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

THE FEASIBILITY STUDY
ON
[illegible]
WATER RESOURCES DEVELOPMENT PROJECT

[illegible]

VOLUME I

SUMMARY REPORT

June, [illegible]
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

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

THE FEASIBILITY STUDY
ON
CIDANAU-CIBANTEN
WATER RESOURCES DEVELOPMENT PROJECT

FINAL REPORT

VOLUME I

SUMMARY REPORT

June, 1992
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

This Report consists of

Volume I	*Summary Report*
Volume II	*Main Report*
Volume III	*Supporting Report (1)*
Volume IV	*Supporting Report (2)*
Volume V	*Data Book*

PREFACE

In response to a request from the Government of the Republic of Indonesia, the Government of Japan decided to conduct a feasibility study on Cidanau-Cibanten Water Resources Development Project and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Indonesia a study team headed by Mr.Tetsuro Okaji of Nippon Koei Co.,Ltd. and composed of members from Nippon Koei Co., Ltd. and Mitsui Consultants Co., Ltd., four times between December 1990 and May 1992.

The team held discussions with the officials concerned of the Government of Indonesia and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Indonesia for their close cooperation extended to the team.

June,1992

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

June, 1992

Yanagiya Kensuke
President
Japan International
Cooperation Agency
Tokyo

Dear Sir,

Letter of Transmittal

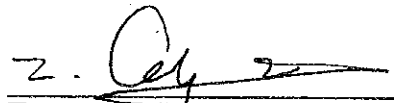
We have the pleasure of submitting to you a Final Report of The Feasibility Study on Cidanau-Cibanten Water Resources Development Project prepared for the consideration by the Government of Indonesia in implementing water resources development for water supply to Cilegon industrial estate and its surrounding areas.

This report consists of five volumes. The Main Report contains the results of the pre-feasibility level study on alternative schemes for water supply to Cilegon industrial estate and its surrounding areas and feasibility study on optimum development plan. Supporting Report (I) contains hydrological, geological and construction material studies to support the plan presented in the Main Report. Supporting Report (II) contains studies on plan formulation study and preliminary design on alternative schemes and the environmental assessment.

