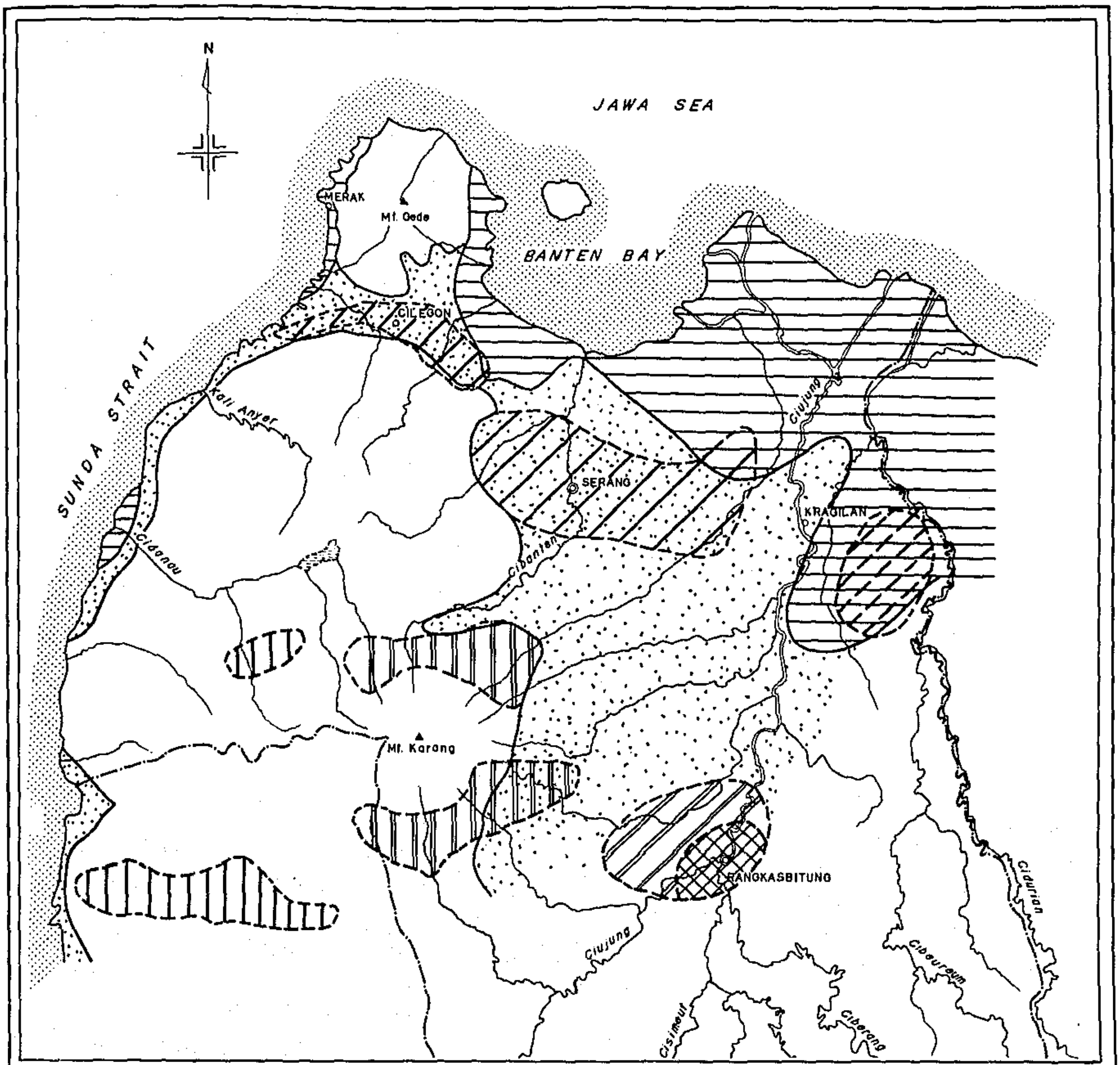

LEGEND

UNCONFINED AQUIFER

- Aquifers with Low Well Yields and Good Quality on the Low Water Table (Class 1)
- Aquifers with Low Well Yields and Fair Quality on the High Water Table (Class 2)

CONFINED AQUIFER

- Aquifers with Moderate Well Yields and Good Quality on the High Water Table (Class 1)
- Aquifers with Low Well Yields and Good Quality (Class 2)
- Aquifers with Low Well Yields and Fair Quality on the Low Water Table (Class 3)
- Aquifers with Low Well Yields and Poor Quality on the High Water Table (Class 4)

SPRING

- Moderate to Large Yields, Good Quality (Class 1)
- Low to Moderate Yields, Fair to Good Quality (Class 2)

Each class is difined in Section 4.

Scale

5 0 5 10 15km

MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
MASTER PLAN ON NORTH BANTEN
WATER RESOURCES DEVELOPMENT

Fig. C-7 Groundwater Conditions in North Banten

JAPAN INTERNATIONAL COOPERATION AGENCY

APPENDIX D

GEOLOGY

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1. REGIONAL TOPOGRAPHY AND GEOLOGY

1.1 Regional Topography

The topography of the Study Area is divided into three main features, i.e. (1) the mountainous area which consists of volcanoes located in the south and northwest of the project region, (2) the higher hilly area located central to northeast and (3) the lower hilly area. The Gunung Halimum (El. 1,929 m) and the Gunung Endut (El. 1,297 m) compose the main part of the southern mountainous area trending eastwest direction. The northwestern mountainous area consists of volcanoes represented by the Gunung Karang (El. 1,778 m) which is situated on the surroundings of the Danau Caldera. In the southern side of Serang-Rangkasbitung-Pandeglang line are higher hills of 200 to 500 m in altitude and lowering towards the north (lower hills), finally alluvial plain spread in the northern coastal margin.

The Ciujung and Cidurian rivers are the main rivers in the region, which originate in the southern mountains. Both the rivers flow into the Java Sea after gathering tributaries; the Cisimeut and Ciberang rivers flow into the Ciujung river near Rangkasbitung and the Cibeureum river into the Cidurian river. In general, these rivers are strongly meandering and terraces are developed in a few relative heights on both the banks. Rivers which originate in the northwestern mountains are minor and finally flow into the Java Sea and the Sunda Strait.

1.2 Geology

The geology of the region consists of tuffaceous sedimentary rocks of Miocene to Pleistocene and volcanic rocks such as andesites, basalts, etc. which are intruded and/or erupted in the age of late Tertiary to Quaternary.

The formations of Miocene to Pleistocene are divided into several formations which are superposed monoclinically from south to north and from lower to upper horizons in order. They are mainly composed of fine to coarse tuffs and pumice tuffs with interbedding of lapilli tuffs in places. In the lower to middle Miocene and in the Pleistocene horizons, limestones are intercalated. The lower Pliocene formations include plant remains and silicificated wood remains. The stratigraphy of North Banten area is shown in Table D-1.

1.2.1 Structure

In general, beddings are dipping in low angles and gently folded. A fracture pattern of NNE-SSW trend and folding axis caused by oscillatory movement, are developed in the Miocene and lower Pliocene strata of the southern area. And in the marginal area of the northwestern mountains is a fracture pattern of NW-SE trend caused by the volcanic activities of the Danau Caldera.

1.2.2 Igneous rock

The southern mountains consist of volcanic breccias and andesite lavas of Pliocene and overlying Quaternary andesites (the Gunung Endut, etc.). The Quaternary igneous rock of the northwestern mountains is possible to divide into old volcanoes and young volcanoes at the event of the Danau Caldera. Basalts and andesites of Mokol-Gede-Tukung Volcano, Meramangblocks, Batukorut-Marikangen Volcano and Pajung Volcano are the old ones. These volcanic activities developed a dome and block-faulting and the center of the dome has subsequently collapsed forming a collapse caldera which has the distance of 13.5 km across in east-west and 15 km across in north-south. After the appearance of the caldera, vital activities of the young volcano has arised again in the south area of the caldera and its surroundings and Tompo-Malang Volcano, Aseupan Volcano and Parakasak Volcano, Pulasari Volcano and Karang Volcano were formed.

2. GEOLOGY OF DAM SITES

2.1 Karian Dam Site

2.1.1 General geology

Geology of the dam site is composed of the marine sedimentary rocks which belong to the Ciracap Beds of Pliocene. These rocks are composed of fine to coarse tuff and pumice tuff intercalated partially by the lapilli tuff and the random sediment of tuffaceous sandy shale. In most of the tuff and pumice tuff, gravels of andesite or basalt, 5 cm to 10 mm in diameter, are mixed. These rocks are generally soft. Especially part of the pumice tuff or the coarse tuff are remarkably soft. The geological map of dam site is shown in Fig. D-1.

Along the river more than 1 km upstream from the dam site, layers of conglomerate are distributed. These layers consist mainly of andesite pebble, less than 5 cm in diameter. Thickness ranges from 0.5 to 5 m. These layers have irregular contact surface with the adjoining layers. Hence, it is possible that these layers are the basal conglomerate, and that the lower layer is the Genteng Beds of lower Pliocene to upper Miocene.

Dip is almost horizontal without exceeding 15° except for a place which is thought to be influenced by fault. However, the geology as a whole shows the folding structure of the slightest degree.

By the observation of the air-photo, it is assumed that a structural line like fault exists along the river centering about the dam site. The meanders of the Ciberang river upstream from the dam site may have relation to the fault. By the results of reconnaissance, several lines of fault are confirmed. They are thought to have the causes of the complicated topography and meandering. These faults are of small size in view of the nature of rock, though full confirmation is not made yet.

Cracks and joints are seldom developed. At some places, development of cracks in the same direction and large cracks are observed. Such places are often accompanied by small streams which also run in the same direction.

On both banks of the river, the river terraces, 3 to 5 m high, are developed. Lower part of the terraces consists of gravel layer, 0.5 to 1 m thick, covered by layer of sandy silt which is 3 to 4 m thick. Colapse is seen on the foot of most of the terraces. The river-bed is covered by sand and gravel, 10 cm or less in diameter, which is assumed to be less than 1 m thick. Layers of top soil and talus deposit on both banks of the river are generally thin. Top soil layer is 0.5 to 1 m thick. Talus deposit is only seen near the small streams and low parts.

2.1.2 Topography and geology of Karian dam site

The Cibera river is flowing at the proposed dam site at El. 17 m with 30 m width in normal water level. River terraces are developed on both banks with relative height of 3 to 5 m and width of 10 to 20 m. Hill side slope on the left bank is ascending at angle of around 30° up to El. 45 m and gradually decreasing slope angle, finally to gentle angle of about 3° up to El. 60 m. On the right bank slope, it is rather steep, angle of about 45° up to El. 60 m and flatten to 5° slope in high elevation.

The dam site comprises of Cipacar beds of Pliocene marine formations. Major formation is fine- to coarse-grained tuff, partly intercalated with lapilli tuff and sandy shale of irregular sedimentation. Pumiceous and coarser-grained faces are often accompanied. These tuffaceous rock is generally soft rock, especially softer in pumiceous faces and coarse-grained faces.

General strike and dip is N80°W and 5°E, showing roughly horizontal and slightly dipping to the upstream direction of the meandered river channel. Joints and cracks are poorly developed in the tuff rock, having trends of N70°W, vertical and parallel to the bedding plane. There are possibly a tectonic line running along right bank of the river, though no actual fault has been found.

Weathered zone of the tuffaceous rock seems to be rather thin, 3 to 5 m thick on the slope and about 1.0 m thick on the riverbed.

Overburdens are top soil covering on the hill slope, talus deposits, terrace deposits developed on both river banks and riverbed deposits. Top soil is generally thin, 0.5 to 1.0 m thick. Talus deposits are found in some depression along ravines. Terrace deposits are riverside deposits of sand and gravel, covered by silty clay. Their thickness is around 0.5 to 1.0 m. Riverbed deposits are sand and gravel of less than 10 cm in diameter, covering riverbed in 2 to 3 m thick.

2.2 Cilawang Dam Site

General geology of the area centering about the Cilawang dam site and the reservoir area are similar to that of the Karian dam site. The geological map of dam site is shown in Fig. D-2.

The Cibeureum river is flowing at the dam site at El. 52 m. Normal river width is about 15 m wide. Small flat ground of 3 to 5 m higher than water level are developed on both banks, a kind of river terrace. Extension of river terrace is irregular and in small scale. The left bank slope is very gentle, around 5° up to El. 83 m. Right bank slope shows moderate angle of 23° up to El. 80 m and then, show gentler slope in higher elevation.

The dam site comprises of a series of marine sedimentary formations of Cipacar beds of Pliocene and Genteng beds of upper Miocene to lower Pliocene. A conglomerate layer (2 to 3 m thick) of round gravel of andesite, less than 5 cm in diameter, appears at the riverbed elevation. The layer is considered as basal conglomerate of the Cipacar beds. The Genteng beds is considered, therefore, to underlie the riverbed. The Cipacar beds are mainly composed of fine- to medium-grained tuff. Lowermost layer of lapilli tuff of 5 to 7 m thick is covering over the basal conglomerate. Major formation of the Genteng bed is possibly composed of fine- to coarse-grained tuff, though it is overlaid by the basal conglomerate.

Strike and dip of the Cipacar beds is N25°W, 10°E, with gentle dip to right bank side. These beds are generally folding gently. Joints and cracks are scarcely developed, though they trend to parallel to bedding. No fault has been found so far but there is possibly a tectonic line of direction of N30°E running through slide area at the upstream right bank side of the dam site.

Weathered zone of the base rock is generally thin as found in the outcrops. Their thickness is around 3 to 5 m on the slope and 1 m thick on the riverbed.

Overburdens on the base rocks are surface soil on the hill, talus deposits, terrace deposits on the river banks and bottom deposits on the riverbed. Surface soil is generally thin (0.5 to 1.0 m thick). Talus deposits are found in the concave slope and at the foot of a slope. Terrace deposit is scarcely developed around dam site. Riverbed deposits are considered to be 0.5 m thick.

2.3 Pasir Kopo Dam Site

General geology of the area centering about the Pasir Kopo dam site and the reservoir area are similar to that of the Karian dam site. The geological map of dam site is shown in Fig. D-3.

The Cisimeut river flows on the dam site at El. 52 m, having 20 to 25 m width. Both bank slopes rise up from the riverbed. Left side slope shows a gentle slope up to El. 70 m and again rises up to El. 120 m with angle of 30°, and then gentler slope is continued to rise. Right side slope shows steeper angle of 38° up to El. 100 m and then, continues 25° slope.

Base rock in the dam site is marine sedimentary rocks of the Cipacar beds of Pliocene. They are mainly lapilli tuff with intercalation of fine- and coarse-grained tuff.

The Cipacar beds are EW-strike and dipping 10° to N-downstream direction. Joints and cracks are scarcely developed, having two kinds of trend, N30°E, 55°E and N70°E, 80°E. No clear fault has been found so far, but some minor faults may be found along river bank and ravines.

Superficial weathered zone of the base rock will be generally thin, 3 to 5 m on the hill slope and 1 m on the riverbed.

Overburdens are surface soil, talus deposits and riverbed sediments. Surface soil is generally thin (0.5 to 1.0 m thick), though a little thicker on the left bank slope. Talus deposits are scarcely found, except in lower skirts of the slopes. Riverbed sediments are sand and gravel less than 20 cm in diameter. Their thickness will be 0.5 to 1.0 m.

2.4 Bojongmanik Dam Site

General geology of the Bojongmanik dam site, reservoir and adjacent areas are similar to that of the Karian dam site. The geological map of dam site is shown in Fig. D-4.

The Ciujung river flows in the Bojongmanik dam site at El. 42 m, having 25 m width. A river terrace of 20 m in width and 3 to 5 m higher than water level is developed on the left bank. Left bank slope rises with 10° angle up to El. 60 m and then rises with 30° angle up to El. 90 m, and again continues rising with 10° angle. Right bank slope rises with 30° angle up to El. 75 m, and then with 10° angle rising higher.

Base rock in the dam site is soft marine sedimentary rocks of the Cipacar beds in Pliocene. They are mostly fine- and coarse-grained tuff with intercalations of lapilli tuff and sandy shale.

The Cipacar beds show gentle warping ranging in N60°-80°E, 8-15°W. Joints and cracks are scarcely developed in the beds, though N30°-60°W, 90° trends are prevailing. No clear fault has been found so far but some minor faults may be found in further survey.

Superficial weathered zone of the base rock will be generally thin, 3 to 5 m thick on the hill slope and 1 to 1.5 m thick in the riverbed.

Overburdens are surface soil, talus deposits, terrace deposits and riverbed sediments. Surface soil is generally thin, 0.5 to 1.0 m thick. Talus deposits are only found in lower parts of the left side slope. Terrace deposits comprises of silty clay extending on the left bank. Riverbed sediments are gravel and sand, less than 10 cm in diameter. Their thickness will be 1.0 to 1.5 m.

2.5 Gadeg Weir Site

The geology of the vicinity of the Gadeg weir site including the reservoir area is similar to that of the Karian dam site. The geological map of weir site is shown in Fig. D-5.

The Cibeureum river flows on the Gadeg weir site at El. 25 m with 15 to 20 m width. Big river terraces are extending on both banks. Hill slopes on both side of the river are rising up to El. 50 m with angle of 20 to 30° and continue rising on gentler slope.

Base rock of the weir site is the Cipacar beds of Pliocene. They are rather soft marine sedimentary rocks, having general strend of NS, 12°W. The Cipacar beds are mostly fine- and coarse-grained tuff, intercalating lapilli tuff and irregularly laminated sandy shale.

Joints and cracks are rarely developed. Though there is few fault found in the site, it is possible that minor fault may exist along meandered river channel.

Superficial weathered zone of the base rock can be assumed to be 3 to 5 m thick on the hill slope and 1 m on the riverbed.

Surface soil and talus deposits are thinly covering hill slope, 0.5 to 1.0 m in thickness. River terrace deposits of silty clay are well developed on both banks of the river. Lower terraces on both banks are about 5 m thick and higher terrace on the right bank is 3 m in thickness. Riverbed deposits are sand and gravels finer than 10 cm in diameter and 0.5 to 1.0 m in thickness.

2.6 Cibanten Dam Site

2.6.1 General geology

Geology of the Cibanten dam site including the reservoir area is composed of two elements. One is volcanic rock mainly consisting of andesite of lower Pliocene or Miocene, and the other is marine sedimentary layer of lower Pleistocene or upper Pliocene which cover the volcanic rocks. Outcrops of andesite is seen on the riverbed, hence andesite is assumed to be distributed underneath the riverbed though extent of distribution is unknown. Above the andesite bed, tuffaceous rocks mainly consisting of pumice tuff are distributed. In the pumice tuff, andesite gravels, 5 to 10 mm in diameter, are mixed as shown in Fig. D-6.

Andesite is hard and compact though joints and cracks in N50°E, 90° or N20°W, 70-80°E directions are observed notably. Tuffaceous rocks are generally soft and cracks are few. In the contact part of andesite and tuff, there are at some places layers of conglomerate of andesite gravel. Gravels are 2 to 3 cm in diameter and the layer is 2 m thick or less. The contact parts of andesite and tuff is compact and water is impermeable through them. The more irregular the surface is, the more compact the contact parts are.

There are flat surfaces on the both banks. They are 1 to 5 m wide and 2 to 3 m high. They are thought to be formed as the contact surface of andesite and tuff. River terrace is hardly seen. The surface layers that cover all of the hilly part will be as thin as 0.5 to 1 m.

2.6.2 Topography and geology of Cibanten dam site

The Cibanten river at the dam site flows at El. 78 m with 15 m width. There are scarcely developed river terrace. Hill slopes on both side are rising from river bank up to El. 105 m with 20 to 25° angle and continue to gentler slopes.

Base rocks at the dam site is andesite of lower Pliocene or Miocene and overlaying pumice-rich, fine- to medium-grained tuff. The former develops over riverbed and lower level of river bank. The latter develops over hill slopes. Their transitional boundary is irregularly horizontal, partly accompanying agglomerate of 2 to 3 cm in diameter clastics and partly hard semi-welded tuff. Overlaying tuff has no outcrop, it seems to be nearby horizontal bedding.

Joints and cracks are well developed in the andesite, but less in the tuffaceous rocks. Major joint system in the andesite is N50°E, 90° and N20°W, 70-80°E. Minor joint system in the tuffaceous rock is N10°-20°W, 90° and N50°-60°E, 70°E-90°. Faults are not yet found so far. But meandering of the river and minor topography might be affected by concealed minor fault.

Superficial weathered zone of bed rock is rather thin, 3 to 5 m thick on the hill slopes and 1.0 m on the riverbed.

Overburdens including surface soil, talus deposits and river bottom sediments are also considered to be thin, 0.5 to 1.0 m thick in surface soil, talus deposits scattered in skirt of hill slope and in concave slope. River bottom sediments are supposed to be around 1.0 m thick.

2.7 Cidanau Dam Site

2.7.1 General geology

In the vicinity of the Cidanau dam site including the reservoir area, the geology consists of the marine sedimentary layer composed of medium to coarse tuff of lower Pleistocene or upper Pliocene, and andesitic lava which is distributed in the area about 400 m upstream from the dam site. It is uncertain whether the andesitic lava is older than the medium to coarse tuff. This andesitic tuff would possibly be older volcanic rock of Pliocene and Miocene. Then it is assumed that there is a fault about 400 m upstream from the dam site and the upstream part therefrom was lifted up. River terraces are rarely seen, and the covering layer and the riverbed deposits are very thin as shown in Fig. D-7.

2.7.2 Topography and geology of Cidanau dam site

The Cidanau river at the dam site flows at El. 28 m with 30 m width. There are scarcely developed river terrace. Hill slope on the left bank side is rising up to El. 70 m with 30° angle and then continues to gentle slope. Right bank slope is rising up to El. 85 m with 15° angle.

Base rocks prevailing in dam site is soft, marine sedimentary rocks of lower Pleistocene or upper Pliocene. An agglomerate with bigger clastics is found in an outcrop at the dam site. It can be an extension of andesite cropped out at about 400 m upstream. These andesites may, therefore, spread on the riverbed or in very shallow underground. Overlaying plio-pleistocene tuffaceous rock has bedding of N15°E, 25°W. Old slope failures are observed on the right bank, up- and down-stream of the dam site. Upstream slope failure is considered to have occurred by fault.

Joints and cracks in the tuffaceous rock are not so many. Joint system is N75°W, 30°E and N15°-30°W, 70°E-90°. Abundant joints and cracks are observed in andesite.

Superficial weathered zone of the bed rock is rather thin, 3 to 5 m thick on the hill slope and 1 to 1.5 m thick on the riverbed.

Surface soil on the hill slope is also thin, 1.0 m thick. Talus deposits are observed only at the slope failure mentioned above at its lower edge. Riverbed deposits are sand and gravel, with diameter of less than 5 to 7 cm. Thickness of the deposits can be assumed to be 1 to 2 m.

2.8 Kali Anyer Dam Site

The dam site is selected in the hill area. The dam will be abutted on hill slope of 15° angle.

Base rocks at the dam site is soft marine sedimentary rocks. They are mostly lapilli tuff, including scattered limestone boulder. These limestone has corrosion cavity and open cracks and loosely cemented. The lapilli tuff shows bedding of N40°E, 15°W and gentle warping. Joints and cracks are generally scarce, but columner joints is developed in some part. No big fault is found but minor fault may possibly be found underground.

Superficial weathered zone of the base rock is rather thin, 3 to 5 m thick on the hill slope and 1 to 1.5 m on the riverbed. Surface soil, talus deposits and riverbed sediments are also considered to be thin.

2.9 Waterway Tunnel Site

The waterway to connect Karian reservoir and Cibeureum will run for about 1 km which consists solely of tunnel. General geology of the vicinity of the tunnel site is similar to that of the Karian dam site.

Topography around the tunnel site shows a gently sloped hilly topography. Height from the tunnel to the ground surface ranges from 45 to 7 m.

Geology which the tunnel will encounter will be the marine sedimentary layer which belongs to the Cipacar beds or Genteng beds of Pliocene. Rocks are fine to coarse tuff intercalated partially by pumice tuff and lapilli tuff. Rocks are generally soft. Especially, parts of pumice tuff and coarse tuff are very soft. Although unconfirmed yet, the bedding is considered to be nearly horizontal. No fault is confirmed, yet there is a possibility that faults will exist. Cracks and joints are generally few. Weathered zone will be thin as a whole. Thickness will be about 5 m (perpendicular to the slope surface). Top layers will be as thin as 1.5 m at the maximum.

Geology of the tunnel site which connects between the Cilawang reservoir and the Cicinta river is similar to that of the Karian dam site. Although, the depth from the tunnel to the ground surface is rather shallow ranging from 25 to 5 m.

The topography and geology of each dam site are summarized in Table D-2.

3. GEOTECHNICAL CONSIDERATIONS

3.1 Strength and Permeability of Base Rocks

Base rocks of all dam sites and tunnel routes in the Study Area are tuffaceous rocks of plio-pleistocene, except those found at riverbed ofthe Cibanten dam site being composed of andesite. Physical aspects of the tuffaceous rocks are described in the following articles.

3.1.1 Physical strength

Tuffaceous rocks in the Study Area are less cracky and generally are classified as soft rock. Their physico-mechanical properties can be summarized in the ranges below.

Variety of Tuff	Strength	Shearing Strength τ_o	Angle of Internal Friction φ	Modules of Elasticity E
Pumice Tuff	low-strength	2 km/cm^2	30°	2,000 kg/cm^2
Coarse-grained Tuff	↓	↓	↓	↓
Sandy Mudstone or Medium- to Fine-Grained Tuff	↓	5 km/cm^2	35°	15,000 kg/cm^2
Lapilli Tuff	higher strength			

Shearing strength of andesite rock, exposed on the riverbed at the Cibanten dam site, can be assumed to be τ_o of 15 to 20 kg/cm^2 according to its rock facies and cracky habits.

3.1.2 Permeability

Tuffaceous bed rock can be considered less permeable because it is scarcely cracked. Permeability coefficient in fresh bed rock can be assumed in the order of 10^{-5} cm/sec and average shearing strength be 3 kg/cm^2. These assumptions are already confirmed in a series of studies carried out by foregoing investigation done by DPU Team. Some of pumice tuff and coarse-grained tuff are less consolidated and some lapilli tuff shows cracky habits. They may have a little higher permeability coefficient.

3.2 Geotechnical Considerations on the Dam Construction

3.2.1 Scale and type of dam

Scale of dam can be decided by topography and bearing capacity of the foundation rock. Most of the dam sites in the Study Area are located on rather soft tuffaceous rocks. Bearing capacity and scale of dam are discussed in this article.

As shearing strength of the tuffaceous rocks in the Study Area can be assumed as 30 to 50 ton/m^2, allowable height of concrete gravity dam will be less than 20 m. In case of special design, such as wedge type, fillet type or base mat type, it is possible to design dam of more than 20 m in height. In case of fill type dam, higher dam can be designed.

In selection of dam type, fill type dam is desirable on rather soft foundation. Availability of embankment material in quality, quantity and transportation are also another important conditions for type selection. Recommendable type of dam are proposed as follows:

Karian Dam:	Fill type
Cilawang Dam:	Concrete gravity or fill type
Gadeg Weir:	Concrete gravity or fill type
Pasir Kopo Dam:	Fill type
Bojongmanik Dam:	Fill type
Cibanten Dam:	Concrete gravity type
Cidanau Dam:	Concrete gravity or fill type
Kali Anyer Dam:	Concrete gravity or fill type

3.2.2 Embankment materials and concrete aggregates

Availability and quality of earth, sand and gravel and rock materials were surveyed for the purpose of embankment of fill dam and concrete aggregates of concrete dam, tunnel lining and appurtenant structures.

Earthy materials cannot be expected from thin overburden on the hill slope. They can be expected from river terraces those develop on both sides of upper and middle reaches of the Ciujung, Cisimeut, Ciberang and Cibeureum rivers in the southeast range of the Study Area. These well developed terraces are generally 3 to 6 m higher than riverbed and silty clay of 1.5 to 3.0 m in thickness is covering their surface.

On the other hand, terrace deposits are not developed in the smaller rivers in the northwest region of the area, where the Cibanten, Cidanau and Kali Anyer dams are located. Supply of earthy materials for embankment of these dams are very difficult.

Sand and gravel materials are available in riverbed and terrace deposits, though mostly expected from the terraces. Sand and gravel layer of 1 to 3 m in thickness is covered by the superficial silty clay layer. They are originated from volcanic rocks those prevail in the upland. Their grain size are mostly 5 to 10 cm in diameter, sometimes mixed with boulders of 30 cm in diameter.

These borrow pits and quarry sites are tentatively selected in this stage of planning. Construction materials required in each dam and tunnel will be sufficient in their qualities and quantities, though detailed investigation should be carried out in feasibility study stages for individual dam project. Embankment material and concrete aggregate required by dams and tunnels in the Study Area are summarized in Table D-3.

3.2.3 Reservoir area

Three major problems in the reservoir area are discussed: possibility of landslide, leakage of reservoir water to outside basin and inundation over mineral resources exploitation activity, if any.

Five dam sites in the southeast regions and three dam sites in the northwest region have common circumstances, respectively. Following discussions are summarized in two major regions.

Among five dams in the southeast region, there are few large scale landslides, except three or four small scale slides, 30 to 50 m along the river channel. Two slides along the upper Pasir Kopo seem to be affected by existing tectonic line. Country rocks prevailing in this region have thin overburden and weathered zone and are less distorted by tectonic activity, resulting very few slide failure. On the other hand, lateral erosion often attacks at the edge of river terrace deposits. It may cause silt deposition in the future reservoir.

There may be some fault lines cutting saddle portions on the catchment ridges of the five reservoirs in the southeast region. Some leakage of reservoir water can be considered through these faults if the saddles are steep and thin. These saddle topography shall be carefully investigated in future stage of feasibility study and detailed design. Some limestones are reported to occur in the lower and middle Miocene formations. But all the proposed reservoirs are located in the upper Miocene formations. Leakage through limestone cannot occur.

Geological formations covering the southeast region are quite similar to those in the Palembang formations in the South Sumatra, where lignite and petroleum have long been exploited. Correlation study shows that the area covering the Karian and Cilawang dam sites is corresponding to the Palembang formation. Aereal reconnaissance survey, however, shows no indication of coal and oil, except small lenticular coal seam and trace of oil indication found in the downstream reach of the Gadeg weir site. There has never been record or fact of production of coal or oil in the past. It is concluded that there is no workable fuel mineral resources in the southeast region.

There is no large-scale landslide at present and in future in the three dam sites in northwest region, except an old slope failure on the right bank slope, upstream of the Cidanau dam site. Bank erosion is not so serious in these three rivers in the northwest region. There is no serious problem in leakage of reservoir water in the Cibanten and

Cidanau dam projects. Tuff formation around the Kali Anyer dam site contains many limestone blocks and fragments which have corrosion cavities and open cracks. Possibility of leakage along the tuff layer shall be further investigated.

Geological conditions in the reservoir areas of three dam sites are all barren in mineral resources and nothing to do with future mineral exploitations development.

3.3 Geotechnical Consideration in Waterway Tunnel Construction

Two tunnel excavations for waterway are proposed in the Study Area. The tunnel routes are laid out in very similar topography and geology. There is no serious problem in ground conditions.

Tuffaceous rock is prevailing all along the tunnel route. It is rather soft but stable, neither cracks nor joints in texture, containing no swelling clay, and is very easy to be excavated. It is crackless and poorly permeable, giving few seepage or gush water during and after excavation.

It is important to point out that the two tunnel routes will pass through under shallow underground and maximum depth is 45 m in the Karian tunnel and 25 m in the Cilawang tunnel. Most of the tunnel will be driven in several to less than 10 m underground. Careful excavation and ceiling support should be provided in excavation. Selection of tunnel route should be carefully studied in further stage of feasibility study and detailed design.

The location of each dam site is shown in Figs. D-8 to D-11.

4. CONTROVERSIAL POINTS AND RECOMMENDATIONS FOR FURTHER GEOTECHNICAL INVESTIGATION

4.1 General

Overall geological survey reveals that the selected dam sites and water tunnel routes are feasible for the development of water resources in the Study Area. Construction scale and type of these dams as well as construction materials are carefully studied and selected based on the topographical and geological circumstances.

Further controversial points to be studied in the subsequent feasibility study and detailed design are proposed in this article. Study procedures are proposed in the Karian and Cilawang dams, Gadeg weir, waterway tunnel connecting future reservoir created by the Karian dam and Gadeg weir, and waterway tunnel connecting the Cilawang reservoir and Cicinta river.

4.2 Controversial Point to be Studied Further

(1) Confirmation of detailed geological conditions of each dam site

Detailed geological feature and structure should be studied by surface geological survey including test core drillings.

(2) Measurements of mechanical properties of the bed rock in each dam site

Tuffaceous rock formations which occupying almost all dam sites in the Study Area rather soft rock faces and their physical and mechanical properties should be carefully studied for detailed design and treatments in construction works. Rock mechanical tests on all faces found in base rock formation in each dam- and structure-site. Andesite flow is found in the riverbed of the Cibanten dam. It is very sound foundation for a low dam, which requires no severe rock mechanical conditions.

(3) Permeability of the bed rock at each dam site

Tuffaceous rocks, prevailing almost all dam sites in the Study Area, are generally less permeable. But some members of coarse-grained and pumiceous tuffs may be more or less permeable. Permeability tests on these tuffs are necessary against its possible leakage. In these permeability tests, it is important to measure allowable pressure to be applied in such a less-consolidated rock. These allowable pressure will be applied to grout treatment of foundation rock during construction stage.

Andesite rock itself is hard and compact, but joints and cracks developed in the rock mass which may affect to increase permeability of the rock body. In situ permeability tests and natural groundwater observation should be carried out in the test bore holes.

(4) Availability and quality of the embankment materials

As for supply source of embankment material, clay, sand and gravel can be expected in the terrace deposits developed along upper reaches of the river. Source of rock material can be expected in the andesite and basalt area, located in the upstream hill area. These borrow pits or quarry sites should be carefully investigated by means of detailed geological survey, test drillings, test pitting and geophysical exploration to confirm their quality and quantity. Some material should be studied at laboratory test and in situ quality tests for the purpose.

(5) Geological conditions along water tunnel route

For excavation of waterway tunnel, geological conditions along the tunnel route and distribution of overburden and weathered conditions around inlet and outlet of the tunnel should be carefully studied by means of test drillings or geophysical exploration. Groundwater level observation and permeability test are also necessary for the purpose. Detailed geological survey items are summarized in Table D-4.

Table D-1 STRATIGRAPHY OF NORTH BANTEN AREA

Age	Stratigraphy	Composition	Thickness (m)
Holocene	Holocene Volcanoes		
Pleistocene			
Upper Middle	Terrace deposits. Volcanoes formed after block-faulting and collapse of the Danau complex.		
Lower	Bojong Beds (and part of Cikeusik Beds in SW Bantam)	Glauconite, tuffaceous, more or less Sandy marls, with Limestone lenses. Pumice tuffs, Basal conglomerates	200
Pliocene			
Upper	Cilegong Beds (Pumice tuff with marine inter-callations) and part of the Cikeusik Beds	Pumice tuffs	50
		Pumice tuffs, rich in hornblende	60
		Pumice tuffs	40
		Pumice tuffs, rich in biotite	50
Middle	Cipacar Beds	Upper part; tuffaceous glauconitic marls, clay, sandstones, andesitic breccia. Lower part; pumice tuffs	400
Lower	Genteng Beds	Pumice tuffs, rich in plant remains and silicified wood.	730
Miocene			
Upper		Intrusions of hornblende andesite	
Upper part of the Middle Miocene	Bojongmanik Beds	Marls and clays with browncoal, tuff sandstone, andesitic gravels. In the upper part also pumice tuffs.	
Lower to Middle Miocene	Badui Beds (and Lower Bojongmanik Beds)	Limestone, marls, clay-shales, Basal andesitic conglomerates and sandstones	
Lower	Sareweh Beds Cimadag Beds Citarate Beds		

Table D-2 TOPOGRAPHY AND GEOLOGY OF DAM SITES

Name of Dam	Topography	Geology: Rock Quality	Geology: Tectonic	Geology: Weathering	Geology: Surface Layer
Karian Dam	River bed; 20 m wide El. 17 m Slope ; Leftside 15°-30° Rightside 45° Terrace ; 3 - 5 m high from river Left 10 m, right 20 m wide	Fine-coarse tuff including Pumice tuff, Lapilli tuff & Sandy shale	Bedding N80°W5°E Crack or joint N70°W90° N80°W5°E assumed fault	River bed 1 m Slope 3 - 5 m	River bed Gravel 2 - 3 m (mainly less than 10 cm in diameter) Slope 0.5 - 1 m
Cilawang Dam	River bed; 15 m wide El. 52 m Slope ; Leftside 5° Rightside 23° Terrace ; 3 - 5 m high from river	Fine-medium tuff Conglomerate Lapilli tuff	Bedding N25°W10°E Crack or joint N25°W10°E assumed fault	Riber bed 1 m Slope 3 - 5 m	River bed Gravel 0.5 m (mainly less than 10 cm in diameter) Slope 0.5 - 1.0 m
Pasir Kopo Dam	River bed; 20 - 25 m wide El. 52 m Slope ; Leftside 30° Rightside 25°-35°	Lapilli tuff including Fine-coarse tuff	Bedding EW10°N Crack or joint N30°E55°E N70°E80°E assumed fault	River bed 1 m Slope 3 - 5 m	River bed Gravel 0.5 - 1 m (mainly less than 10 cm in diameter) Slope 0.5 - 1 m
Bojongmanik Dam	River bed; 25 m wide El. 42 m Slope ; Leftside 10°-30° Rightside 30° Terrace ; 3 - 5 m high from river Left 20 m wide	Fine-coarse tuff including Pumice tuff, Lapilli tuff & Sandy shale	Bedding N60°-80°E 8°-15°W Crack or joint N30°-60°W90° assumed fault	River bed 1 - 1.5 m Slope 3 - 5 m	River bed 1 - 1.5 m (mainly less than 10 cm in diameter) Slope 0.5 - 1 m
Gadeg Weir	River bed; 15 - 20 m wide El. 25 m Slope ; Leftside 20°-30° Rightside 30° Terrace ; 5 - 10 m high from river Left 20 m wide Right 80 m wide	Fine-coarse tuff including Pumice tuff, Lapilli tuff & Sandy shale	Bedding NS12°W Crack or joint a few	River bed 1 m Slope 3 - 5 m	River bed Gravel 0.5 - 1 m (mainly less than 10 cm in diameter) Slope 0.5 - 1 m
Cibanten Dam	River bed; 15 m wide El. 78 m Slope ; Leftside 15° - 20° Rightside 25°	River portion Andesite Slope Fine-medium tuff	Bedding (tuff) Nearly horizontal Crack or joint Tuff-N10°W90° N50°E90° And.-N50°E90° N20°N80°E	River bed 1 m Slope 3 - 5 m	River bed 1 m Slope 0.5 - 1 m
Cidanau Dam	River bed; 30 m wide El. 28 m Slope ; Leftside 30° Rightside 15°	Medium-coarse tuff including Lapilli tuff (River portion: Andesite?)	Bedding N15°E25°W Crack or joint N75°W30°E N15°-30°W70°E -90° assumed fault	River bed 1 - 1.5 m Slope 3 - 5 m	River bed Gravel 1 - 2 m (mainly less than 7 cm in diameter) Slope 1 m
Waterway Tunnel	Depth from surface Karian: Maximum; 45 m, Minimum; 7 m Cilawang: Maximum; 25 m, Minimum; 5 m	Fine-coarse tuff including Pumice tuff & Lapilli tuff	Bedding Nearly horizontal Crack or joint a few	5 m	1 m

Table D-3 EMBANKMENT MATERIALS AND CONCRETE AGGREGATES

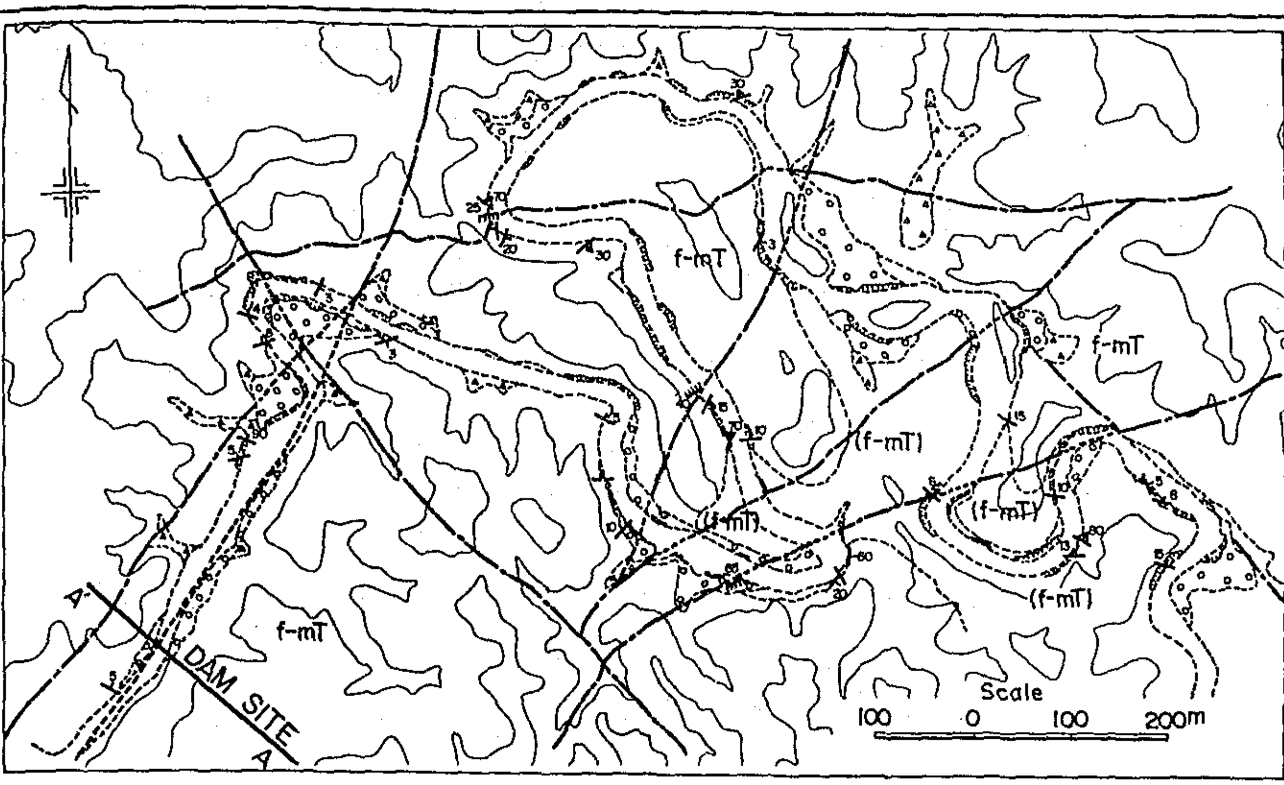
	Earth Materials		Sand & Gravel Materials		Rock Materials	
	Object	Location	Object	Location	Object	Location
Karian Dam	River terrace, Deposits	7 - 10 km upstream around Lebakpicung village	River terrace, Deposits	7 - 10 km upstream around Lebakpicung village	Andesite, Dyke	11 km upstream Gunung Sendi
Cilawang Dam	River terrace, Deposits	4 - 5 km downstream around Gadeg village	River terrace, Deposits	Southwest, 7 km Lebakpicung village	Andesite & Besalt, Dyke	10 km southwest Gunung Sendi, 10 km south Gunung Guradog
Gadeg Weir	River terrace, Deposits	Nearby dam site around Gadeg village	River terrace, Deposits	Southwest, 10 km Lebakpicung village	Andesite & Besalt, Dyke	14 km south Gunung Sendi, 14 km south Gunung Guradog
Pasir Kopo Dam	River terrace, Deposits	3 - 4 km upstream around Bonlarnaga village	River terrace, Deposits	3 - 4 km upstream around Bonlarnaga	Andesite, Lava	7 - 8 km southeast Gunung Monggurang
Bojongmanik Dam	River terrace, Deposits	Nearby dam site around Bunut village	River terrace, Deposits	Not available nearby	Andesite, Lava	10 km south Terongbuoe village
Cibanten Dam	Overburden on hill slope, River terrace	Nearby dam site a little short in quantity	Terrace & riverbed, Deposits	Nearby dam site a little short in quantity	Andesite	3 km northwest Pasir Leka village
Cidanau Dam	Overburden on hill slope, River terrace	Nearby dam site a little short in quantity	Terrace & riverbed, Deposits	Nearby a little short in quantity	Andesite	1 - 3 km upstream
Kali Anyer Dam	Overburden on hill slope	Nearby dam site a little short in quantity	—	Not available	Andesite	1 - 2 km south hill area
Waterway Tunnel (Karian-Gadeg)			Terrace & riverbed, Deposits	6 km upstream Lebakpicung	Andesite, Dyke	9 km upstream Gunung Sendi
Waterway Tunnel (Cilawang)			Terrace & riverbed, Deposits	Not available nearby	Andesite & Besalt, Dyke	10 km southwest Gunung Sendi, 10 km south Gunung Guradog

Table D-4 (1/2) DETAILED GEOLOGICAL SURVEY ITEMS

Survey Area		Survey Items & Amount	Purpose	Remarks
Karian Dam	Dam Site	Test Drillings A 6-hole, total 240 m	Subsurface study of over-burden, weathered zone and base rock	Already finished by DPU investigation team
		Test Drillings B 2-hole, total 80 m	Rock conditions of the base rock	Supplementary drillings to the above
		Permeability tests 25 nos. (each 3 m-section)	Measurements of permea-bility	Same as the above
		Groundwater level observation	Groundwater conditions	Observations at drill holes A and B
		Surface geological survey		Field survey
		Rock mechanical tests in laboratory	Rock mechanical properties of the bed rock	Clay, sand and gravel
	Embankment Materials (Clay, Sand and Gravel)	Geophysical Exploration 4-measure line, 4.0 km total	Distribution of clay, sand and gravel	
		Surface geological survey		Field survey
		Test Pittings 4-point	Subsurface quality and distribution	
		Material tests	Quality of the material on the samples taken	Clay, sand and gravel
	Embankment Materials (Rock Materials)	Test Drillings A 6-hole, total 210 m	Distribution and quality of the quarry	Around Gunung Guradog
		Test Drillings B 6-hole, total 210 m	ditto	Around Gunung Sendi
		Surface geological survey		Field survey
		Rock mechanical tests in laboratory	Physical qualities for embankment material and for concrete aggregates	
Cilawang Dam	Dam Site	Surface geological survey		Field survey
		Test Drillings 5-hole, total 190 m	Subsurface study of over-burden, weathered zone and base rock	
		Permeability tests 58 nos. (each 3m-section)	Measurement of permeability	At all test boring holes
		Groundwater observation		ditto
		Rock mechanical tests in laboratory	Tests are omitted. Data obtained at the Karian dam site can be applied in the case of Cilawang dam site.	
	Embankment Materials	Survey are omitted. The materials are common with those of the Karian dam.		