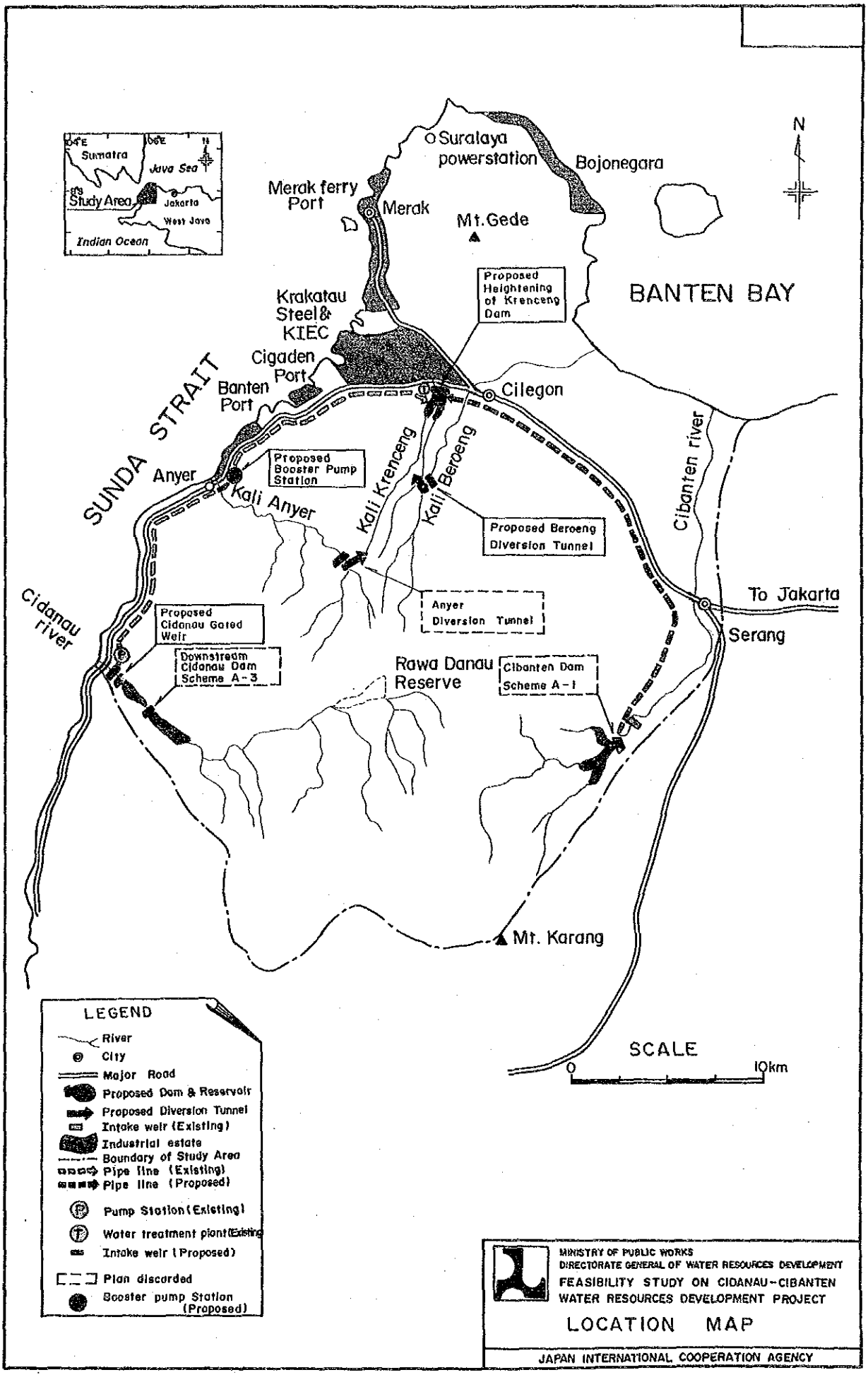
All members of the Study Team wish to express grateful acknowledgment to the personnel of the Advisory Committee, Ministry of Foreign Affairs, Embassy to Indonesia as well as officials and individuals of Indonesia for their assistance extended to the Study Team.

In conclusion, the Study Team sincerely hopes that the study results would contribute to the future water resource development for water supply to Cilegon industrial estate and its surrounding area.

Yours, sincerely



Tetsuro Okaji
Team Leader
The Feasibility Study on
Cidanau-Cibanten Water Resources
Development Project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SUMMARY REPORT

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1. INTRODUCTION

1.1 Project Background

Since the establishment of P.T. Krakatau Steel in Cilegon in 1971, the investment activities of related enterprises and factories have been accelerated recently in the Cilegon industrial estate located at the western part of the North Banten area.

Presently, the water for the industrial estate above is taken from the Cidanau river at 1 km upstream from the estuary and supplied by pumps through a 1.4 m diameter and 27.2 km long pipeline. Full capacity of existing pipeline is designated at 2.0 m^3/sec,while the present supply is remaining at about 0.8 m^3/sec.

Shortage of water supply is getting serious especially in drought years due to that the water is taken from the Cidanau river by free intake and that natural daily run-off in the Cidanau river in dry season is limited to less than 1.0 m^3/sec in once in 10 year drought year.

The water demand at Cilegon industrial area including P.T. Krakatau Steel in the year of 2000 is forecasted to be remarkably increased especially by increase of production of Krakatau Steel. Besides, the demand for municipal water for surrounding cities of industrial estate such as Anyer, Merak and Serang is also increased. There are also increasing water demand in the coastal area due to development of tourism.

To serve the water deficit for the North Banten Region located at about 120 km west of Jakarta city, the master plan study on North Banten water resources development has been carried out by JICA in July 1983 and the feasibility study on Karian multipurpose dam project has been carried out by the Japan International Cooperation Agency (hereinafter called "JICA") in 1985, aiming mainly at irrigation water supply.

In the Karian feasibility study,the water demands in the Cilegon area in the year 2000 was estimated at 3.5 m^3/sec and the study proposed to supply industrial and municipal water (M&I), about 1.1 m^3/sec by pump with 4.9 km pipeline to convey water from the tail end of the Pamarayan Barat primary canal to Cilegon.
However, owing to the rapid economic growth in JABOTABEK (Jakarta-Bogor-Tangerang-Bekasi) area, the Karian scheme is planned to be reviewed and updated to meet the change of purpose from irrigation to M&I uses for western Jakarta.

Under such condition, the water resources development in the Study Area where

bordered by the sea in the north and west, by the Cibanten river in the east and by the Cidanau river in the south has become one of priority project so as not to discourage the national growth created by the Cilegon and its surrounding coastal industrial estate.

In order to meet the future water demand of the western area of North Banten,the Government of Indonesia aimed for development of water resources with special purpose for water supply to the above areas, and requested to the Government of Japan in November 1988 for the feasibility study on the water resources development in the Study Area covered by both Cibanten and Cidanau rivers,aiming for urgent water supply. In response to the request, the Government of Japan dispatched a preliminary survey team to Indonesia in September 1989. The Scope of Work was agreed between the Directorate General of Water Resources Development,Ministry of Public Works (hereinafter called "DGWRD") and JICA on October 4, 1989.

1.2 Objective of the Study

The objective of the study is to examine technical and socio-economic feasibility of the project which envisages mainly the municipal and industrial water supply in the study area, especially,

(i) to confirm possible water potential by dam development schemes in both Cidanau and Cibanten river basins and others and decide the development priority of alternative schemes in the first stage,
(ii) to conduct the feasibility study on the optimum development scheme in the second stage.

1.3 Work Progress

JICA dispatched the Study Team for the Feasibility Study from the middle of December, 1990. Since then, the JICA Study Team has made investigations and studies on the Project in close cooperation with the DGWRD's and Cisadane-Jakarta-Cibet-Banten (hereinafter called "CJCB") counterpart engineers.

From the result of investigation study during 1st field work from mid December 1990 to mid March 1991, the following matters were found out;

(i) The water source of Cibanten river is rather small and also due to existing irrigation water requirement in its downstream area, the development yield,

about 0.45 m^3/sec created by the proposed Cibanten dam will not be sufficient against the growing demand in and around the Cilegon area.

(ii) The Cidanau river has abundant water sufficient for water supply for the above water demand area. However, the geological condition of the proposed dam sites in the middle reaches of the Cidanau river is very poor and the cost of water supply would be quite high.

(iii) In the situations above, DGWRD suggested that the development plan of Rawa Danau should be reconsidered after the environmental problem would be settled.

The study Team pointed out that it would not be easy because it is beyond the Scope of Work in this Study although the Rawa Danau storaged dam plan will be more beneficial than other schemes mentioned above.

As a results of review of site investigation at home office, the height of downstream Cidanau dam site was restricted less than 35 m owing to the dam criteria in Japan and its gross storage become about 7×10^6 m^3. The development yield is limited to about 2.0 m^3/sec even though the dredging for sediment is fully maintained.

From the above results, it was found out that the reservoirs created by the dams in the Cidanau and Cibanten rivers could not be sufficient against the water demand in and around the Cilegon area in the year of 2000 which is forecasted to be 3.5 m^3/sec.

Considering the above situations, the joint meeting was held between JICA, Advisory Committee and the Study Team on June 1991 to discuss the scope of further study. As a result of the joint meeting, following two plans were picked up as alternative plans for the feasibility study on Cidanau-Cibanten project and additional field investigations were planned to be carried out.

(i) Storage plan by heightening of the existing Krenceng reservoir which aims to store the water of Cidanau river during wet season.

(ii) Storage plan by provision of a weir with high gates located at just upstream of the existing Krakatau intake weir which could flush the sediment.

Owing to the decision of joint meeting, the working schedule was modified to carry

out the field investigation for proposed Krenceng dam and Cidanau gated weir site in August 1991.

After completion of second field investigation, the Interim Report was compiled.

In the Minute of Meeting on the Interim Report between the Study Team, the Advisory committee and the DGWRD on November 8, 1991 the following three (3) schemes were selected as the priority schemes for the feasibility study as below;

(i) Scheme K-1 : Heightening of Krenceng dam without diversion tunnel
(ii) Scheme K-2 : Heightening of Krenceng dam with Beroeng diversion tunnel
(iii) Scheme C-3 : Heightening of Krenceng dam with Beroeng diversion tunnel and Cidanau gated weir

The field investigation work in the Second Stage was carried out for one month in mid December 1991 to mid January 1992 in accordance with the Minute of Meeting on the Interim Report.