Table D-4 (2/2) DETAILED GEOLOGICAL SURVEY ITEMS

Survey Area		Survey Items & Amount	Purpose	Remarks
Gadeg Weir	Weir Site	Surface geological survey		Field survey
		Test Drillings A 4-hole, total 120 m	Subsurface study of over-burden, weathered zone and base rock	Already finished by DPU investigation team
		Test Drillings B 2-hole, total 60 m	Base rock conditions with permeability tests	Supplementary drillings to the above
		Permeability tests 18 nos. (each 30 m-section)	Measurement of permea-bility in the bore hole in bed rock	Supplementary measurements at the bore hole in Test Boring A
		Groundwater observation		Observations at the Test Drilling Hole A and B
		Rock mechanical tests	Tests are omitted. Data obtain at the Karian Dam site can be used, as the base rock is the same.	
	Embankment Materials	Survey are omitted.	The material are common with those of the Karian dam site.	
	Waterway & Tunnel (Karian - Gadeg)	Test drilling 7-holes, 260 m	Subsurface study of over-burden, weathered zone and base rock around inlet and outlet of the tunnel	Drillings are already finished by DPU investi-gation team
		Observation of ground-water	Groundwater conditions	Observations at all test bore holes
		Surface geological survey		Field survey
	Waterway & Tunnel at Cilawang	Test drillings 6-hole, 220 m	Subsurface study of over-burden, weathered zone and base rock around inlet and outlet of the tunnel	
		Permeability tests 20 nos. (each 3 m-section)		
		Groundwater observation	Groundwater conditions	Observations at all bore holes
		Surface geological survey		Field survey



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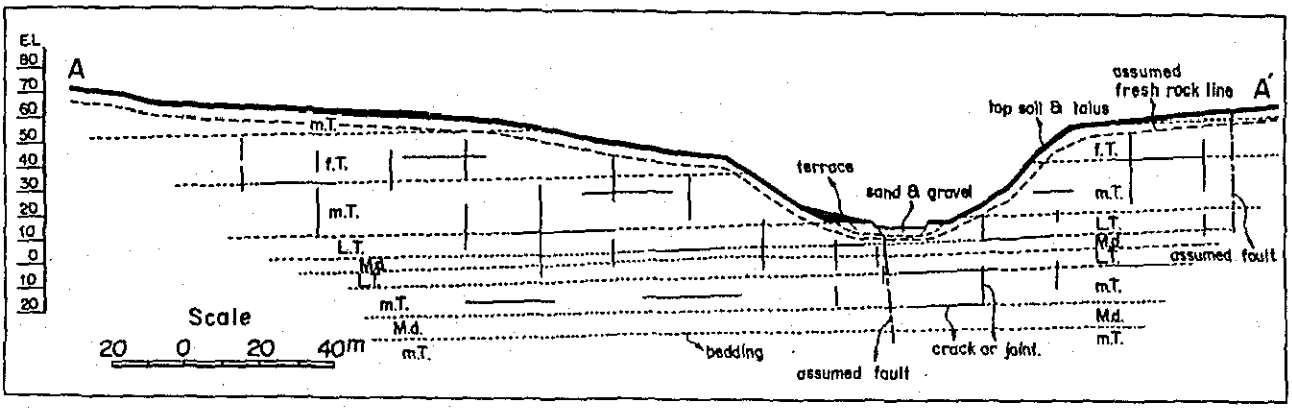

PROFILE OF DAM AXIS

LEGEND

- Topsoil & Talus Deposite
- Terrace Deposit
- f-mT Fine ~ Medium Tuff (Pliocene)
- fT Fine Tuff
- mT Medium Tuff
- LT Lapilli Tuff
- Md Sandy Shale
- (f-mT) Fine ~ Medium Tuff (Miocene)
- Bedding
- Joint or Crack
- Fault
- Assumed Fault
- Failure portion

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Fig. D-1 Geological Map of Karian Dam Site

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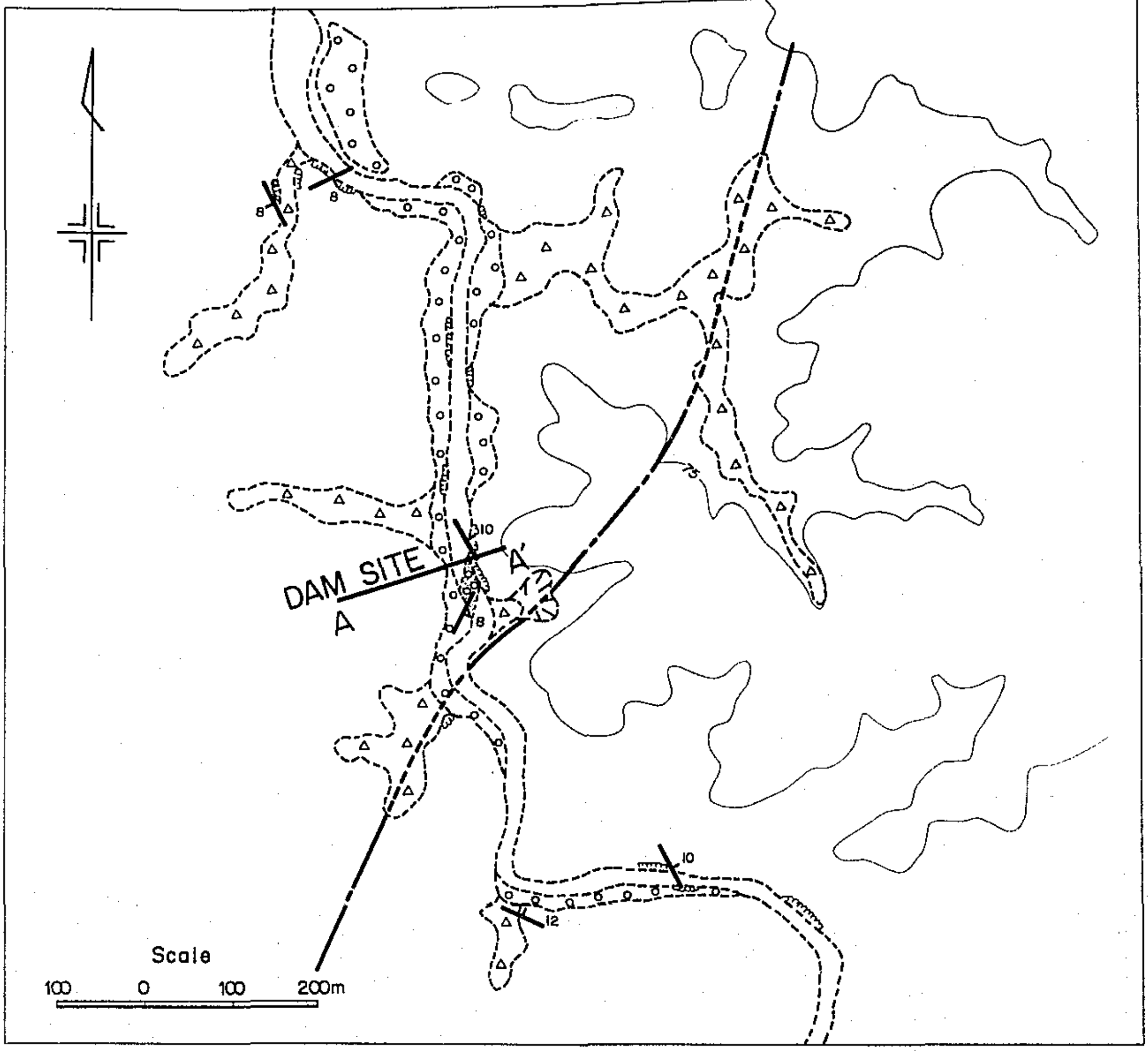

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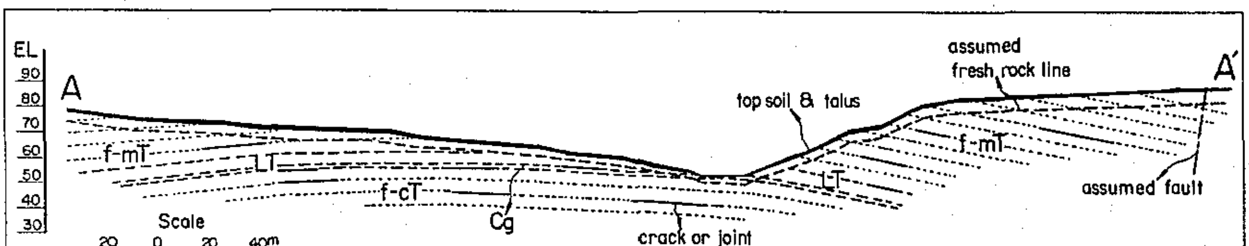

PROFILE OF DAM AXIS

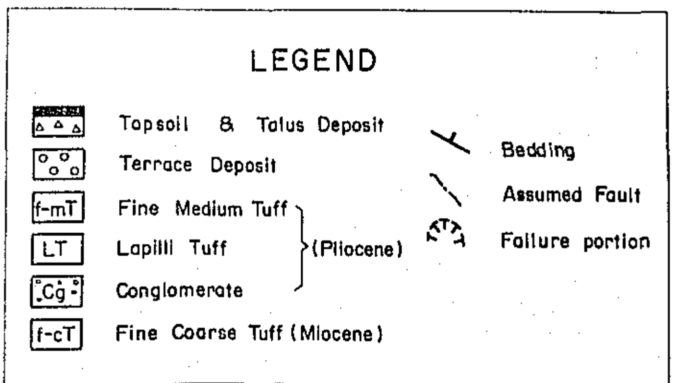

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Fig. D-2 Geological Map of Cilawang Dam Site

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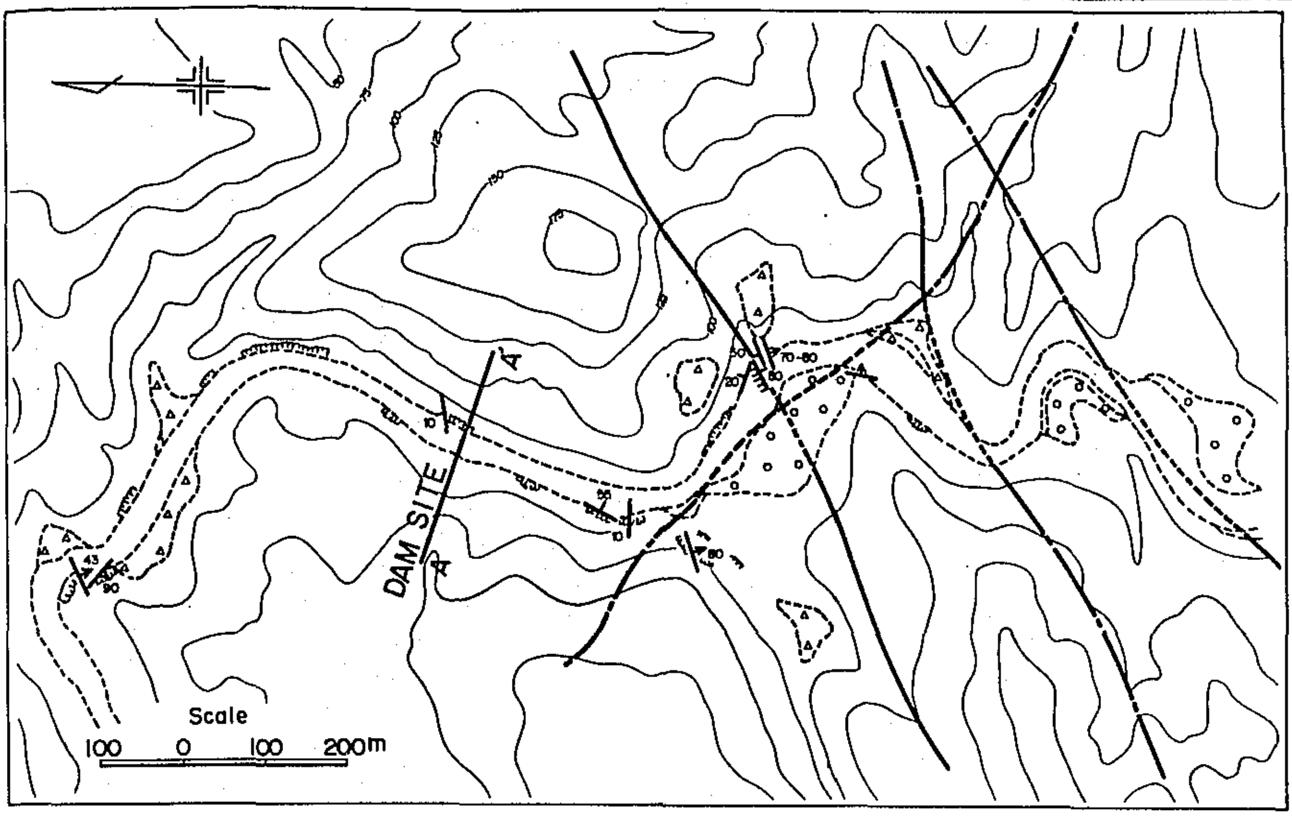

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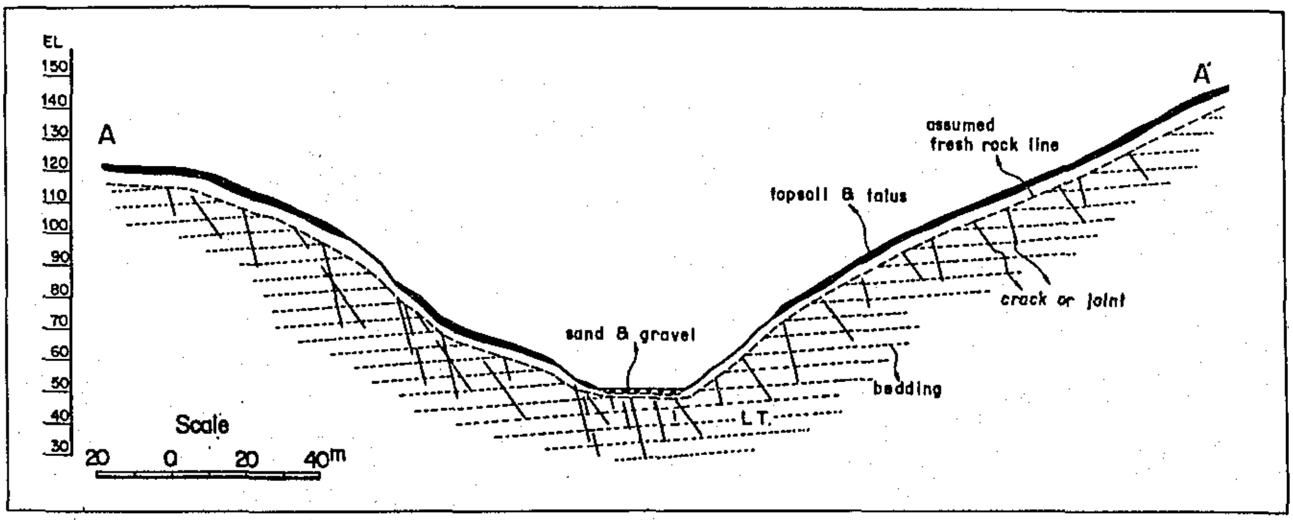

PROFILE OF DAM AXIS

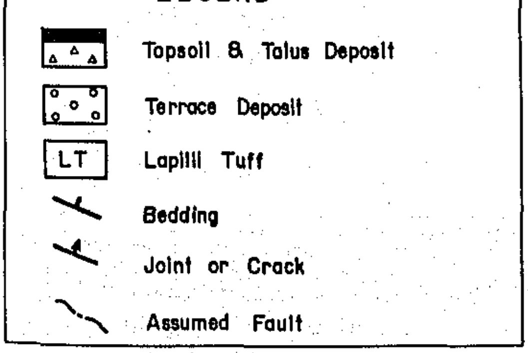

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Fig. D-3 Geological Map of Pasir Kopo Dam Site

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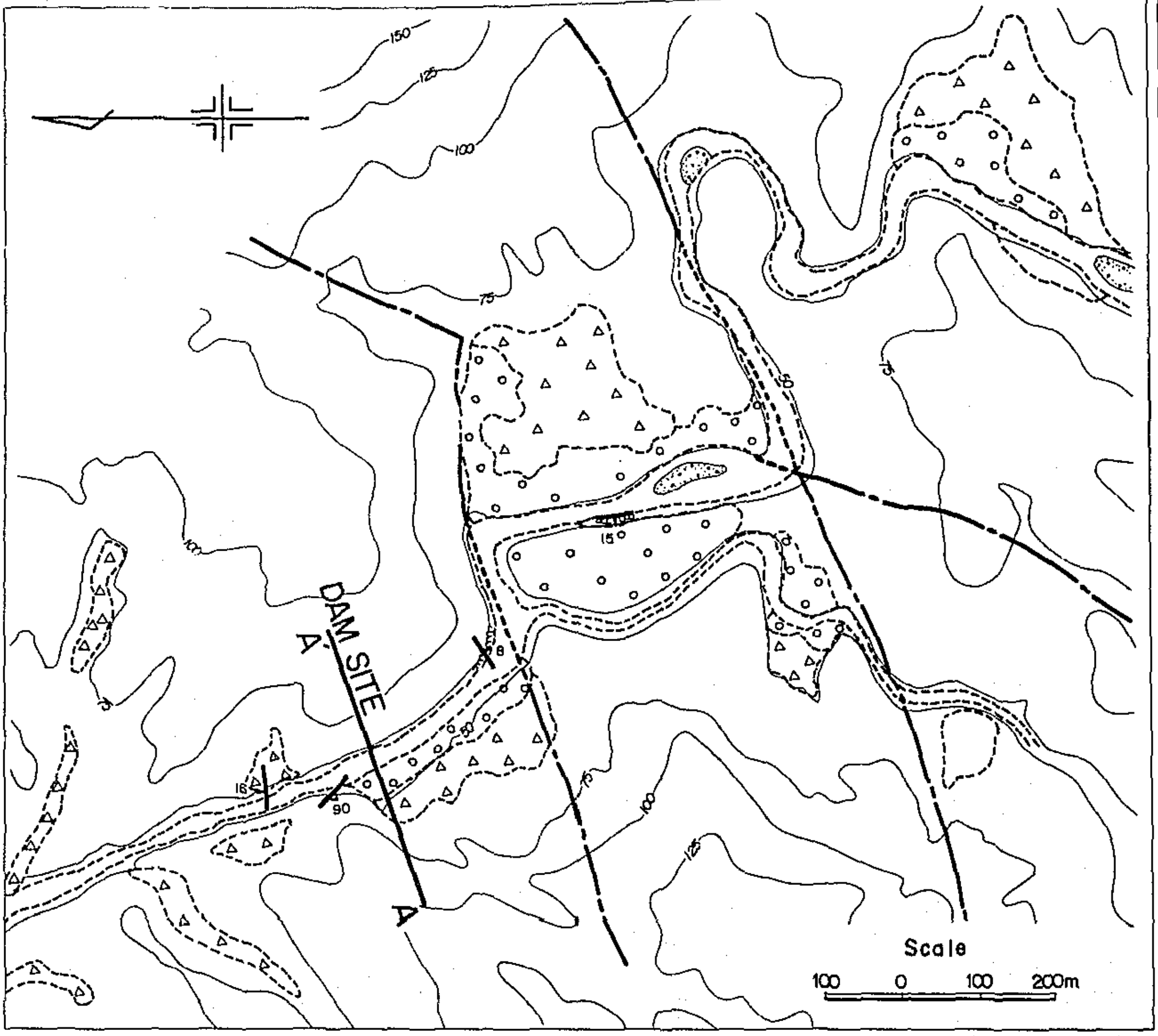

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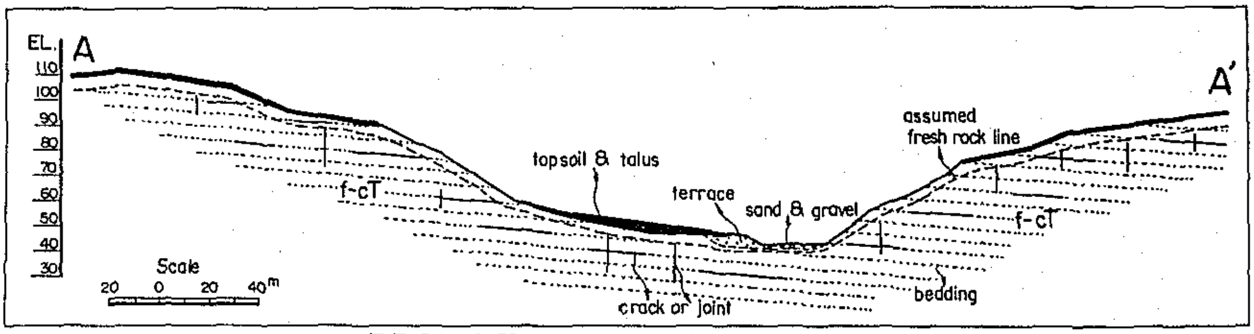

PROFILE OF DAM AXIS

LEGEND

- Topsoil & Talus Deposit
- Terrace Deposit
- f-cT Fine ~ Coarse Tuff
- Bedding
- Assumed Fault

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Fig. D-4 Geological Map of Bojongmanik Dam Site

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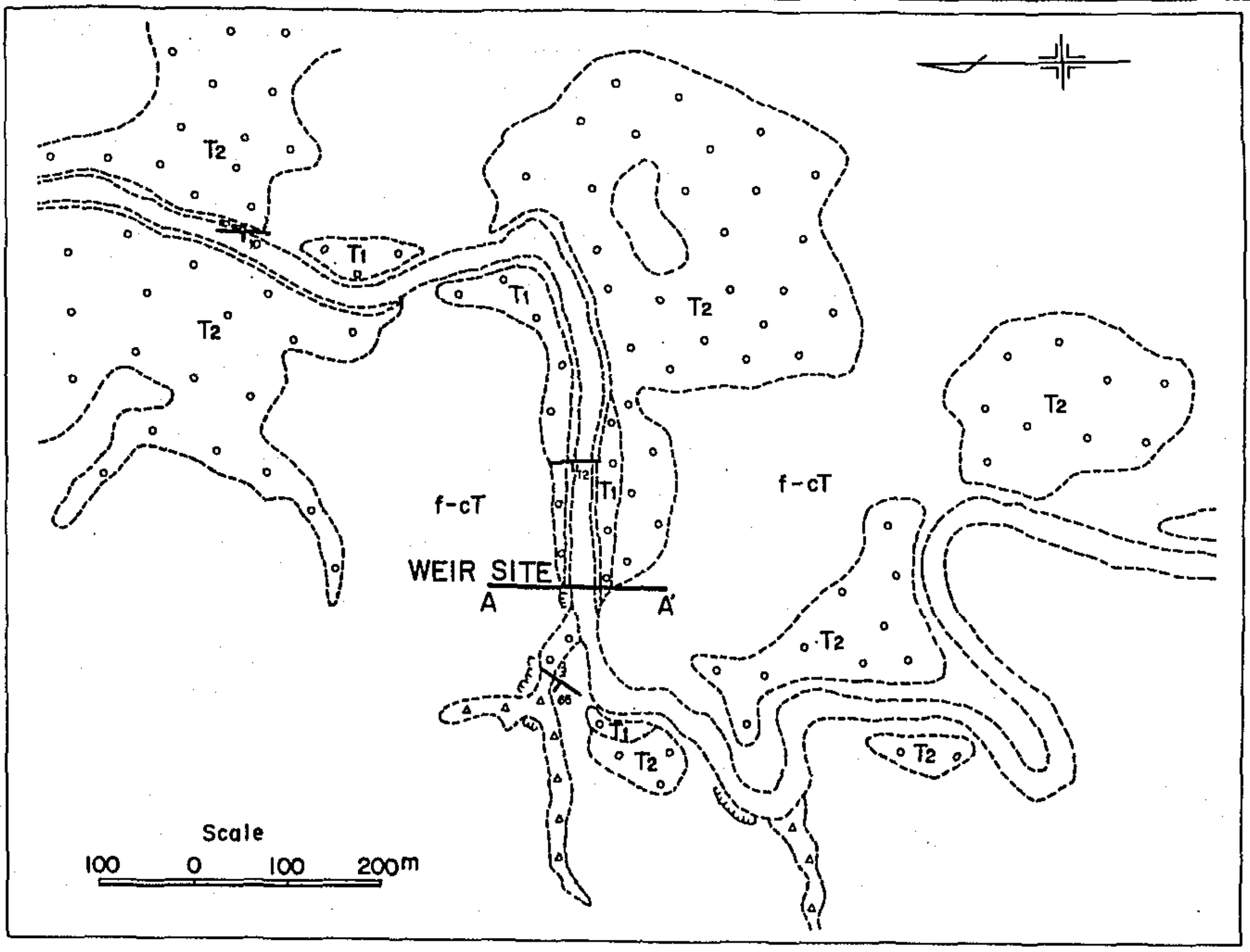

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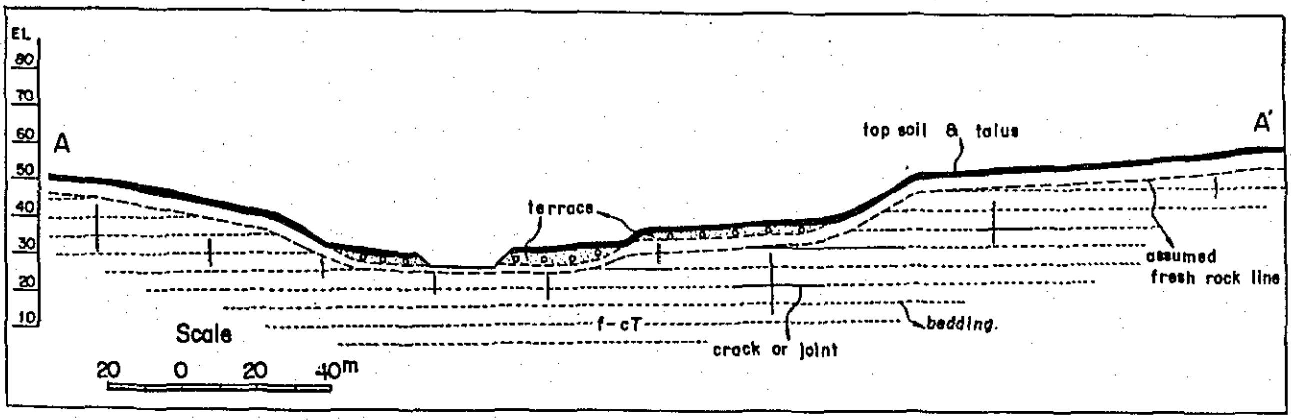

PROFILE OF WEIR AXIS

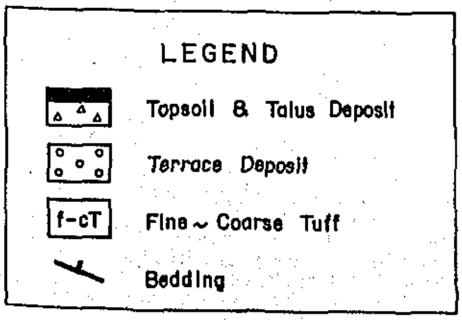

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Fig. D-5 Geological Map of Gadeg Weir Site

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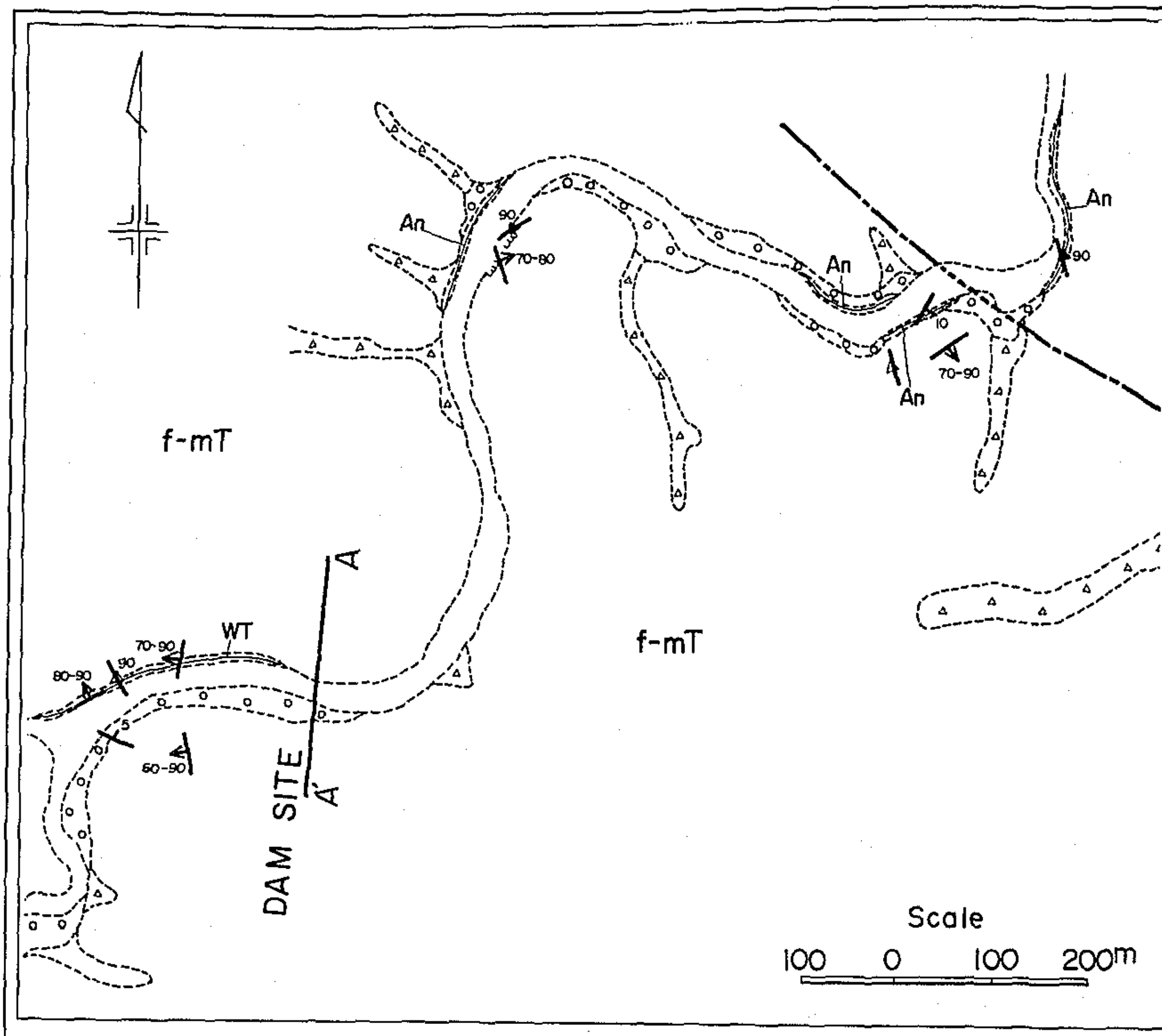

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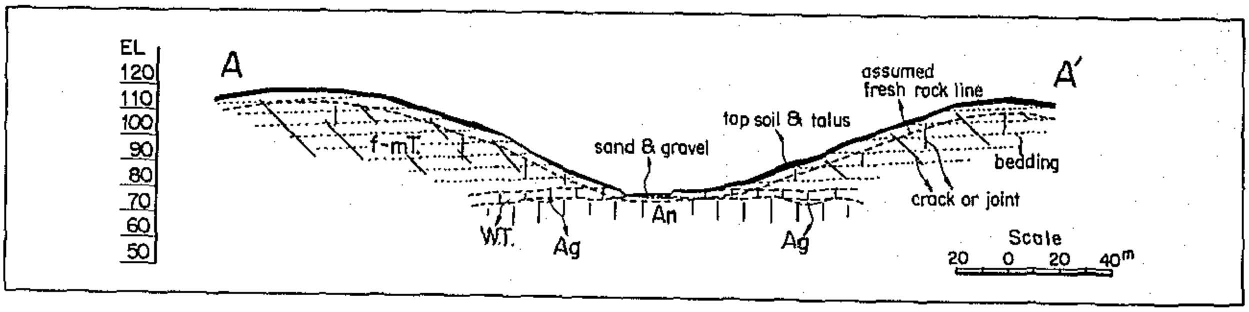

PROFILE OF DAM AXIS

LEGEND

- Topsoil & Talus Deposit
- Terrace Deposit
- f-mT Fine~Medium Tuff
- WT Welded Tuff
- An Andesite
- Ag Agglomerate
- Bedding
- Joint or Crack
- Assumed Fault

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Fig. D-6 Geological Map of
Cibanten Dam Site

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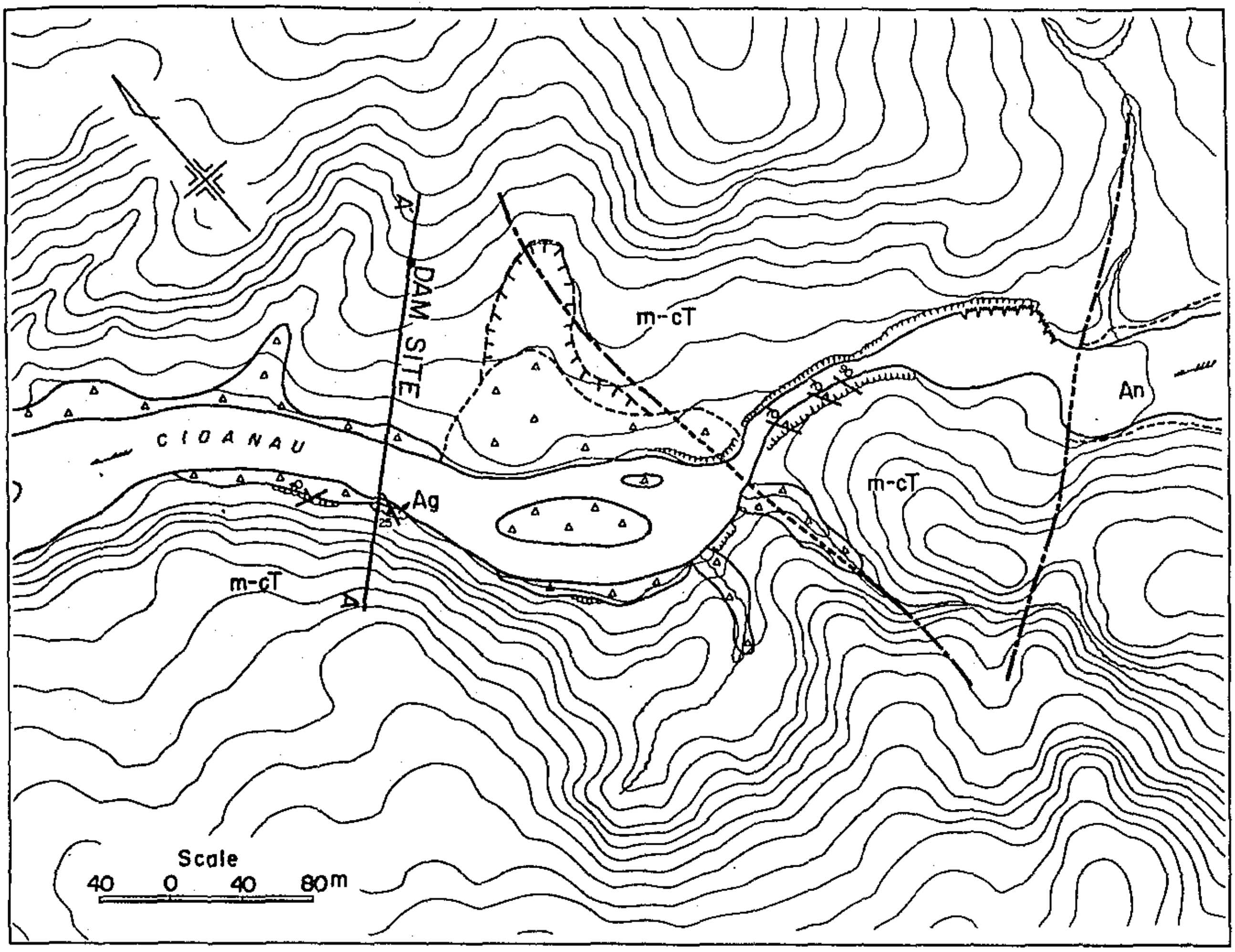

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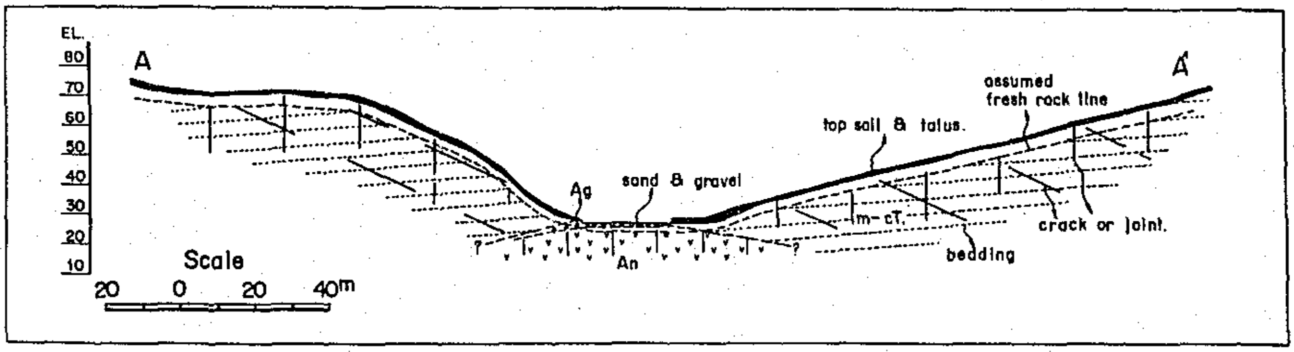

PROFILE OF DAM AXIS

LEGEND

- Topsoil & Talus Deposit
- m-cT Medium ~Coarse Tuff
- An Andesite
- Ag Agglomerate
- Bedding
- Joint or Crack
- Assumed Fault
- Failure Portion

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Fig. D-7 Geological Map of Cidanau Dam Site

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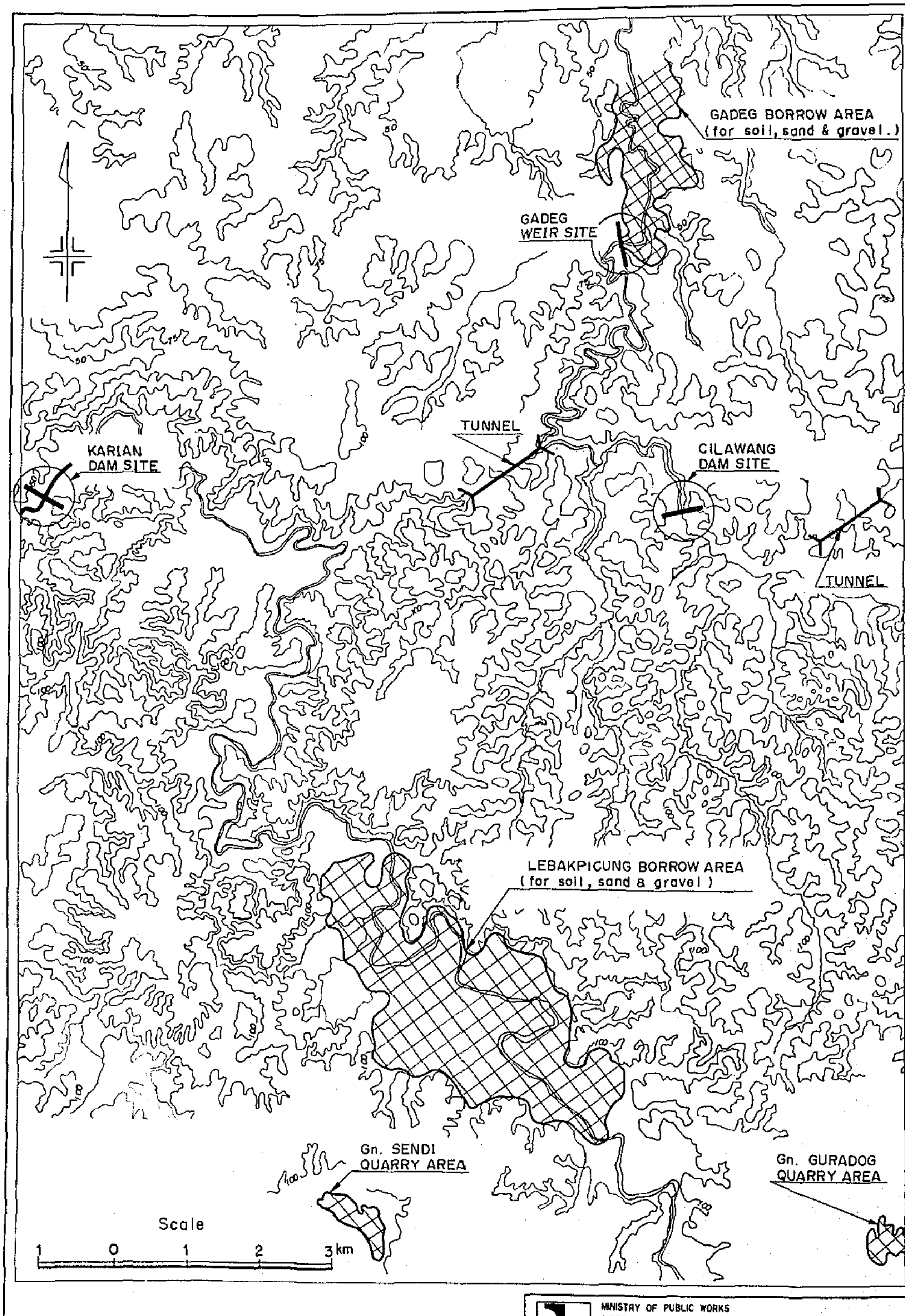

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Fig. D-8 Location of Karian Dam, Cilawang Dam and Gadeg Weir

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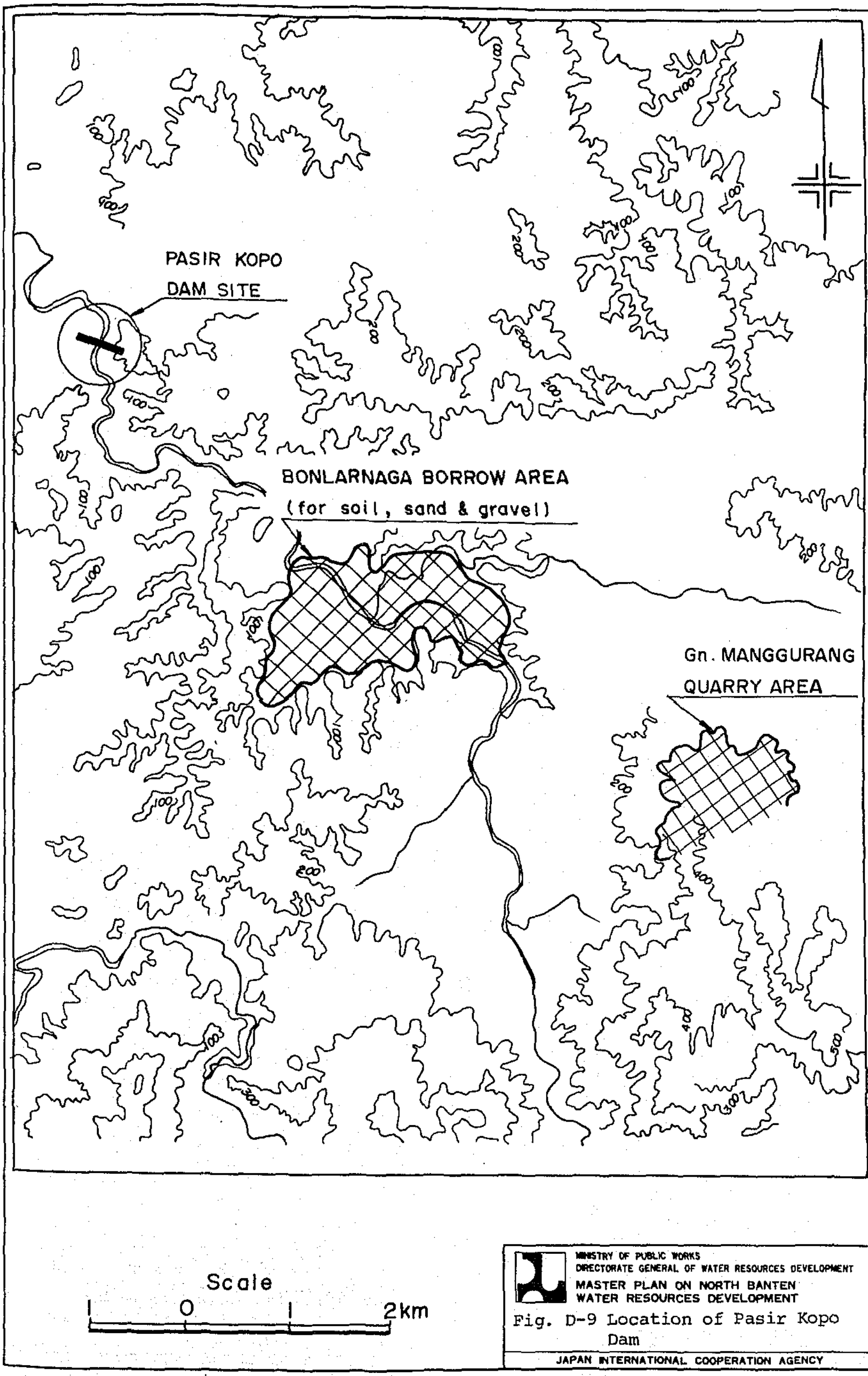

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Fig. D-9 Location of Pasir Kopo Dam