Upon completion of field work, the Study Team immediately reviewed the site investigations at the home office. The Draft Final Report was prepared in mid January to mid April, 1992.

The meeting on the Draft Final Report between the Study Team, the Advisory Committee and the DGWRD was held on May 6 to 14, 1992.

1.4 Study Area and Location

The study area is situated in the northwest corner of the Province of West Java. It is bordered by the Banten Sea in the north, by the Sunda Strait in the northwest, by the watershed of the Cibanten river in the east, and by the watershed of the Cidanau in the south. The Study Area is 1,050 km^2.

1.5 List of Reports

This Final Report summarizes all the results of the investigations and feasibility study made in the first stage and second stage as well as the conclusions and recommendations reached through the study.

The Final Report comprises;

(i) one volume of Summary Report (Volume I),
(ii) one volume of Main Report (Volume II),
(iii) two volumes of Supporting Report (Volume III & IV) and
(iv) one volume of Data Book (Volume V).

Volume II is the Main Report containing the feasibility study on the Project which is composed not only of the priority development scheme but also other conceivable alternative schemes.

Volume III and IV are the Supporting Report compiled in eight appendixes to support the Main Report.

2. SITE CONDITIONS

2.1 Socio-economy

According to information obtained from the departments/agencies of the Government of Indonesia and interview survey with private enterprises conducted by this Study, agriculture is the main stay of the Kabupaten. In the manufacturing sector, state owned company of Krakatau Steel is dominant,which have the biggest share in the steel production in the country. Since late 1980s, industrialization consisting mainly chemical industries,made remarkable progress in Bojonegara and Anyer areas. Tourism is also developing rapidly in the Kabupaten located in around Merak and Anyer areas mainly for accommodating weekend tourists from Jakarta though the scale is rather limited.

At present,toll road reaches up to around Cilegon city from Jakarta which is expected to be extended to Merak town where a major ferry port facing the Sunda Strait is located.

2.2. Existing Water Supply Facilities

The present Krakatau water supply system consists of the water intake and pump station (Q=3,000 m^3/hr × 4 units and pump head of 67.1 m) located at 1 km upstream of the Cidanau river estuary, a 27.2 km long with 1.4 m diameter water transmission pipe line, Krenceng receiving reservoir with the effective storage of 3.155×10^6 m^3,Krenceng pump station(Q=1,840 m^3/hr × 5 units and pump head of 12.3 m) and water treatment plant (Q=2,400 m^3/hr × 3 plants).

2.3. Water Demand Projection

The present water use for the domestic and industrial water in the study area in early 1991 is summarized as below.

(unit:cms)

Water source	Krakatau's supply system	Desalination plant	Deep well	Small river	Total
Domestic water	0.05	0.01	0.02	0.02	0.10
(%)	(50)	(10)	(20)	(20)	
Industrial water	0.69	0.04	0.01	0.03	0.77
(%)	(89)	(5.3)	(1.5)	(4.0)	
Total	0.74	0.05	0.03	0.05	0.87

Note: 1] excluded Serang which is supplied by the spring water gushed out from the slopes of the Gunung Karang throughout the year.

The future water demand is forecasted as below. However, after the field interview, the water requirement by the manufacturing enterprises is growing and changing rapidly owing to the latest development plan of industrial complex. By data source received from DGWRD, water demand in 2010 year will reach 7.14 m^3/sec.

(unit:cms)

Water use	Projection year				
	1990	1995	2000	2005	2010
Domestic water	0.10	0.30	0.69	0.97	1.33
Industrial water	0.77	1.76	2.61	2.70	3.61
Total	0.87	2.06	3.30	3.67	4.94 (7.14)*

Note: excluded Serang which is supplied by the spring water.
* included latest request by the manufacturing enterprises.

2.4 Meteology and Hydrology

The climate of the Study Area is generally characterized as a tropical monsoon with small variation of 26°C to 27°C on average monthly air temperature throughout the year. The period from April to May is first transition between the two monsoons and the second transition period is between October and November. The first transition period during June to September is called the dry season and second transition period during December to March is called the wet season.