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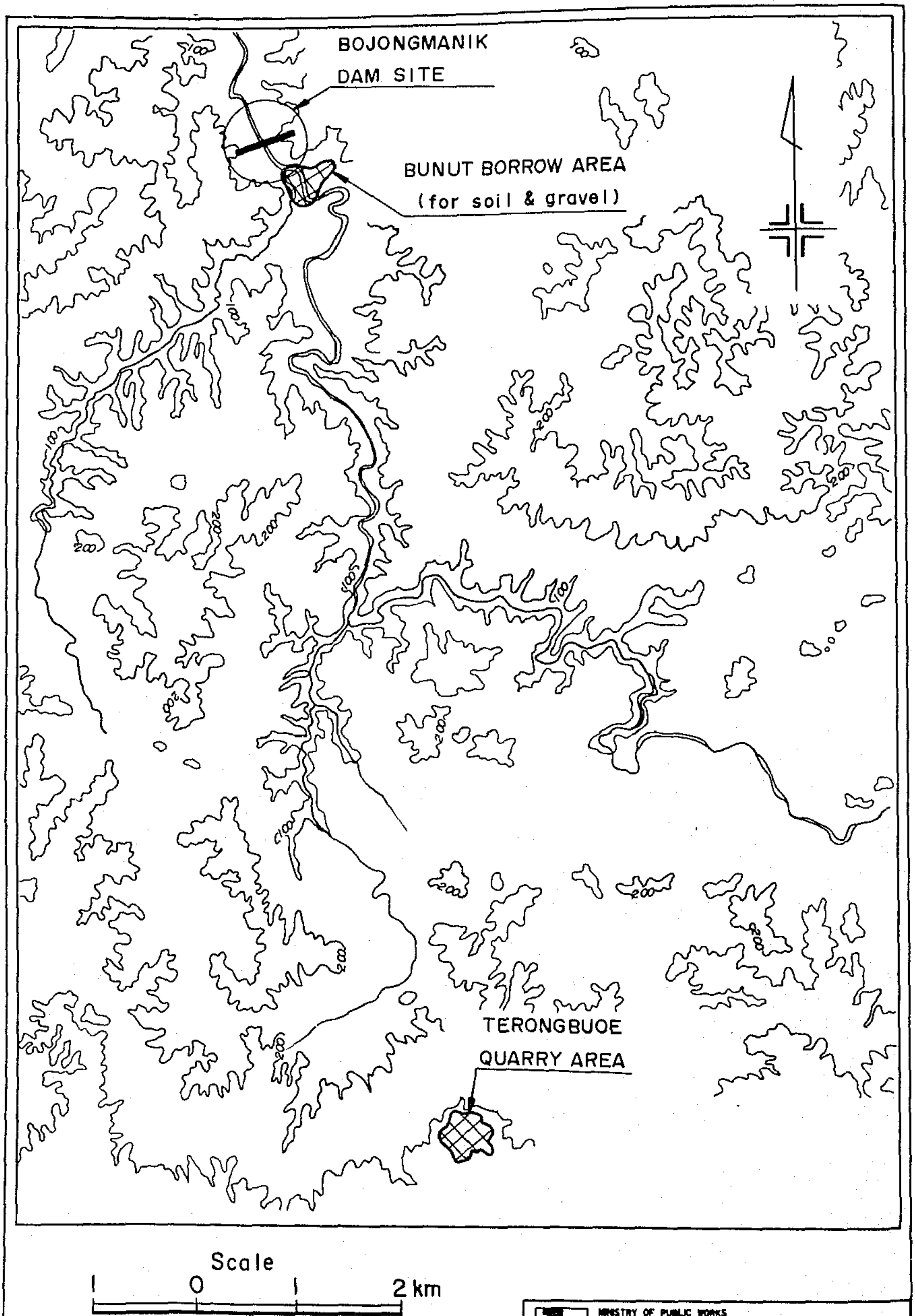

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Fig. D-10 Location of Bojongmanik Dam

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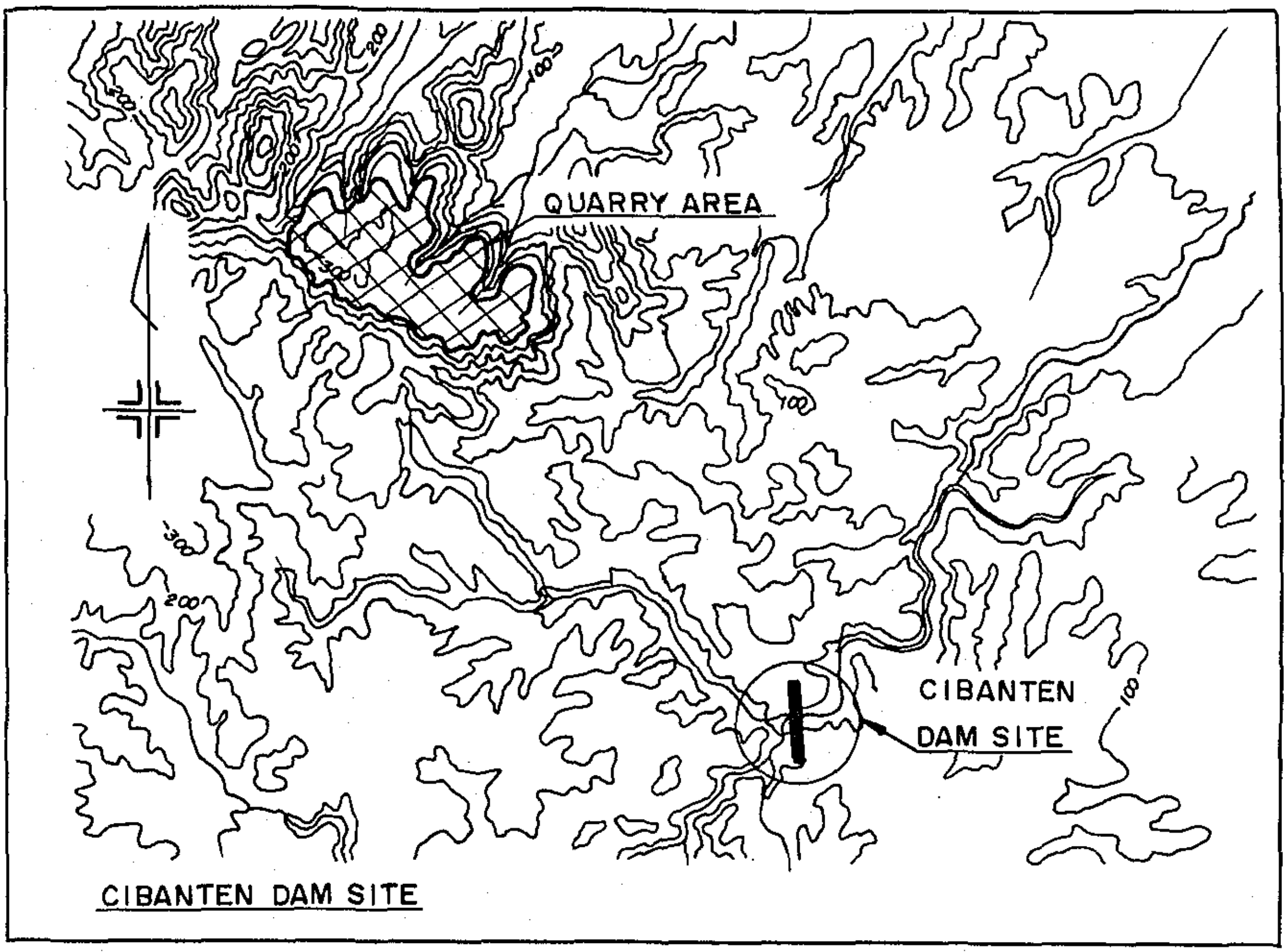

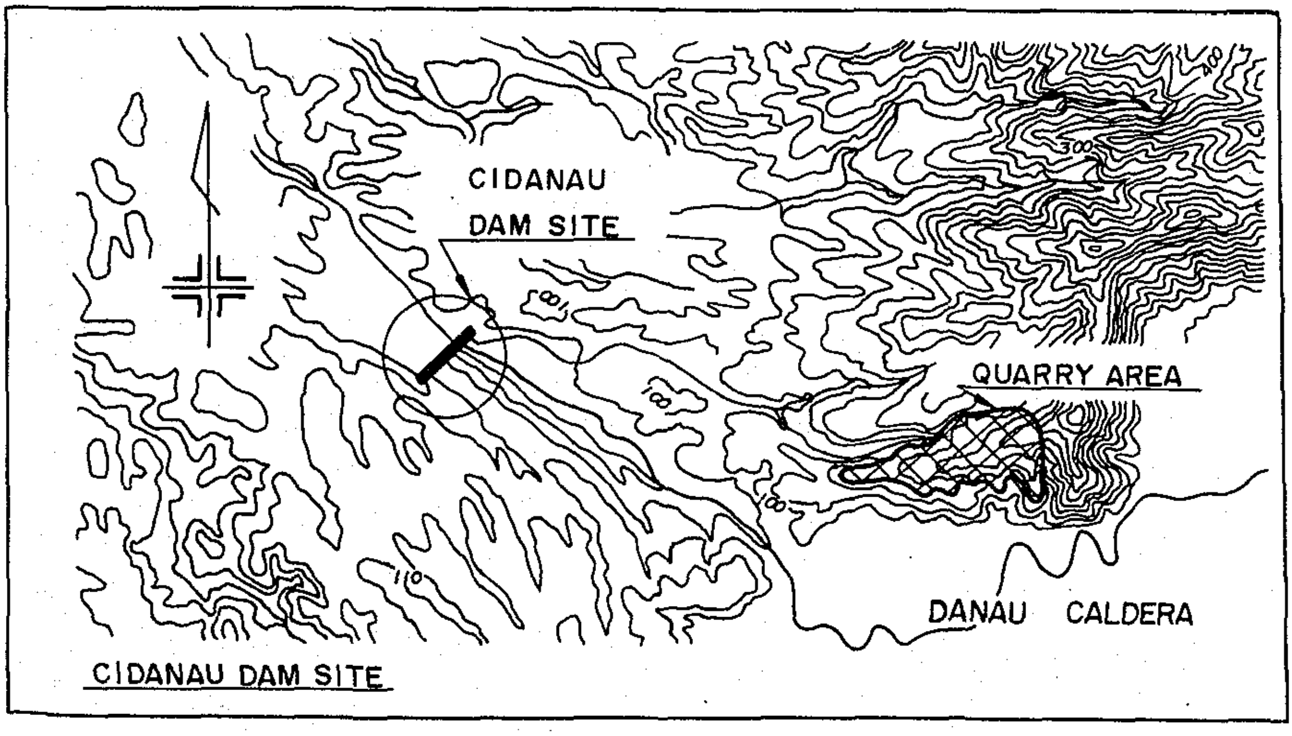

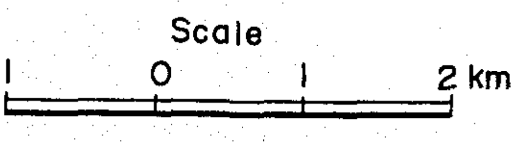

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Fig. D-11 Location of Cibanten and Cidanau Dams

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APPENDIX E
FLOOD CONTROL

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1. INTRODUCTION

This Appendix examines the present situation of rivers in the North Banten area and the actual condition of inundation, and summarizes the results of study on the flood control plan of the Ciujung river, the largest river in this area. The Ciujung river caused a heavy inundation damage owing to a flood in November 1981 and, therefore, there is a strong demand for flood prevention among local residents.

Moreover, with the Ciujung river as the water source, a large paddy growing area is formed in the Ciujung river basin. Also, along with the water resources development program, the expansion of irrigated areas in this river basin and the improvement of land productivity are expected.

Accordingly, flood prevention of the Ciujung river is of major importance as the foundation of agricultural and industrial development. It also leads to the stability of public sentiment and the development of national economy as well.

In the present study, besides the Ciujung river, the flow capacity of the Cibanten river which flows down through Serang, the largest city in the North Banten area, is investigated, and the appropriateness of the river improvement plan which is currently being carried forward by PROSIDA is confirmed.

2. PRESENT CONDITION OF RIVER

2.1 General

2.1.1 Rivers

(1) River

The North Banten area is located in the northwest of the Province of West Java. Its northern part faces the Java Sea, while the western part faces the Sunda Strait.

Rivers in the Study Area may be broadly classified into two groups. The former flowing north into the Java Sea originates from the mountainous zone represented the Gunung Sanggabuwana of El. 1,919 m and the Gunung Karang of El. 1,778 m, both of which form the southern boundary of the Study Area, while the latter flows west into the Sunda Strait.

In the Study Area, there are eight large and medium scale rivers whose catchment area are more than 50 km^2 each as shown in Fig. E-1. The Ciujung river is the largest river among them and the Cibanten, Cibeureum and Cidanau rivers are typical medium-scale rivers. Besides, there are other medium and minor rivers. The catchment area by river is shown in Table E-1 and summarized below. The channel length and slope of catchment by river are also summarized in Table E-1.

River	Catchment Area (km^2)	Remarks
Ciujung	1,850	River mouth facing Java Sea
Cibeureum	255	Confluence of the Cidurian river
Cibanten	183	River mouth facing Banten Bay
Cidanau	222	River mouth facing Sunda Strait

(2) Conditions of river improvement

Among rivers in the Study Area, those which are under improvement work are the Ciujung, Cibanten, and other medium and minor rivers flowing into Banten Bay. This improvement plan covers the river which run through the Ciujung irrigation scheme area and is being carried forward by PROSIDA. The improvement schedule from 1980 to 1984 has been made out. The rivers being improved, improvement sections and work schedules are shown in Fig. E-2.

On the basis of this plan, banking works extending 9 km along the Ciujung river and 6 km along the Cibanten river are under way at present. Both rivers have a design discharge of 25 years return period. Also, for other medium and minor rivers, the plan has been drawn up with 5 years return period.

2.1.2 Flood and inundation

Inundated areas in the Study Area are investigated. The areas along the Ciujung river, which have suffered from a particularly heavy inundation damage, are shown in Figs. E-3 and E-4. These illustrations are prepared on the bases of 5-year inundation investigation data from 1977 to 1981 obtained at DPUPs, Serang and Pandeglang-Rangkasbitung, and information locally obtained through interview survey made under the present study.

It is said that the flood in November 1981 caused the most serious damage among floods occurred in the past. The area inundated by the flood in November 1981 was about 9,000 ha in the whole Study Area. Out of this, the inundated area along the Ciujung river was about 6,000 ha, corresponding to two-thirds of the whole inundated area. The areas that suffered from a heavy damage by this flood were distributed in the neighborhood of Rangkasbitung and along the right bank downstream from Kragilan, where several sections of embankments were destroyed and overtopped. The inundation damage summarized is as below.

Item	Around Rangkasbitung	Right Bank Downstream from Kragilan
Inundated area	600 ha	3,800 ha
Inundated houses	2,400 houses	3,600 houses
Inundation depth	1.5 to 2.0 m	1.0 to 1.5 m

2.2 River Subject to the Study

According to the results of field survey, the past inundated areas in the Study Area are concentrated in the Ciujung irrigation scheme area extending along the both sides of the Ciujung river and the left bank of lower reaches of the Cidurian river. With the inundation damage caused by the flood in November 1981, there arose a strong demand for flood prevention among local residents. Especially, flood prevention in the areas around Rangkasbitung has become a major importance since then.

The present study covers the Ciujung river basin having the abovementioned demand and the Cibanten river which runs through Serang, the largest city in the Study Area, to study a flood control plan for the improvement of productivity in the inundated area along with the water resources development program in this area.

2.3 Ciujung River System

2.3.1 General conditions

(1) River basin

The Ciujung river has a catchment area of 1,850 km^2 and a channel length of 135 km, and flows into the Java Sea. The riverbed slope is

1/6,000 to 1/5,000 between the river mouth and the Kragilan bridge which is located at 18.3 km point from the river mouth and 1/3,000 from Kragilan to the Pamarayan weir of 37.1 km point and Rangkasbitung of 54.0 km point.

Three main tributaries, i.e. the upper Ciujung, Ciberang, and Cisimeut rivers, join at Rangkasbitung. The riverbed slope of the upper Ciujung river changes from 1/2,400 to 1/700, and the slope in upper reaches in the mountain upstream from Bojongmanik is 1/51. Similar conditions are recognized with respect to the other two tributaries.

The configuration of the basin and the conditions of tributary confluences are shown in Fig. E-5.

(2) Condition of river channel

The Ciujung river, according to its characteristics, may be classified into the following four sections as shown in Fig. E-6. The present condition of river channel for each section is described hereunder.

- river mouth to Kragilan bridge;
- Kragilan bridge to Pamarayan weir;
- Pamarayan weir to Rangkasbitung; and
- upstream from Rangkasbitung.

(3) River mouth to Kragilan bridge

The national highway between Jakarta and Merak bridges the Ciujung river at Kragilan. In the section from the Kragilan bridge to the river mouth, the river improvement work is under way mainly comprising the levee raising for a stretch of 9 km.

The channel in this section is made up of high water channel with river width of 170 m and low water channel of 100 m in river width. The design discharge is 1,100 m^3/s. This discharge is applied to the lower reaches from the Pamarayan weir.

(4) Kragilan bridge to Pamarayan weir

To convey irrigation water from the Pamarayan weir to the Ciujung irrigation scheme, the right and left bank primary canals are constructed along the Ciujung river. The embankment of both canals forms the boundary of flooded areas of the Ciujung river. The left bank tributaries Cisangu, Ciasem and Cibungun meet the main stem of the Ciujung river in this section. These tributaries cause inundation in their upper reaches just upstream from each crossing point over the said irrigation canal. The approximate river width of this section ranges from 100 to 150 m and the riverbed slope is 1/3,200.

About 3 km upstream from the Kragilan bridge, there is a large river bend and the riverbank is considerably collapsing.

(5) Pamarayan weir to Rangkasbitung

In this section, the Ciujung river still remains in a primitive stage. Meanderings are remarkable throughout the section and the riverbank is also collapsing considerably. The Pamarayan weir affects the reaches just upstream from the weir because the gates are closed in order to secure the intake water level. Therefore, the rise of the riverbed is conspicuous, caused by heavy sedimentation and it results in the increase in water level at the time of flood.

The configuration of the confluence of the Ciberang river is in extremely intricate condition, leading to the collapse of the left and right banks upstream from the railway and road bridges at Rangkasbitung. As the river channel flows through the urban area of Rangkasbitung, it is necessary to take a countermeasure against the collapse of the riverbank.

(6) Upper Ciujung river upstream from Rangkasbitung

The upper reaches of Ciujung river upstream from Rangkasbitung have a small inundated area at the time of flood, but there are such problems as the breakage of roads and paddy fields along the river owing to the collapse of the riverbank. The riverbed slope is from 1/2,400 to 1/770 and the river width is 50 m on an average.

(7) Ciberang river upstream from Rangkasbitung

In the upper reaches of the Ciberang river, there are few cropped areas and infrastructures that suffer from damage, accordingly the necessity of flood prevention is low. In the section of about 3.5 km from the confluence of the Ciujung river where the Cisimeut river joins at the left bank, however, there are houses along the river and they are suffering from flood damage. In this section, there were some large river bends in the past. Although measures have been taken to increase the flow capacity by shortcut, these measures are not sufficient.

As the Cisimeut river meets the Ciberang river at right angle and also because of the geological weakness, considerable sliding of the riverbank is recognized. Thus, groynes are installed to control the inflow of water and to promote channel stability.

The riverbed slope is 1/2,500 up to the confluence of the Cisimeut river and 1/1,300 upstream from the confluence. The river width is about 50 m.

(8) Cisimeut river

Houses and farm lands are distributed along the Cisimeut river and these situation is similar to the upper Ciujung river. Therefore, the necessity of flood control is low. The riverbed slope ranges from 1/2,000 to 1/560 and the river width is about 50 m.

2.3.2 Existing structures

The main structures along the Ciujung river are the Pamarayan weir, several bridges, dyke and groyne.

(1) Pamarayan weir

The Pamarayan weir is the intake weir for the Ciujung irrigation scheme, completed in 1918, with 10 gates of 6 m in height and 12 m in span. The gate had been manually operated at the beginning, but the gate has been operating by electric power since 1982.

When a flood occurred in November 1981, the gates were put into operation by manpower. At the time of a peak discharge, it is said that the weir was kept fully open. Because of scouring of the downstream of the weir and large sliding on both banks, improvement works are being carried out at present. The structure of the weir is shown in Fig. E-7.

(2) Bridges

The following five bridges cross over the Ciujung river in the Study Area.

- Tirtayasa bridge	3 km from river mouth
- Kragilan bridge	18 km from river mouth
- Rangkasbitung railway bridge	53 km from river mouth
- Rangkasbitung road bridge	53 km from river mouth
- Ciberang bridge	55 km from river mouth

Besides, a new bridge for the Jakarta-Merak highway is being constructed at the upstream near Kragilan. Among the above-mentioned bridges, the structures of four bridges obtained are shown in Figs. E-8 and E-9.

(3) Dyke and groyne

The dyke which is being constructed at present is located along the lower reaches of the Ciujung river downstream from Kragilan and its configuration is shown in Fig. E-10. The structure of the groyne installed on the left bank of the Ciberang river and its locations are shown in Fig. E-11. Moreover, one concrete groyne is installed on the left bank of the Ciujung river at 1.0 km upstream from the Pamarayan weir.

2.3.3 Flow capacity

(1) Cross section

The survey of the river cross section used in the present study of flow capacity was carried out in August 1982. Measuring sections and intervals are described as below.

The flow capacities of the Ciujung and Ciberang rivers are studied based on data supplied by P3SA. For the Ciujung river, the length of measuring section totals 54 km from the river mouth to Rangkasbitung and, for the Ciberang river, 14 km up to the Karian dam site. Intervals are 200 to 500 m for both rivers.

As for the upper Ciujung and Cisimeut rivers, the study is based on data supplied by JICA. For the upper Ciujung river, the length of measuring section is 40 km up to the Bojongmanik dam site and, for the Cisimeut river, 30 km up to the Pasir Kopo dam site. Intervals are 5 km.

(2) Calculation method and roughness coefficient

The flow capacity is estimated by non-uniform flow calculation for the Ciujung and Ciberang rivers, and by uniform flow calculation for the upper Ciujung and Cisimeut rivers. The Manning's roughness coefficient of each river is determined in the following manner.

For the Ciujung river as well as the Ciberang river, up to the confluence of the Cisimeut river, it is assumed that the roughness coefficient (n) is 0.035, 0.030 and 0.025 and the river discharge (Q) is 500, 750, 1,000, 1,500 and 2,000 m^3/s according to local conditions. In calculating water level by non-uniform flow formula, IBM large model computers installed at the Center for Data Processing and Statistics, DPU, were used for the calculation.

From the results of calculation, water levels at Jengjing (No. 183 point), Kragilan bridge (No. 150 point), Pamarayan weir (No. 104 point) and Rangkasbitung (No. 58 point) are determined and the rating curve obtained at each point is shown in Table E-2 and Fig. E-12. Further, at the Kragilan bridge and Rangkasbitung, the other rating curves according to measured water levels and discharges are established as shown in Fig. E-13.

The calculated rating curve agrees generally with the measured rating curve when the assumed roughness coefficient is 0.03. During the field investigation period in the present study, the roughness coefficient was measured in the lower reaches of the Kragilan bridge. The result of the measurement shows that the roughness coefficient would be 0.025.

Regarding riverbed materials which are composed of silt-mixed sand in the whole section of the Ciujung river, the grain size becomes a little smaller in the lower reaches near the river mouth, but it shows little change in the reaches upstream from the Kragilan bridge. Thus, the roughness coefficient is assumed to be about 0.025 for the low water channel and 0.03 for the time of a flood, taken into consideration the loss owing to banks and meanderings.

As for the upper Ciujung river, the downstream riverbed materials consist of silt-mixed sand with small pebbles appearing on the riverbed surface from Rangkasbitung to 10 km point in the upstream and then the grain size increases toward the upper stream to river heads. The river terrace becomes a little high compared with that in Rangkasbitung, but there is no major differences in its condition. Accordingly, the roughness coefficient is assumed to be 0.03 for the section between Rangkasbitung and 10 km point and 0.035 for its upper reaches.

As for the Cisimeut river, the roughness coefficient is assumed to be 0.035 judging from local conditions.

(3) Calculation of flow capacity of Ciujung and Ciberang rivers

The conditions adopted for calculation of flow capacity according to non-uniform flow water levels are described below.

Water level at downstream end is determined to be -0.4 m (= 1.1 m - 1.5 m). Where, 1.1 m is a value according to the planned tide level by PROSIDA, while 1.5 m is the difference of the measured value of P3SA's bench marks at Pamarayan and a corresponding value indicated by the mark on the Pamarayan weir.

As for discharge, the following eight cases are examined:

	Discharge (m^3/s)							
River Section	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
Ciujung River								
No. 194 to 109 point	200	300	500	750	1,100	1,600	1,800	2,000
No. 109 to 55 point	180	260	440	660	970	1,400	1,600	1,800
Ciberang River								
No. 54 to 40 point	140	210	350	520	770	1,100	1,200	1,400
No. 40 to 1 point	80	120	190	290	420	600	680	740

As for backwater due to piers of the Pamarayan weir, its height is calculated by D'Aubuisson formula.

(4) Calculated water level and flow capacity

Calculated water levels according to the roughness coefficients and calculating conditions determined in the above are shown in Fig. E-14 with respect to the discharge cases 1, 3, 4, 5, 6 and 7. The calculated water levels at major points are shown in Table E-3.

Thus, the discharge is obtained at lower elevation among the right and left bank ground elevations as shown in Table E-4 and Fig. E-15. The mean flow capacity in each section is summarized as below.

River Section	Flow Capacity (m^3/s)
Ciujung River	
River Mouth to Kragilan	1,000
Kragilan to Pamarayan Weir	700
Pamarayan Weir to Rangkasbitung	400
Ciberang River	
Downstream of Cisimeut River Confluence	400
Upstream of Cisimeut River Confluence	300

(5) Flow capacities of upper Ciujung and Cisimeut rivers

The calculation is made following in the same manner described in the above. The discharge obtained is shown in Tables E-5 and E-6 and Figs. E-16 and E-17. The flow capacities of the upper Ciujung and Cisimeut rivers at the lower elevation among the right and left bank ground elevations are as shown below.

River Section	Flow Capacity (m^3/s)
Upper Ciujung River	
0 to 10 km point	400
10 to 25 km point	200
25 to 30 km point	430
30 to 40 km point	750
Cisimeut River	
0 to 5 km point	400
5 to 20 km point	200
20 to 30 km point	400

2.4 Cibanten River System

2.4.1 General conditions

(1) River basin

The Cibanten river rises from the Gunung Karang, flows northwards through the west of Serang and the flatland area of the Ciujung irrigation scheme and drains to Banten Bay. This medium-scale river has a catchment area of 183 km^2 with a main stem length of 39 km and a stream gradient of 1/6,000 to 1/100 as shown in Fig. E-18.

(2) Conditions of river channel

The channel runs through a valley formed in the vicinity of Serang and its upper reaches. As the channel is lower than surrounding land, damage by a flood is slight, while the agricultural land downstream from Serang has suffered from inundation damage in the past. Hence, as a part of the drainage improvement project on Ciujung irrigation scheme, the improvement of the lower reaches of the Cibanten river has been planned and the work for its 6 km portion is under way at present.

This river improvement plan covers a return period of 25 years and a design flood discharge of 280 m^3/s or specific runoff of 1.53 $m^3/s/km^2$. Judging from the basin scale, land utilization, topography and other aspects of the Cibanten river, it can be considered that its initial object has been attained by this river improvement plan as far as flood control is concerned.

2.4.2 Flow capacity

The cross-sectional and longitudinal survey maps with an interval of 5 km obtained in the present study are used to calculate the flow capacity of the Cibanten river. Calculation is made on the basis of a uniform flow.

Also, the Manning's roughness coefficient of 0.035 is taken for the section where the river runs through the valley upstream from Serang, while for the improvement section where the river runs through the low land downstream from Serang, the roughness coefficient is 0.03 in the low water channel and 0.06 in the high water channel. The results of calculation are shown in Table E-7 and Fig. E-19.

The slope used for this calculation is a riverbed slope for the section upstream from 5 km point and a design water-surface slope for the section downstream from 5 km point according to the longitudinal section drawn up by PROSIDA. As a result, the flow capacity calculated is 296.4 m^3/s at 5 km point in the river improvement channel of the downstream part and 293.6 m^3/s as the minimum discharge at the point subjected to calculation for the upstream part.

2.4.3 Matters of concern

Here follows a description of the matters of concern arising from the present channel condition.

On the right bank upstream from the road bridge located about 2.5 km upstream from the river mouth, there are the ruins of the Banten dynasty. A part of these ruins is located in the river areas, and this obstructs the flow at the time of a flood. It is, therefore, necessary to investigate the flow capacity in this section and the method of preserving the ruins as well. For this purpose, the study by a non-uniform flow may be required by making a cross-sectional survey at intervals of about 100 m.

Similarly, it is necessary to check if the allowance of the height of a railway bridge or road bridge is sufficient. If found insufficient, it is necessary to take such countermeasures as rebuilding the bridge.

3. FLOOD DAMAGE WITHIN CIUJUNG RIVER BASIN

3.1 Flood Damage Survey

Based on informations obtained by inquiries made at the flooded sites and data taken from DPUPs Serang and Pandeglang-Rangkasbitung, a fact-finding survey on the inundated situation within the Ciujung river basin was conducted during the field investigation period in the present study.

Data collected consists of the inundated area, number of submerged buildings such as residences, shops, schools and mosques, flooded farm-land areas such as paddy fields, upland fields and plantations, and submerged depth. As a result of the survey, the inundated situation caused by the flood in November 1981 is revealed clearly. It is found that the flood in November 1981 inflicted the largest damage among all floods occurred in the past.

3.2 Flood Damage

Damages caused by the flood in November 1981 are estimated using the following conditions as the basis.

3.2.1 Inundated area

Based on topographical map of 1/50,000 in scale and the land use map of 1/25,000 in scale which was drawn up during 1977/1978, the inundated area caused by the flood in November 1982 is divided according to the form of land use and submerged depth. In consideration of the local topography, the following ratios are used for the classification by the submerged depth.

	Submerged Depth (m)			
	0.0 - 0.49	0.50 - 0.99	1.00 - 1.49	1.50 - 1.99
Inundated area ratio				
From river mouth to Kragilan bridge	1	2	4	-
Upstream from Kragilan bridge	1	1	2	4

Table E-8 shows the inundated area classified by the submerged depth, having the breakdown in both areas upstream and downstream from the Pamarayan weir.

3.2.2 Damages to houses and buildings, and household effects

Based on the data obtained from flood damage reports issued in November 1981 as well as those obtained from the inquiries made at the flooded site, damages of submerged houses and household effects are estimated, using the following conditions:

(1) The number of houses and buildings, being composed of residences, shops, schools and mosques, in the inundated area is set at 30 buildings per hectare in a village.

(2) The shares of shops and mosques in the number of submerged houses and buildings are set at 1.5% and 1.0%, respectively.

(3) Based on the data obtained by DPUPs Serang and Pandeglang-Rangkasbitung, the number of submerged schools is set at five for the area downstream from the Pamarayan weir and two for that upstream from the weir.

(4) Based on the data from BAPPEDA Serang and from the results of the said inquiries, unit damage values of houses and household effects are set at the appraisement given in Table E-9.

(5) As estimated damages of household effects differ depending on the submerged depth, the rate as shown in Table E-10 is used, which is obtained by referring to values used in other surveys conducted in Indonesia, for example, that for Ular river.

(6) The floor level of houses is set at 10 cm above ground level.

(7) As for the damage rate of houses and household effects, values adopted in the Outline of Economic Survey on Flood Control prepared by the Ministry of Construction, Japan are used as shown in Tables E-11 and E-12.

Total number of submerged houses and buildings caused by the flood in November 1981 is tabulated in Table E-13. Total damages to houses and buildings, and household effects and stored goods caused by the flood in November 1981 are estimated under the aforementioned conditions, amounting to Rp 2,365 x 10^6 for the area from the river mouth to the Pamarayan weir and Rp 1,983 x 10^6 for the area upstream from the Pamarayan weir.

3.2.3 Damages to crops

The category of agricultural land use in the inundated area by the flood in November 1981 is classified by using the land use map of 1/25,000 in scale as the basis. Table E-14 shows the inundated area classified by the category of land use. As for the paddy fields of 3,050 ha in the flooded area, only 210 ha in which planting had been completed at the time of flood generation were added up as damaged areas by the flood in November 1981. It is reported that the period of inundation over paddy fields was four days and the inundation depth was from 0.5 to 1.5 m.

The growth stage of rice plants at the time of the flood was distributed over a wide range from maturation period to tillering stage just after transplanting including fallow period. Further, as no record was available on the individual growth stages of the damaged paddy fields, the damage rate in the present study is presupposed as being 50%.

The majority of the inundated upland crop fields when flooded in November 1981 were those on which cassava and maize were cultivated. Besides, various upland crops including sweet potatoes and peanuts were cultivated, but the cultivated areas for such crops were quite small. Accordingly, cassava and maize were taken as the representative upland crops. The mean damage rate is assumed to be 10% for cassava and 100% for maize.

The inundated orchards, which are mixed-cultivation lands of bananas and bamboo, suffered from no flood damage as the bamboo served as protections for fruit trees.

Actual damages are calculated in the following manner. The unit price is obtained by calculating first gross production value, obtained by multiplying the average yield of the inundated area by the minimum government-buying price of rice in 1982 for the paddy areas and the farm gate price in 1982 for the cassava and maize areas, and then subtracting the crop production cost that is not needed after damage generation. The unit prices are then multiplied by the damaged area and damaged rate to obtain the actual damages. The amount of crop damages caused by the flood in 1981 totalled to Rp 169 x 10^6 in the downstream area of the Pamarayan weir as shown in Table E-15 and Rp 15 x 10^6 in the upstream area as shown in Table E-16.

In the future, when the year-round irrigation system will be completed and the cropping calender will be stabilized, a flood arising during the period between November and January would inundate the whole paddy fields within the flood prone area having a scale equivalent to the maximum experienced flood. In calculating the flood control benefit for paddy fields alone, damages calculated by the following method are used in place of the actual flood damage. With the mean damage rate assumed to be 50%, the farm gate price, yield and production costs are calculated by adopting the economic price of paddy used in the irrigation benefit calculations. Economic damages to field crops and fruit trees in the flood prone area shall be considered to be the same as the actual damage values.

3.2.4 Losses due to suspension of business activities

Following the method adopted in the Outline of Economic Survey on Flood Control, losses due to suspension of business activities are set at 6% of the total damages to buildings and household effects.

Consequently, the calculated results of losses due to suspension of business activities incurred by the flood in November 1981 amount to Rp 142 x 10^6 for the downstream area from the Pamarayan weir and Rp 119 x 10^6 for the upstream area from the weir.

3.2.5 Damages to public works and agricultural facilities

As detailed data on the damages to public works and agricultural facilities were not available, the method described in the Outline of Economic Survey on Flood Control is adopted in the present survey.

For the downstream area from the Pamarayan weir, the damage rate is set at 79.5% of the damage amount of buildings and household effects comprising 28.2% for roads and bridges, 5.6% for agricultural land, 43.4% for agricultural facilities and 2.3% for electric power, while, for the upstream area from the weir, it is set at 90.5% comprising 28.2% for roads and bridges, 5.6% for agricultural land, 43.4% for agricultural facilities, 2.3% for electric power and 11.0% for railways.

Consequently, damages to public works and aqricultural facilities caused by the flood in November 1981 amount to Rp 1,880 x 10^6 for the downstream area from the Pamarayan weir and Rp 1,794 x 10^6 for the upstream area from the weir.

3.2.6 Total flood damage

When the above-mentioned damages are totalled, the whole damages caused by the flood in November 1981 amount to Rp 4,557 x 10^6 for the area from the river mouth up to the Pamarayan weir and Rp 3,911 x 10^6 for the area upstream from the Pamarayan weir, thus bringing the total damages for the whole section along the Ciujung river to Rp 8,468 x 10^6 at the 1982 current price level. Table E-17 gives the breakdown. It is noted that the economic crop damage value of Rp 1,137 x 10^6 as shown in Table E-18 and the whole damage value of Rp 9,421 x 10^6 are adapted for the estimate of flood control benefit.

3.3 Average Annual Flood Damage

3.3.1 Estimate of the probability

Scale of the probable discharge of the flood in Nov. 1981 and of the no-damage discharge is estimated by the Thomas plotting, with the collected data of the Rangkasbitung gauging station over a period of 10 years from 1972 to 1981 as shown in Table E-19. Fig. E-20 shows the calculated results.

3.3.2 Probable scale of no-damage discharge

The results of non-uniform flow calculation for the Ciujung river show that the no-damage discharge at the Rangkasbitung gauging station will be approximately 500 m^3/s. An estimation of probability of this discharge from Fig. E-20 shows that it is roughly equivalent to a probability of 1/1. Accordingly, the probability scale of the no-damage discharge is set at 1/1.

3.3.3 Probability estimation for the flood in November 1981

From the calculated results of the non-uniform flow of the Ciujung river, the flow corresponding to the flood mark stage at the Rangkasbitung bridge is estimated to be 1,150 m^3/s. A probability appraisal of this flow from Fig. E-20 shows, taking into account the present condition of natural flooding along the upper reaches of Rangkasbitung, that it is roughly equivalent to a probability of 1/20.

3.3.4 Average annual flood damage

Damages are assessed on the assumption that the no-damage flow probability will be equivalent to 1/1 and the damages caused by the flood in November 1981 will be equivalent to a probability of 1/20. Also, damages for other probable years are calculated based on interpolation and extrapolation. Thus, probable flood damages in the inundated area along the Ciujung river are obtains as shown in Fig. E-21. Then, average annual flood damages are estimated as summarized below.

	Average Annual Flood Damage (Rp 10^6)	
Return Period	Upstream from the Pamarayan Weir	Whole Inundated Area
10 years	1,357	3,269
50 years	1,665	4,012

4. FLOOD CONTROL AND RIVER IMPROVEMENT PLAN

4.1 General

4.1.1 Ciujung river

(1) Study principle

The Ciujung river improvement plan is studied with respect to the master plan and the first stage plan. The latter puts an emphasis on the flood control measures in and around Rangkasbitung.

(2) Design scale

In the master plan level, the return period of the design flood discharge of other rivers Indonesia is 50 years in the case of the Jeneberang and the Kali Brantas. In the case of the Bengawan Solo and the Kali Madiun, the return period is 40 years. Taking into consideration these examples, the return period of the Ciujung river is assumed to be 50 years for the master plan level as shown in Fig. E-22.

In the first stage plan, the return period is assumed to be 10 years.

(3) Flood control method

Generally, the following four methods are employed for flood control, i.e. construction of dam, river improvement, excavation of flood way and provision of retarding basin.

In the Ciujung river, the last two methods could not be applied owing to the existing topographic conditions. In the present study, therefore, the first two cases are examined.

4.1.2 Cibanten river

According to the Cibanten river improvement plan, the return period is set at 25 years and the design flood discharge at 280 m^3/s. The improvement work in the section of about 6 km from the river mouth has been under way.

Judging from the catchment area and the condition of land utilization, the return period of 25 years is appropriate. The flow capacity of the river cross section is sufficient for the design flood of 280 m^3/s. Thus, in the present study, the Cibanten river improvement plan which is currently being carried forward is confirmed to be appropriate. However, in the downstream of the river, there are the ruins of the Banten dynasty and these ruins are expected to obstruct the cross section in the event of a flood. Hence, it will be necessary to carry out a study from the aspect of hydraulics and preserving the ruins as well.

4.2 Flood Regulation by Dam

4.2.1 Dam and reservoir plan

The flood control storage of dam and reservoir must be determined in such consideration that it secures water resources necessary for the development of the North Banten area and also it is effective in flood control of the Ciujung river. As for the water resources development plan, three dams in the Ciujung river, i.e. Karian, Pasir Kopo and Bojongmanik, are studied. The main features of these dams are shown in Table E-20.

4.2.2 Design flood between dam and river

(1) Standard project flood

The standard project flood is a basic standard hydrograph at the specific projected sites along the river, which is used as the basis for the flood control planning. Generally, the standard project flood is derived from the design storm rainfall of a probability of exceedance corresponding to the required safety of flood control. An estimation of the standard project flood is supposed to be done under the condition of no flood regulation measures and no flooding or inundation along the river course. The terms of "the standard project flood" have already been employed in the following reports:

- Jeneberang River Flood Control Project (Phase II), Main Report and Supporting Report (I), December 1981, JICA; and
- Survey and Study for the Development of Sala River Basin, Main Report and Supporting Report (Part One and Part Two), January 1974, OTCA.

The peak discharge of the estimated standard project flood is generally larger than the flood peak discharge obtained from the flood discharge data at the gauging station, which may be affected by the natural flooding or inundation along the river course. Based on the estimated standard project flood, the flood control plan will be established with the optimum distribution of projected flood discharge into the river channel improvement and the flood regulation measures such as dam, retarding basin and diversion channel.

The distribution of standard project flood in the master plan and first stage plan levels is shown in Fig. E-23 which corresponds to Fig. B-11 in Appendix B.

(2) Flood control plan of each dam

The method of flood control comes in the following three types:

- constant-quantity discharge by gate operation;
- constant-rate, constant-quantity discharge by gate operation; and
- natural discharge by orifice or overflow.

Here, the overflow-type natural discharge which is easy to manage at the time of a flood, is selected. The flood control capacity of each dam is established in such a way as to minimize the flood burden to the downstream river, while making adjustment with irrigation storage.

Main items of the flood control plan of each dam are as shown below. Also, the relation between the flood control storage of each dam and the outflow discharge is determined in accordance with Fig. E-24. The flood control storage is set at 20% extra over the calculated value.

Items	Karian	Pasir Kopo	Bojongmanik
Standard project flood (m^3/s)	740	850	590
Outflow discharge (m^3/s)	300	280	190
Flood control discharge (m^3/s)	440	570	400
Flood control storage (10^6 m^3)	30	15	16

4.2.3 Effect of dams on the Ciujung river

If the whole outflow from the catchment areas of 619 km^2 is controlled by the three dams such as Karian, Pasir Kopo and Bojongmanik against the standard project flood of 50 years in return period, the outflow from the remaining catchment areas at the Kragilan bridge becomes 1,300 m^3/s, thus making it possible to reduce the standard project flood of 2,000 m^3/s by 700 m^3/s. But, it exceeds the present design discharge of 1,100 m^3/s.

From this point, only the construction of dams is not enough for flood control. Hence, it is necessary to work out a flood control plan by means of rational combination of dam and river improvement with consideration for the relation between construction cost and benefit.

Here, in view of the effect of water utilization and flood control, the design discharge at each point of the Ciujung river is determined with the following combinations of dam construction: (1) no dam, (2) Karian dam alone, (3) Kalian plus Pasir Kopo dams and (4) Karian plus Pasir Kopo plus Bojongmanik dams. The results obtained are shown in Table E-21, and the distribution is shown in Fig. E-25. Also, the hydrograph before and after flood control is shown in Fig. E-26.

4.3 River Improvement Plan

4.3.1 General

(1) Section subject to the study

The section subject to the study is as follows.

As for the Ciujung river, the section of 54 km from the river mouth to Rangkasbitung, including the confluence treatment of the Ciberang river, is subject to the study. In the case of the first stage plan, if the design flood is less than 1,100 m^3/s, the section of 17 km from the Pamarayan weir to Rangkasbitung is subject to the study. In this case, there is insufficient flow capacity in the section between the Kragilan bridge and the Pamarayan weir. In some parts of this section, flood may occur and remain untouched. However, flood damages are small and the first stage plan aims mainly at flood control in and around Rangkasbitung. Hence, the flood control plan will be studied in the next stage.

As for the upper Ciujung river, the section of 10 km which has suffered from flood is subject to the study. In the first stage plan, the section up to 5 km around Rangkasbitung, which suffered from heavy inundation in November 1981, is subject to the study.

As for the Ciberang river, the section of 3.5 km up to the confluence of the Cisimeut river adjacent to Rangkasbitung is subject to the study. In the upper reaches from this point, the river is mountainous river and flood damage is very small. Also, after completion of the Karian dam, the problem can be solved by the flow capacity of the existing channel as it is.

As for the Cisimeut river, the river regime is relatively similar to that of the upper Ciujung river and damage by a flood is small so that the necessity of improvement is low. However, the Cisimeut river meets at right angle with the Ciberang river, thus aggravating the collapse of the right bank of the Ciberang river. At present, protection is provided by groyne but this is not sufficient. In the master plan level, therefore, improvement of the confluence is studied.

(2) Manning's roughness coefficient

The Manning's roughness coefficient in the section subject to the study is 0.03 in the low water channel, as the result of study in Subsection 2.3.3 when setting the standard cross section of river, and that in the high water channel is 0.06.

(3) Standard cross section of dyke

The standard cross section of dyke is planned as shown in Fig. E-27, with its standard crown width is 4.0 m. When it is used as road, the width is 6.0 m according to the cross section of dyke under construction by PROSIDA on the lower reaches of the Ciujung as illustrated in Fig. E-10. In the first stage plan, however, the standard cross section is planned with a crown width of 3 m. Also, the side slope of dyke is planned at 1:2 in both slopes of inner or land side and outer or river side. If the height is more than 5 m, a 3-m berm is used on the river side 3 to 4 m below the crown, and on the land side 2.5 m below the crown.

(4) Longitudinal profile

The design water level is determined by non-uniform flow calculation. In this case, the tidal level at river mouth is planned at -0.4 m (= 1.1 m - 1.5 m) according to the existing plan by PROSIDA, taking account of the difference of P3SA's bench mark and the mark on the weir at Pamarayan.

Also, the freeboard of 1.0 m will be provided throughout the section subject to the study. The design bed slope is determined in consideration of the shortcut to be described hereunder and the existing riverbed slope.

(5) Standard cross section

The side slope in the low water channel is 1:2. Also, the standard design depth in the low water channel is 4 m in consideration of the existing channel depth. The width of the high water channel is more than 30 m. The standard cross section of each section is shown in Fig. E-27.

(6) Shortcut

The shortcut is planned in the section where it is difficult to maintain the stability of channels owing to the development of meanderings. In the section between No. 85 point 7.6 km upstream from the Pamarayan weir and No. 64 point, meanderings are remarkable. By the shortcut of this section, the stability of channels will be promoted and, at the same time, the flow capacity will be increased for flood control in and around Rangkasbitung.

Furthermore, the present configuration of confluence of the Ciberang and upper Ciujung rivers obstructs the flow resulting in that a direct damage will be to the town area in Rangkasbitung owing to the collapse of the river bank. In the master plan level, therefore, excavation of new channels is planned according to the configuration of confluence.

(7) Dredging

The riverbed in the upstream reaches of the Pamarayan weir is rising owing to sediment in the riverbed, leading to a rise in water level at the time of flood. Because of this, the riverbed is to be dredged.

4.3.2 Alternatives and design flood distribution

(1) Alternative plan

Following considerations are given in the first place for the study of alternative plans:

- The return period is compared between 10 years and 50 years.
- A dam out of the three dams proposed is selected. Here, judging from the effect of flood control in and around Rangkasbitung and the economic viewpoint, two dams, i.e. Karian and Pasir Kopo, are subject to the study. The Bojongmanik dam is to be developed along with the development of the basin in the future.
- The excavation of a new shortcut channel with treatment of confluence of the Ciberang and upper Ciujung rivers is to be planned for the master plan level. In the first stage plan, the existing channel is to be improved by some embankment.

Thus, the alternative plan consists of seven cases, i.e. F-0 to F-3 for the first stage plan and M-1 to M-3 for the master plan, as shown in Table E-22.

(2) Design flood distribution

The design flood distribution of each alternative is given in Table E-21 and Fig. E-25.

4.3.3 River improvement in the master plan level

Alternative plans M-1, M-2 and M-3 cover the improvement of whole section upstream from the river mouth. Here follows a description of fundamental matters concerning river improvement.

(1) Alignment

The river channel alignment is to be designed as smooth as possible with due regard to the conditions of land utilization along the river, the existing river channel, the riparian structures and the cost of river improvement works.

The cross section is also designed with due consideration to the same conditions given to the river channel alignment. In all alternative plans, the existing cross sections of the river are adopted except for the shortcut of the upstream reaches from the Pamarayan weir after studying the conditions mentioned in the above.

The shortcut alignment is described below. Fig. E-28 shows the proposed alignment.

(2) Longitudinal profile and shortcut

The longitudinal profile of the alternative plan M-2 is shown in Fig. E-29. It is so designed as to assure the stability of the river channel and the flow capacity of each cross section on the principle of keeping the influences on the structures to the minimum.

The location of the shortcut is shown in Fig. E-28. The change in channel length and riverbed gradient by shortcut is summarized below. The total length of river channel will be reduced by 9.0 km from 64.0 km to 55.0 km.