Mean annual rainfall of recent 21 years between 1970 and 1990 was 2,500 mm per annum. In the southern corner of the area, the annual rainfall reaches 3500 but decreases

towards the north to 2,000 mm.

Mean annual runoff at Kubang Baros gauging station during 1980 to 1990 in the Cidanau river is 13.0 m^3/sec and mean annual runoff at Serut gauging station during 1980 to 1990 in the Cibanten river is 2.0 m^3/sec.

Mean annual sediment yield at the Cibanten dam site was estimated by measuring the sediment in the first field work during January to March,1991,resulting in 900 m^3/km^2/year. Cidanau dam site was 500 m^3/km^2/year, rather small due to the sediment being trapped in the Rawa Danau.

2.5 Geology

The study area is mainly composed of tuffaceous strata called "Banten Tuff". The old volcanic rocks which develop at Mt.Gede and other adjacent mountains include andesitic and basaltic lava flows, volcanic breccia and tuff. The younger volcanic produced by Mt.Karang are also composed of breccia and lava of pyroxene andesite to basalt. Banten Tuff and recent alluvial deposits like tuffaceous sand, silt and clay generally develop in the Study Area.

In this Study, the twenty one (21) bore-holes were drilled throughout the First and Second stages and its total drilling length was 570 m.

The weakly welded pumice tuff layers which compose the foundation beds of the Krenceng damsite, are sufficient for a low fill type dam.

The mechanical strength of the foundation beds around the existing pumping station is also sufficient for the weir. But loose materials should be replaced by mass concrete. The permeability coefficients of the soft rocks, such as unconsolidated pumice tuff, range in the order of 10^{-5} m/sec. Comparatively high lugeon values, which are equivalent to the permeability coefficient of about K= 10^{-4} m/sec, were obtained from the boreholes which penetrate welded pumice tuff layers. The foundation rocks of these damsites are possible to be treated by normal grouting using cement milk.

2.6 Construction Materials

The rock quarry sites for the riprap material are distributed in Anyer and Bojonegara area, about 4-5 km from the existing Krenceng dam site. The borrow areas for impervious core material are distributed in about 1 km upstream of the existing Krenceng dam. Filter

material will be obtained from the rivers in around Anyer and also by crushing rock material if necessary. Concrete aggregate will be also obtained by crushing rock material if necessary.

3. PLAN FORMULATION

3.1. General

Plans for the schemes were formulated in four (4) steps, incorporating information available at each Field and Home Work throughout First stage and Second stage.

3.2 Identification of Dam Sites

(1) First Selection of Proposed Dam Sites

Various possible damsites are identified in the study area through site reconnaissance by the JICA Study Team. The following nine (9) damsites and two (2) intake weir sites are identified.

Scheme	Identified dam site & intake sites	Name of river	Basin area (km^2)	Location (upstream of estuary)
A-1	Cibanten	Cibanten	73.15	22 km
A-4&A-5	Up-Cidanau	Cidanau	199.5	7.5 km
A-2	Mid-Cidanau	Cidanau	204.1	4.7 km
A-3	Down-Cidanau	Cidanau	208.25	3.5 km
A-6	Upstream of Krakatau intake	Cidanau	214.95	1.2 km
A-4-4	Up-Anyer	Anyer	31.2	3.5 km
A-4-3	Mid-Anyer	Anyer	38.6	3.0 km
A-4-1&A-4-2	Down-Anyer	Anyer	41.3	2.0 km
K-1, K-2 &K-3	Heightening of Krenceng dam	Krenceng	13.3	4.0 km
	Beroeng intake *	Beroeng	12.1	15.0 km
	Anyer intake *	Anyer	17.5	12.5 km

Note: * means proposed intake weir site.

(2) Final Selection of Proposed Dam Sites

Among nine (9) damsites and two (2) intake weir sites identified, five (5) damsites were discarded based on the following reasons.

: Middle Cidanau damsite (Scheme A-2)

Serious geotechnical difficulties are envisaged for the stability of dam foundation. The possible effective storage volume is very small comparing to the downstream Cidanau

dam site even though the sediment would be removed by maintenance dredging. Therefore the development cost would be quite high. Thus this dam site is not taken up.

: Anyer Dam Sites (A-4-1, A-4-2, A-4-3 & A-4-4)

There is a lot of irrigated areas and houses in the downstream anyer river basin. Thus the Anyer storaged dam plan will bring the social problem due to the resettlement of inhabitants in the inundation area. Thus the Anyer dam site is not taken up.

: Upstream Cidanau damsite (A-4 & A-5)

Based on a rough study, technically, a very large water storage of around 100 million m^3 could be developed by provision of a small dam, 10 m height at the outlet of Rawa Danau and by raising the lake water level up to about El.91.0 m, and the available water supply would be about 8 m^3/sec. Thus the Rawa Danau storaged dam plan will be the most beneficial with very low water cost comparing to other damsites. However, this scheme is not taken up as it is beyond the Scope of Work in this Study. It is a prerequisite in the TOR that, the full supply water level of the Cidanau damsite should be settled so as not to submerge the Rawa Danau which is a nature reserve area.

In view of the potential of development of Rawa Danau storage scheme as mentioned above, it is suggested by DGWRD that the development of Rawa Danau should be reconsidered after the environmental problem would be settled.

3.3 Comparative Study of Alternative Single Development Schemes

The six alternative development scheme are formulated as below.

1) A-1: Cibanten dam development scheme

Construction of a storaged type dam in the Cibanten river, together with a 28 km pipeline to convey water from the dam site to the existing Krenceng receiving reservoir at Cilegon,and an additional water treatment plant.

2) A-3: Downstream Cidanau dam development scheme

Construction of a storaged type dam in the Cidanau river,together with an additional water treatment plant. Water is conveyed from the existing Krakatau intake weir to the existing Krenceng receiving reservoir at Cilegon through the existing 27.2 km pipe line.

3) A-6: Cidanau gated weir development scheme

Construction of a weir with high gate located at just upstream of existing Krakatau intake weir, together with an additional water treatment plant. Water is conveyed from the existing Krakatau intake weir to the existing Krenceng reservoir at Cilegon through the existing 27.2 km pipe line.

4) K-1: Heightening Krenceng dam development scheme without diversion tunnel

Heightening of Krenceng dam along its downstream slope,additional pumping station at Krakatau intake, construction of booster pumping station at intermediate point,replacement of Krenceng pump and construction of an additional water treatment plant. Water is conveyed from the existing Krakatau intake weir to the heightened Krenceng reservoir through the existing 27.2 km pipe line.

5) K-2: Heightening Krenceng dam development scheme with Beroeng diversion tunnel

Heightening of Krenceng dam and construction of a diversion tunnel from Beroeng river to the Krenceng basin,additional pumping station at Krakatau intake, construction of booster pump station at intermediate point, replacement of Krenceng pump station at Krenceng reservoir and construction of an additional water treatment plant near Krenceng. Water is conveyed from the existing Krakatau intake weir to the heightened Krenceng reservoir.

6) K-3:Heightening Krenceng dam development scheme with two diversion tunnels

Heightening of Krenceng dam and construction of two diversion tunnels from Beroeng river to the Krenceng basin and Anyer river to Krenceng basin, additional pumping station at Krakatau intake, construction of booster pump station at intermediate point, replacement of Krenceng pump station at Krenceng reservoir and construction of an additional water treatment plant near Krenceng. Water is conveyed from the existing Krakatau intake weir to the heightened Krenceng reservoir.

3.4 Comparative Study of Alternative Combined Development Schemes

The alternative combined development schemes which for the increasing of development yield are divided into three groups in terms of the type of development for the

heightening Krenceng dam and formulated by nine (9) alternatives as below;

Scheme	Single scheme to be combined
B-1	K-1 plus A-1
B-2	K-1 plus A-3
B-3	K-1 plus A-6
C-1	K-2 plus A-1
C-2	K-2 plus A-3
C-3	K-2 plus A-6
D-1	K-3 plus A-1
D-2	K-3 plus A-3
D-3	K-3 plus A-6

(1) Water Balance Study

The water balance study for fifteen (15) alternatives including the single and combined development schemes is carried out by five (5)-day mean inflow transposed by the runoff records of both Kubang Baros and Serut gauging station from 1980 to 1989. The required effective storage for corresponding safe yield is obtained by maximum drought during the period of 10 years from 1980 to 1989.