	River Mouth to Kragilan	Kragilan to Pamarayan Weir	Pamarayan Weir to Rangkasbitung	Upper Ciujung River
Channel Length (km)				
Present	18.3	18.8	16.9	10.0
After shortcut	17.5	16.1	13.2	8.2
Difference	0.8	2.7	3.7	1.8
Riverbed Gradient				
Present	1/5,000	1/3,200	1/3,000	1/2,400
After shortcut	1/4,780	1/2,600	1/2,200	1/1,490

(3) Cross section and design high water level

The design cross section, as described in the above, is assumed as identical to the present condition as a rule, except for the shortcut section. However, in the Ciujung river, the embankment height of dykes is generally not enough, hence both banks require embankment having sufficient height in most of the whole section.

Fig. E-30 shows the cross section of the alternative plan M-2. Also, the standard cross section in the shortcut section is shown in Fig. E-31.

The design high water level of each alternative plan is calculated by the non-uniform flow formula. The design embankment height is given by adding freeboard 1.0 m to the said high water level.

(4) Dredging in the upstream reaches of the Pamarayan weir

In the section of about 8 km upstream from the Pamarayan weir, the riverbed rises so that the water level goes up in case of a flood, thus affecting the areas along the river and the neighborhood of Rangkasbitung as well. In the alternative plan M-2, a line is planned to connect the gate sill height of the Pamarayan weir with the mean riverbed at Rangkasbitung. The design riverbed gradient of this section is 1/2,200. Sediments above this design riverbed height are to be dredged up to 3 m at the maximum.

(5) Excavation of flood way with confluence treatment

The outline of excavation of flood way with confluence treatment for the upper Ciujung and Ciberang rivers is described below.

Fig. E-28 shows shortcut plan for the section from No. 64 to No. 54 points. In this section, the existing ground height is high, and there is a section where the maximum excavating depth is 15 m, making it necessary to newly construct two railway bridges and one road bridge. Economically, therefore, conditions in this section are not favourable.

However, the confluence form of both rivers is irrational against river flow, leading to erosion and collapse of both banks downstream from the confluence. Hence, in this area where there are many habitations, it is expected that a fundamental countermeasure will be required in the future. In the master plan, this countermeasure is proposed for each alternative plan.

The improvement plan of the confluence of the Cisimeut river with confluence treatment of the Cisimeut and Ciberang rivers is outlined below.

As the Cisimeut river meets at right angle with the Ciberang river, the right bank of the Ciberang river at the confluence is suffering from considerable erosion and collapse, and a countermeasure is taken at present by some groynes. From a topographical standpoint, however, this is not enough and a fundamental countermeasure is required.

In the master plan, a proposal is intended to move the Cisimeut river downstream from the current confluence and to open the flood way of about 900 m so as to provide a rational plan to overcome such problems as configuration against the flow.

4.3.4 River improvement in the first stage plan level

In the first stage plan, dredging in the upstream reaches of the Pamarayan weir and shortcut are proposed with an emphasis placed on flood control in and around Rangkasbitung and consideration given to the stability of channels and the aspect of cost as well.

However, no treatment of the confluence of the upper Ciujung and Ciberang rivers would be made for the reason that the flood way requires new construction of two railway bridges and one road bridge and also large amount of excavation, resulting in increase in construction cost. At the present moment, therefore, no benefit can be expected.

According to the alternative plan F-1, the design flood is 1,400 m^3/s at Rangkasbitung, which exceeds the existing design flood of 1,100 m^3/s in the lower reaches. In this case, therefore, the whole river section upstream from the river mouth is subject to the study.

According to the alternative plans F-2 and F-3, the design flood at Rangkasbitung is 1,100 m^3/s and 1,000 m^3/s, respectively, owing to flood regulation by dam. In these cases, therefore, the upper reaches from the Pamarayan weir are subject to the study.

(1) Alignment

The alignment is fundamentally the same as that of the master plan level. As for the cross section, the width between both embankments is to be the same, and the low water channel in the shortcut section is to be established to match the design flood. In the implementation stage for the master plan level, width extension of the low water channel and levee raising are to be carried out as shown in Fig. E-32.

(2) Longitudinal profile and shortcut

The design riverbed gradient is to be the same as that of the master plan level. Also, the high water level is determined by non-uniform flow calculation according to the design flood as shown in Fig. E-33. The shortcut upstream from the Pamarayan weir is planned for the section from No. 85 to No. 64 points. The existing channel length of 6.4 km is to be shortened to 3.7 km with a reduction of 2.7 km.

The decrease of water level at Rangkasbitung by shortcut is shown in Fig. E-34, and this is more effective compared with the dredging plan for the section from the Pamarayan weir to No. 85 point described in below. Table E-23 shows the effect of shortcut and dredging on water level at Rangkasbitung.

(3) Cross section

The cross section in the alternative plan F-2 is shown in Fig. E-35. In this case, the design river width and channel configuration are to be the same in each alternative plan, and the design flood water level and embankment height are to be based on the needed water level according to the non-uniform flow calculation. The standard cross section in the shortcut section is shown in Fig. E-36.

(4) Dredging in the upstream reaches of the Pamarayan weir

Dredging in the upstream reaches of the Pamarayan weir is to be the same as that established for the master plan level, and the dredging depth is to be determined according to the design riverbed. In this case, the quantity of sand to be dredged is determined to secure a cross section necessary to allow a design flood to flow with safety, and it will also be smaller than that of the master plan level.

4.3.5 Cost estimate of alternative plan

(1) Construction cost of river improvement

With respect to each alternative plan mentioned in the aobve, the construction cost of river improvement works is estimated on the bases of unit construction cost as shown in Table E-24 and unit price of land acquisition and compensation as shown in Table E-25.

The estimated construction cost for each alternative plan in the master plan level and the first stage plan level is summarized in Table E-26. The river improvement cost without any dam is broken down in Table E-27 (1/3) for the alternative plan F-1 and Table E-28 (1/3) for the alternative plan M-1, respectively. The river improvement cost with flood regulation by one dam, Karian, is tabulated in Table E-27 (2/3) for the alternative plan F-2 and Table E-28 (2/3) for the alternative plan M-2. The cost necessary for river improvement combined with construction of two dams, Karian plus Pasir Kopo, is shown in Table E-27 (3/3) for the alternative plan F-3 and Table E-28 (3/3) for the alternative plan M-3.

Among the three alternatives of the first stage plan level, as seen in Table E-26, the unit cost of river improvement excluding price contingency is Rp 555 x 10^6/km for F-1, Rp 387 x 10^6/km for F-2 and Rp 347 x 10^6/km for F-3, respectively. As the costs for construction of new bridges and excavation of new flood way are included in the river improvement costs for the three alternatives of the master plan level, the unit cost increases to Rp 723 x 10^6/km for M-1, Rp 699 x 10^6/km for M-2 and Rp 688 x 10^6/km for M-3, respectively.

Table E-29 shows a sample of estimation of land acquisition and compensation costs for river improvement works.

(2) Construction cost for dam and share of flood control sector

Among the Karian, Pasir Kopo and Bojongmanik dams subject to the present study, the Karian dam has the largest flood control effect and the other two dams have also similar effect.

From the economical viewpoint of stored water utilization in each reservoir, the Karian dam of which effectively stored water will be fully used for the irrigation purpose in the existing Ciujung and new K-C-C irrigation areas is most advantegeous, followed by the Pasir Kopo dam. Thus, these two dams among the three are selected for the study on combination of river improvement and dam construction.

The total construction costs of the Karian and Pasir Kopo dams are shown in Table E-30. The cost for the latter is summed up when the dam is constructed at the optimum scale in combination with the Karian dam.

The share of dam construction by flood control sector is obtained by extracting the construction cost directly necessary for flood control from the total construction cost and then multiplying the capacity ratio of flood control to active storage of each reservoir by the extracted construction cost. The said capacity ratio is estimated to be 0.138 for the Karian dam of which flood storage capacity is 30 x 10^6 m^3 and active storage capacity is 218 x 10^6 m^3, and 0.181 for the Pasir Kopo dam of which flood storage capacity is 15 x 10^6 m^3 and active storage capacity is 83 x 10^6 m^3 when the dam is constructed in combination with the Karian dam to meet the future water demand in 2000. The shared dam construction cost by flood control sector is Rp 6,081 x 10^6 for the Karian dam and Rp 6,777 x 10^6 for the Pasir Kopo dam excluding price contingency as shown in Table E-31.

(3) Cost necessary for flood control

The cost necessary for flood control is obtained as the sum of the river improvement cost and the share of the dam construction cost by flood control sector as below. The cost includes price contingency.

Items		F-1	F-2	F-3	M-1	M-2	M-3
		Alternative Plan					
Dam	(Rp 10^6)	0	9,448	20,116	0	9,448	20,116
River	(Rp 10^6)	54,515	14,602	13,067	76,305	73,669	72,472
Total	(Rp 10^6)	54,515	24,050	33,183	76,305	83,117	92,588

In the first stage plan level, therefore, the alternative plan F-2 which covers the Karian dam construction and the river improvement of upstream reaches from the Pamarayan weir is lowest in cost, while in the master plan level, the alternative plan M-1 which covers only the river improvement is low in cost. Hence, a collective judgment must be made from the aspect of economy and development of water resources as well. Particularly, considering an effect of the area in and around Rangkasbitung where there is a strong demand for flood control, the alternative plan F-2 in the first stage plan level is considered to be appropriate.

5. RIVER MAINTENANCE FLOW

5.1 River Maintenance Flow

River maintenance flow means the rate of flow required to maintain adequately the functions of river. In all kinds of irrigation plans, it is needed to take into consideration this maintenance flow in estimating the irrigation water demand and the available amount of water to be developed in the future.

The rate of flow required for adequate maintenance of the river functions means the flow necessary at the time of water shortage with overall consideration given to river transportation, fisheries, scenic view, prevention of salt intrusion, prevention of river mouth blockage, protection of river control facilities, maintenance of groundwater level, preservation of animals and plants, maintenance of water quality, irrigation water right etc. Also, another consideration is to establish the maintenance flow in such a way that it can be maintained at the time of water shortage equivalent to the first rank in the past 10 years, taking into account the relation with water utilization. In order to establish adequately this maintenance flow, it is necessary to make detailed investigation about each item mentioned in the above.

5.2 Maintenance Flow of the Ciujung River and Karian Dam

In the case of the Ciujung river, upstream from the Pamarayan weir, the amount of water needed to secure irrigation water supply is maintained. Downstream from this point, however, it is necessary to establish adequately the maintenance flow.

Regarding the Ciujung river, there are no particular items that bear apprehensions as mentioned in the above. As for the depth of water required for transportation of fishing boats near the river mouth, there is no particular problem at present because the river lies in the tidal compartment. As there is no intake of water in the downstream reaches of the Pamarayan weir, it can be considered that no salt injury is caused through the Ciujung river.

Thus, for the present study, the river maintenance flow is derived from the drought discharge of 10 years return period at the Rangkasbitung gauging station, which is estimated to be 4.55 m^3/s on the basis of drought discharge data for 11 years from 1972 to 1982 as shown in Table E-32 and Fig. E-37.

The Pamarayan weir and the Karian dam are the points subject to the study. The maintenance flow, at each subject point, is calculated in the following manner with consideration given to the catchment areas and the annual losses. The estimated river maintenance flows are 4.70 m^3/s at the Pamarayan weir and 1.4 m^3/s at the Karian dam as shown in Table E-33.

6. CONSTRUCTION PLAN

6.1 General

Here follows a description of the Ciujung river improvement plan with priority given to the alternative plan F-2 which is effective to the vicinity of Rangkasbitung where there is a strong demand for flood control. Such flood control as the alternative plan F-2 is immediately required and is low in cost. The period of construction works is set at five years considering the pressing importance of flood control. The first two years will be spent for detailed design.

6.2 Construction Works

Earth work will form the nucleus of river improvement works. The volume of earth work is 1.29×10^6 m^3 for dredging, 1.09×10^6 m^3 for excavation and 1.22×10^6 m^3 for embankment.

Dredging is to be carried out by a transportable dredger. In order to finish dredging work within its target period of about 30 months, a dredger with monthly average capacity of about 40,000 m^3 is required. Prior to executing dredging work, it is necessary to examine carefully the dredging section through a geological survey of its riverbed.

Excavation is to be carried out mainly by means of bulldozers and back-hoes. The soil excavated near the river bank is to be conveyed by dump trucks and utilized for embankment.

6.3 Construction Schedule

Construction work is to be executed in the order of effect of decreasing water level on Rangkasbitung. Firstly, shortcut in the section from No. 85 to No. 64 points is done followed by riverbed dredging and banking works between the Pamarayan weir and No. 85 point. Finally, construction work centers around embankment upstream from No. 64 point including upper Ciujung and Ciberang rivers.

The volume of earth work in each section is summarized below.

Item	Unit	Shortcut No. 85 to No. 64	Dredging Pamarayan to No. 85	Embankment Upstream from No. 64	Total
Dredging	10^3 m^3	280	1,006	0	1,286
Excavation	10^3 m^3	345	508	234	1,087
Embankment (1)	10^3 m^3	343	701	132	1,176
Embankment (2)	10^3 m^3	0	0	45	45
Sub-total	10^3 m^3	343	701	177	1,221
Total		968	2,215	411	3,594

The construction schedule is prepared in consideration of the above-mentioned earth work as shown in Fig. E-38. This schedule is also applicable to other alternatives proposed as the first stage plan level. On the other hand, the construction period for the master plan level is assumed to be seven years, considering the works to be executed in the whole section from the river mouth. The construction schedule is shown in Fig. E-38.

In the case of the alternative F-2, construction of the Karian dam is to be started simultaneously, with the construction period assumed to be seven years. If the construction work is assumed to start in 1985, therefore, it will be eight years later or 1992 when the safety against the flood with a return period of 10 years is exhibited.

7. COST ESTIMATE

7.1 Composition of Construction Cost

The river improvement cost consists of earth work, sluice and equipment, land acquisition, engineering and administration and physical contingency. The construction cost is estimated on the basis of prices in 1982. Also, estimation is made using the following exchange rate as of 1982.

US$1 = Rp 690 = ¥245

The unit costs used in estimating direct construction cost are shown in Table E-24. Unit land acquisition and compensation costs are estimated as shown in Table E-25.

Costs other than direct construction cost are estimated as below. For government administration and engineering services, considering that their total will account for about 15% of direct construction cost, the following values are used:

(1) Government administration cost is assumed to be 3.8% of local currency portion of direct construction cost.

(2) Engineering cost is assumed to be 6.5% of local currency portion and 20% of foreign currency portion of direct construction cost.

(3) Physical contingency is assumed to be 20% of the sum of direct construction, land acquisition and compensation, government administration and engineering costs.

(4) Price contingency is taken into account at annual escalation rate of 7.0% for foreign currency portion and 10% for local currency portion.

7.2 Construction Cost

(1) Construction Cost

The construction cost of each alternative is given in Sub-section 4.3.5. The work quantities and the breakdown of construction costs for the respective alternative plans are shown in Tables E-27 and E-28.

The dredging cost as shown in Tables E-27 and E-28 covers the purchase of a dredger and the implementation of dredging works. The purchase cost summed up in the construction cost is Rp 845 x 10^6. The proposed purchase of a dredger is based on the judgment made from silting up of the present channel in the upstream of the Pamarayan weir and the necessity of maintenance of the channel by dredging even after improvement.

Land acquisition and compensation are estimated with the average price required for land acquisition per hectare including compensation. It is assumed to be Rp 4.0 x 10^6, from the result of sample estimation for the alternative plan M-2 as shown in Table E-29.

With regard to the proposed alternative plan F-2, the cost of river improvement alone is summarized below with the breakdown of foreign and currency portions.

Item	Foreign Currency (Rp 10^6)	Local Currency (Rp 10^6)	Total (Rp 10^6)
Direct Construction Cost	4,476	2,242	6,718
Land Acquisition	-	505	505
Engineering and Administration	903	233	1,136
Physical Contingency	1,076	596	1,672
Sub-total	6,455	3,576	10,031
Price Contingency	2,440	2,131	4,571
Total	8,895	5,707	14,602

The construction costs of the Karian and Pasir Kopo dams are shown in Table E-30, referring to Appendix K. The costs of intake tunnel and related facilities which are required for purposes other than flood control are deducted from the total dam construction cost. Then, this cost is allocated at the ratio of flood control storage to active storage as described in Sub-section in 4.3.5. The shared dam construction cost by flood control sector is shown in Table E-31.

With regard to the alternative plan F-2, the summary of river improvement cost and the shared construction cost of the Karian dam is tabulated below with the breakdown of foreign and local currency portions.

Item	Foreign Currency (Rp 10^6)	Local Currency (Rp 10^6)	Total (Rp 10^6)
Shared Dam Cost	1,990	1,297	3,287
River Improvement Cost	4,476	2,242	6,718
Sub-total	6,466	3,539	10,005
Land Acquisition	0	1,775	1,775
Engineering and Administration	1,259	388	1,647
Physical Contingency	1,545	1,140	2,685
Total	9,270	6,842	16,112
Price Contingency	3,832	4,106	7,938
Grand Total	13,102	10,948	24,050

The results of estimation of total cost including the shared dam construction cost for each alternative plan are summarized below with the breakdown of foreign and local currency portions. All the costs include the price contingency.

Alternative Plan	Foreign Currency (Rp 10^6)	Local Currency (Rp 10^6)	Total (Rp 10^6)
F-0	4,207	5,241	9,448
F-1	33,316	21,199	54,515
F-2	13,102	10,948	24,050
F-3	17,529	15,654	33,183
M-1	45,517	30,788	76,305
M-2	48,764	34,353	83,117
M-3	53,478	39,110	92,588

(2) Annual disbursement schedule

The annual disbursement schedule for each alternative plan is worked out as shown in Table E-34 for the first stage plans F-1 to F-3 in Table E-35, for the master plans M-1 to M-3 and in Table E-36 for F-2, F-3, M-2 and M-3 after shared dam construction cost on the basis of the construction schedule.

7.3 Operation and Maintenance Cost

Annual operation and maintenance cost for both cases of river improvement alone and combined with dam construction is to be 0.5% of the direct construction cost estimated above. The annual operation and maintenance cost in each alternative is summarized below.

Alternative	Operation and Maintenance Cost (Rp 10^6): River Improvement Cost Alone	Operation and Maintenance Cost (Rp 10^6): With Shared Dam Cost
F-0	20	20
F-1	141	141
F-2	40	60
F-3	36	80
M-1	198	198
M-2	192	212
M-3	189	233

8. BENEFIT

The average annual flood damage by the existing channel of the Ciujung river is as described in Chapter 3. The benefit, as the amount of damage decrement by the flood control effect of dam and river improvement, is estimated according to the following consideration:

(1) In the master plan level, the average annual flood damage decrement at 50 years return period is assumed to be a benefit and the value of Rp 4,012 x 10^6 in the whole section upstream from the river mouth is used.

(2) In the alternative plan F-0 for flood regulation by the Karian dam alone, the difference between the average annual flood damage after completion of dam and the present average annual flood damage at 10 years return period is assumed to be a benefit at the value of Rp 670 x 10^6.

(3) In the alternative plan F-1 which requires river improvement upstream from the river mouth in the first stage plan level, the average annual damage decrement of Rp 3,269 x 10^6 at 10 years return period in the whole section upstream from the river mouth is assumed to be a benefit.

(4) In the alternative plans F-2 and F-3 where the river improvement section upstream from the Pamarayan weir is subject to the study in the first stage plan level, the amount of average annual damage decrement by dam in the section from the Pamarayan weir to the river mouth is added to the average annual damage decrement of Rp 1,357 x 10^6 in the section upstream from the Pamarayan weir at 10 years return period as a benefit, totalling to Rp 1,986 x 10^6 for F-2 and Rp 2,229 x 10^6 for F-3.

Thus, the benefit of each alternative is summarized below. In the combined case of river improvement and dam construction, the benefit by river improvement can be expected from two years before completion of dam.

	Alternative	1990 6th Year	1991 7th Year	1992 8th Year
F-0:	Karian dam alone	-	-	670
F-1:	River improvement alone	-	-	3,269
F-2:	River improvement with Karian dam	862	862	1,986
F-3:	River improvement with Karian plus Pasir Kopo dams	643	643	2,229
M-1:	River improvement alone	-	-	4,012
M-2:	River improvement with Karian dam	-	-	4,012
M-3:	River improvement with Karian plus Pasir Kopo dams	-	-	4,012

9. PROPOSED FLOOD CONTROL PLAN

The study is carried out with respect to the master plan level for 50 years return period as an overall plan and the first stage plan level for 10 years return period which is intended to cope, in a short period of time, with the situation in and around Rangkasbitung where flood control is pressingly required.

In the master plan level, taking into consideration the condition of the Ciujung river in the future, shortcut and other measures to accompany the treatment of the confluence of the Ciberang and Ciujung rivers are examined as the overall plan. However, considering the execution of this plan which covers improvement of the whole section upstream from the river mouth, an excessively heavy investment will be required as far as the socio-economic level in the present basin is concerned.

On the other hand, the first stage plan requires less investment and can cope with the situation in and around Rangkasbitung which has been suffering from a great deal of flood damage. Moreover, each alternative in this first stage plan level is advantageous to the relation between investment and benefit. The analytical results of its economic effect at the discount rate of 10% are summarized in the following table, referring to Appendix L.

Alternative	Net Production Value (Rp 10^6)	B/C Ratio	EIRR (%)
F-0	-323	0.91	9.2
F-1	-4,326	0.79	8.1
F-2	741	1.07	10.7
F-3	-2,143	0.85	8.6

From these results, the first stage alternative plan F-2 which consists of the construction of the Karian dam and the river improvement upstream from the Pamarayan weir is proposed as the flood control plan in the present study on the river improvement.

REFERENCES

1. DESIGN DRAINAGE PROJECT, CIUJUNG SUB-PROJECT FINAL REPORT, Vol. 2, Annex 1 Drainage Block Design Notes, May 1981, PROSIDA

2. REPORT OF NOVEMBER 1981 FLOOD, November 1981, Seksi Serang Wilayah Pengairan Banten

3. REPORT OF NOVEMBER 1981 FLOOD, November 1981, Seksi Pandeglang - Rangkasbitung, Wilayah Pengairan Banten

4. REPORT OF FLOOD IN BANTEN, November 1981, P3SA, DPU

5. CRITERIA FOR RIVER AND DEBRIS CONTROL ENGINEERING, 1976, Ministry of Construction, Japan

6. OUTLINE OF ECONOMIC SURVEY ON FLOOD CONTROL, March 1980, Ministry of Construction, Japan

7. OPEN CHANNEL HYDRAULICS, 1959, McGRAW HILL, Ven Te Chow

8. SURVEY AND STUDY FOR DEVELOPMENT OF SALA RIVER BASIN SUPPORTING REPORT PART-TWO FLOOD CONTROL AND RIVER IMPROVEMENT, January 1974, OTCA, Japan

9. FEASIBILITY REPORT ON ULAR RIVER FLOOD CONTROL AND IMPROVEMENT OF IRRIGATION PROJECT, July 1978, Japan International Cooperation Agency

10. LOWER JENEBERANG RIVER FLOOD CONTROL PROJECT, SUPPORTING REPORT 1 HYDROLOGY, October 1980, Japan International Cooperation Agency

Table E-1 CATCHMENT AREA BY RIVER IN NORTH BANTEN AREA

River	Catchment Area (km^2)	Channel Length (km)	Average Slope of Catchment
Ciujung River	1,850	135	1/170
Ciberang River	331	85	1/45
Cisimeut River	458	71	1/47
Upper Ciujung River	594	82	1/105
Cibeureum River	255	67	1/68
Cibanten River	183	39	1/22
Cidanau River	222	38	1/22
Kari Anyer River	50	17	1/25

Table E-2 CIUJUNG RIVER WATER LEVEL CALCULATED BY NON-UNIFORM FLOW FORMULA

Unit: m

No.	Point	n	Discharge Q (m^3/s)					
			500	750	1000	1250	1500	2000
183	Jengjing	0.025	0.777	1.734	2.451	2.810	3.202	3.931
		0.030	1.111	2.075	2.652	3.134	3.568	4.368
		0.035	1.421	2.320	2.940	3.456	3.924	4.790
150	Kragilan Bridge	0.025	3.143	4.216	5.075	5.769	6.394	7.496
		0.030	3.597	4.736	5.623	6.380	7.055	8.247
		0.035	4.006	5.194	6.132	6.938	7.659	8.935
104	Pamarayan Weir	0.025	7.842	8.750	9.540	10.244	10.885	12.047
		0.030	8.213	9.219	10.086	10.859	11.569	12.849
		0.035	8.559	9.657	10.596	11.437	12.208	13.599
58	Rangkasbitung Railway Bridge	0.025	15.587	16.498	17.268	17.956	18.591	19.736
		0.030	15.966	16.957	17.806	18.562	19.253	20.506
		0.035	16.315	17.387	18.301	19.120	19.870	21.223

Remarks: No. = Measuring point
n = Manning's roughness coefficient

Table E-3 CIUJUNG RIVER WATER LEVEL BY NON-UNIFORM FLOW CALCULATION

No.	Dis.	Q	H	Q	H	Q	H	Q	H
CU 194	0.00	200	-0.400	300	-0.400	500	-0.400	750	-0.400
CU 189	2.36	200	-0.341	300	-0.269	500	-0.044	750	0.373
CU 183	5.49	200	0.017	300	0.409	500	1.236	750	2.107
CU 175	8.99	200	0.319	300	0.851	500	1.828	750	2.797
CU 172	10.44	200	0.482	300	1.047	500	2.055	750	3.042
CU 169	11.81	200	0.630	300	1.220	500	2.245	750	3.246
CU 166	13.04	200	0.883	300	1.493	500	2.532	750	3.548
CU 159	15.05	200	1.259	300	1.908	500	2.988	750	4.042
CU 155	16.45	200	1.425	300	2.106	500	3.230	750	4.331
CU 150	18.31	200	1.743	300	2.457	500	3.615	750	4.741
CU 145	20.62	200	2.091	300	2.831	500	4.015	750	5.165
CU 128	24.76	200	3.032	300	3.714	500	4.864	750	6.025
CU 126	25.76	200	3.325	300	3.970	500	5.089	750	6.236
CU 122	27.88	200	3.944	300	4.505	500	5.525	750	6.621
CU 117	30.20	200	4.759	300	5.299	500	6.253	750	7.284
CU 111	33.29	200	5.689	300	6.222	500	7.142	750	8.135
CU 107	35.35	180	6.239	260	6.821	440	7.790	660	8.797
P. WEIR	37.07	180	6.615	260	7.178	440	8.170	660	9.188
CU 97	38.85	180	10.365	260	10.259	440	10.767	660	11.667
CU 94	40.10	180	10.929	260	11.400	440	11.807	660	12.332
CU 90	42.18	180	11.214	260	11.718	440	12.339	660	13.038
CU 85	44.70	180	11.932	260	12.423	440	13.226	660	14.051
CU 75	47.61	180	12.748	260	13.262	440	14.172	660	15.068
CU 73	48.76	180	13.065	260	13.580	440	14.481	660	15.361
CU 64	51.08	180	13.860	260	14.355	440	15.272	660	16.184
CU 58	53.25	180	14.218	260	14.739	440	15.692	660	16.624
CU 54	54.03	140	14.330	210	14.870	350	15.851	520	16.807
CU 40	57.49	140	15.304	210	15.857	350	16.799	520	17.731
CU 32	60.65	80	16.329	120	16.932	190	17.853	290	18.861
CU 22	64.17	80	17.892	120	18.469	190	19.325	290	20.306
CU 10	66.55	80	19.274	120	19.790	190	20.567	290	21.482
CU 4	67.85	80	20.656	120	21.004	190	21.582	290	22.361
CU 194	0.00	1,100	-0.400	1,600	-0.400	1,800	-0.400	2,000	-0.400
CU 189	2.36	1,100	1.032	1,600	1.920	1,800	2.271	2,000	2.622
CU 183	5.49	1,100	2.865	1,600	3.743	1,800	4.062	2,000	4.369
CU 175	8.99	1,100	3.738	1,600	4.821	1,800	5.206	2,000	5.573
CU 172	10.44	1,100	4.027	1,600	5.164	1,800	5.568	2,000	5.954
CU 169	11.81	1,100	4.247	1,600	5.380	1,800	5.779	2,000	6.158
CU 166	13.04	1,100	4.587	1,600	5.765	1,800	6.181	2,000	6.575
CU 159	15.05	1,100	5.141	1,600	6.386	1,800	6.822	2,000	7.233
CU 155	16.45	1,100	5.498	1,600	6.827	1,800	7.295	2,000	7.739
CU 150	18.31	1,100	5.940	1,600	7.308	1,800	7.791	2,000	8.247
CU 145	20.62	1,100	6.399	1,600	7.798	1,800	8.291	2,000	8.758
CU 128	24.76	1,100	7.303	1,600	8.765	1,800	9.282	2,000	9.772
CU 126	25.76	1,100	7.512	1,600	8.981	1,800	9.501	2,000	9.995
CU 122	27.88	1,100	7.868	1,600	9.324	1,800	9.843	2,000	10.334
CU 117	30.20	1,100	8.485	1,600	9.916	1,800	10.431	2,000	10.919
CU 111	33.29	1,100	9.305	1,600	10.718	1,800	11.229	2,000	11.715
CU 107	35.35	970	9.980	1,400	11.411	1,600	11.923	1,800	12.411
P. WEIR	37.07	970	10.394	1,400	11.850	1,600	12.387	1,800	12.899
CU 97	38.85	970	12.193	1,400	13.029	1,600	13.467	1,800	13.905
CU 94	40.10	970	12.947	1,400	13.746	1,600	14.122	1,800	14.496
CU 90	42.18	970	13.866	1,400	14.888	1,600	15.341	1,800	15.782
CU 85	44.70	970	15.012	1,400	16.154	1,600	16.639	1,800	17.105
CU 75	47.61	970	16.109	1,400	17.333	1,600	17.843	1,800	18.328
CU 73	48.76	970	16.388	1,400	17.598	1,600	18.103	1,800	18.583
CU 64	51.08	970	17.255	1,400	18.521	1,600	19.051	1,800	19.555
CU 58	53.25	970	17.710	1,400	18.985	1,600	19.520	1,800	20.029
CU 54	54.03	770	17.906	1,100	19.187	1,200	19.737	1,400	20.227
CU 40	57.49	770	18.832	1,100	20.096	1,200	20.573	1,400	21.122
CU 32	60.65	420	19.958	600	21.190	680	21.639	740	22.122
CU 22	64.17	420	21.354	600	22.554	680	23.016	740	23.424
CU 10	66.55	420	22.491	600	23.640	680	24.087	740	24.444
CU 4	67.85	420	23.252	600	24.295	680	24.718	740	25.048

Remarks: No. = Measuring point, Dis. = Distance (km), Q = Discharge (m^3/s), H = Water level (m)
CU = Ciujung, and P. WEIR = Pamarayan Weir

Table E-4 FLOW CAPACITY OF CIUJUNG RIVER

Measuring Point	Depth (m)	River Width (m)	Flow Capacity (m^3/s)
CU 194	7.0	279.5	
CU 189	7.9	260.6	1,759.5
CU 183	8.2	182.1	1,256.6
CU 175	6.5	126.0	650.1
CU 172	5.5	157.2	749.4
CU 169	6.4	110.2	978.6
CU 166	6.3	117.0	821.4
CU 159	8.4	85.9	1,123.6
CU 155	6.8	115.8	724.7
CU 150	8.2	118.5	1,018.2
CU 145	5.9	122.8	603.2
CU 128	5.7	127.2	814.3
CU 126	7.3	126.6	670.2
CU 122	3.8	118.1	519.3
CU 117	3.8	110.6	434.3
CU 111	6.3	115.5	808.3
CU 107	5.6	113.9	636.6
P. WEIR	7.0	142.6	1,455.8
CU 97	2.7	187.5	514.0
CU 94	15.8	78.0	410.3
CU 90	3.2	130.5	481.2
CU 85	3.2	140.0	375.8
CU 75	5.2	105.1	283.3
CU 73	3.0	100.0	194.7
CU 64	4.1	125.0	220.4
CU 58	4.7	124.8	418.8
CU 54	6.6	80.8	557.0
CU 40	4.0	79.0	275.8
CU 32	5.4	48.9	292.2
CU 22	4.6	64.4	262.8
CU 10	4.9	68.2	311.6
CU 4	6.6	82.7	653.9

Remarks: CU = Ciujung
P. WEIR = Pamarayan Weir

Table E-5 FLOW CAPACITY OF UPPER CIUJUNG RIVER

Distance (km)	Ground Height (m)	River Width (m)	Cross-sectional Area of Stream (m^2)	Wetted Perimeter (m)	Hydraulic Mean Depth (m)	Velocity (m/s)	Discharge (m^3/s)
0.0	L 16.5	62.3	239.7	64.4	3.72	1.63	391.5
	R 17.4	63.9	296.5	67.0	4.43	1.83	543.1
5.0	L 21.2	70.0	401.9	75.8	5.30	2.07	829.9
	R 19.8	70.0	304.0	72.7	4.18	1.76	535.5
10.0	L 23.8	56.7	365.3	65.2	5.60	1.84	672.2
	R 19.0	47.1	109.7	48.7	2.25	1.00	109.7
15.0	L 26.0	52.0	307.9	57.6	5.34	1.78	548.1
	R 22.9	46.1	155.6	47.9	3.25	1.28	199.2
20.0	L 29.3	44.6	286.7	55.5	5.17	1.74	498.9
	R 24.5	33.6	100.1	38.6	2.59	1.10	110.1
25.0	L 34.0	60.6	466.9	68.4	6.82	2.72	1,270.0
	R 29.8	52.4	229.6	55.1	4.17	1.96	450.0
30.0	L 37.4	65.1	463.8	73.7	6.29	2.58	1,196.6
	R 33.0	49.1	219.9	52.4	4.20	1.97	433.2
35.0	L 38.8	50.0	260.4	54.6	4.77	2.92	760.4
	R 38.8	50.0	260.4	54.6	4.77	2.92	760.4
40.0	L 46.8	48.2	253.5	52.6	4.82	2.94	745.3
	R 46.8	48.2	253.5	52.6	4.82	2.94	745.3

Remarks: L = Left bank
R = Right bank

Roughness Coefficient

0.0 to 5.0 km n = 0.03
5.0 to 40.0 km n = 0.035

Table E-6 FLOW CAPACITY OF CISIMEUT RIVER

Distance (km)	Ground Height (m)	River Width (m)	Cross-sectional Area of Stream (m^2)	Wetted Perimeter (m)	Hydraulic Mean Depth (m)	Velocity (m/s)	Discharge (m^3/s)
0.0	L 18.0	55.3	236.2	58.1	4.06	1.63	385.0
	R 20.6	60.9	387.6	66.9	5.79	2.06	798.5
5.0	L 20.0	56.3	230.9	59.5	3.88	1.58	364.8
	R 20.2	56.4	242.2	59.9	4.04	1.62	392.4
10.0	L 22.5	44.0	156.8	47.8	3.28	1.41	221.1
	R 21.4	43.6	108.5	45.2	2.40	1.15	124.8
15.0	L 25.6	51.4	216.5	55.7	3.89	1.58	342.1
	R 23.2	46.6	97.9	48.0	2.04	1.61	157.6
20.0	L 28.5	46.7	122.1	48.4	2.52	1.72	210.0
	R 29.0	47.0	145.6	49.5	2.94	1.90	276.6
25.0	L 37.1	52.9	170.6	55.6	3.07	2.11	360.0
	R 36.9	52.7	160.0	55.1	2.90	2.46	393.6
30.0	L 52.8	59.2	404.0	65.4	6.18	4.06	1,640.2
	R 52.8	59.2	404.0	65.4	6.18	4.06	1,640.2

Remarks: L = Left bank
R = Right bank

Roughness Coefficient

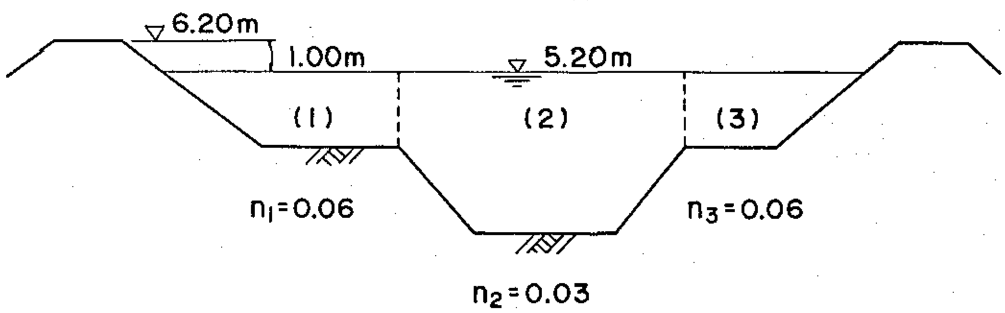
n = 0.035

Table E-7 FLOW CAPACITY OF CIBANTEN RIVER

Distance (km)	Ground Height (m)	River Width (m)	Cross-sectional Area of Stream (m^2)	Wetted Perimeter (m)	Hydraulic Mean Depth (m)	Velocity (m/s)	Discharge (m^3/s)
5.0	5.2	96.1	237.2	-	-	-	296.4
10.0	L 13.4	51.8	321.3	59.9	5.36	2.12	681.2
	R 12.5	51.8	274.7	58.1	4.73	1.95	535.7
15.0	L 22.0	23.3	105.6	32.0	3.30	2.78	293.6
	R 24.0	27.5	156.4	38.6	4.05	3.18	497.4
20.0	L 36.7	34.1	132.3	37.0	3.58	3.99	527.9
	R 43.0	46.5	389.2	57.2	6.81	6.14	2,389.7
25.0	L 65.7	38.1	125.3	41.2	3.04	4.74	593.9
	R 67.0	40.1	176.1	44.8	3.94	5.63	991.4

Remarks: L = Left bank Roughness Coefficient
R = Right bank $n = 0.035$

Cross Section at 5.0 km Point



Section	River Width (m)	Cross-sectional Area of Stream (m^2)	Wetted Perimeter (m)	Hydraulic Mean Depth (m)	Roughness Coefficient	Velocity (m/s)	Discharge (m^3/s)
Cross Section at 5.0 km Point							
(1)	43.6	40.2	50.2	0.80	0.060	0.28	11.3
(2)	32.2	159.4	37.9	4.21	0.030	1.70	270.0
(3)	20.3	37.6	27.3	1.38	0.060	0.40	15.1
Total	96.1	237.2	-	-	-	-	296.4

Remarks: Slope of design water level = 1/2,630

Table E-8 INUNDATED AREA ALONG CIUJUNG RIVER BY FLOOD IN NOV. 1981

Unit: ha

River Section	Land Use	Inundated Depth (m) 0.00 to 0.49	0.50 to 0.99	1.00 to 1.49	1.50 to 1.99	Total
River Mouth to Pamarayan Weir	Wet Paddy Field	490	870	1,760	190	3,310
	Upland Crop Field	60	80	160	190	490
	Tree Crop	30	60	120	40	250
	Fish Pond	550	-	-	-	550
	Village	30	40	90	40	200
	Sub-total	1,160	1,050	2,130	460	4,800
Upstream from Pamarayan Weir	Wet Paddy Field	10	10	30	50	100
	Upland Crop Field	60	60	130	260	510
	Tree Crop	20	20	40	80	160
	Village	10	10	20	40	80
	Sub-total	100	100	220	430	850
Whole River Section	Wet Paddy Field	500	880	1,790	240	3,410
	Upland Crop Field	120	140	290	450	1,000
	Tree Crop	50	80	160	120	410
	Fish Pond	550	-	-	-	550
	Village	40	50	110	80	280
	Total	1,260	1,150	2,350	890	5,650

Table E-9 APPRAISEMENT OF HOUSES AND BUILDINGS, AND HOUSEHOLD EFFECTS OR STORED GOODS AT 1982 PRICE LEVEL

Unit: Rp 10^6

Kind of Houses and Buildings	Appraisement		
	Houses and Buildings	Household Effects or Stored Goods	Total
Residence (A)	1.0	0.5	1.5
Residence (B)	2.0	1.0	3.0
Shop	2.0	2.0	4.0
School	7.5	1.5	9.0
Mosque	3.0	1.0	4.0

Remarks: Because of the presence of a comparatively large number of farmhouses, the appraisement of Residence (A) is adopted for the area from the river mouth up to the Pamarayan weir, whereas that of Residence (B) is adopted for the area up-stream from the Pamarayan weir.

Table E-10 RATE OF APPRAISEMENT OF HOUSEHOLD EFFECTS BY INUNDATED DEPTH ABOVE FLOOR LEVEL

Unit: %

Kind of Houses and Buildings	Inundated Depth above Floor Level (m)						
	0 to 0.5	0.5 to 1.0	1.0 to 1.5	1.5 to 2.0	2.0 to 2.5	2.5 to 3.0	Over 3.0
Residence	55	80	90	95	99	100	100
Shop	40	65	75	90	95	99	100
School & Mosque	55	85	95	99	100	100	100

Table E-11 DAMAGE RATE OF INUNDATED HOUSES AND BUILDINGS

Inundated Depth above Floor (m)	Damage Rate
0 - 0.49	0.030
0.50 - 0.99	0.068
1.00 - 1.49	0.099
1.50 - 1.99	0.143
2.00 - 2.49	0.209

Source: Outline of Economic Survey on Flood Control, Ministry of Construction, Japan

Table E-12 DAMAGE RATE OF INUNDATED PROPERTIES

Kind of Properties	Damage Rate
Household Effects of Residence	0.690
Stored Good of Shop	0.597
Properties of School, Mosque	0.632

Source: Outline of Economic Survey on Flood Control, Ministry of Construction, Japan

Table E-13 NUMBER OF INUNDATED HOUSES AND BUILDINGS ALONG CIUJUNG RIVER BY FLOOD IN NOV. 1981

Unit: number

River Section	Kind of Houses and Buildings	Inundated Depth (m)				Total
		0.00 to 0.49	0.50 to 0.99	1.00 to 1.49	1.50 to 1.99	
River Mouth to Pamarayan Weir	Residence	880	1,170	2,630	1,170	5,850
	Shop	10	20	40	20	90
	School	1	1	2	1	5
	Mosque	9	12	27	12	60
	Sub-total	900	1,203	2,699	1,203	6,005
Upstream from Pamarayan Weir	Residence	290	290	590	1,170	2,340
	Shop	5	5	10	20	40
	School	0	0	0	2	2
	Mosque	3	3	6	12	24
	Sub-total	298	298	606	1,204	2,406
Whole River Section	Residence	1,170	1,460	3,220	2,340	8,190
	Shop	15	25	50	40	130
	School	1	1	2	3	7
	Mosque	12	15	33	24	84
	Total	1,198	1,501	3,305	2,407	8,411

Table E-14 INUNDATED CROP AREA ALONG CIUJUNG RIVER BY FLOOD IN NOV. 1981

Unit: ha

Crops	River Section		
	River Mouth to Pamarayan Weir	Upstream from Pamarayan Weir	Whole Section
Wetland Paddy	210 (3,050)/1	-	210
Upland Crops			
Maize	150	400	550
Cassava	340	110	450
Sub-total	490	510	1,000
Tree Crops/2	250	160	410
Brackish Water Fish Pond	550	-	550
Total	1,500	670	2,170

Remarks: /1 = Damage area after completion of year-round irrigation system
/2 = Mixed planting of banana and bamboo

Table E-15 CROP DAMAGE VALUES IN DOWNSTREAM AREA OF PAMARAYAN WEIR BY FLOOD IN NOV. 1981

Crops	Gross Inundated Area (ha)	Net Planted Area (ha)	Unit Damage Value (Rp/ha)	Average Damage Factor	Damage Value/1 (Rp 10^6)
Wetland Paddy	210	168	280,000	0.50	23.52
Upland Crops					
Maize	150	120	45,000	1.00	5.40
Cassava	340	272	200,000	0.10	5.44
Sub-total	490	392			10.84
Tree Crops	250	125	-/2	-	-
Brackish Water Fish Pond	550	385	700,000	0.50	134.75
Total	1,500	1,070			169.11

Remarks: /1 = Values based on the market price at the end of 1982
/2 = No crop damage occurred

Table E-16 CROP DAMAGE VALUES IN UPSTREAM AREA OF THE PAMARAYAN WEIR BY FLOOD IN NOV. 1981

Crops	Gross Inundated Area (ha)	Net Planted Area (ha)	Unit Damage Value (Rp/ha)	Average Damage Factor	Damage Value/1 ($Rp\ 10^6$)
Wetland Paddy	-	-	-	-	-
Upland Crops					
Maize	400	320	45,000	1.00	14.40
Cassava	110	44	200,000	0.10	0.88
Sub-total	510	364			15.28
Tree Crops	160	80	-/2	-	-
Total	670	444			15.28

Remarks: /1 = Values based on the market price at the end of 1982
/2 = No crop damage occurred

Table E-17 ACTUAL FLOOD DAMAGE AT 1982 PRICE ALONG CIUJUNG RIVER BY FLOOD IN NOV. 1981

Unit: $Rp\ 10^6$

Item	River Section		
	River Mouth to Pamarayan Weir	Upstream from Pamarayan Weir	Whole River Section
Houses and Buildings, Household Effects	2,365.30	1,982.75	4,348.05
Crops	169.11	15.28	184.39
Suspension of Business Activities	141.92	118.97	260.88
Public Facilities	1,880.41	1,794.39	3,674.80
Total	4,556.74	3,911.39	8,468.13

Table E-18 ECONOMIC VALUES OF CROP DAMAGE BY FLOOD

Unit: Rp 10^6

River Section	Wetland Paddy	Upland Crops		Brackish Water Fish Pond	Total
		Maize	Cassave		
River Mouth to Pamarayan Weir	976.00/1	5.40	5.44	134.75	1,121.59
Upstream from Pamarayan Weir	0	14.40	0.88	-	15.28
Whole River Section	976.00	19.80	6.32	134.75	1,136.87

Remarks: /1 = Gross Inundated Area 3,050 ha
Net Planted Area 2,440 ha
Unit Damage Value 800,000 (Rp/ha)
Average Damage Factor 0.50

Table E-19 ANNUAL FLOOD DISCHARGE AT THE RANGKASBITUNG GAUGING STATION FROM 1972 TO 1981

Unit: m^3/s

Ranking	Day/Month/Year	Annual Flood Discharge
1	17/11/1981	1,150
2	08/02/1979	772
3	29/01/1978	712
4	21/01/1977	697
5	04/03/1976	688
6	04/01/1972	637
7	23/11/1980	590
8	06/01/1974	552
9	14/02/1975	534
10	21/09/1973	510

Table E-20 COMPARISON OF PRINCIPAL FEATURES OF DAM AND RESERVOIR

Item	Unit	Karian Dam	Pasir Kopo Dam	Bojongmanik Dam
River		Ciberang	Cisimeut	Upper Ciujung
Catchment area	km^2	288	172	159
Storage capacity	10^6 m^3	261.2	162.5	56.0
Active storage capacity	10^6 m^3	218.0	136.7	33.0
Flood storage capacity	10^6 m^3	30.0	15.0	16.0
Available storage capacity	10^6 m^3	188.0	121.7	17.0
Dead storage capacity	10^6 m^3	43.2	25.8	23.0
Storage efficiency		196	116	39
Type of dam		Rockfill	Rockfill	Rockfill
Dam crest	El. m	70	115	90
Dam height	m	52	67	47
Dam crest length	m	510	245	330
Crest width	m	10	10	10
Dam volume	10^6 m^3	1.11	1.19	0.84

Table E-21 DESIGN FLOOD DISTRIBUTION OF CIUJUNG RIVER

Unit: m^3/s

	First Stage Plan (10 years)			Master Plan (50 years)			
	Case 10-0	Case 10-1	Case 10-2	Case 50-0	Case 50-1	Case 50-2	Case 50-3
Ciujung River							
Kragilan bridge	1,600	-	-	2,000	1,700	1,600	1,400
Pamarayan weir	1,400	1,100	1,000	1,800	1,500	1,400	1,200
Rangkasbitung	1,400	1,100	1,000	1,800	1,500	1,400	1,200
Upper Ciujung River							
Rangkasbitung	760	760	760	1,100	1,100	1,100	950
Cipanas river confluence	690	690	690	910	910	910	610
Cipetuj river confluence	560	560	560	740	740	740	390
Bojongmanik dam site	450	450	450	590	590	590	190
Ciberang River							
Ciujung river confluence	1,100	750	650	1,400	1,100	780	780
Cisimeut river confluence	600	230	230	740	300	300	300
Karian dam site	600	230	230	740	300	300	300
Cisimeut River							
Ciberang river confluence	740	740	520	990	990	670	670
Ciminyak river confluence	670	670	270	930	930	380	380
Pasir Kopo dam site	610	610	210	850	850	280	280

Remarks:
10-0 = 10 years return period, no dam
10-1 = 10 years return period, Karian dam alone
10-2 = 10 years return period, Karian plus Pasir Kopo dams
50-0 = 50 years return period, no dam
50-1 = 50 years return period, Karian dam alone
50-2 = 50 years return period, Karian plus Pasir Kopo dams
50-3 = 50 years return period, Karian plus Pasir Kopo plus Bojongmanik dams

Table E-22 ALTERNATIVE RIVER IMPROVEMENT PLANS

Item	Length (km)	Alternative Plan						
		First Stage Plan (10 Years)				Master Plan (50 Years)		
		F-0	F-1	F-2	F-3	M-1	M-2	M-3
Design Flood Distribution Case		10-1	10-0	10-1	10-2	50-0	50-1	50-2
River Improvement								
Ciujung River								
River Mouth - Pamarayan	37.07	-	+	-	-	+	+	+
Pamarayan - No. 64 point	14.01	-	+	+	+	+	+	+
No. 64 point - No. 54 point (Present Channel)	2.95	-	+	+	+	-	-	-
No. 64 point - No. 54 point (Shortcut)	1.91	-	-	-	-	+	+	+
Upper Ciujung River	F: 5.50 M: 10.00	-	+	+	+	+	+	+
Ciberang River	3.46	-	-	-	-	+	+	+
Cisimeut River (Shortcut)	0.90	-	-	-	-	+	+	+
Total Length of Improvement		0	59.53	22.46	22.46	67.35	67.35	67.35
Construction of Dam								
Karian Dam		+	-	+	+	-	+	+
Pasir Kopo Dam		-	-	-	+	-	-	+

Remarks: Design flood distribution case = Ref. Table E-21
+ = Implementation
F-0 = Karian dam alone
F-1 & M-1 = River improvement alone
F-2 & M-2 = River improvement combined with Karian dam
F-3 & M-3 = River improvement combined with Karian plus Pasir Kopo dams

Table E-23 EFFECT OF DREDGING AND SHORTCUT ON WATER LEVEL AT RANGKASBITUNG

Condition	Water Level (m)	Drawdown (m)	Discharge (m^3/s)
Present condition	19.0	-	1,400
Dredging (Pamarayan - No. 85 point)	18.6	0.4	1,400
Shortcut (No. 85 point - No. 64 point)	18.1	0.9	1,400
Dredging and Shortcut	17.6	1.4	1,400
Karian dam (Present channel)	18.2	0.8	1,100

Table E-24 UNIT CONSTRUCTION COST

Unit: Rp

Item	Unit	Unit Price		Total
		F.C	L.C	
Dredging	m^3	1,520	580	2,100
Excavation	m^3	330	220	550
Embankment 1	m^3	300	370	670
Embankment 2	m^3	2,380	2,340	4,720
Sod Facing	m		330	330
Pavement	m	60	2,160	2,220
Groyne	PC		11,000,000	11,000,000
Sluice	PC	230,000	11,730,000	11,960,000
Drainage Ditch	m	2,960	3,700	6,660
Bridge	m	3,640,000	1,860,000	5,500,000

Remarks: Embankment 1 = By excavated materials
Embankment 2 = By borrowed within 5 km

Table E-25 UNIT PRICE OF LAND ACQUISITION AND COMPENSATION

Unit: Rp 10^6

Item	Unit	Price
Land		
Paddy field	ha	5.0
Upland	ha	2.0
Forest	ha	1.5
Settlement	ha	3.0
House		
Simple house	house	1.0
Simple permanent house	house	2.0

Table E-26 COMPARISON OF SUMMARIZED CONSTRUCTION COST OF EACH ALTERNATIVE PLAN

Unit: Rp 10^6

Item	Alternatives					
	F-1	F-2	F-3	M-1	M-2	M-3
1. Direct construction cost	23,533	6,718	6,064	33,028	31,952	31,473
2. Land acquisition	1,663	505	404	2,127	2,004	1,938
3. Engineering and administration	3,946	1,136	1,031	5,479	5,324	5,254
4. Physical contingency	5,829	1,672	1,500	8,127	7,856	7,733
Sub-total	34,971	10,031	8,999	48,761	47,136	46,397
5. Price contingency	19,544	4,571	4,068	27,544	26,533	26,074
Total	54,515	14,602	13,067	76,305	73,669	72,471
6. Improvement length (km)	63.0	25.9	25.9	67.4	67.4	67.4

Table E-27 (1/3) RIVER IMPROVEMENT COST
(FIRST STAGE PLAN F-1)

Unit: Rp 10^6

Item	Unit	Q'ty	Cost		
			FC	LC	Total
1. Direct Construction Cost					
Preparatory works			1,428	712	2,140
Civil works					
Dredging	10^3 m^3	5,917	9,838	3,432	13,270
Excavation	10^3 m^3	6,212	2,050	1,366	3,416
Embankment 1	10^3 m^3	1,685	506	623	1,129
Embankment 2	10^3 m^3	133	317	311	628
Sod facing	10^3 m^2	692	-	228	228
Pavement	10^3 m^2	7,200	-	16	16
Groyne	PC	8	-	88	88
Sluice	PC	5	1	59	60
Drainage ditch	m	92,016	272	341	613
Miscellaneous			1,299	646	1,945
Sub-total			15,711	7,822	23,533
2. Land Acquisition	ha	416	-	1,663	1,663
3. Government Administration			-	293	293
4. Engineering Services			3,142	511	3,653
5. Physical Contingency			3,771	2,058	5,829
Total			22,624	12,347	34,971
6. Price Contingency			10,692	8,852	19,544
Grand Total			33,316	21,199	54,515

Remarks: FC = Foreign currency portion
LC = Local currency portion

Table E-27 (2/3) RIVER IMPROVEMENT COST
(FIRST STAGE PLAN F-2)

Unit: Rp 10^6

Item	Unit	Q'ty	Cost		
			FC	LC	Total
1. Direct Construction Cost					
Preparatory works			374	183	557
Civil works					
Dredging	10^3 m^3	1,285	2,799	745	3,544
Excavation	10^3 m^3	1,087	359	239	598
Embankment 1	10^3 m^3	1,176	353	435	788
Embankment 2	10^3 m^3	46	108	107	215
Sod facing	10^3 m^2	448	-	148	148
Pavement	10^3 m^2	7,000	0	15	15
Groyne	PC	3	-	33	33
Sluice	PC	1	0	12	12
Drainage ditch	m	37,184	110	138	248
Miscellaneous			373	187	560
Sub-total			4,476	2,242	6,718
2. Land Acquisition	ha	126	-	505	505
3. Government Administration			-	85	85
4. Engineering Services			903	148	1,051
5. Physical Contingency			1,076	596	1,672
Total			6,455	3,576	10,031
6. Price Contingency			2,440	2,131	4,571
Grand Total			8,895	5,707	14,602

Remarks: FC = Foreign currency portion
LC = Local currency portion

Table E-27 (3/3) RIVER IMPROVEMENT COST (FIRST STAGE PLAN F-3)

Unit: Rp 10^6

Item	Unit	Q'ty	Cost		
			FC	LC	Total
1. Direct Construction Cost					
Preparatory works			344	160	504
Civil works					
Dredging	10^3 m^3	1,145	2,586	664	3,250
Excavation	10^3 m^3	1,026	338	226	564
Embankment 1	10^3 m^3	945	283	350	633
Embankment 2	10^3 m^3	46	109	106	215
Sod facing	10^3 m^2	294	-	97	97
Pavement	10^3 m^2	7,000	0	15	15
Groyne	PC	3	-	33	33
Sluice	PC	1	0	12	12
Drainage ditch	m	35,417	105	131	236
Miscellaneous			342	163	505
Sub-total			4,107	1,957	6,064
2. Land Acquisition	ha	101	-	404	404
3. Government Administration			-	74	74
4. Engineering Services			828	129	957
5. Physical Contingency			987	513	1,500
Total			5,922	3,077	8,999
6. Price Contingency			2,232	1,836	4,068
Grand Total			8,154	4,913	13,067

Remarks: FC = Foreign currency portion
LC = Local currency portion

Table E-28 (1/3) RIVER IMPROVEMENT COST (MASTER PLAN M-1)

Unit: Rp 10^6

Item	Unit	Q'ty	Cost FC	Cost LC	Cost Total
1. Direct Construction Cost					
Preparatory works			1,949	1,054	3,003
Civil works					
Dredging	10^3 m^3	6,121	10,149	3,550	13,699
Excavation	10^3 m^3	11,039	3,643	2,428	6,071
Embankment 1	10^3 m^3	3,593	1,078	1,329	2,407
Embankment 2	10^3 m^3	88	210	206	416
Sod facing	10^3 m^2	1,062	-	350	350
Pavement	10^3 m^2	7,200	0	16	16
Groyne	PC	8	-	88	88
Sluice	PC	5	1	59	60
Drainage ditch	m	96,120	284	356	640
Bridge	LS		2,348	1,200	3,548
Miscellaneous			1,772	958	2,730
Sub-total			21,434	11,594	33,028
2. Land Acquisition	ha	532	-	2,127	2,127
3. Government Administration			-	435	435
4. Engineering Services			4,287	757	5,044
5. Physical Contingency			5,144	2,983	8,127
Total			30,865	17,896	48,761
6. Price Contingency			14,652	12,892	27,544
Grand Total			45,517	30,788	76,305

Remarks: FC = Foreign currency portion
LC = Local currency portion

Table E-28 (2/3) RIVER IMPROVEMENT COST
(MASTER PLAN M-2)

Unit: Rp 10^6

Item	Unit	Q'ty	Cost		
			FC	LC	Total
1. Direct Construction Cost					
Preparatory works			1,908	997	2,905
Civil works					
Dredging	10^3 m^3	6,121	10,149	3,550	13,699
Excavation	10^3 m^3	11,171	3,687	2,457	6,144
Embankment 1	10^3 m^3	2,544	763	941	1,704
Embankment 2	10^3 m^3	46	111	108	219
Sod facing	10^3 m^2	874	-	288	288
Pavement	10^3 m^2	7,200	0	16	16
Groyne	PC	8	-	88	88
Sluice	PC	5	1	59	60
Drainage ditch	m	96,120	284	356	640
Bridge	LS		2,348	1,200	3,548
Miscellaneous			1,734	907	2,641
Sub-total			20,985	10,967	31,952
2. Land Acquisition	ha	501	-	2,004	2,004
3. Government Administration			-	411	411
4. Engineering Services			4,197	716	4,913
5. Physical Contingency			5,036	2,820	7,856
Total			30,218	16,918	47,136
6. Price Contingency			14,341	12,192	26,533
Grand Total			44,559	29,110	73,669

Remarks: FC = Foreign currency portion
LC = Local currency portion

Table E-28 (3/3) RIVER IMPROVEMENT COST (MASTER PLAN M-3)

Unit: Rp 10^6

Item	Unit	Q'ty	Cost		
			FC	LC	Total
1. Direct Construction Cost					
Preparatory works			1,889	973	2,862
Civil works					
Dredging	10^3 m^3	6,121	10,149	3,550	13,699
Excavation	10^3 m^3	11,151	3,680	2,453	6,133
Embankment 1	10^3 m^3	2,136	641	790	1,431
Embankment 2	10^3 m^3	26	63	62	125
Sod facing	10^3 m^2	822	-	271	271
Pavement	10^3 m^2	7,200	0	16	16
Groyne	PC	8	-	88	88
Sluice	PC	5	1	59	60
Drainage ditch	m	96,120	284	356	640
Bridge	LS		2,348	1,200	3,548
Miscellaneous			1,717	883	2,600
Sub-total			20,772	10,701	31,473
2. Land Acquisition	ha	484	-	1,938	1,938
3. Government Administration			-	401	401
4. Engineering Services			4,154	699	4,853
5. Physical Contingency			4,985	2,748	7,733
Total			29,911	16,487	46,398
6. Price Contingency			14,192	11,882	26,074
Grand Total			44,103	28,369	72,472

Remarks: FC = Foreign currency portion
LC = Local currency portion

Table E-29 LAND ACQUISITION AND COMPENSATION COST FOR RIVER IMPROVEMENT PLAN M-2

Item	Unit	Q'ty	Cost (Rp 10^6)
Land			
Paddy field	ha	250	1,250
Upland	ha	138	276
Forest	ha	36	54
Settlement	ha	25	75
Others	ha	51	54
Sub-total		500	1,709
Compensation			
Simple house	pc	147	147
Simple permanent house	pc	74	148
Sub-total		221	295
Total			2,004

Table E-30 CONSTRUCTION COST OF KARIAN AND PASIR KOPO DAMS

Unit: Rp 10^6

Item	Karian Dam	Pasir Kopo Dam
1. Direct Construction Cost		
Preparatory works	2,320	2,060
Diversion works	3,160	3,900
Coffer dam	480	500
Main dam	10,430	8,650
Spillway and intake	3,630	5,130
Metal work	3,800	2,480
Tunnel	1,660	-
Sub-total	25,480	22,720
2. Land Acquisition	9,200	5,100
3. Engineering and Administration	3,820	3,410
4. Physical Contingency	7,700	6,250
Total	46,200	37,480
5. Price Contingency	25,620	20,720
Grand Total	71,820	58,200

Table E-31 SHARED DAM CONSTRUCTION COST BY FLOOD CONTROL SECTOR

Unit: Rp 10^6

Item	Karian Dam	Pasir Kopo Dam
1. Direct Construction Cost	3,287	4,106
2. Land Acquisition	1,270	923
3. Engineering and Administration	511	617
4. Physical Contingency	1,013	1,131
Total	6,081	6,777

Table E-32 PROBABLE LOW WATER FLOW AT RANGKASBITUNG GAUGING STATION

Observed Low Water Flow

i	Year	Discharge (m^3/s)	F(xi)
1	1972	3.60	0.08333
2	1982	4.10	0.16667
3	1976	9.70	0.25000
4	1977	10.60	0.33333
5	1979	14.20	0.41667
6	1980	22.50	0.50000
7	1975	24.00	0.58333
8	1978	25.80	0.66667
9	1974	32.20	0.75000
10	1981	34.60	0.83333
11	1973	40.30	0.91667

Remarks: $F(xi) = \frac{i}{N + 1}$, N = 11

Probable Low Water Flow

Return Period	Discharge (m^3/s)
50.0	2.17
40.0	2.37
30.0	2.68
25.0	2.90
20.0	3.21
15.0	3.69
10.0	4.55
7.5	5.37
5.0	6.95
4.0	8.16
3.0	10.32
2.0	15.62

Table E-33 CALCULATION OF RIVER OF MAINTENANCE FLOW AT PAMARAYAN, RANGKASBITUNG AND KARIAN DAM

Item	Unit	Pamarayan	Rangkasbitung	Karian Dam
Catchment area	km^2	1,451	1,383	288
Annual total rainfall	mm	3,301	3,350	4,282
Rainfall excess	mm	2,101	2,150	3,082
Maintenance flow	m^3/s	4.66	4.55	1.35

Remarks: Maintenance flow at Pamarayan

$$Q = 4.55 \times \frac{1,451}{1,383} \times \frac{2,101}{2,150} = 4.66 \doteqdot 4.7 \ (m^3/s)$$

Maintenance flow at Karian dam

$$Q = 4.55 \times \frac{288}{1,383} \times \frac{3,082}{2,150} = 1.35 \doteqdot 1.4 \ (m^3/s)$$

Table E-34 ANNUAL DISBURSEMENT SCHEDULE OF RIVER IMPROVEMENT COST FOR FIRST STAGE PLAN

Unit: Rp 10^6

Item	Total		1985		1986		1987		1988		1989		1990		1991	
	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC
(1) Alternative Plan F-1																
Direct construction	15711	7822	-	-	-	-	3967	1643	3271	1721	3419	1799	2973	1564	2081	1095
Land acquisition	-	1663	-	-	-	333	-	499	-	399	-	349	-	83	-	-
Gov. administration	-	293	-	-	-	59	-	88	-	70	-	61	-	15	-	-
Engineering services	3142	511	314	51	471	77	472	76	471	77	471	77	472	76	471	77
Physical contingency	3771	2058	63	10	94	94	888	461	749	454	778	457	689	348	510	234
Sub-total	22624	12347	377	61	565	563	5327	2767	4491	2721	4668	2743	4134	2086	3062	1406
Price contingency	10692	8852	55	13	127	186	1657	1284	1810	1663	2339	2118	2505	1980	2199	1608
Total	33316	21199	432	74	692	749	6984	4051	6301	4384	7007	4861	6639	4066	5261	3014
(2) Alternative Plan F-2																
Direct construction	4476	2242	-	-	-	-	2019	725	1210	747	1247	770	-	-	-	-
Land acquisition	-	505	-	-	-	116	-	152	-	136	-	101	-	-	-	-
Gov. administration	-	85	-	-	-	20	-	25	-	23	-	17	-	-	-	-
Engineering services	903	148	145	24	190	31	189	31	190	31	189	31	-	-	-	-
Physical contingency	1076	596	29	5	38	33	442	187	280	187	287	184	-	-	-	-
Sub-total	6455	3576	174	29	228	200	2650	1120	1680	1124	1723	1103	-	-	-	-
Price contingency	2440	2131	25	6	51	66	824	520	677	687	863	852	-	-	-	-
Total	8895	5707	199	35	279	266	3474	1640	2357	1811	2586	1955	-	-	-	-
(3) Alternative Plan F-3																
Direct construction	4107	1957	-	-	-	-	1899	633	1088	652	1120	672	-	-	-	-
Land acquisition	-	404	-	-	-	93	-	121	-	109	-	81	-	-	-	-
Gov. administration	-	74	-	-	-	15	-	22	-	21	-	16	-	-	-	-
Engineering services	828	129	132	21	174	27	174	27	174	27	174	27	-	-	-	-
Physical contingency	987	513	26	4	35	27	415	161	252	162	259	159	-	-	-	-
Sub-total	5922	3077	158	25	209	162	2488	964	1514	971	1553	955	-	-	-	-
Price contingency	2232	1836	23	5	47	54	774	447	610	593	778	737	-	-	-	-
Total	8154	4913	181	30	256	216	3262	1411	2124	1564	2331	1692	-	-	-	-

Table E-35 ANNUAL DISBURSEMENT SCHEDULE OF RIVER IMPROVEMENT COST FOR MASTER PLAN

Unit: Rp 10^6

Item	Total		1985		1986		1987		1988		1989		1990		1991	
	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC
(1) Alternative Plan M-1																
Direct construction	21434	11594	-	-	-	-	5169	2435	4530	2550	4735	2667	4118	2319	2882	1623
Land acquisition	-	2127	-	-	-	425	-	638	-	511	-	447	-	106	-	-
Gov. administration	-	435	-	-	-	87	-	131	-	104	-	91	-	22	-	-
Engineering services	4287	757	429	76	643	114	643	113	643	114	643	113	643	114	643	113
Physical contingency	5144	2983	86	15	129	125	1162	664	1035	656	1075	664	952	512	705	347
Sub-total	30865	17896	515	91	772	751	6974	3981	6208	3935	6453	3982	5713	3073	4230	2083
Price contingency	14652	12892	75	19	174	249	2169	1847	2502	2404	3233	3074	3462	2916	3037	2383
Total	45517	30788	590	110	946	1000	9143	5828	8710	6339	9686	7056	9175	5989	7267	4466
(2) Alternative Plan M-2																
Direct construction	20985	10967	-	-	-	-	5074	2303	4431	2413	4632	2522	4028	2194	2820	1535
Land acquisition	-	2004	-	-	-	401	-	601	-	481	-	421	-	100	-	-
Gov. administration	-	411	-	-	-	82	-	123	-	99	-	86	-	21	-	-
Engineering services	4197	716	420	71	629	108	630	107	629	108	630	107	629	108	630	107
Physical contingency	5036	2820	84	14	126	118	1141	627	1012	620	1052	627	931	485	690	329
Sub-total	30218	16918	504	85	755	709	6845	3761	6072	3721	6314	3763	5588	2908	4140	1971
Price contingency	14341	12192	73	18	170	235	2129	1745	2447	2274	3163	2905	3386	2760	2973	2255
Total	44559	29110	577	103	925	944	8974	5506	8519	5995	9477	6668	8974	5668	7113	4226
(3) Alternative Plan M-3																
Direct construction	20772	10701	-	-	-	-	5030	2247	4384	2354	4583	2462	3985	2140	2790	1498
Land acquisition	-	1938	-	-	-	388	-	581	-	465	-	407	-	97	-	-
Gov. administration	-	401	-	-	-	80	-	121	-	96	-	84	-	20	-	-
Engineering services	4154	699	416	69	623	105	623	105	623	105	623	105	623	105	623	105
Physical contingency	4985	2748	83	14	125	115	1131	611	1001	604	1041	612	922	472	682	320
Sub-total	29911	16487	499	83	748	688	6784	3665	6008	3624	6247	3670	5530	2834	4095	1923
Price contingency	14192	11882	72	17	168	228	2110	1701	2421	2214	3130	2833	3351	2689	2940	2200
Total	44103	28369	571	100	916	916	8894	5366	8429	5838	9377	6503	8881	5523	7035	4123

Table E-36 ANNUAL DISBURSEMENT SCHEDULE OF RIVER IMPROVEMENT COST INCLUDING SHARED DAM CONSTRUCTION COST FOR FIRST STAGE AND MASTER PLANS

Unit: Rp 10^6

Item	Total		1985		1986		1987		1988		1989		1990		1991	
	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC
(1) Alternative Plan F-2																
River Improvement Cost	6455	3576	174	29	228	200	2650	1120	1680	1124	1723	1103	-	-	-	-
Shared Dam Construction Cost for Karian																
Direct construction	1990	1297	-	-	-	-	295	196	393	251	468	294	540	360	294	196
Land acquisition	-	1270	-	-	-	635	-	635	-	-	-	-	-	-	-	-
Gov. administration	-	75	-	-	-	-	-	15	-	15	-	15	-	15	-	15
Engineering services	356	80	72	17	72	17	35	8	40	8	48	10	55	12	34	8
Physical contingency	469	544	14	3	14	130	66	171	87	55	103	64	119	78	66	43
Sub-total	2815	3266	86	20	86	782	396	1025	520	329	619	383	714	465	394	262
Total	9270	6842	260	49	314	982	3046	2145	2200	1453	2342	1486	714	465	394	262
Price Contingency	3832	4106	38	10	71	325	947	995	887	888	1173	1147	433	441	283	300
Grand Total	13102	10948	298	59	385	1307	3993	3140	3087	2341	3515	2633	1147	906	677	562
(2) Alternative Plan F-3																
River Improvement Cost	5922	3077	158	25	209	162	2488	964	1514	971	1553	955	-	-	-	-
Shared Dam Construction Cost for Karian	2815	3266	86	20	86	782	396	1025	520	329	619	383	714	465	394	262
Shared Dam Construction Cost for Pasir Kopo																
Direct construction	2464	1642	-	-	-	-	365	248	487	318	579	372	669	456	364	248
Land acquisition	-	923	-	-	-	462	-	461	-	-	-	-	-	-	-	-
Gov. administration	-	95	-	-	-	-	-	19	-	19	-	19	-	19	-	19
Engineering services	417	105	83	21	83	21	38	9	49	13	63	16	63	16	38	9
Physical contingency	577	554	17	4	17	97	81	148	107	70	128	82	146	98	81	55
Sub-total	3458	3319	100	25	100	580	484	885	643	420	770	489	878	589	483	331
Total	12195	9662	344	70	395	1524	3368	2874	2677	1720	2942	1827	1592	1054	877	593
Price Contingency	5334	5992	50	15	89	504	1047	1334	1079	1051	1474	1410	965	1000	630	678
Grand Total	17529	15654	394	85	484	2028	4415	4208	3756	2771	4416	3237	2557	2054	1507	1271
(3) Alternative Plan M-2																
River Improvement Cost	30218	16918	504	85	755	709	6845	3761	6072	3721	6314	3763	5588	2908	4140	1971
Shared Dam Construction Cost for Karian	2815	3266	86	20	86	782	396	1025	520	329	619	383	714	465	394	262
Sub-total	33033	20184	590	105	841	1491	7241	4786	6592	4050	6933	4146	6302	3373	4534	2233
Price Contingency	15731	14169	86	22	189	494	2252	2221	2657	2475	3473	3201	3819	3201	3255	2555
Total	48764	34353	676	127	1030	1985	9493	7007	9249	6525	10406	7347	10121	6574	7789	4788
(4) Alternative Plan M-3																
River Improvement Cost	29911	16487	499	83	748	688	6784	3665	6008	3624	6247	3670	5530	2834	4095	1923
Shared Dam Construction Cost for Karian	2815	3266	86	20	86	782	396	1025	520	329	619	383	714	465	394	262
Shared Dam Construction Cost for Pasir Kopo	3458	3319	100	25	100	580	484	885	643	420	770	489	878	589	483	331
Sub-total	36184	23072	685	128	934	2050	7664	5575	7171	4373	7636	4542	7122	3888	4972	2526
Price Contingency	17294	16038	99	27	210	679	2384	2587	2890	2672	3826	3505	4315	3690	3570	2878
Total	53478	39110	784	155	1144	2729	10048	8162	10061	7045	11462	8047	11437	7578	8542	5394

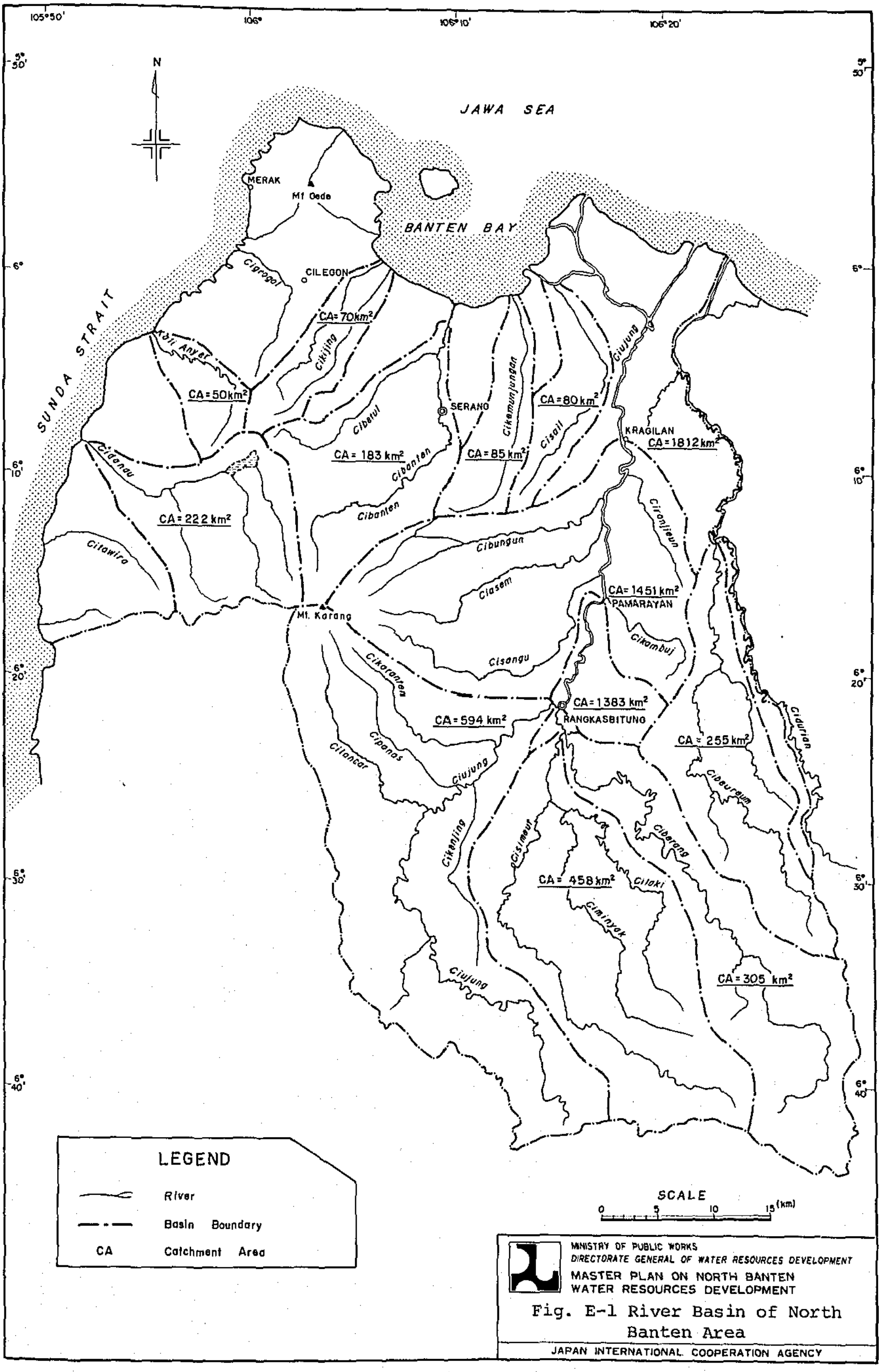


Fig. E-1 River Basin of North Banten Area

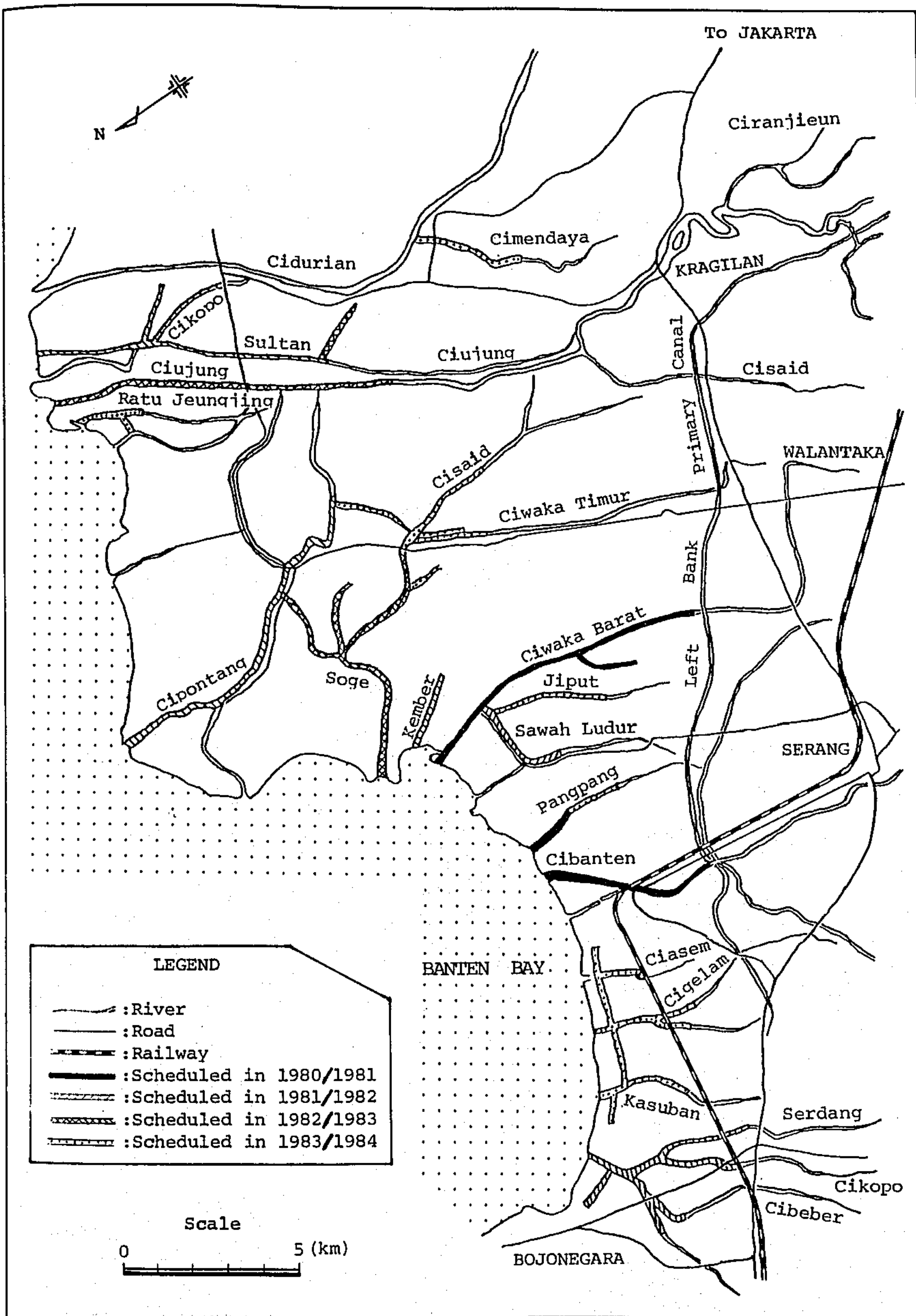


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Fig. E-2 Location of River Improvement Works

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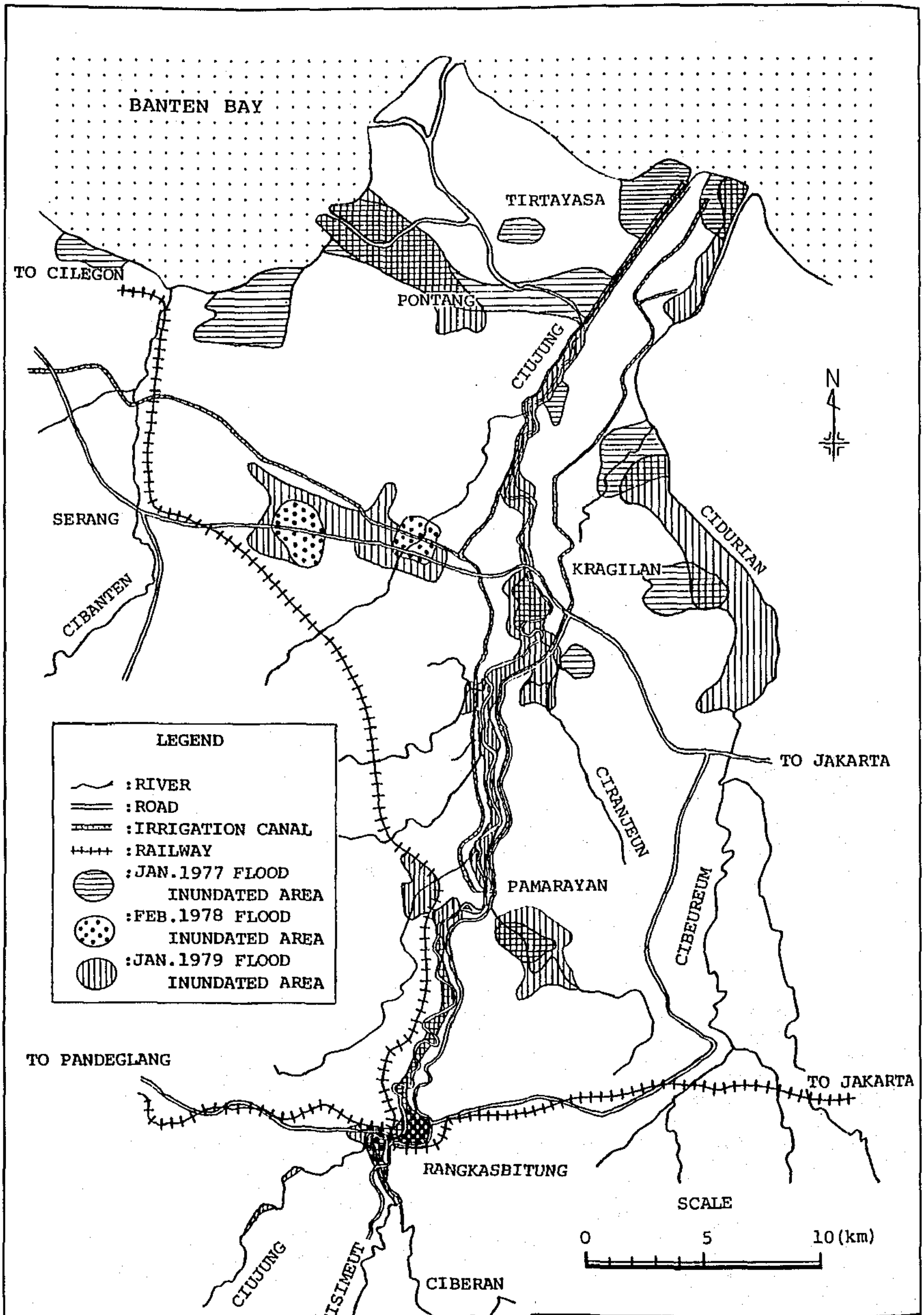

SOURCE: DPUP (SERANG & PANDEGRANG -RANGKASBITUNG)

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Fig. E-3 Inundated Area in and around Ciujung River Basin (1977 - 1979)

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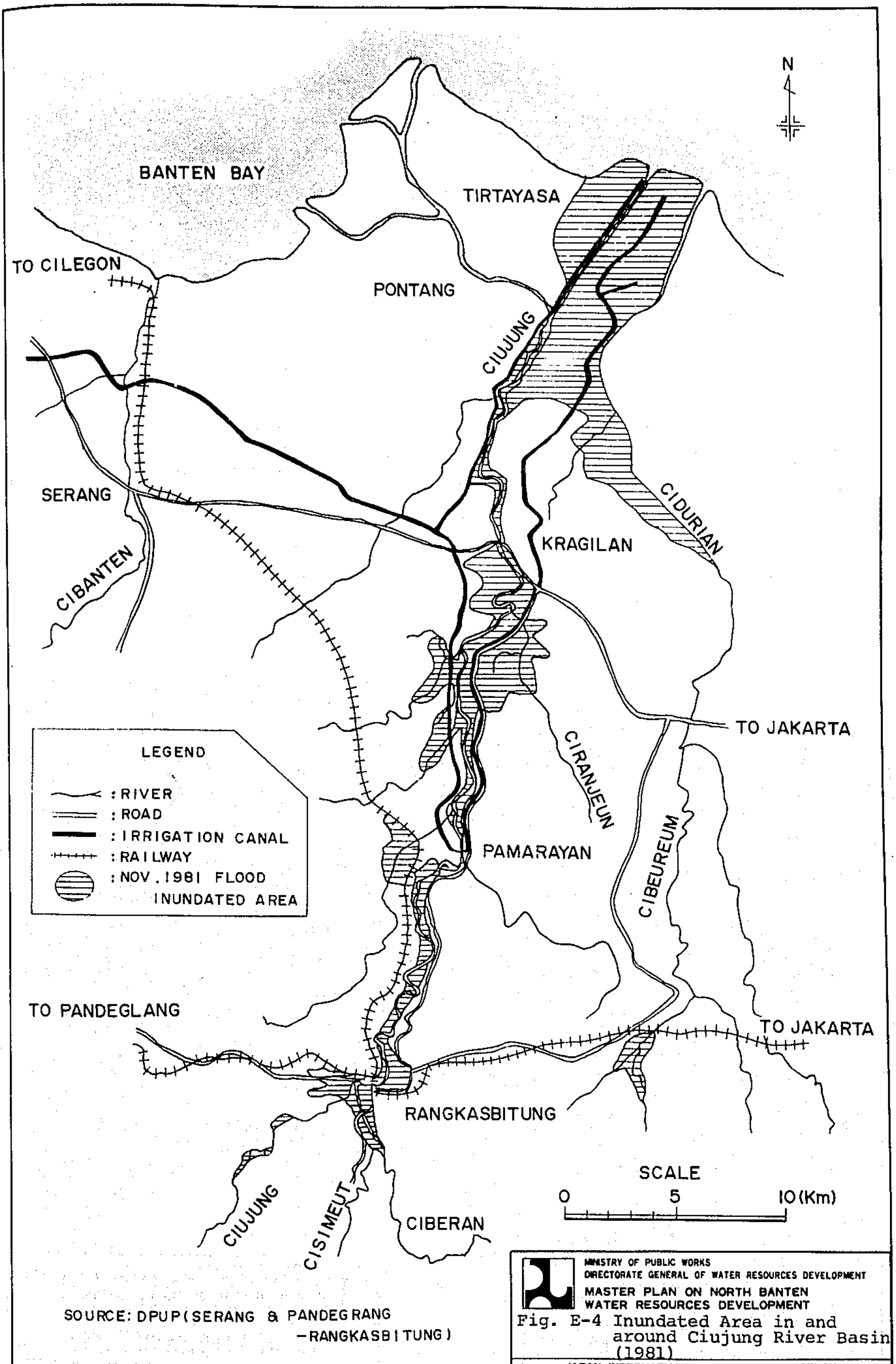

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Fig. E-4 Inundated Area in and around Ciujung River Basin (1981)

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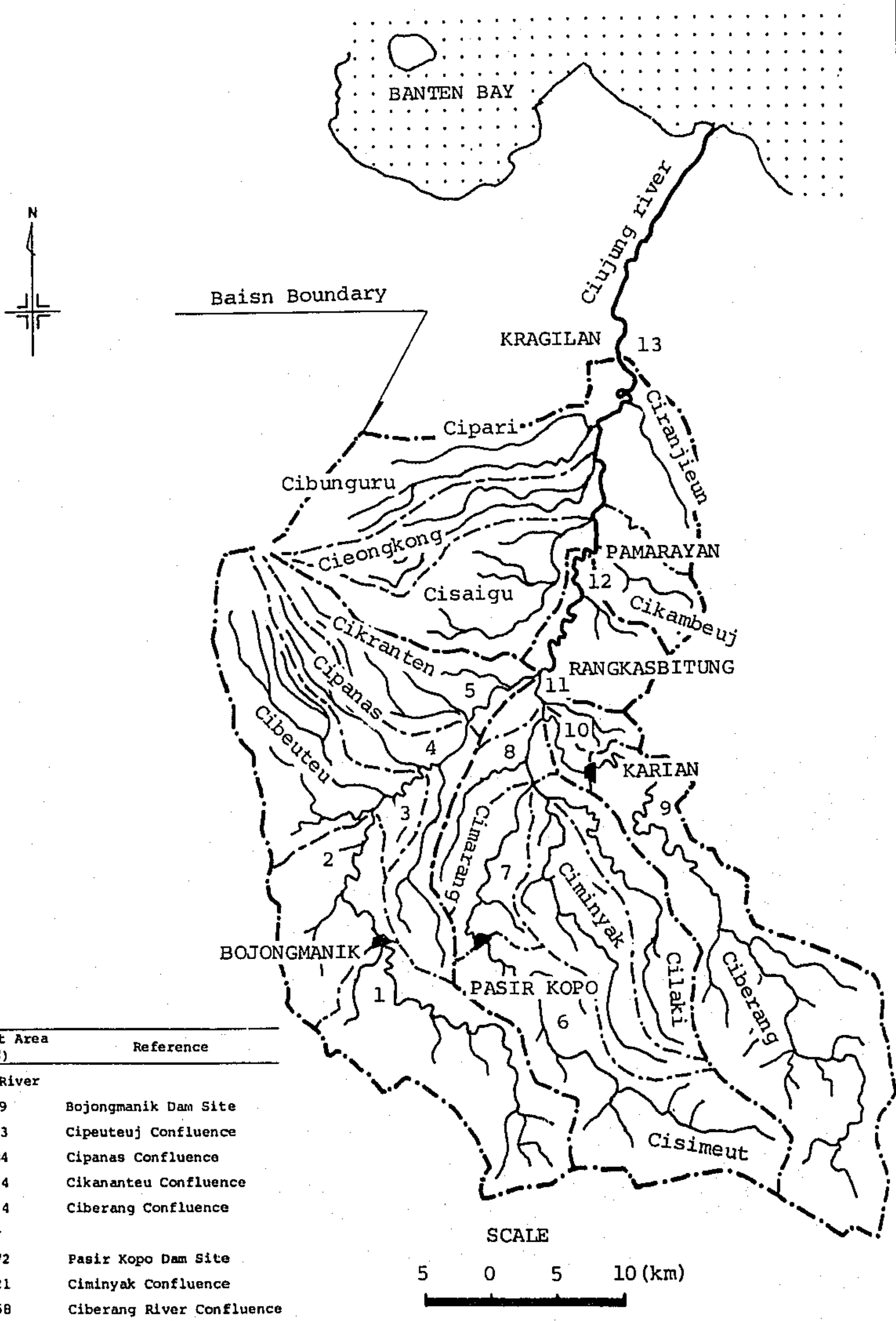

No.	Catchment Area (km2)	Reference
Upper Ciujung River		
1	159	Bojongmanik Dam Site
2	273	Cipeuteuj Confluence
3	384	Cipanas Confluence
4	514	Cikananteu Confluence
5	594	Ciberang Confluence
Cisimeut River		
6	172	Pasir Kopo Dam Site
7	221	Ciminyak Confluence
8	458	Ciberang River Confluence
Ciberang River		
9	288	Karian Dam Site
10	305	Cisimeut Confluence
11	789	Ciujung River Confluence
Ciujung River		
5+11	1383	Rangkasbitung
12	1451	Pamarayan Weir
13	1812	Kragilan Bridge

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Fig. E-5 Ciujung River Basin