(2) Maximum exploitable dam scale and development yield for alternative single and combined development schemes

The maximum exploitable dam scale and development yield for single and combined schemes is summarized as below.

Scheme	Maximum exploitable dam height (m)	Effective storage volume (10^6 m^3)	Developme -nt yield (cms)	Existing yield (cms)	Increment -al yield (cms)	Total system yield (cms)	Water demand of forecast in 2005 (cms)	Surplus/ deficit (cms)
A-1	45 1]	14.9	0.45	1.97 4]	0.45	2.42	3.67	-1.25
A-3	35 2]	2.95	1.825	1.97	0.09	2.06	3.67	-1.61
A-6	24.2 3]	3.44	1.970	1.97	0.235	2.205	3.67	-1.465
K-1	24 1]	12.87	3.10	1.97	1.13	3.10	3.67	-0.57
K-2	24 1]	12.87	3.15	1.97	1.18	3.15	3.67	-0.52
K-3	24 1]	12.87	3.20	1.97	1.23	3.20	3.67	-0.47
B-1			3.55	1.97	1.58	3.55	3.67	-0.12
B-2			3.4	1.97	1.43	3.4	3.67	-0.27
B-3			3.435	1.97	1.465	3.435	3.67	-0.235
C-1			3.60	1.97	1.63	3.60	3.67	-0.07
C-2			3.445	1.97	1.475	3.445	3.67	-0.225
C-3			3.49	1.97	1.52	3.49	3.67	-0.18
D-1			3.65	1.97	1.68	3.65	3.67	-0.02
D-2			3.49	1.97	1.52	3.49	3.67	-0.18
D-3			3.54	1.97	1.57	3.54	3.67	-0.13

Notes: 1] due to topographic constraint
2] due to geological constraint
3] due to hydro-mechanical constraint
4] Based on the results of simulation study for the existing Krakatau water supply system

3.5 Selection of Priority Scheme

The comparative study on the above fifteen (15) alternative schemes was made through comprehensive evaluation from the economic, technical and social aspects. Among alternatives above, K-3 is the highest in EIRR. Second highest EIRR is with the Scheme K-2, third is with the Scheme K-1 and fourth is the Scheme C-3. However, K-3 is discarded because there is more than 330 ha of paddy field in the downstream of Anyer main river excluding its tributaries, and the diversion to Krenceng reservoir may cause various social effect to the downstream.

Thus, the following three (3) schemes were selected as the priority scheme for the feasibility study;

(i) Scheme K-1 : Heightening of Krenceng dam without diversion
(ii) Scheme K-2 : Heightening of Krenceng dam with Beroeng diversion
(iii) Scheme C-3 : Heightening of Krenceng dam with Beroeng diversion and Cidanau gated weir

3.6 Plan Optimization

The optimal development scale of each scheme component was studied by comparing the capitalized net benefit of various alternative scales based on the net benefit maximization criteria.

After fixing the development scale, the reservoir operation was finalized so as to obtain the net supply yield for each scheme which means the safe yield after the evaporation loss from the reservoir.

	Description	Scheme K-1	Scheme K-2	Scheme C-3	
1)	Reservoir	Heightening of Krenceng	Heightening of Krenceng	Heightening of Krenceng	Cidanau Gated Weir
2)	NHWL (El-m)	29.00	29.00	29.00	21.20
3)	LWL (El-m)	18.00	18.00	18.00	1.50
4)	Diversion tunnel				
	In-diameter (m)	-	1.50	1.50	-
	Max. discharge (cms)	-	4.0	4.0	-
5)	Net supply yield (cms)	3.05	3.11	3.11	0.325
6)	Incremental net supply yield (cms)**	1.11	1.17	1.495*	
7)	Max. capacity of water conveyance (cms)	3.05	3.11	3.435*	
8)	Annual water conveyance from Cidanau river ($10^6m^3/yr$)	83.501	77.522	87.771	
9)	Annual water diversion from Beroeng river ($10^6m^3/yr$)	-	10.062	10.062	

Notes: * Summation of Heightening of Krenceng and Cidanau gated weir
** Means the net supply yield due to the Project minus the net supply yield for the existing Krenceng, 1.94 cms

4. PRELIMINARY DESIGN

4.1 General

From the results of comparative study for the structural components, the design features for the heightening of Krenceng dam, Cidanau gated weir and Beroeng diversion tunnel are summarized as below.