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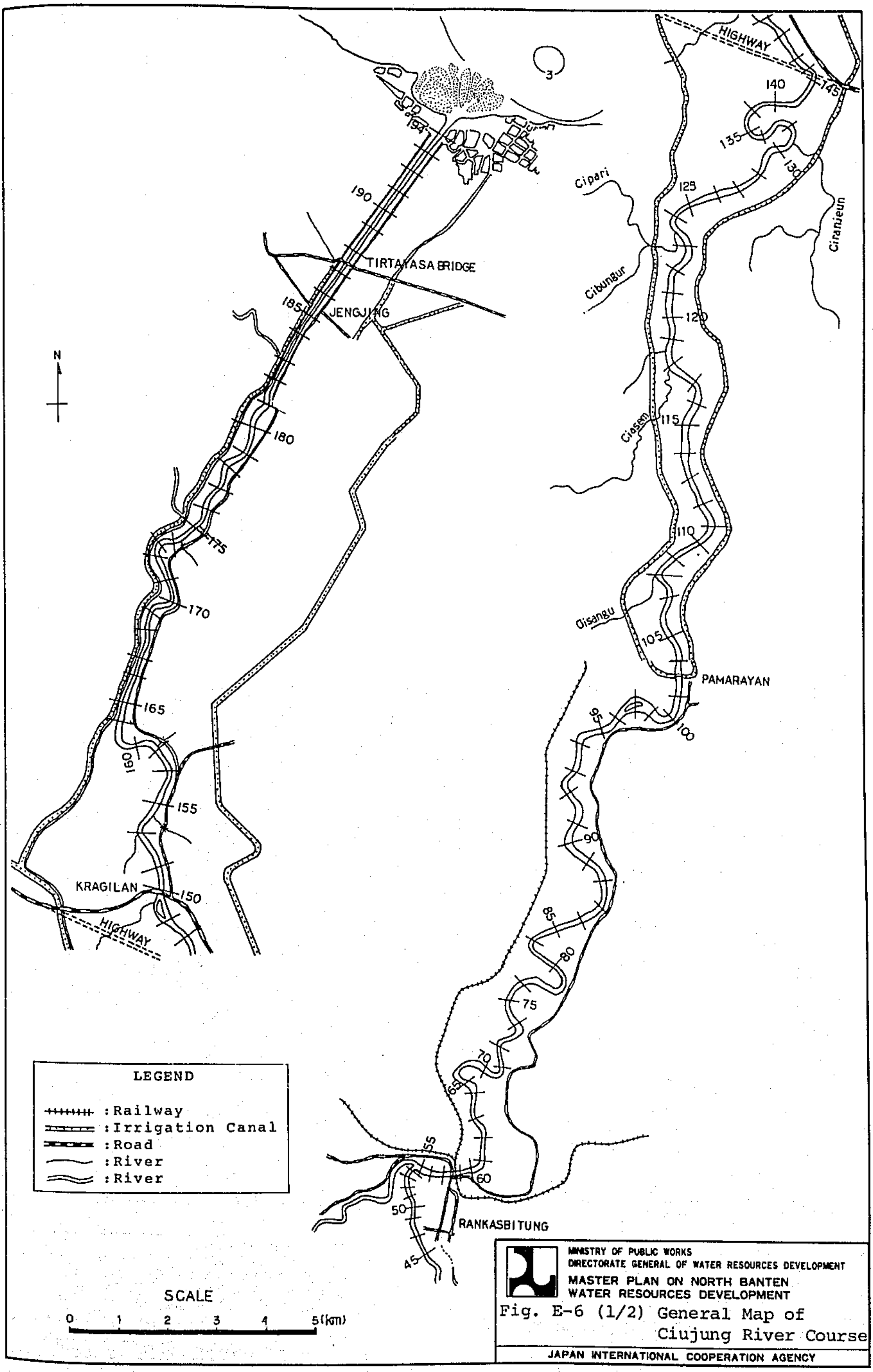

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Fig. E-6 (1/2) General Map of Ciujung River Course

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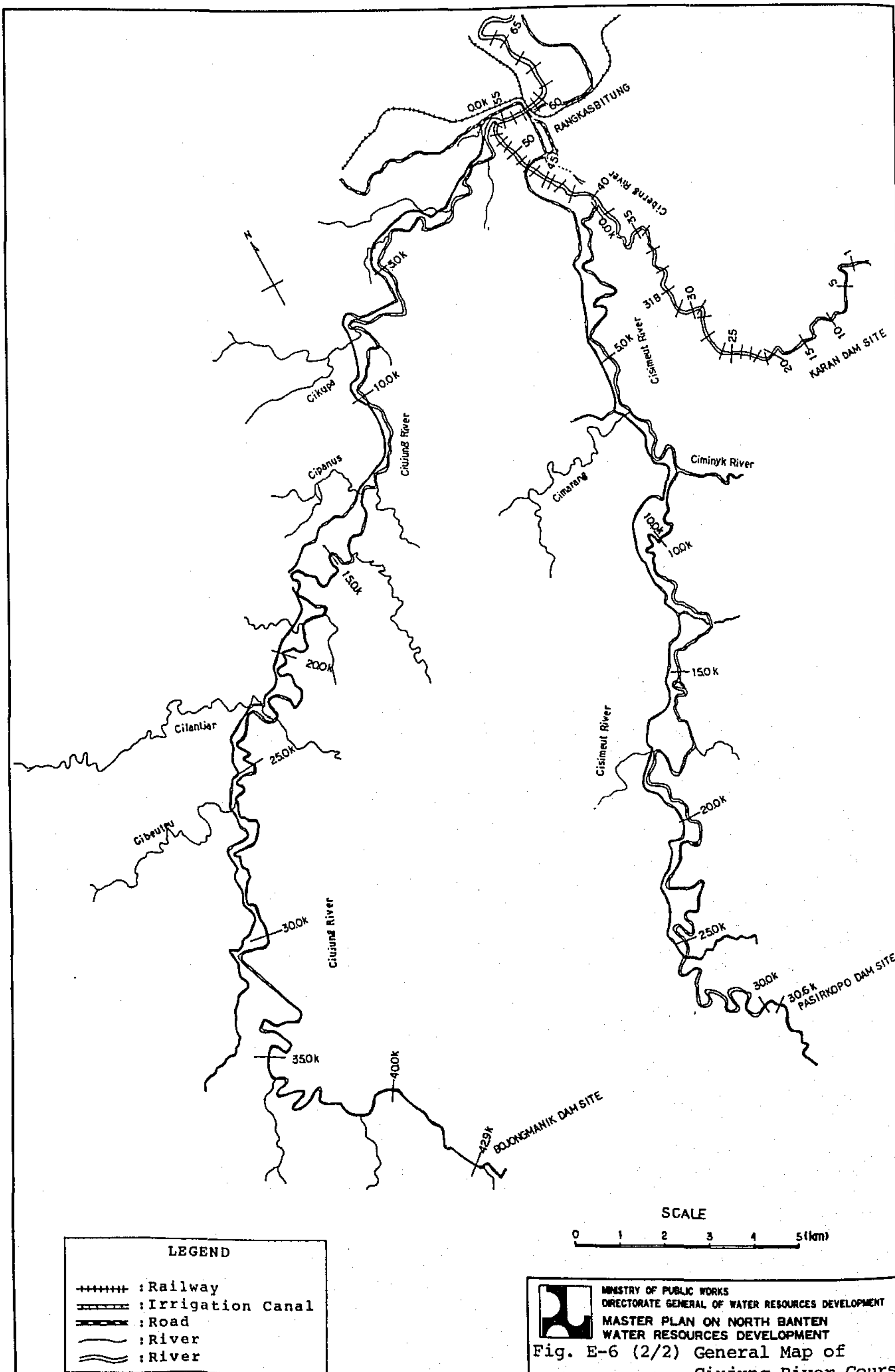

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Fig. E-6 (2/2) General Map of Ciujung River Course

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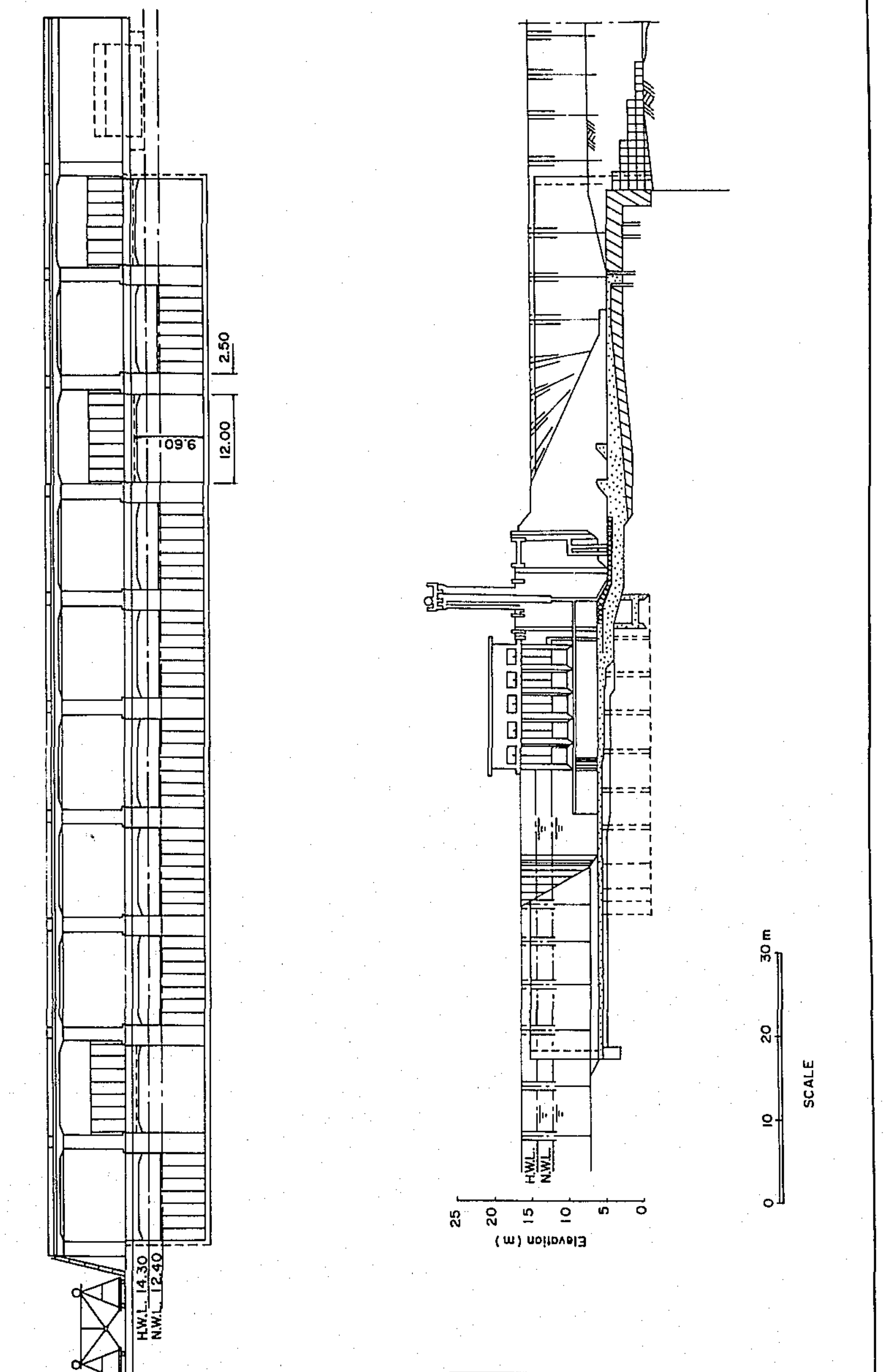

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Fig. E-7 Pamarayan Weir

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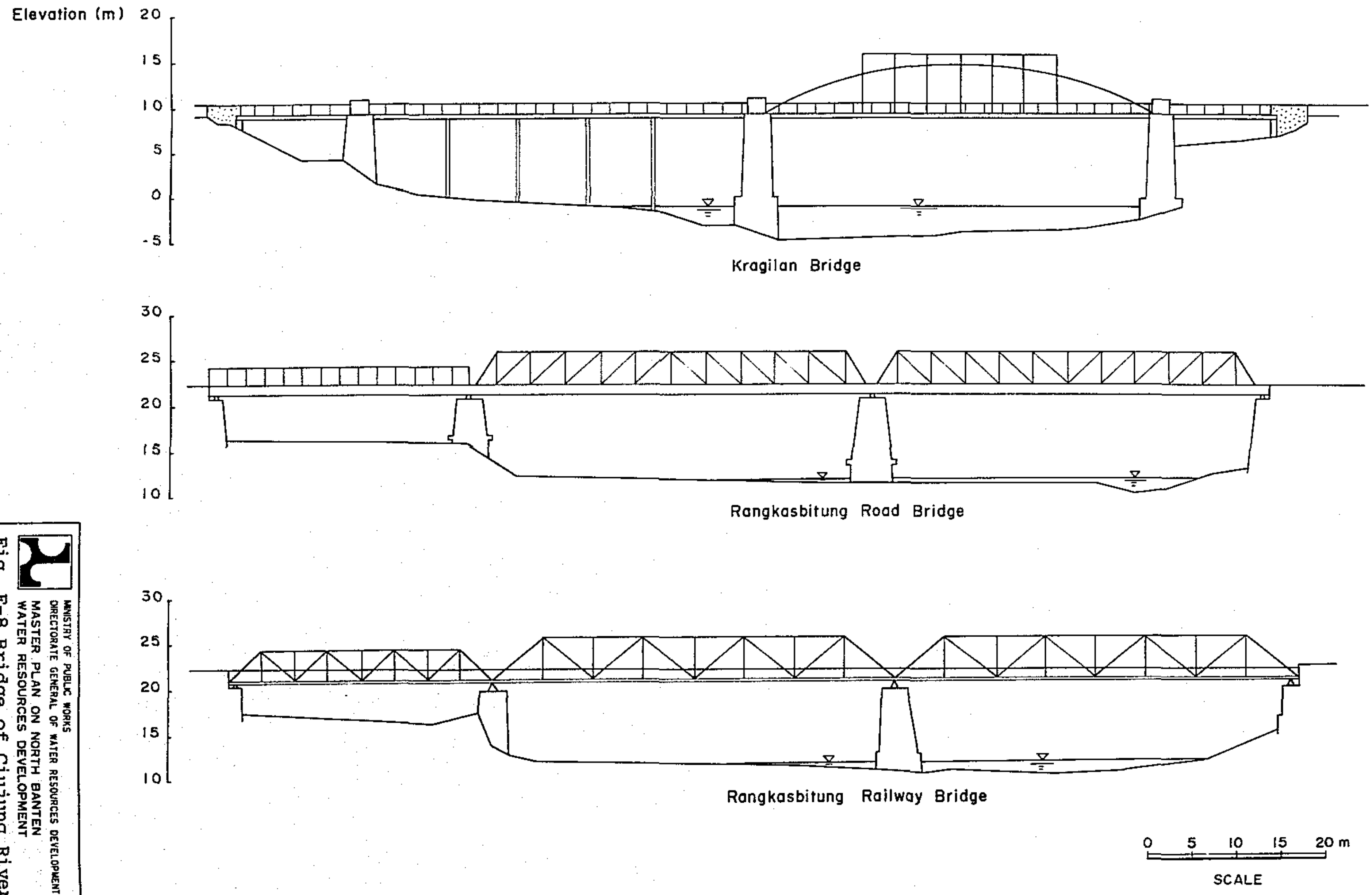

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Fig. E-8 Bridge of Ciujung River

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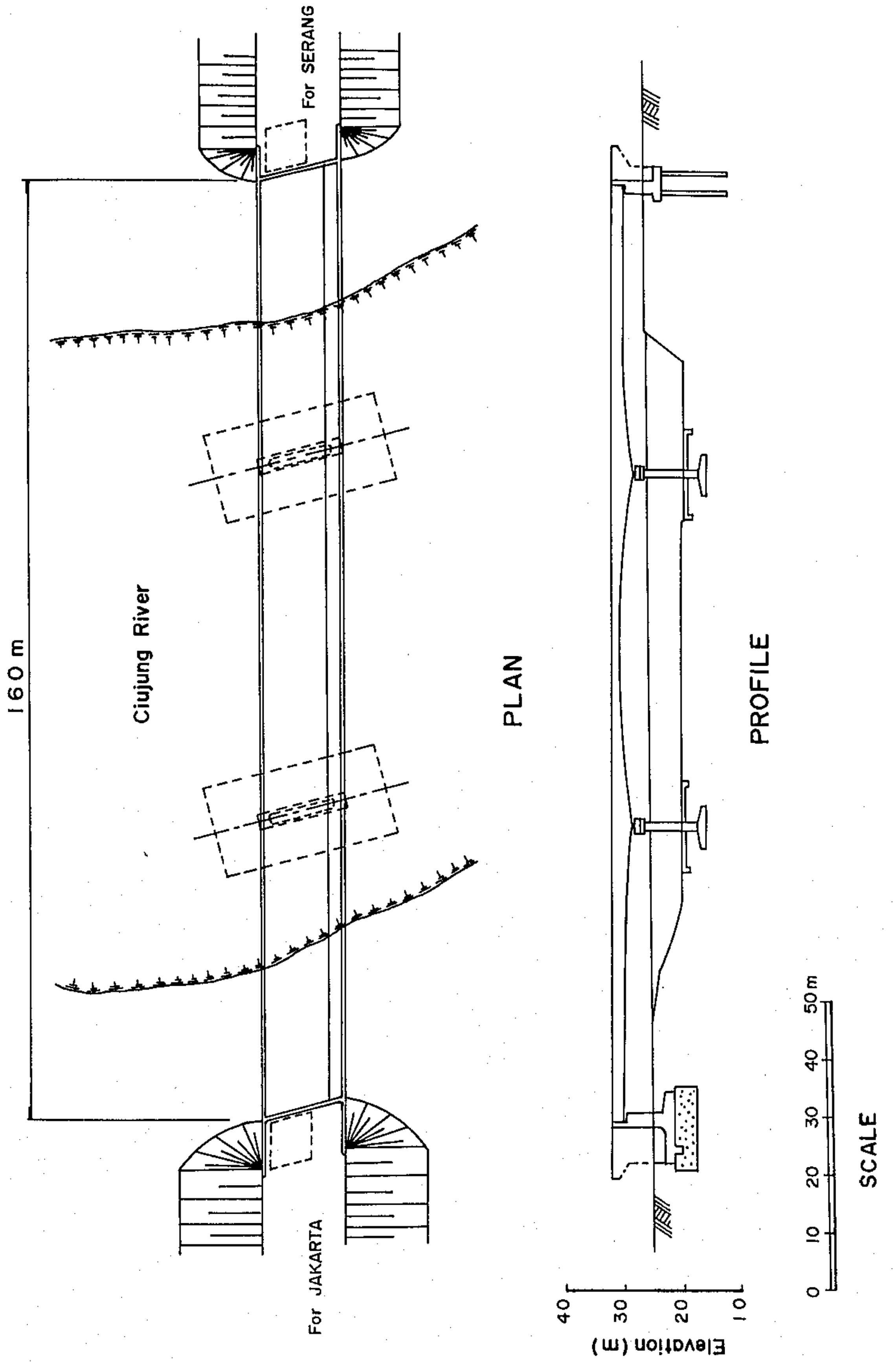

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Fig. E-9 New High Way Bridge

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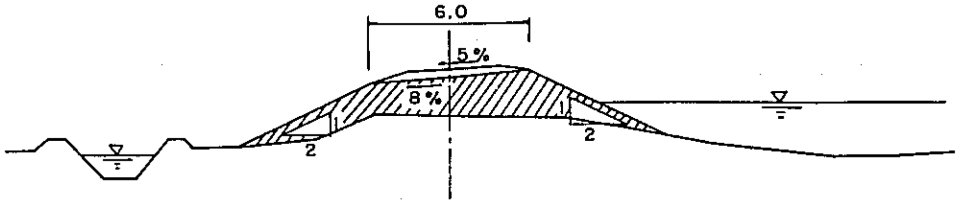
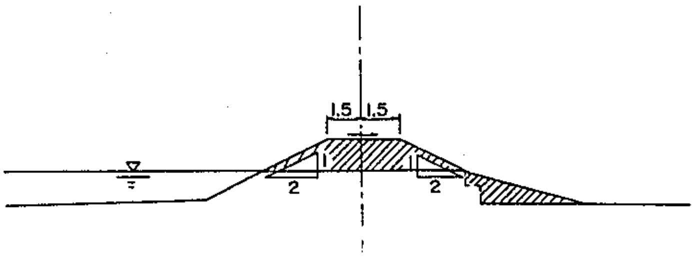
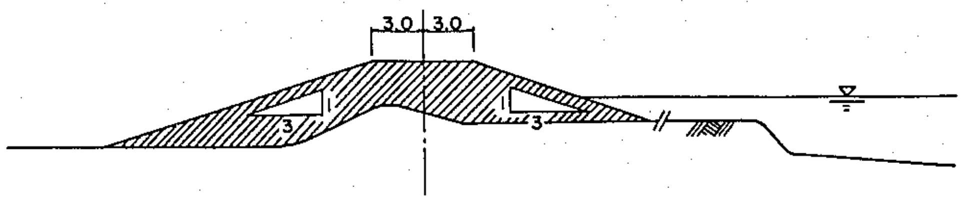
Left Bank



Right Bank



Left Bank



Right Bank

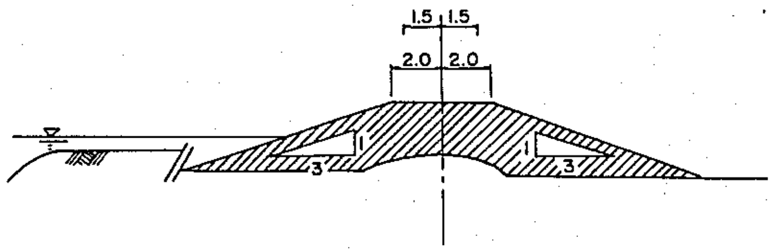


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Fig. E-10 Cross Section of Dyke
(Ciujung River)

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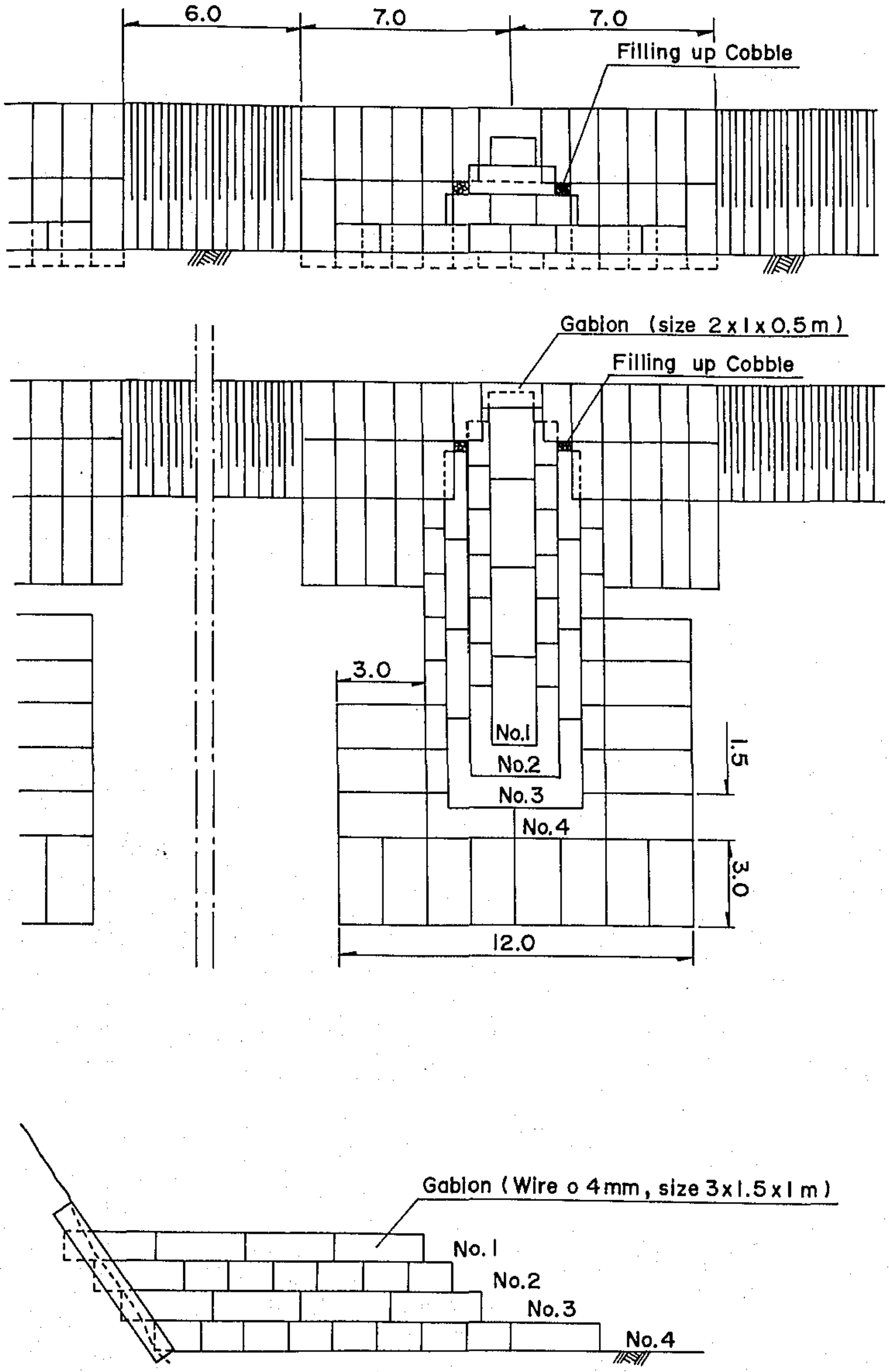

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Fig. E-11 Groyne on Ciberang River

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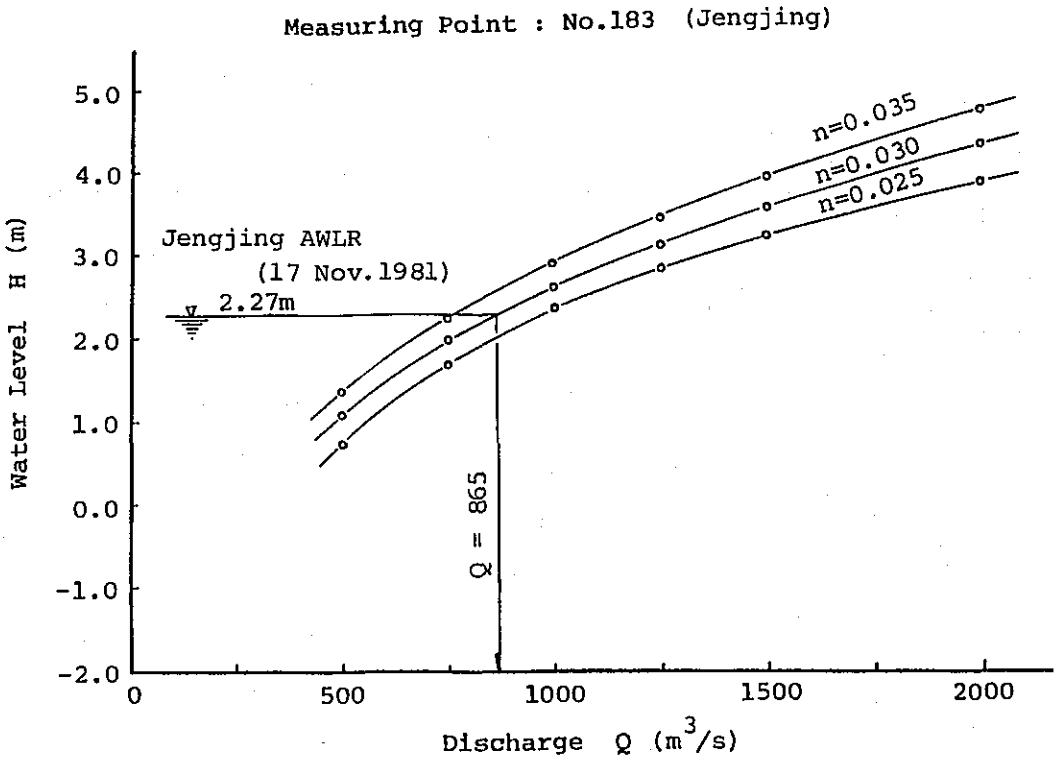

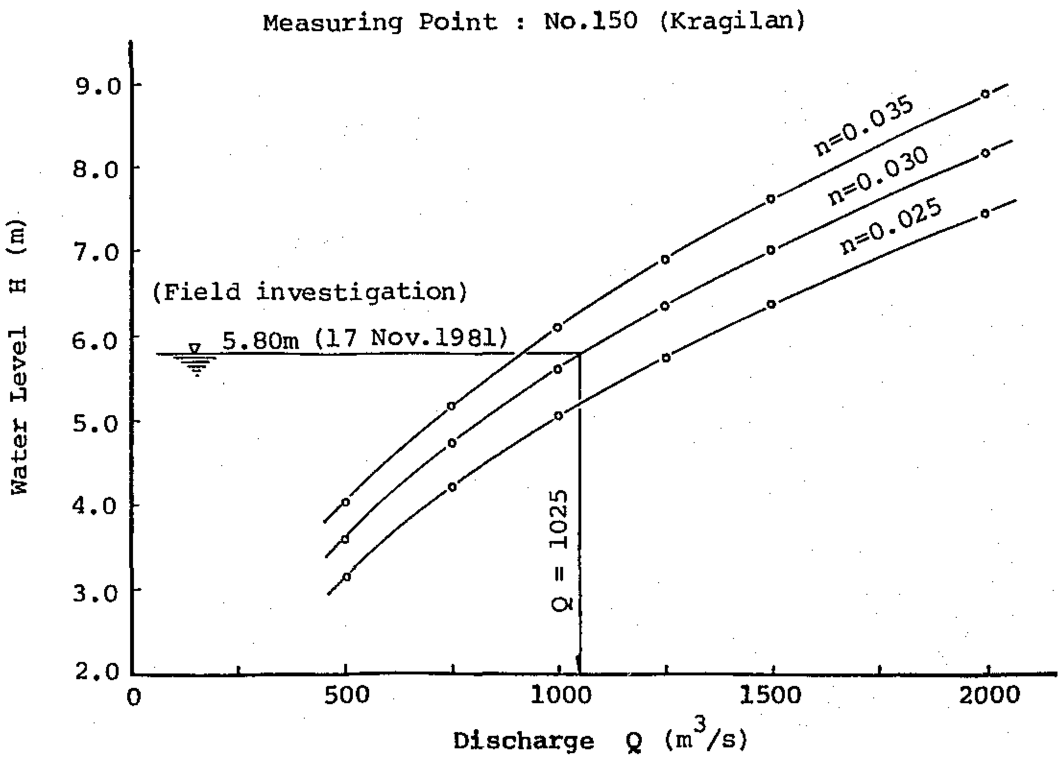

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Fig. E-12 (1/2) Calculated Rating Curve

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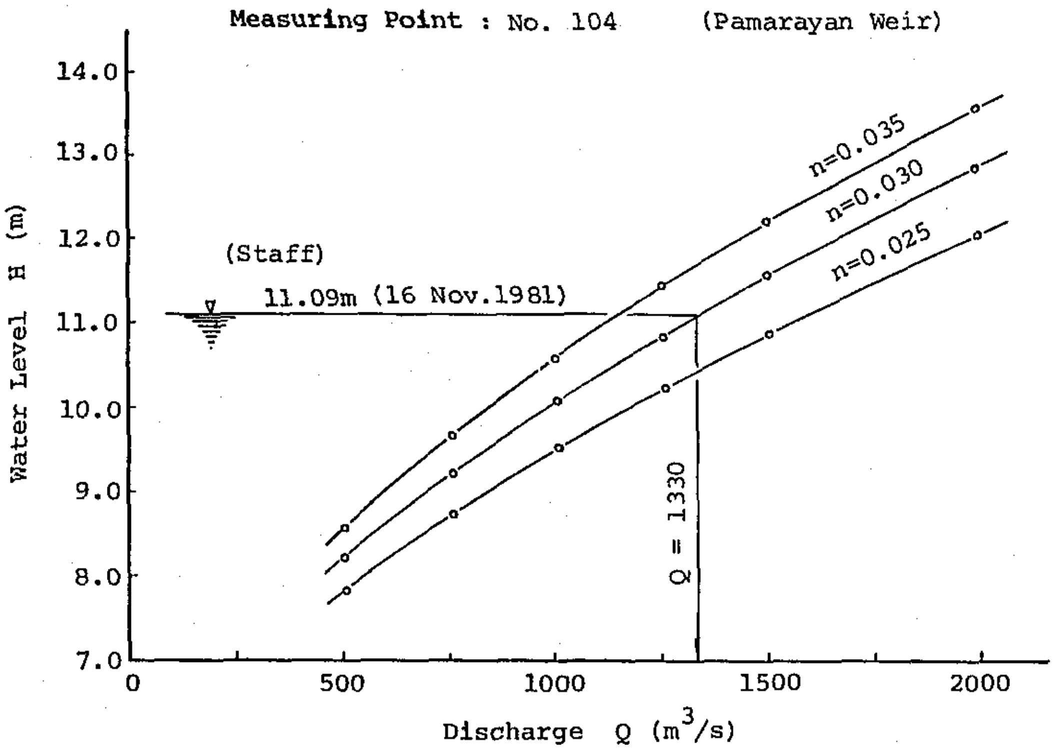

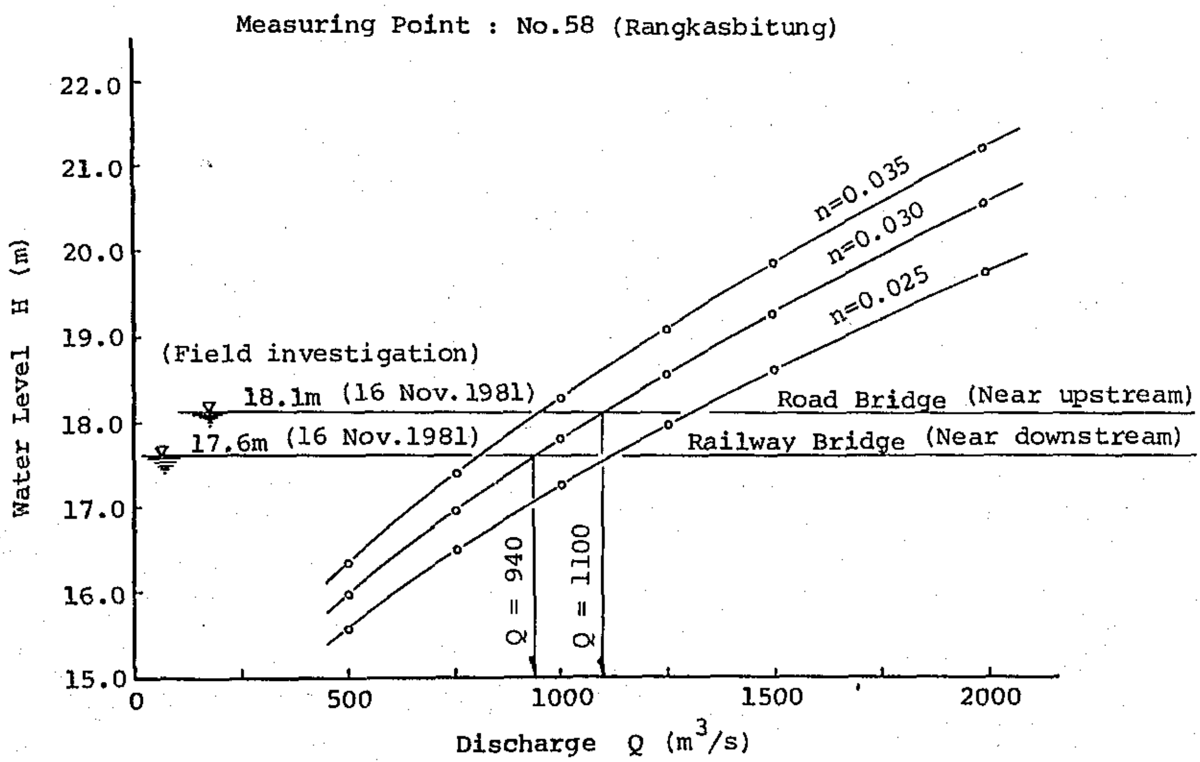

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Fig. E-12 (2/2) Calcualted Rating Curve

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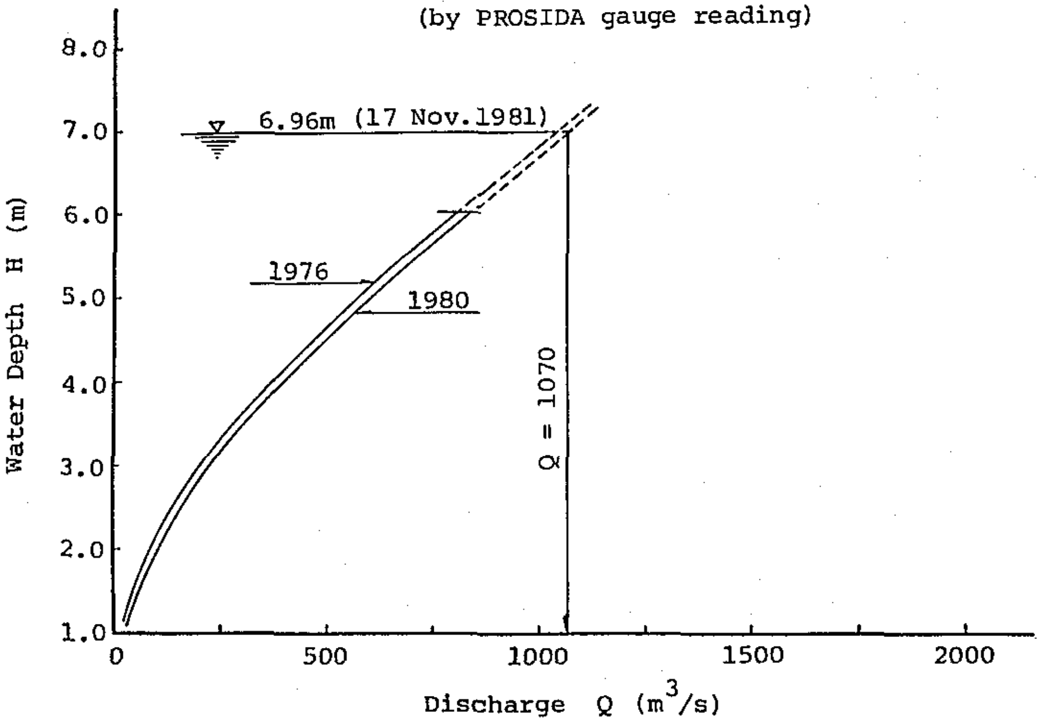
Observed Rating Curve at Kragilan AWLR (PROSIDA)
(by PROSIDA gauge reading)



Observed Rating Curve at Rangkasbitung (DPMA)

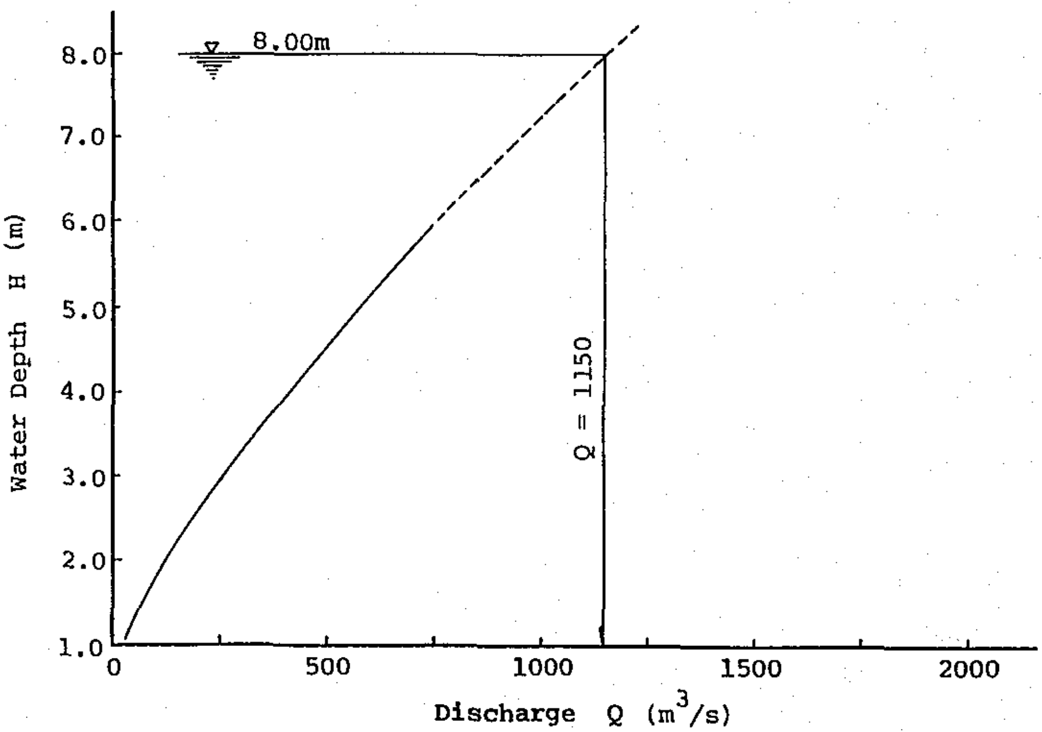


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Fig. E-13 Observed Rating Curve

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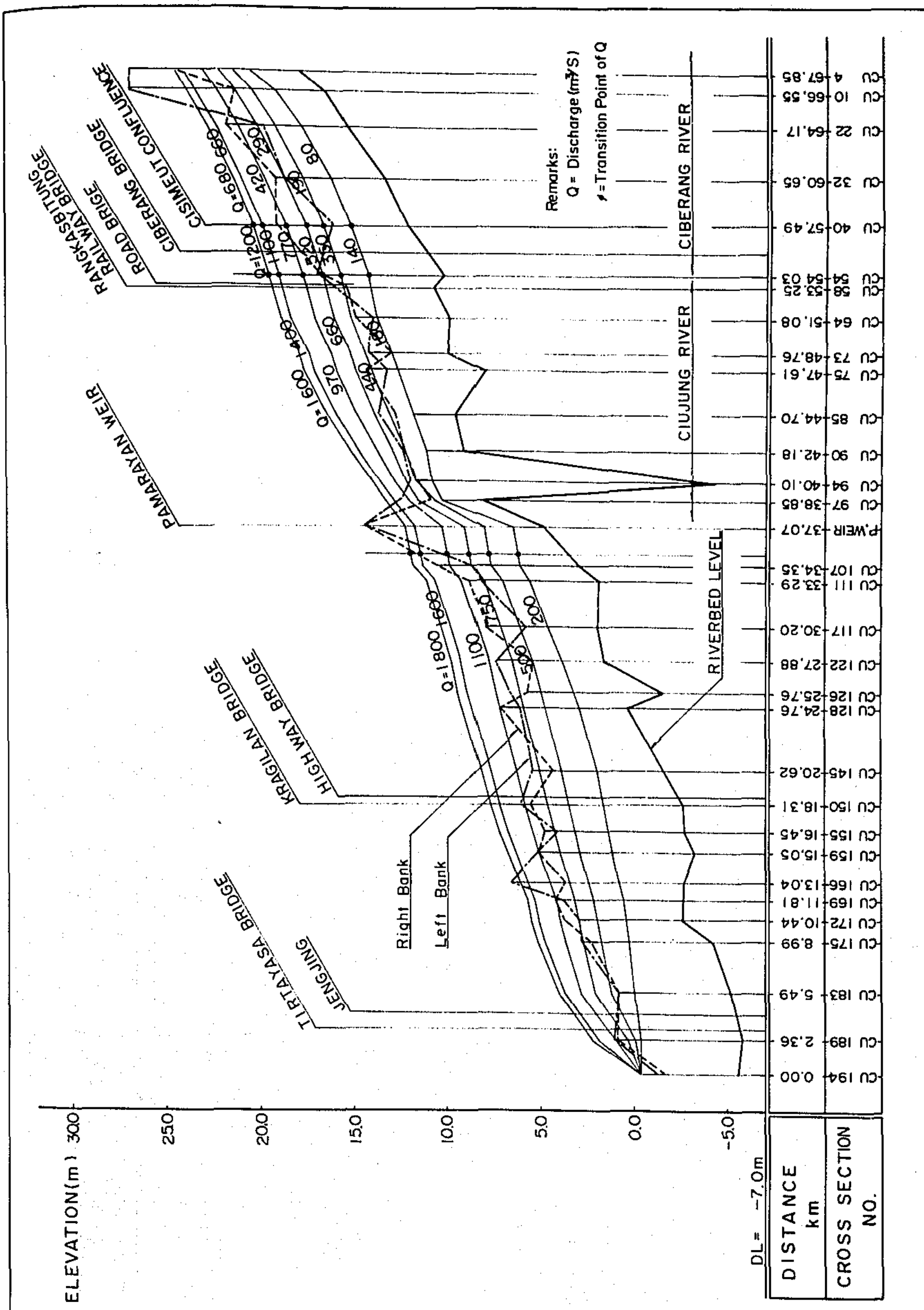

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Fig. E-14 Present Longitudinal Profile of Ciujung River

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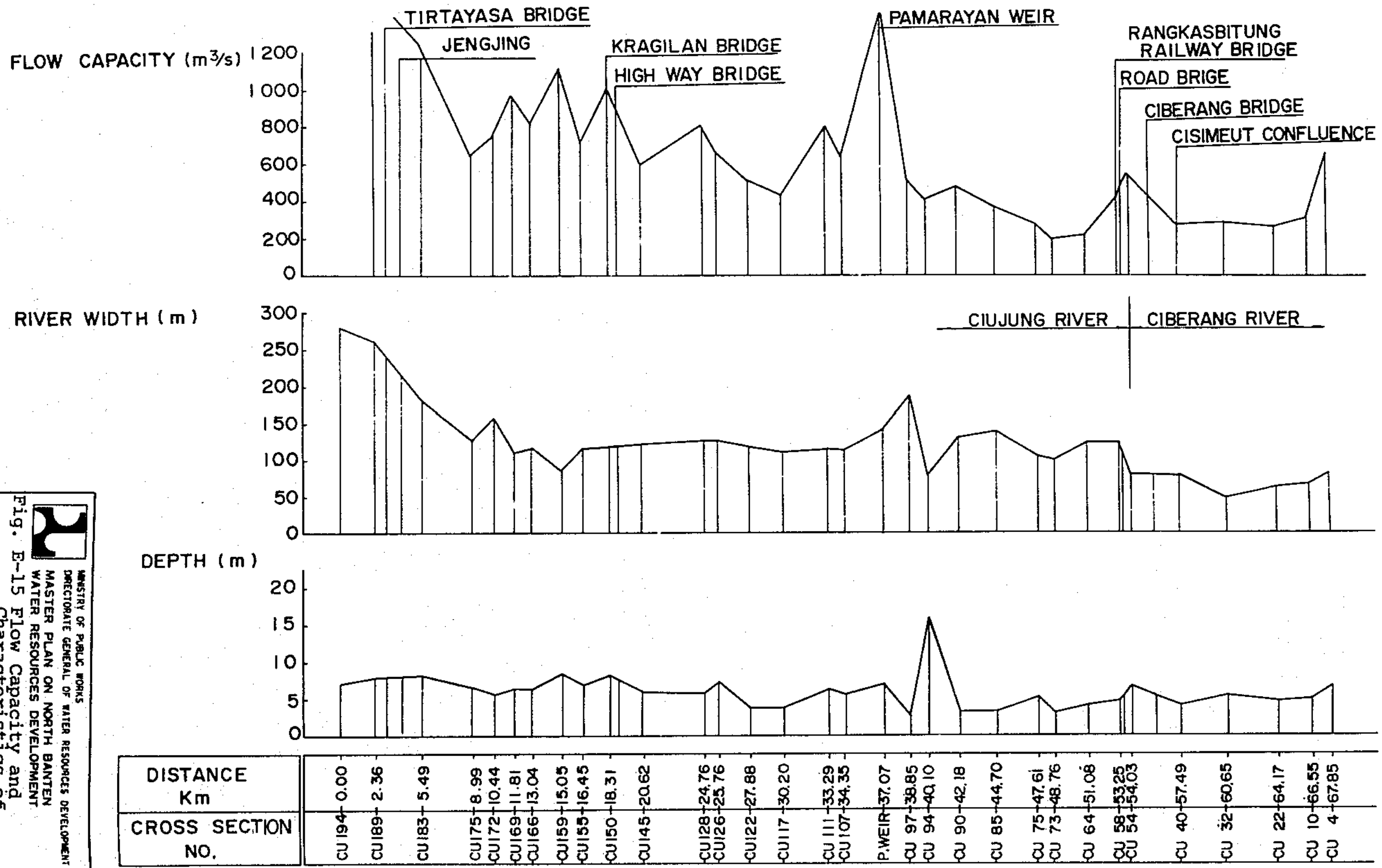

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Fig. E-15 Flow Capacity and Characteristics of Ciujung River

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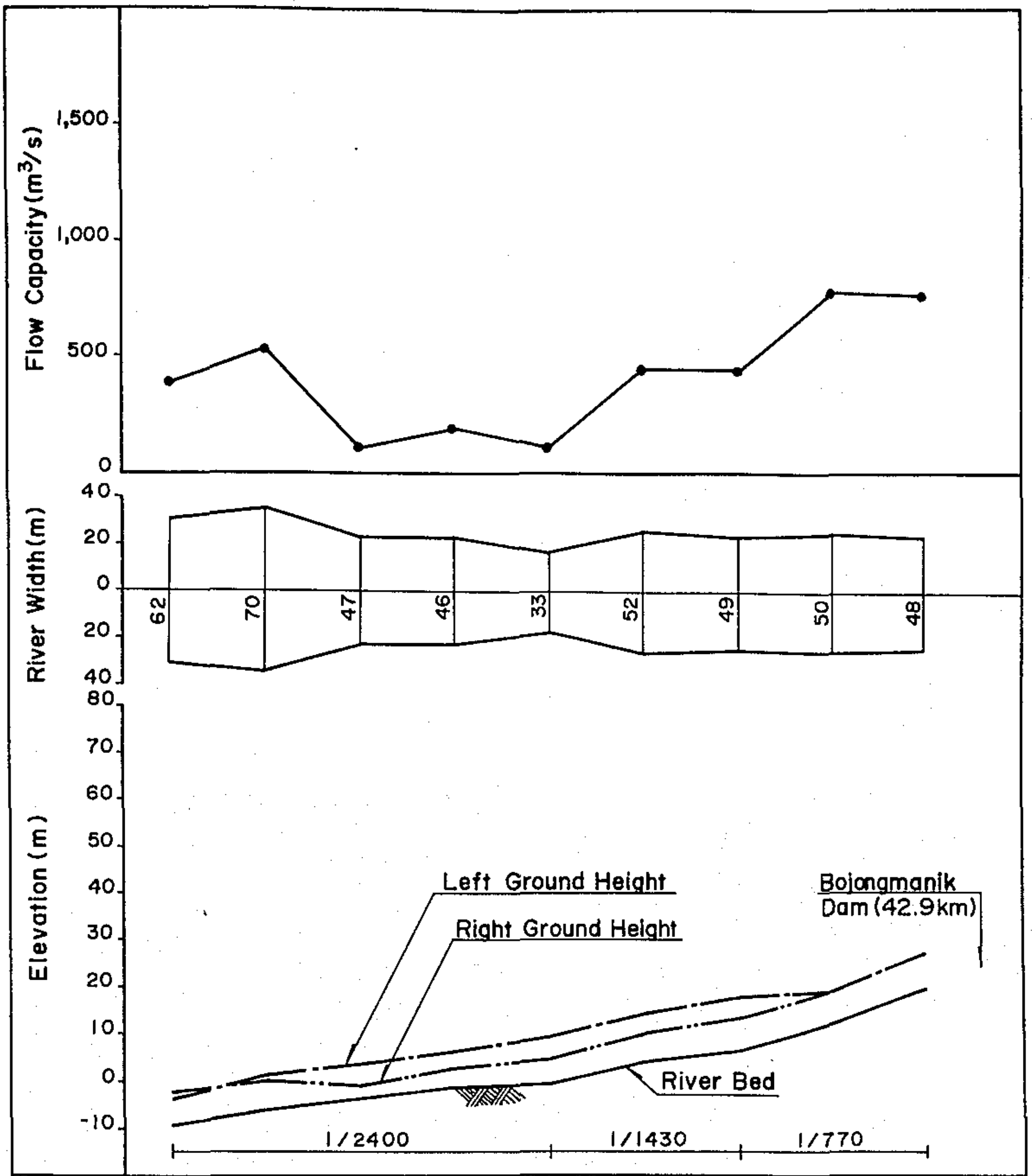

Flow Capacity (m3/s)	391	535	109	199	110	450	433	760	745
Left Ground Height (m)	16.50	21.20	23.80	26.00	29.30	34.00	37.40	38.80	46.80
Right Ground Height (m)	17.40	19.80	19.00	22.90	24.50	29.80	33.00	38.80	46.80
River Bed Height (m)	10.67	13.88	16.11	18.39	19.34	23.80	26.33	31.99	39.30
Distance (km)	0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0

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WATER RESOURCES DEVELOPMENT

Fig. E-16 Characteristics of Upper Ciujung River

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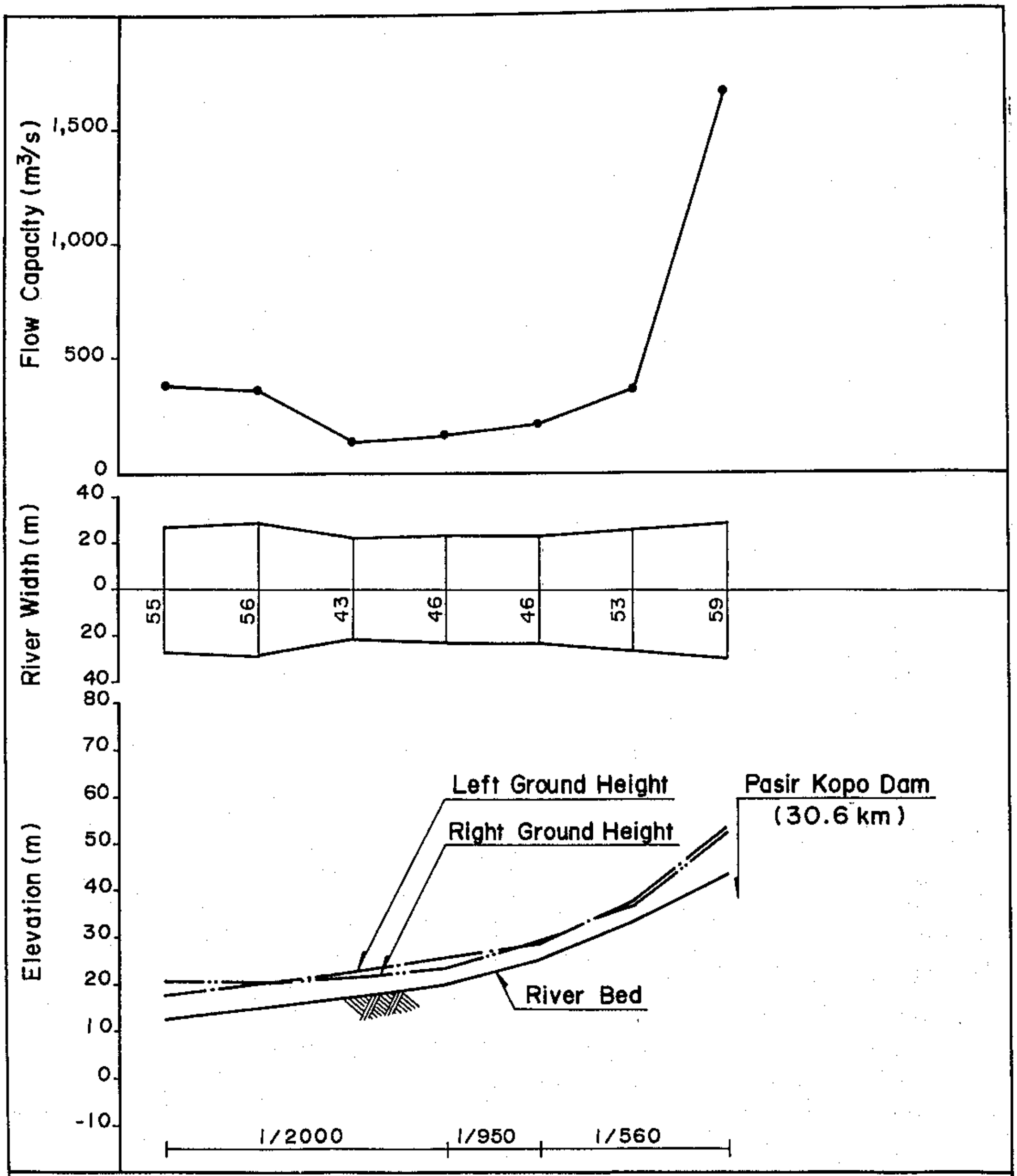

Flow Capacity (m^3/s)	385	364	124	157	210	360	1640
Left Ground Height (m)	18.00	20.00	22.50	25.60	28.50	37.10	52.80
Right Ground Height (m)	20.60	20.20	21.40	23.20	29.00	36.90	52.80
River Bed Height (m)	12.64	15.04	17.23	19.93	25.19	33.15	43.04
Distance (km)	0.0	5.0	10.0	15.0	20.0	25.0	30.0

MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
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Fig. E-17 Characteristics of Cisimeut River

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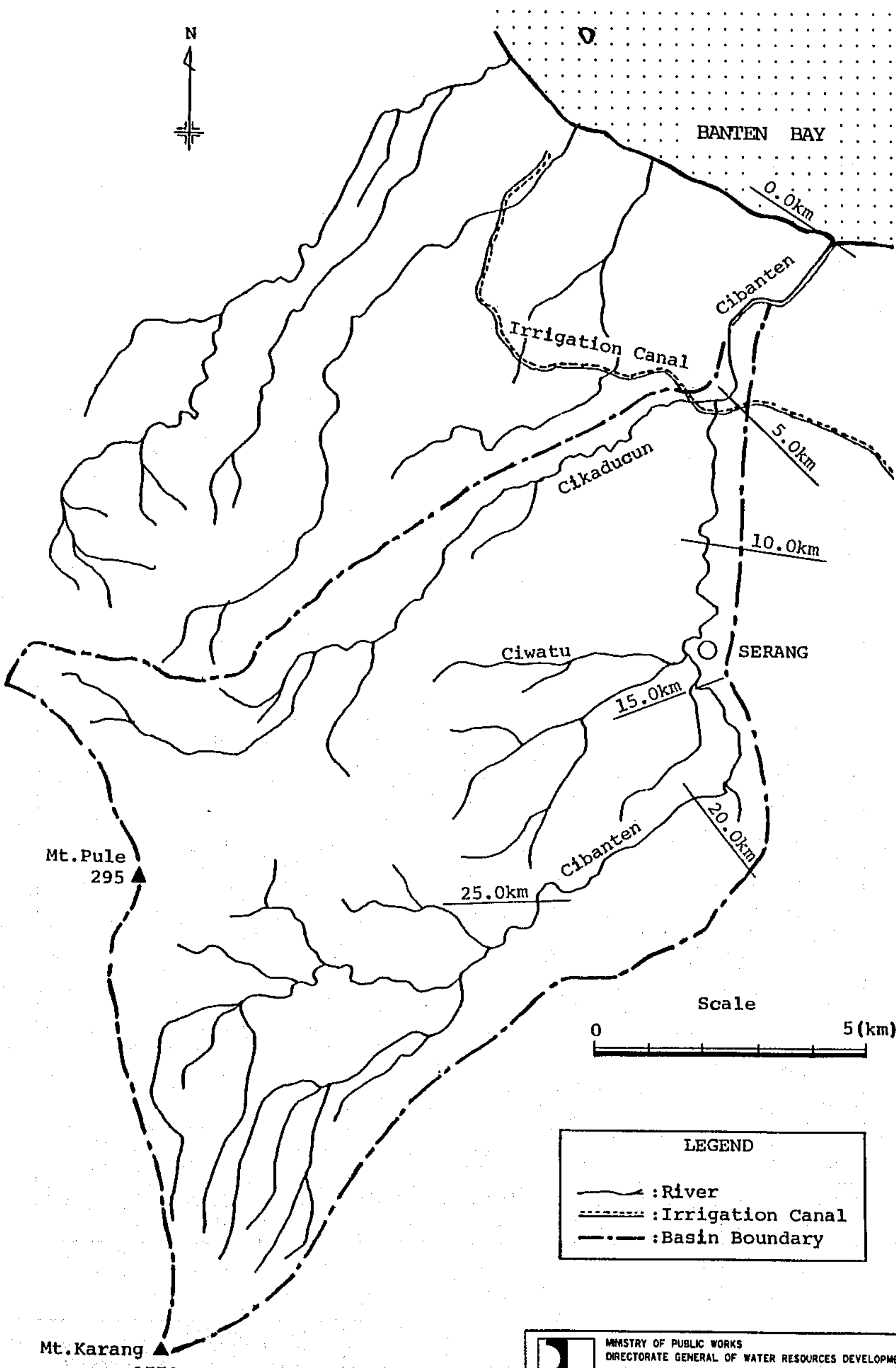

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Fig. E-18 Cibanten River Basin

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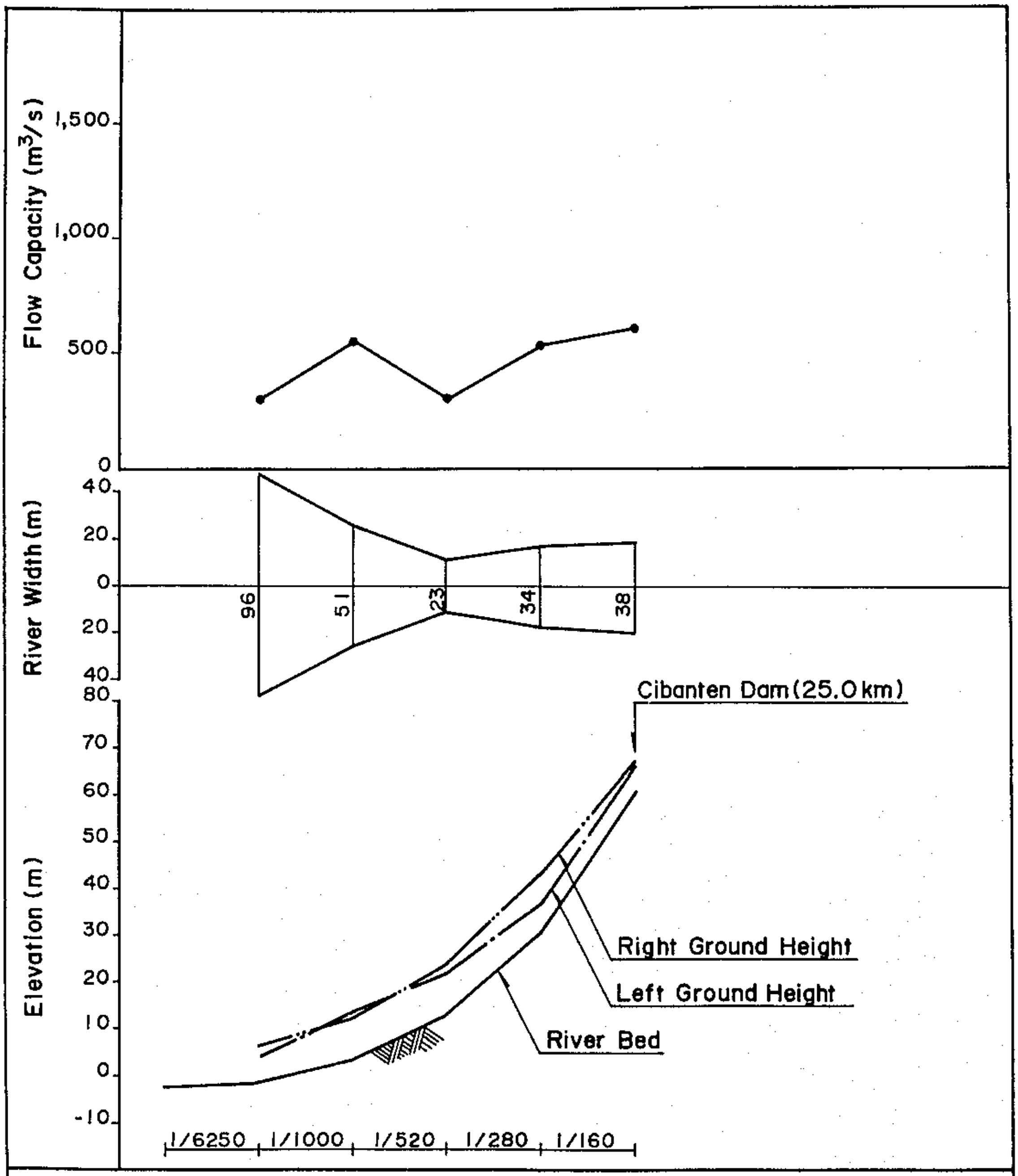

Flow Capacity (m^3/s)		296	535	293	527	593
Left Ground Height (m)		4.40	13.40	22.00	36.70	65.70
Right Ground Height (m)		6.20	12.50	24.00	43.00	67.00
River Bed Height (m)	2.26	-1.46	3.54	13.06	30.53	60.06
Distance (km)	0.0	5.0	10.0	15.0	20.0	25.0

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Fig. E-19 Characteristics of Cibanten River

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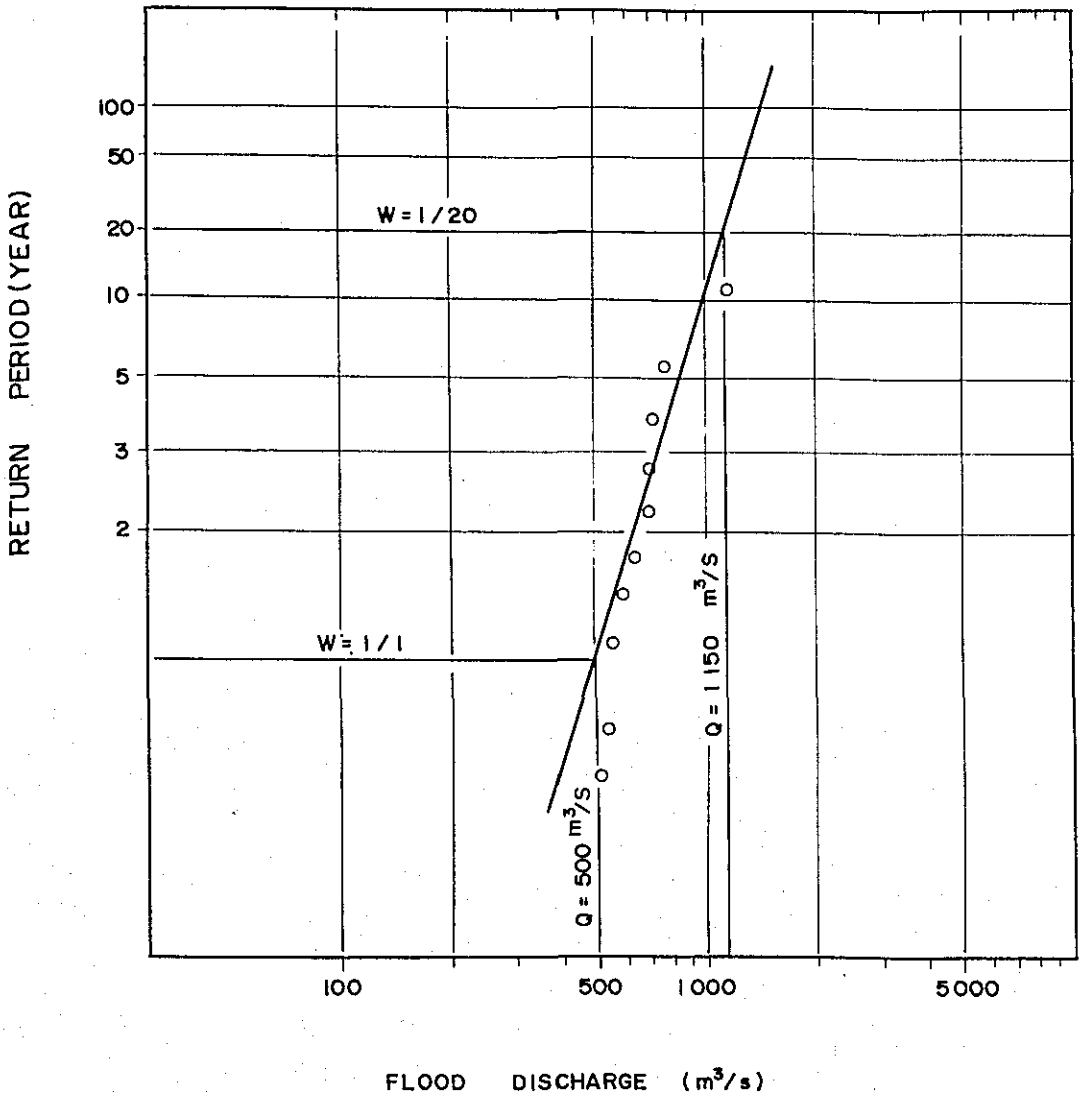

Remarks: Derived from flood peak data at Rangkasbitung affected by flooding and inundation along upstream reaches, resulting in smaller peak values than those of standard project flood.

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Fig. E-20 Probable Flood Discharge at Rangkasbitung Gauging Station

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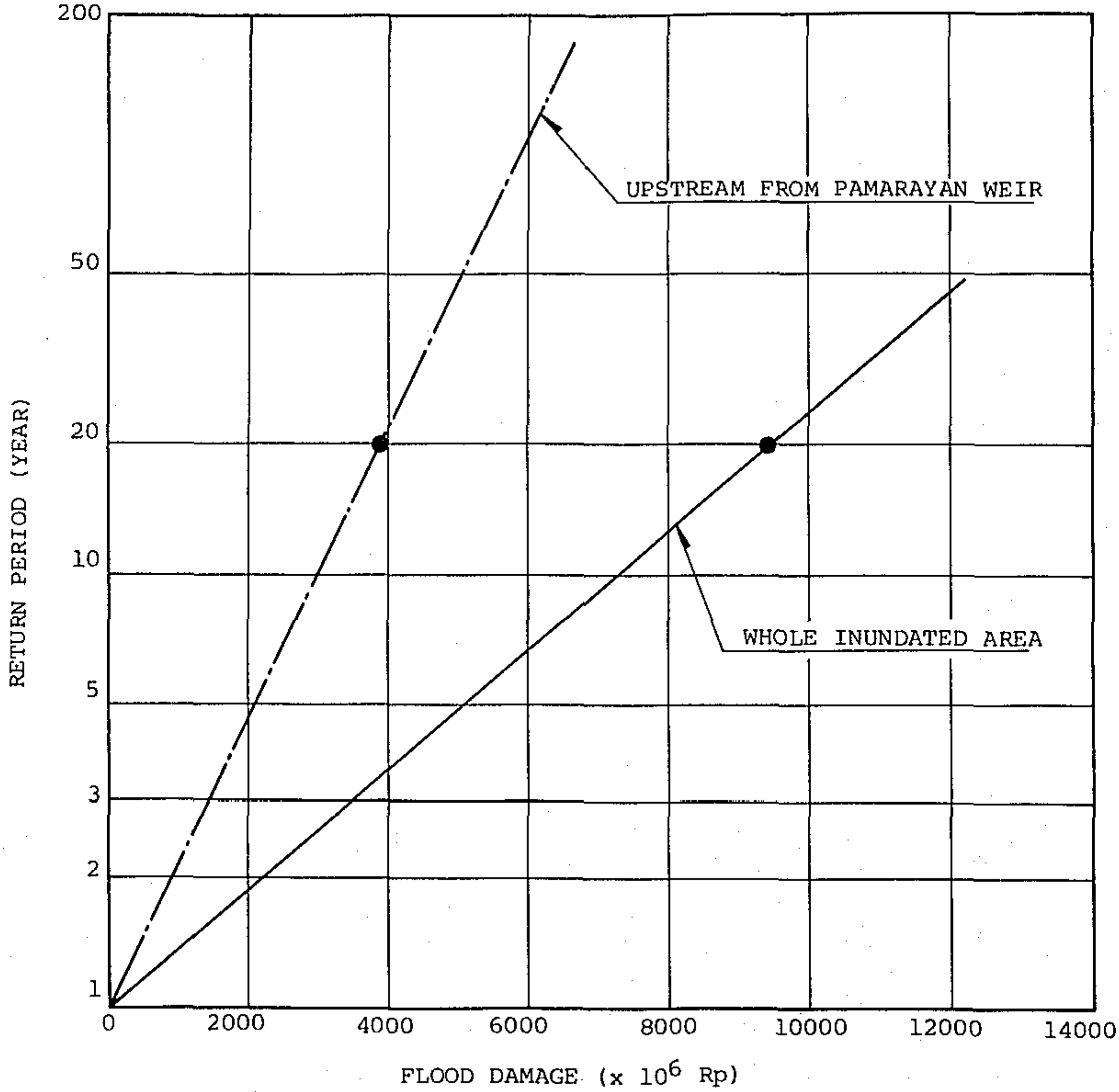

Probable Flood Damage along Ciujung River (Unit: 10^6Rp)

Retern Period / Section	1	10	20	50
Upstream from Pamarayan Weir	0	3015	3911	5110
Whole Inundated Area	0	7263	9421	12309

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Fig. E-21 Probable Flood Damage along Ciujung River

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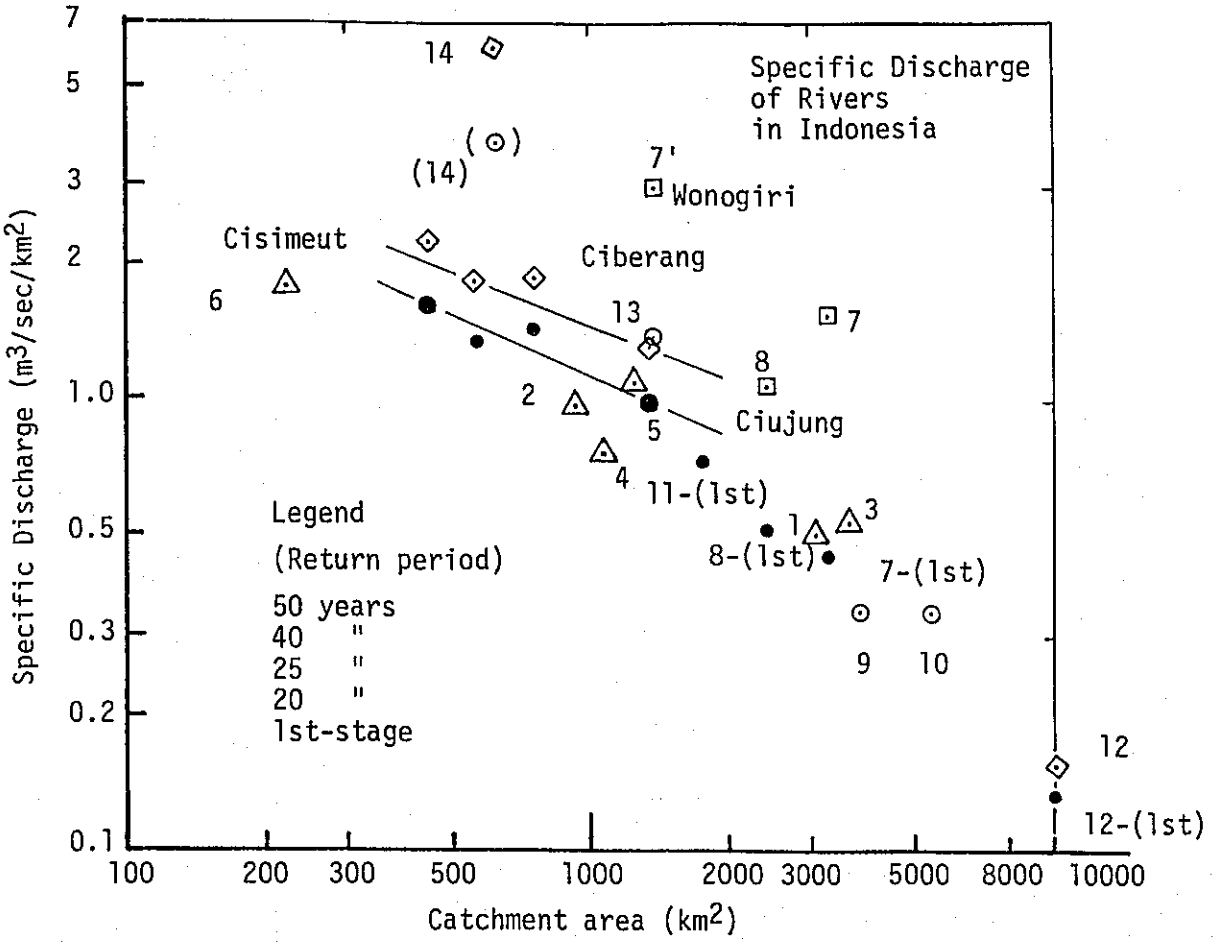

No.	Name of river	Province	Catchment Area (km2)	Design Flood (m3/s)	Specific Dis-charge (m3/s /km2)	Re-turn Pe-riod (year)	1st-stage
1	Sungai Cimanuk	West Java	3,006	1,440	0.48	25	
2	Kali Serang	Central Java	937	900	0.96	25	
3	Sungai Citanduy	West Java	3,680	1,900	0.52	25	
4	Sungai Ular	North Sumatra	1,080	800	0.74	25	
5	Kali Pemali	Central Java	1,228	1,300	1.06	25	
6	Sungai Cipanas	West Java	220	385	1.75	25	
7	Bengawan Solo	Central/East	3,320	5,240 (2,000)	1.58 (0.60)	40	1,500(10y)
8	Kali Madiun	East Java	2,400	2,600	1.08	40	1,200(17y)
9	Sungai Wanpu	North Sumatra	3,840	1,320	0.34	20	
10	Sungai Arakundo	Aceh	5,495	1,800	0.33	20	
11	Sungai Kring Aceh	Aceh	1,775			20	1,300 (5y)
12	Kali Brantas	East Java	10,000	1,500	0.15	50	1,300(10y)
13	Sungai Bila	South Surawesi	1,368	1,900	1.39	20	
14	Jeneberang	South Surawesi	624	3,700 (2,300)	5.39 (3.69)	50	

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Fig. E-22 Specific Discharge of Rivers in Indonesia

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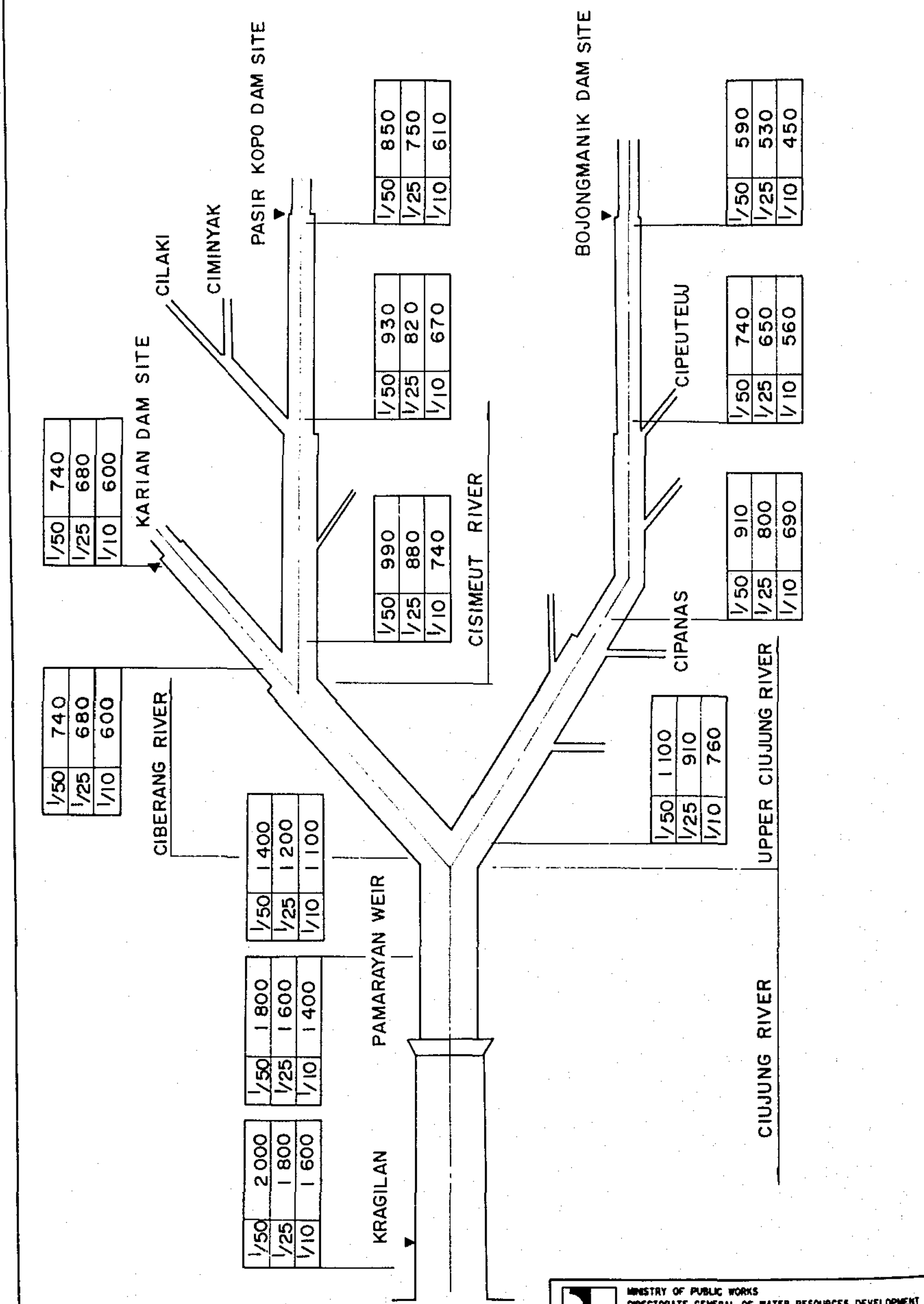

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Fig. E-23 Standard Project Flood Distribution

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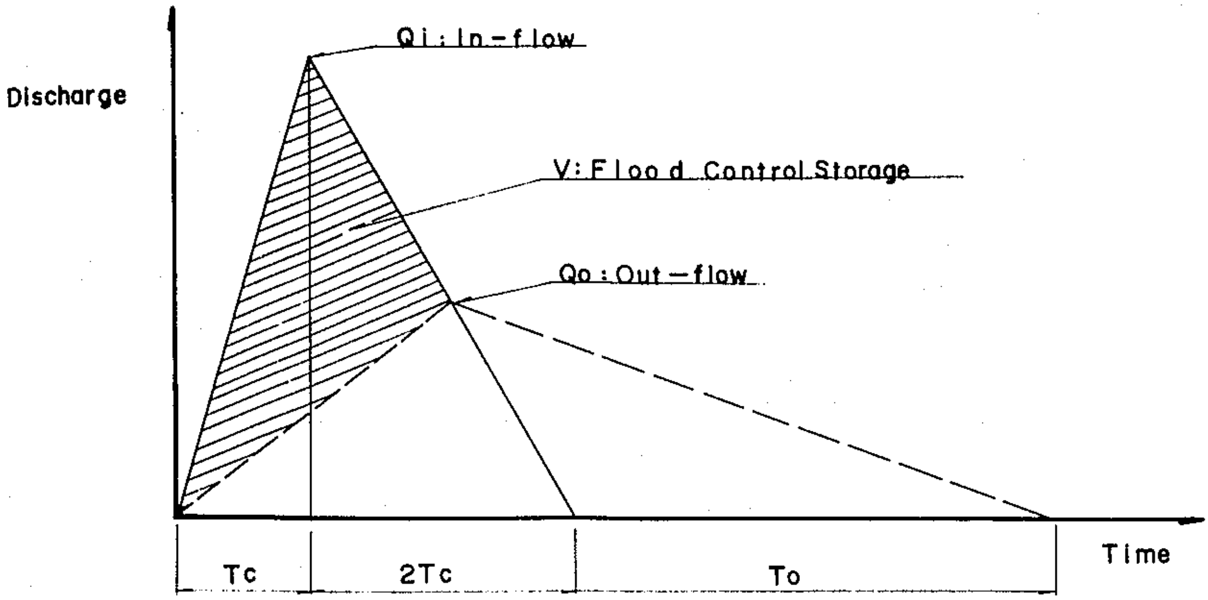

	Qi (m^3/s)	Qo (m^3/s)	V ($10^6 m^3$)	Tc (hr)
Karian Dam	740	300	30.0	9
Pasir Kopo Dam	850	280	15.0	4
Bojongmanik Dam	590	190	16.0	6

Remark : Return period 50 years

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Fig. E-24 Flood Regulation by Dams

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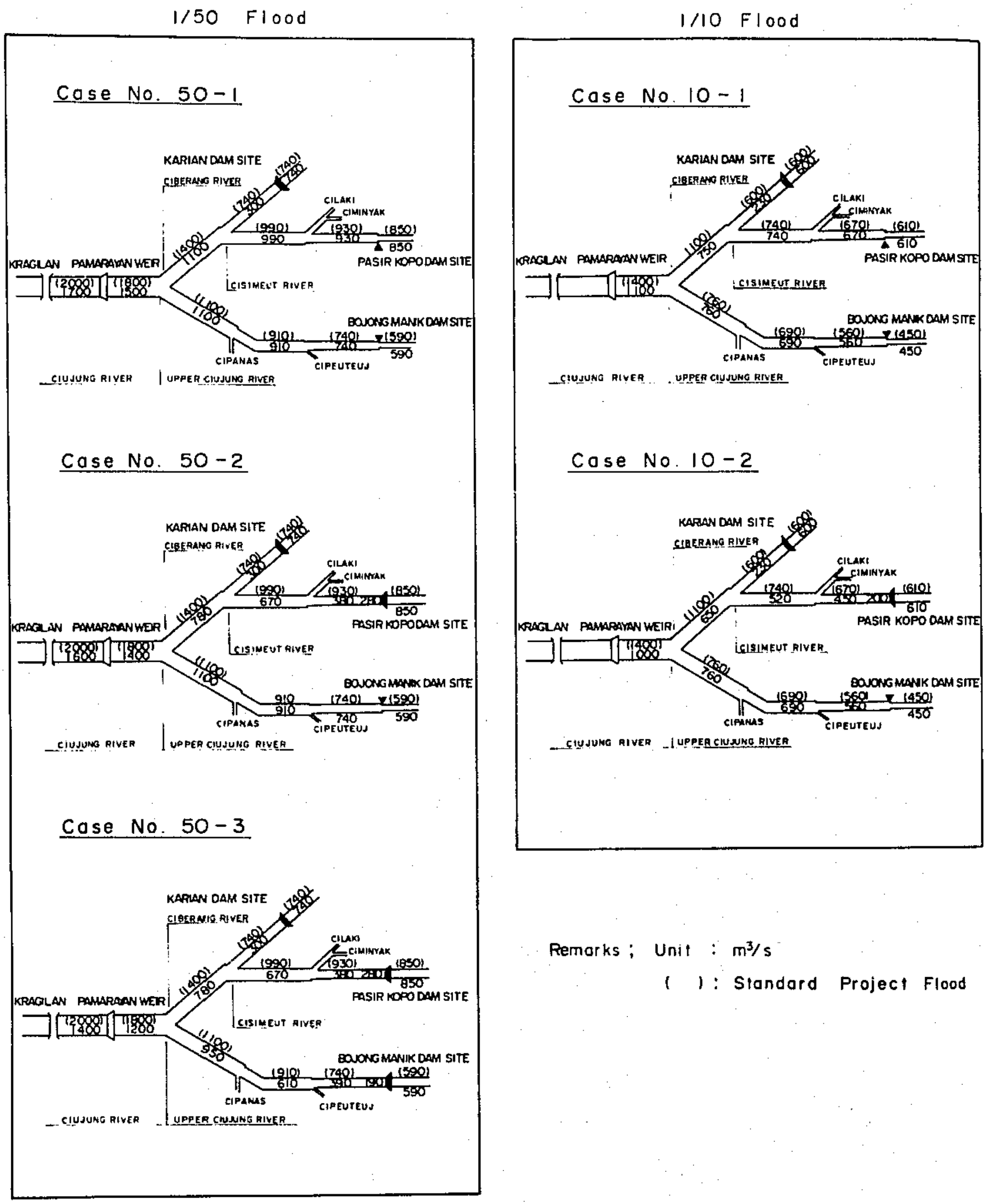

Remarks ; Unit : m^3/s

( ) : Standard Project Flood

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Fig. E-25 Design Flood Distribution of Ciujung River

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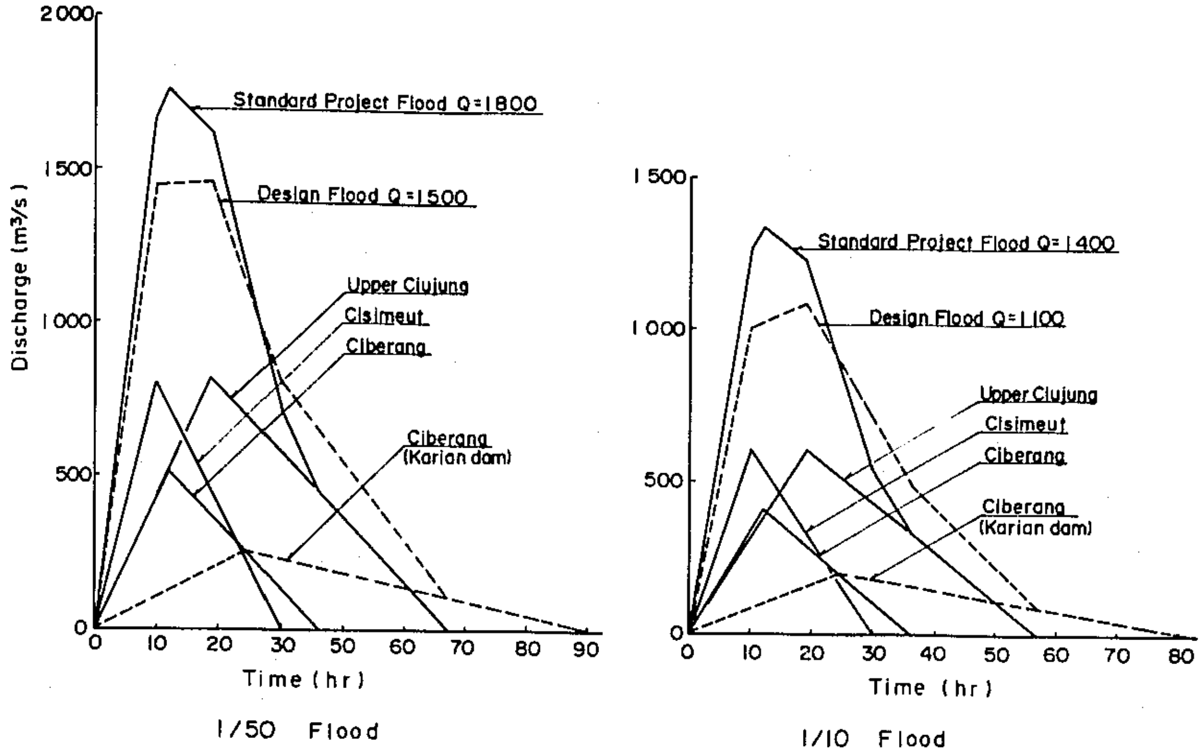
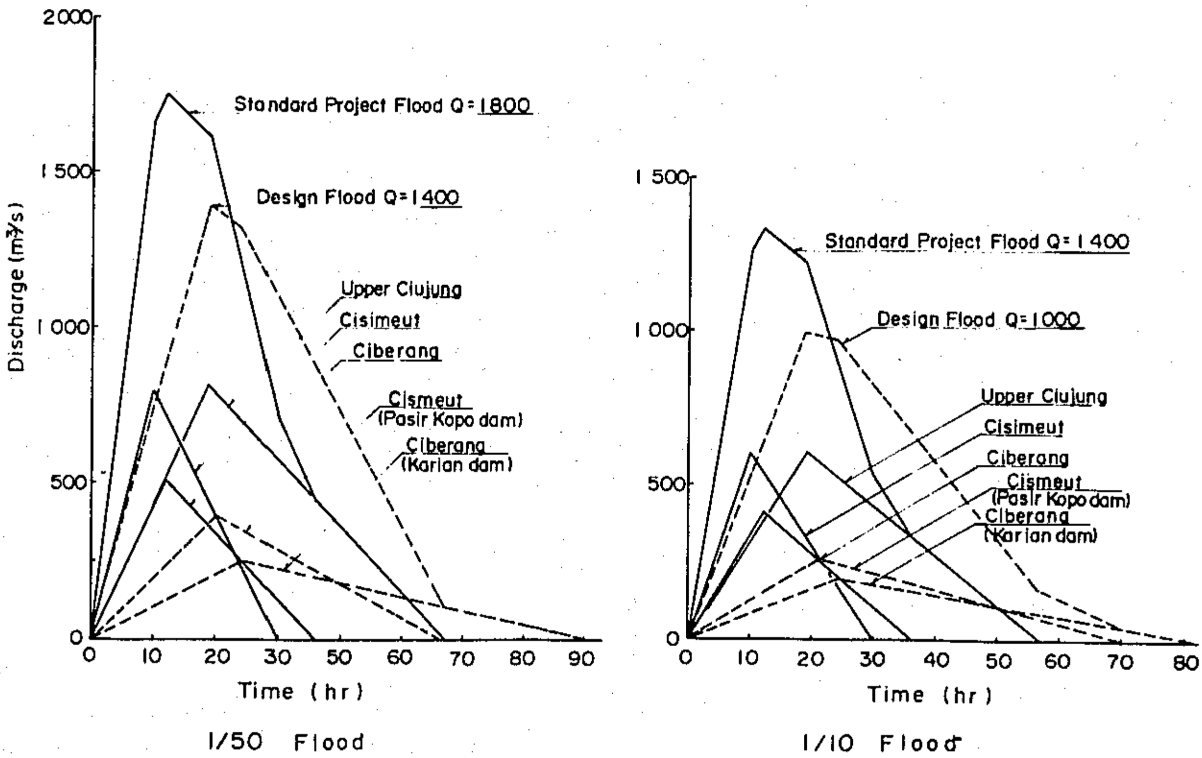


KARIAN DAM



KARIAN + PASIR KOPO DAMS

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Fig. E-26 Regulated Flow at Rangkasbitung

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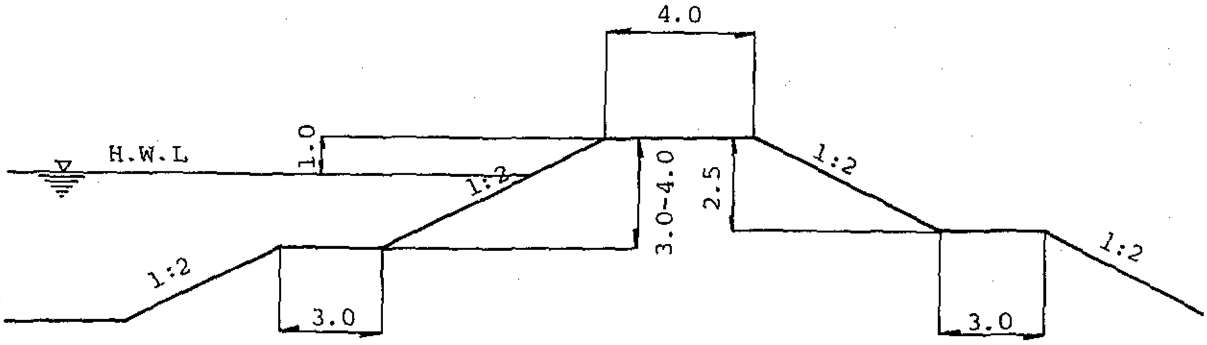
Standard Cross Section of Dyke Unit: m



Standard Cross Section Unit: m

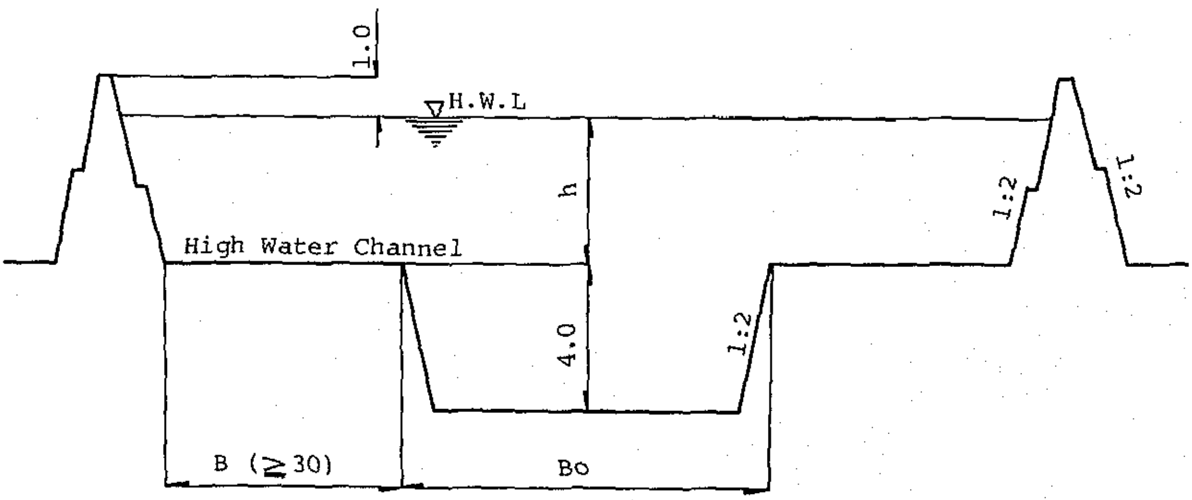


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Fig. E-27 Standard Cross Section of Dyke and Channel

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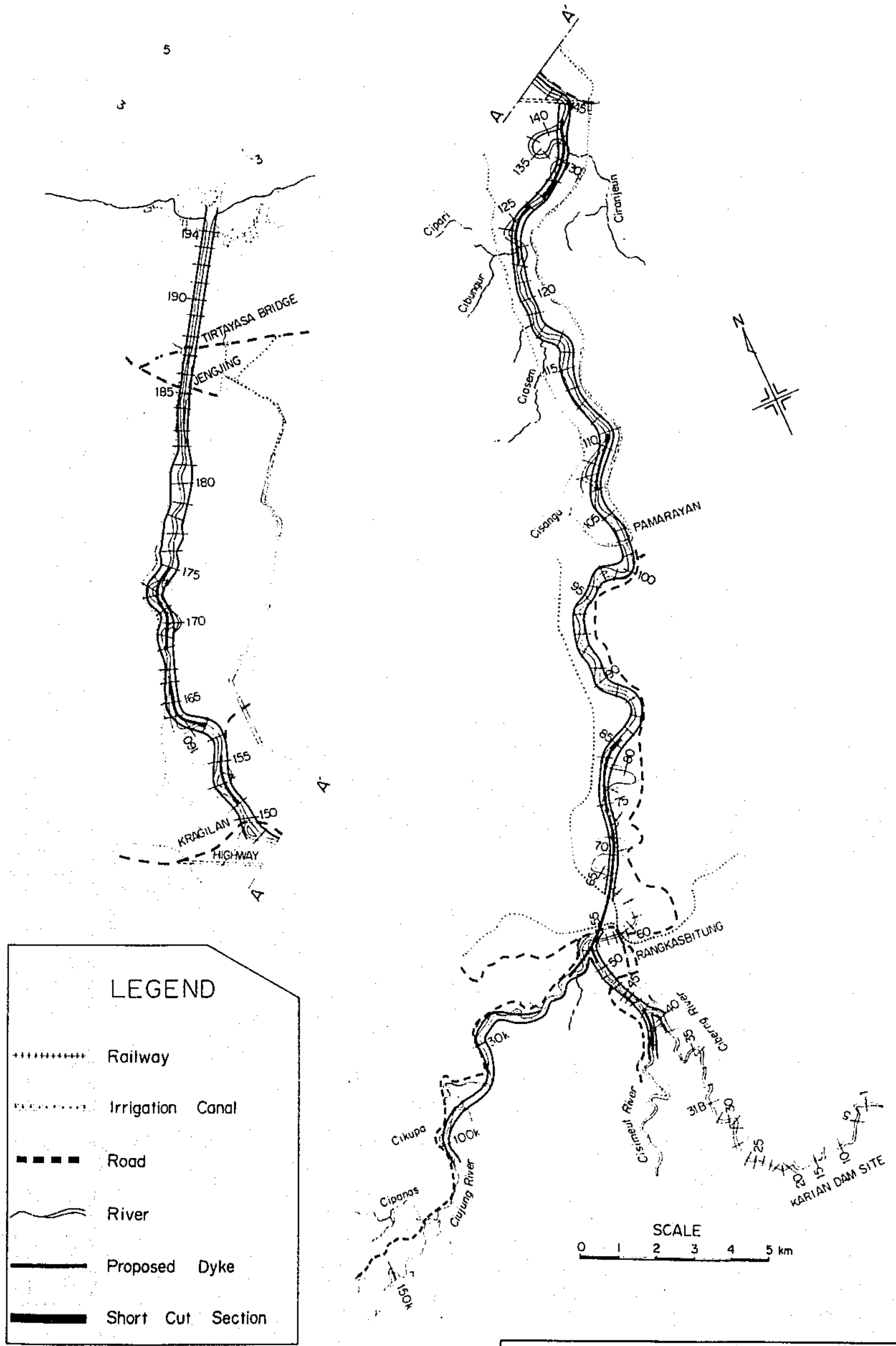

Alternative M-1, M-2, M-3.

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Fig. E-28 Proposed Alignment for Master Plan Level

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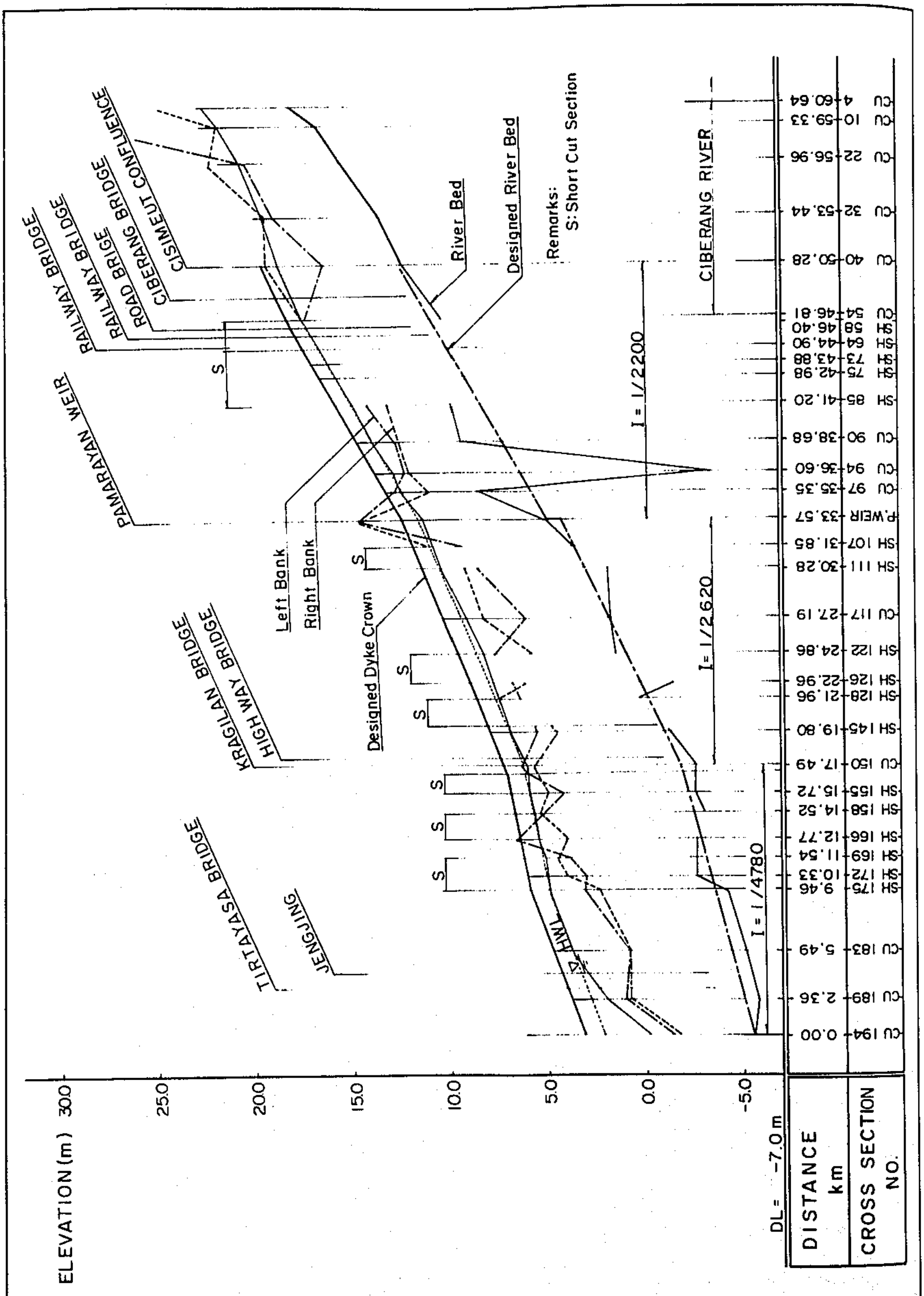

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Fig. E-29 Longitudinal Profile for Master Plan Level (Alternative M-2)

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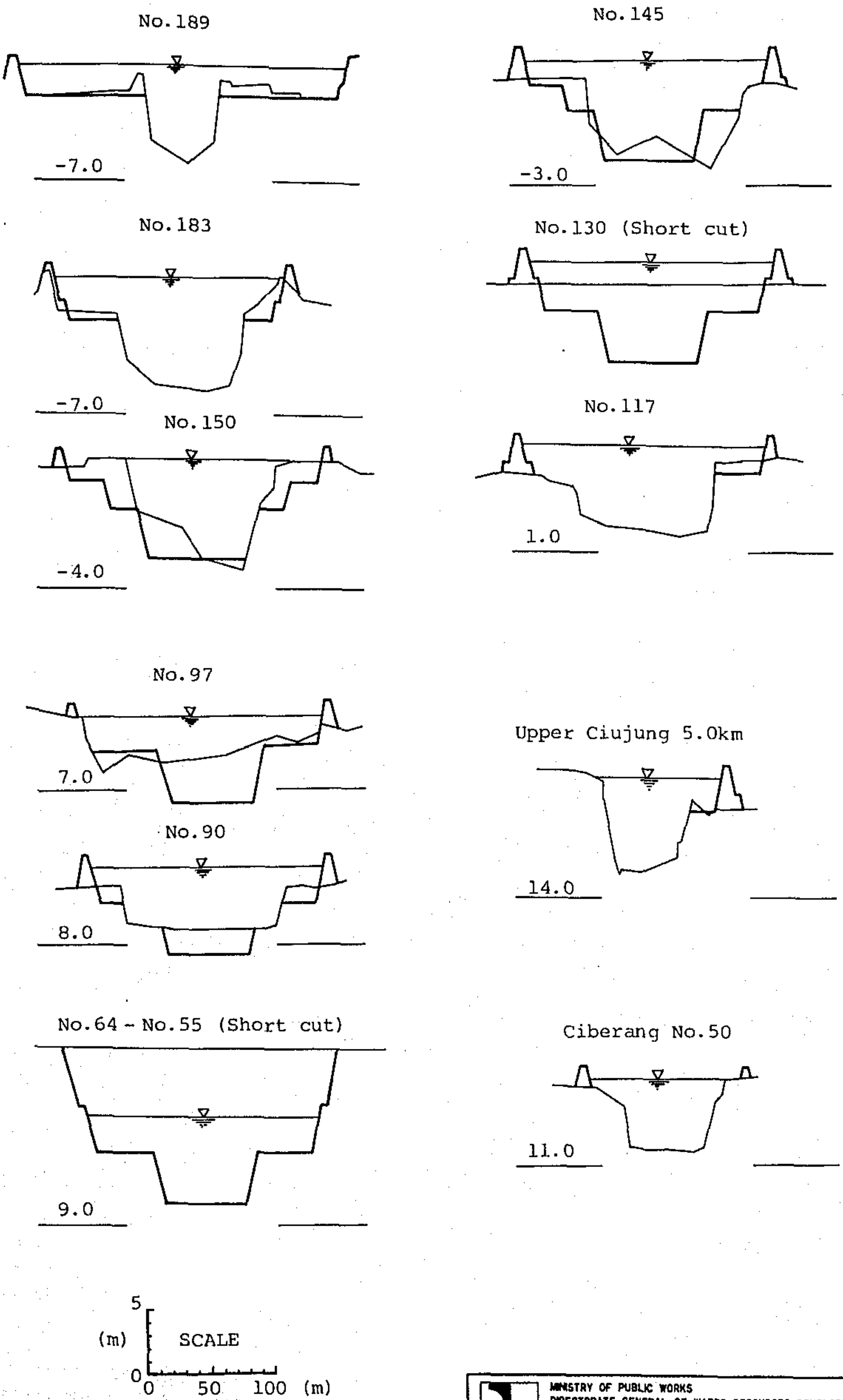

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Fig. E-30 Cross Section for Master Plan Level (Alternative M-2)

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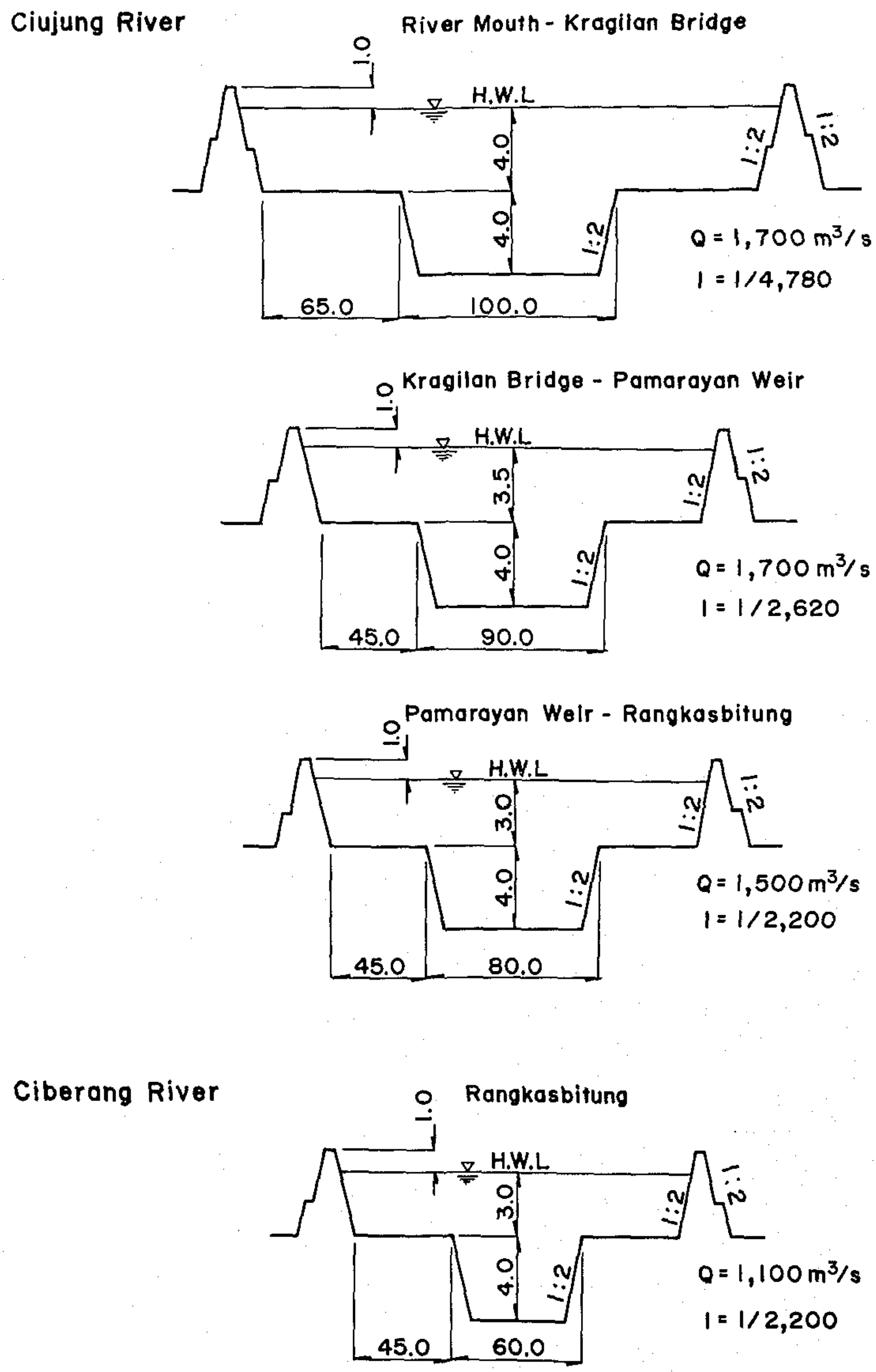

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Fig. E-31 Standard Cross Section for Master Plan Level (Alternative M-2)

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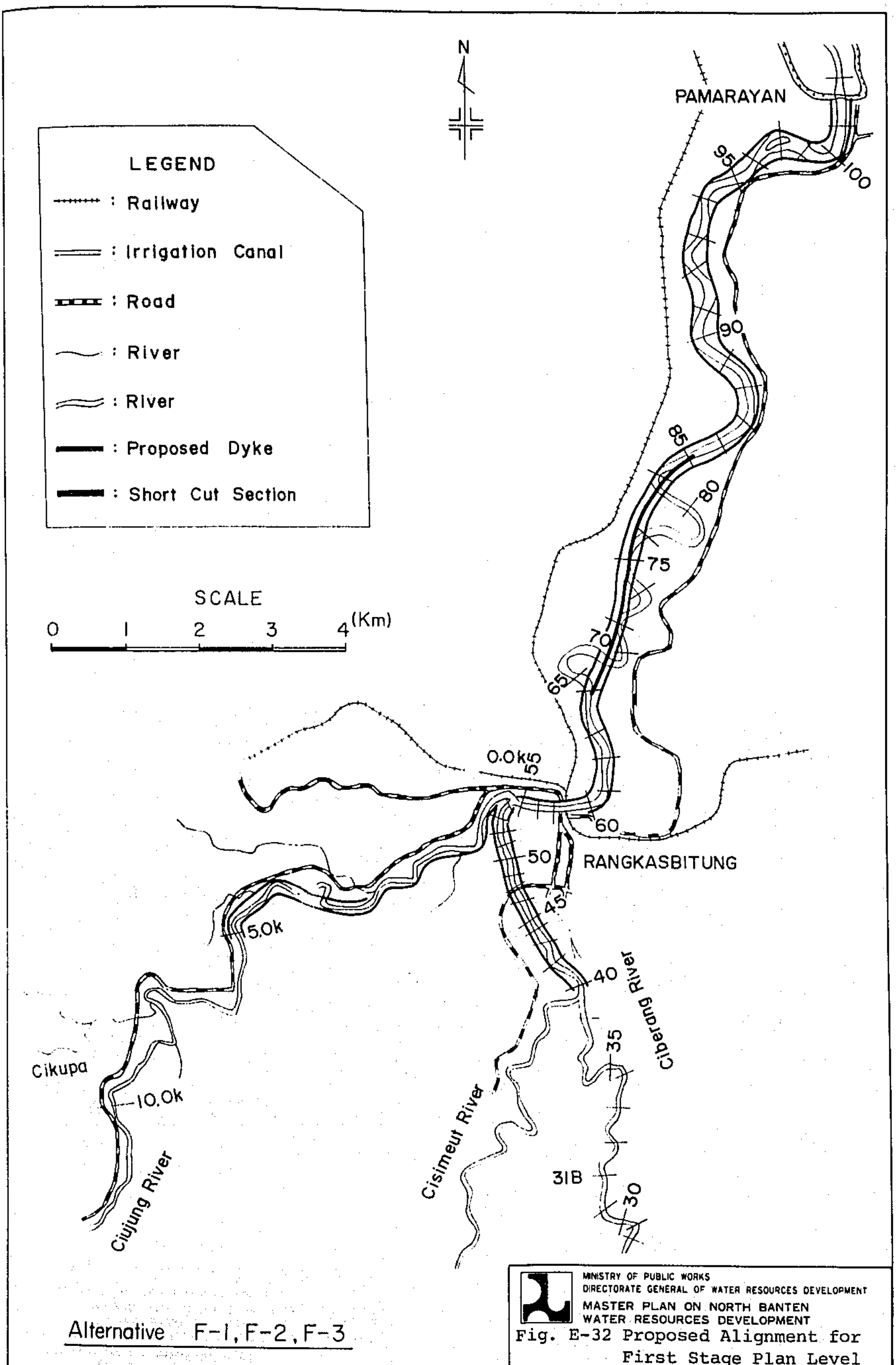

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Fig. E-32 Proposed Alignment for First Stage Plan Level

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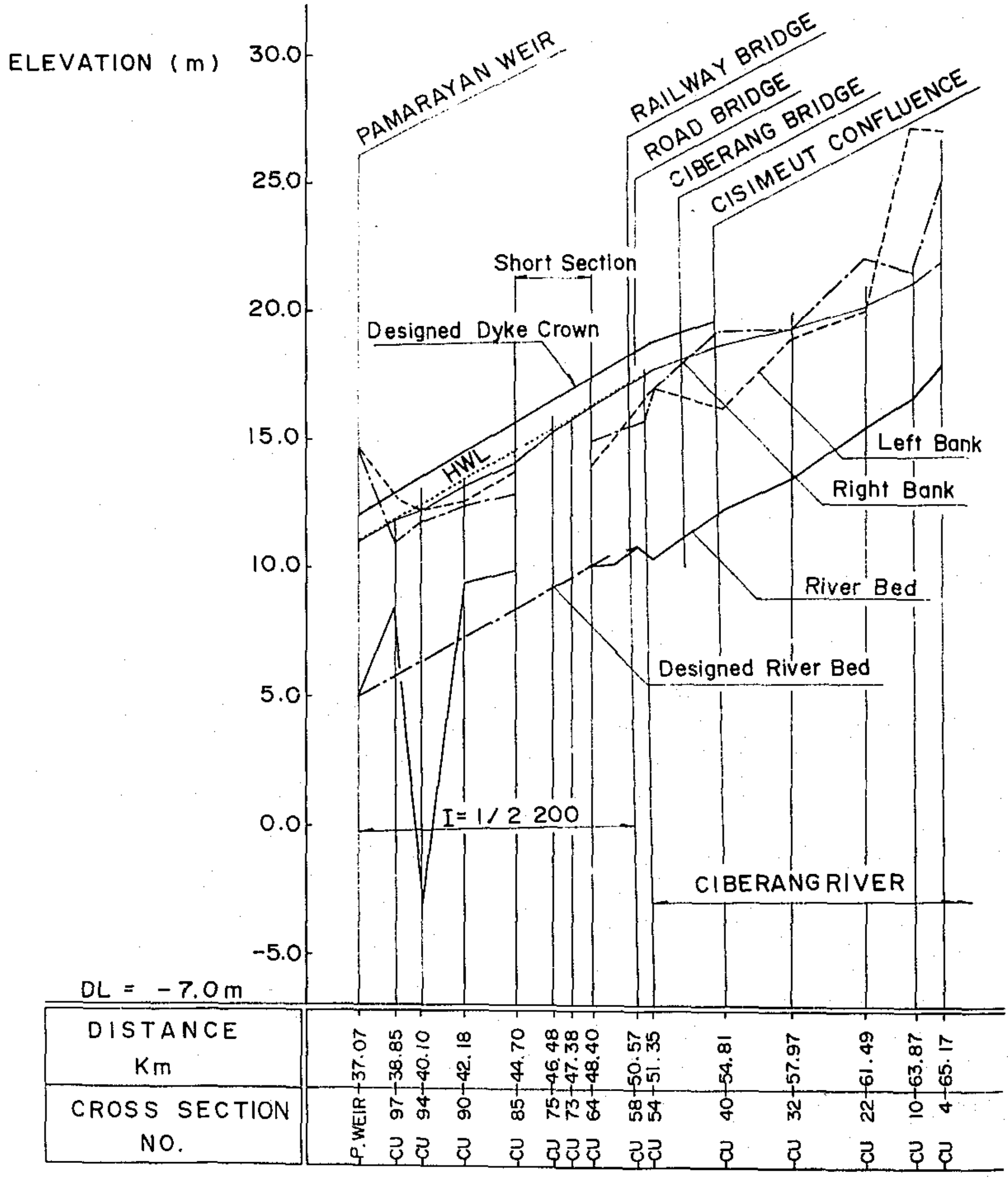

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Fig. E-33 Longitudinal Profile for First Stage Plan Level (Alternative F-2)

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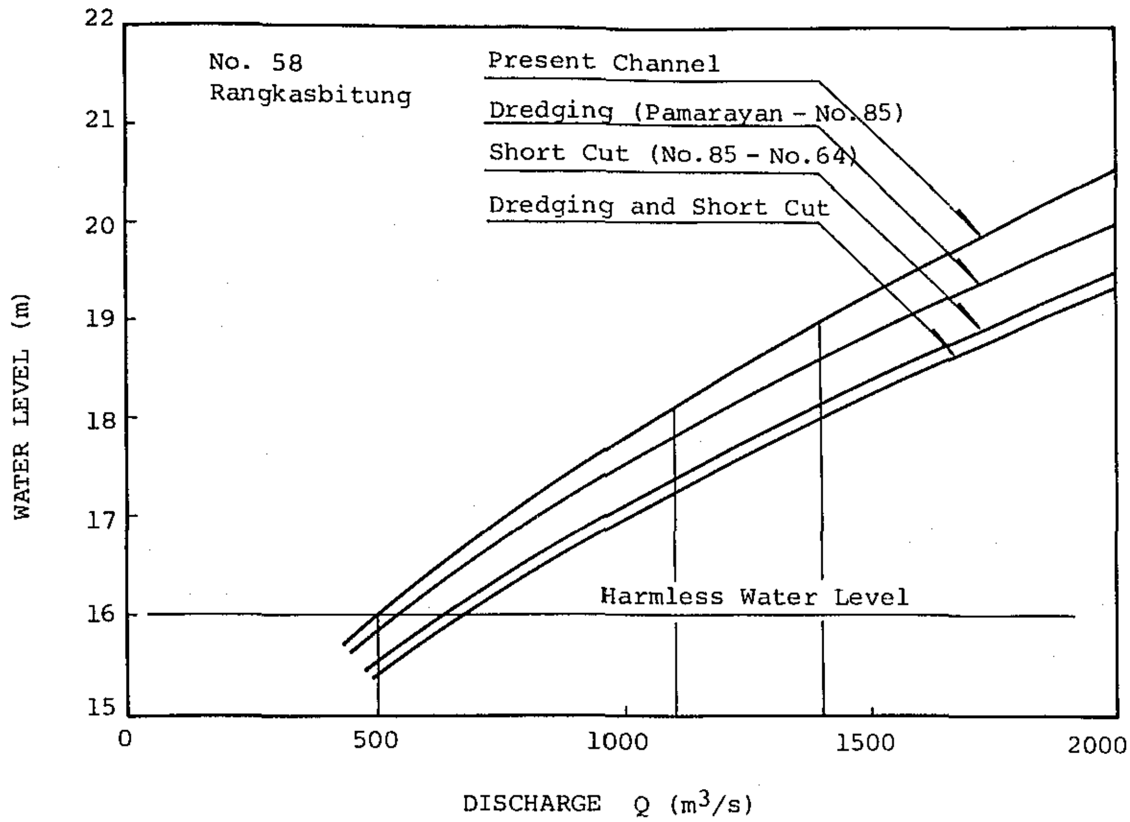

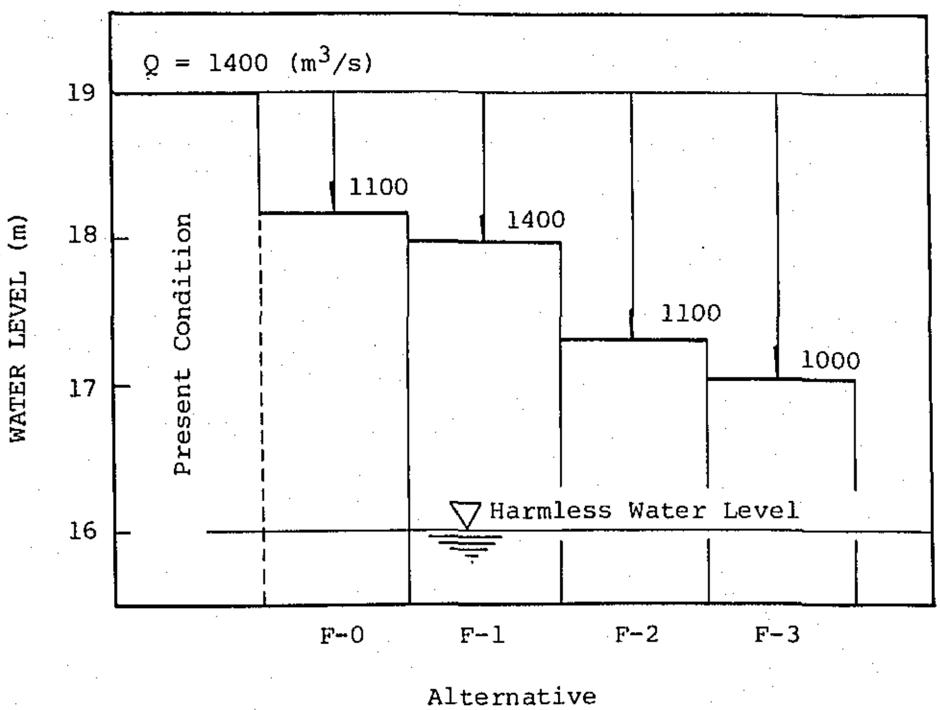

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Fig. E-34 Effect of Shortcut and Dredging on Rangkasbitung

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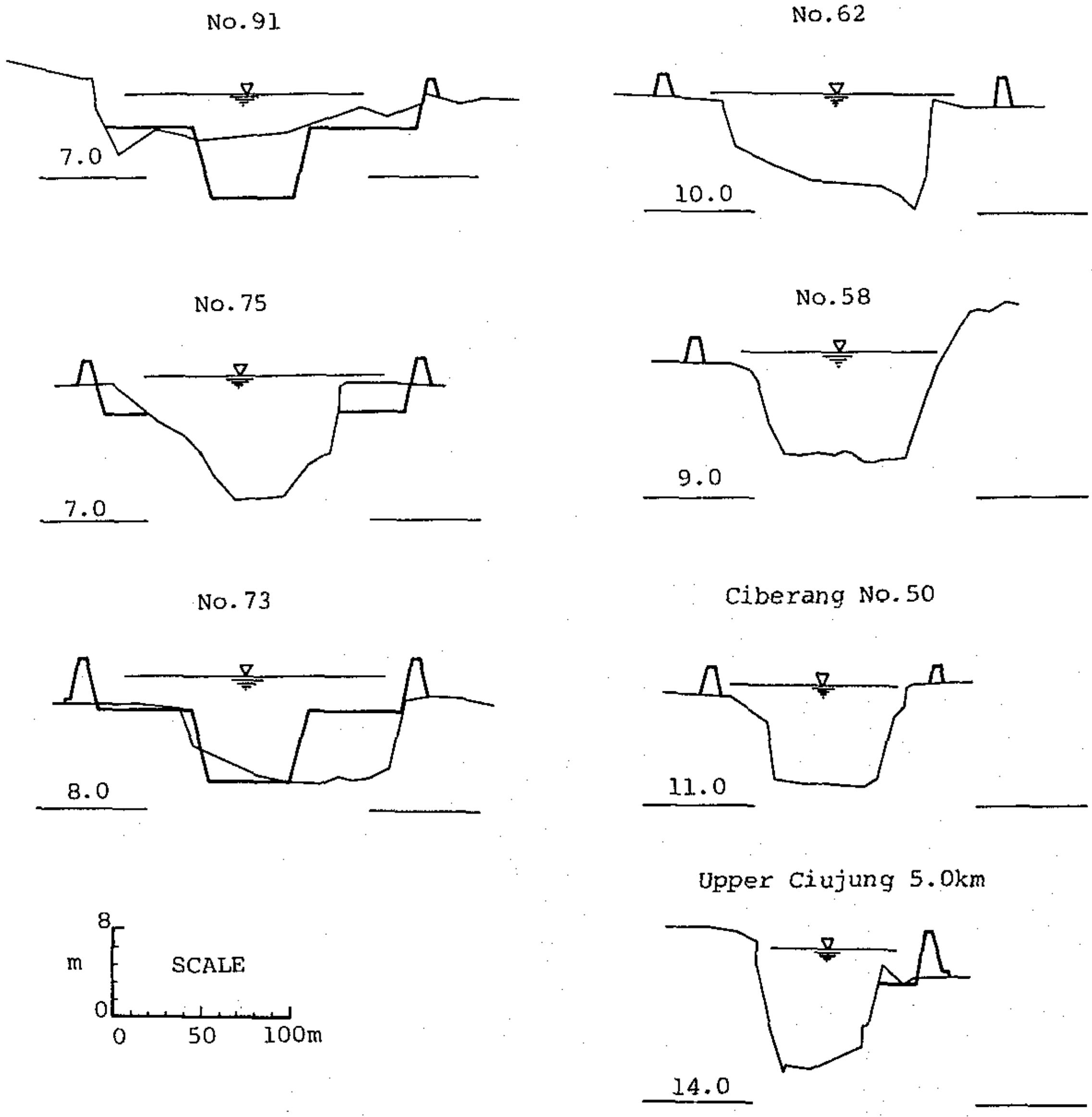

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Fig. E-35 Cross Section for First Stage Plan Level (Alternative F-2)

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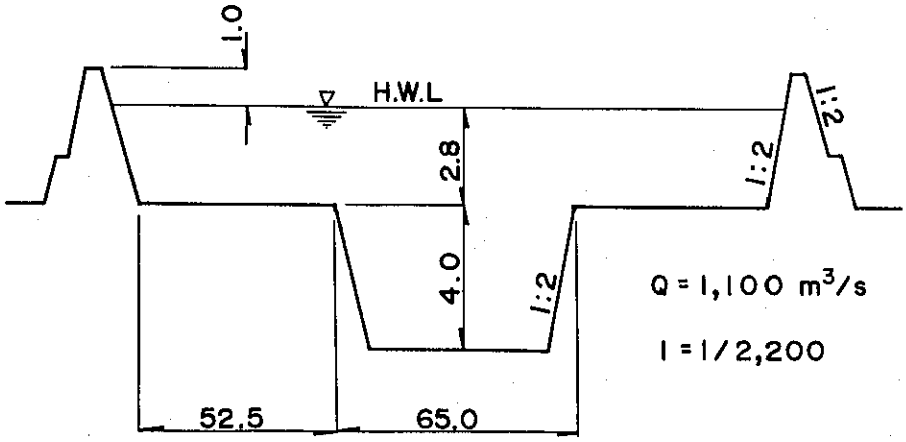
Ciujung River Pamarayan Weir - Rangkasbitung



Ciberag River Rangkasbitung

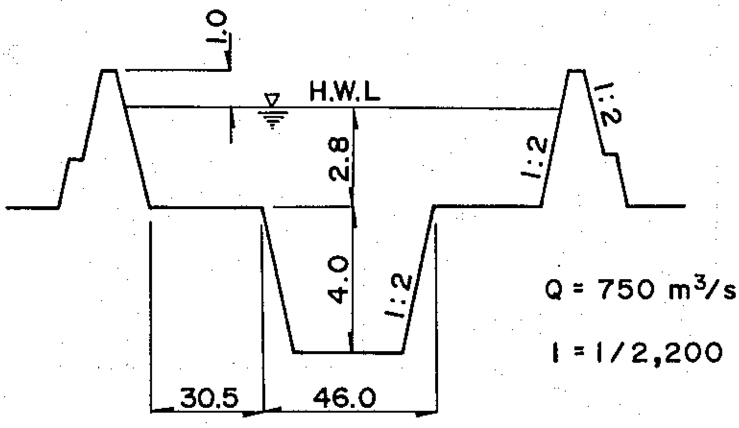


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Fig. E-36 Standard Cross Section for First Stage Plan Level (Alternative F-2)

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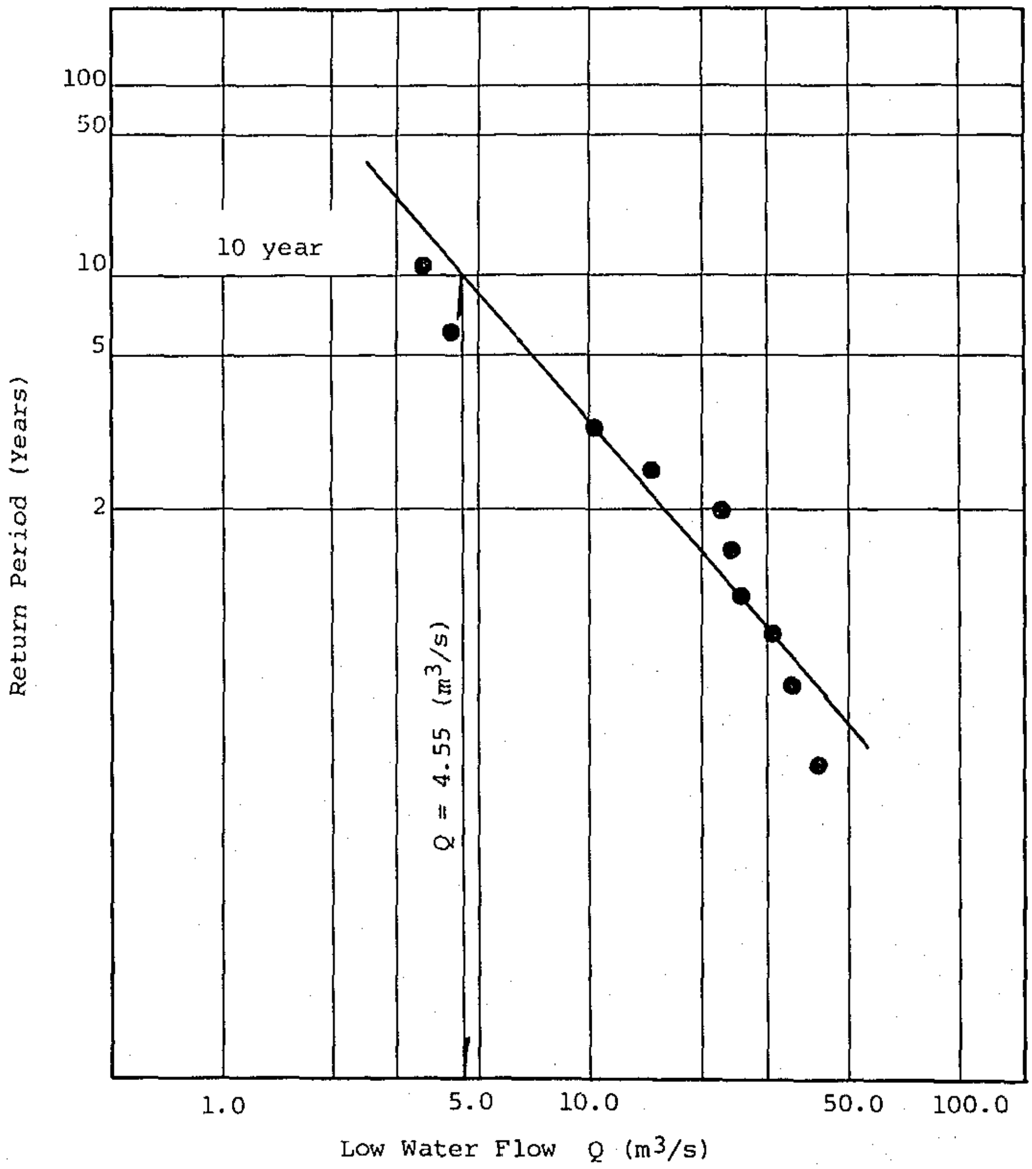

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Fig. E-37 Probable Low Water Flow at Rangkasbitung

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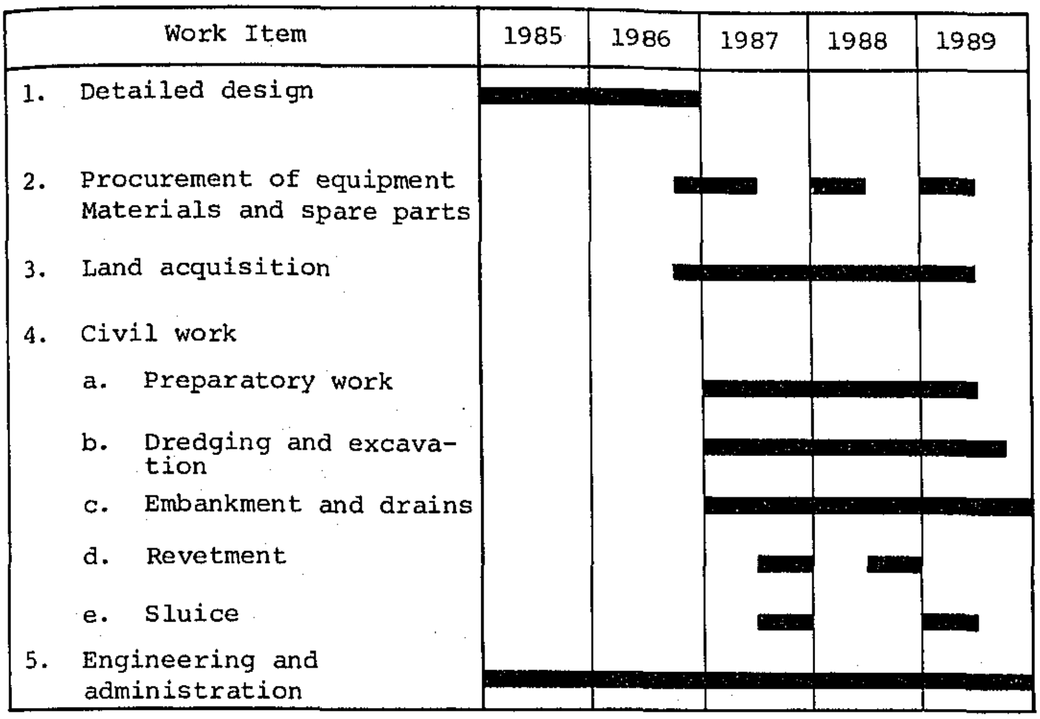
First Stage Plan



Master Plan

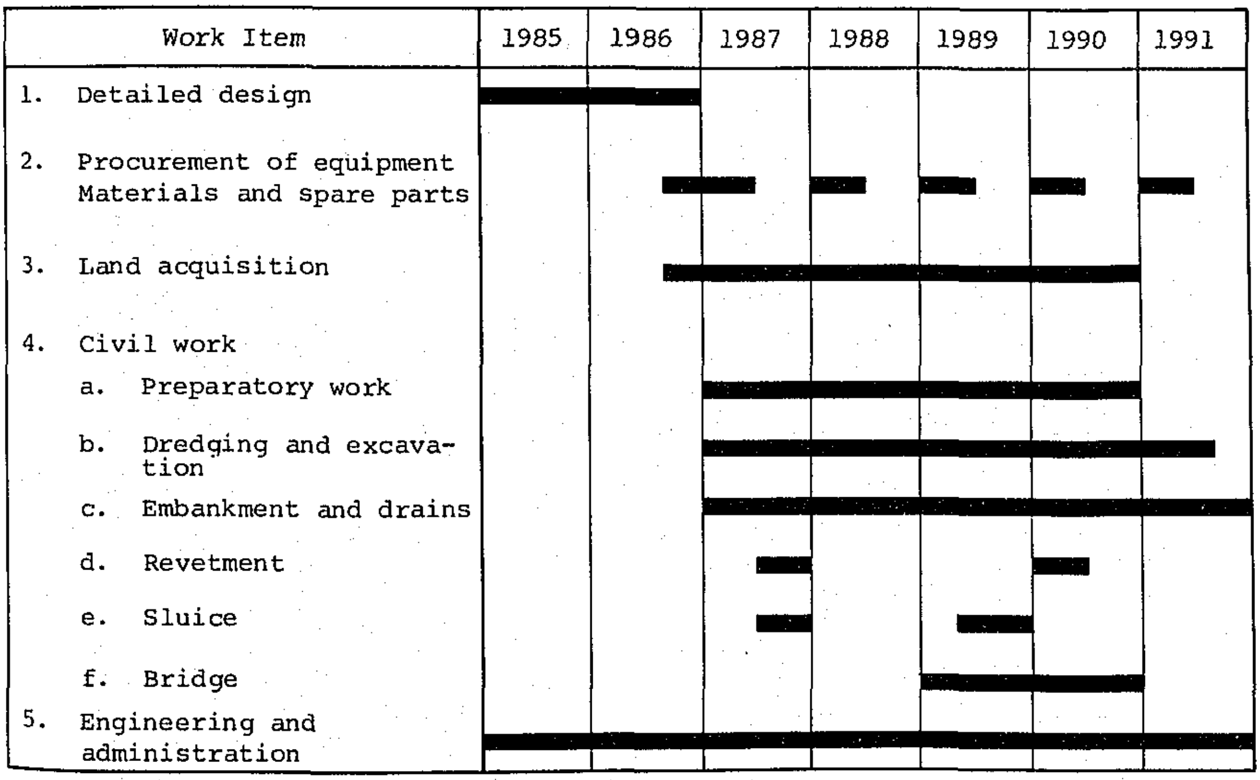


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Fig. E-38 Construction Schedule

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