4.2 Heightening of Krenceng Dam

- Dam axis — Downstream toe of existing dam in view of foundation treatment
- Dam crest — El.32.00 heightened by 7.5 m above existing
- Dam type and slope — Impervious random earthfill dam with 1:3.0 in upstream and 1:2.5 in downstream
- Dam height — 24 m high in maximum
- Crest length — 2911 m with crest width of 10 m
- Spillway type — Gated overflow type with net width of 15.5 m
- Spillway gate — 2 Nos.of roller gate × 7.75 m width × 4.3 m high
- Energy dissipator — Hydraulic jump type

4.3 Cidanau Gated Weir

- Dam axis — 200 m upstream of existing Krakatau intake weir
- Dam type — Concrete gravity dam with vertical in U/S and 1:0.6 in D/S
- Spillway type — Gated overflow type with net width of 51 m
- Spillway gate — 3 Nos.of roller gate × 17 m width × 20 m high
- Outlet facility for water supply

Inlet	:	1400 dia embedded steel conduit in dam
Pipe line to valve house	:	1400 dia steel conduit in 150 m
Valve house	:	1400 guard gate valve and 1400 hollowjet valve
Energy dissipator	:	3.5 m wide × 5.5 m depth × 39.4 m length

4.4 Beroeng Diversion Tunnel

- Diversion tunnel

  In-diameter & length : 1.50 m dia and 280 m length

  Invert ele. at inlet portal :El.37.10 m (No slope)

- Intake weir

Crest ele. of non-overflow section	:	El.44.10 m in 53.5 m wide
Crest ele. of overflow section	:	El.40.10 m in 20 m wide
Crest length and weir height	:	length with 2 m width and 12 m high
Weir type	:	Concrete gravity with vertical in U/S and 1:1.0 in D/S

- Outlet facility

Irrigation and maintenance flow	:	800 × 800 guard gate, 800 steel conduit and 800 howell-bunger
Flushing against sediment	:	2000 × 2000 guard gate, 2000 steel conduit and 2000 × 2000 outlet gate

4.5 Water Conveyance Facilities

	Description	Existing	Additional Facility for the Project		
			K-1	K-2	C-3
1)	Intake and sand trap basin *	2 units x 77.6mL x 6.5mWx 1.8mH	1 unit x 77.6mL x 6.5mW x 1.8mH	1 unit x 77.6mL x 6.5mW x 1.8mH	1 unit x 77.6mL x 6.5mW x 1.8mH
2)	Cidanau pump station *	4 units x 1000kW	2 units x 550kW	2 units x 580kW	2 units x 740kW
3)	Booster pump station *	-	4 units x 1150kW	4 units x 1200kW	4 units x 1500kW
4)	Krenceng pump station **	5 units x 110kW	4 units x 310kW	4 units x 320kW	4 units x 350kW
5)	Surge tank ***	1 unit	2 unit	2 unit	2 unit
6)	Water treatment plant *	3 units x $0.7m^3/sec$	3 units x $0.5m^3/sec$	3 units x $0.5m^3/sec$	4 units x $0.5m^3/sec$

Note: * added facilities
** replaced facilities
*** including added and replaced ficilities

5. CONSTRUCTION PLAN AND COST ESTIMATE

(1) Implementation Schedule

Owing to the following conditions, the construction work of the Project will take 7 years including the detailed design and tendering and the earliest possible date of the Project operation will be the year 2000.

Detailed design and preparation of tender documents	1993-1994
Tendering & contracting and land acquisition	1995
Main construction works	1996-1999

(2) Cost Estimate

The unit construction cost is estimated by foreign and local currency portion at the end of 1991 constant price level. The exchange rate of currency is US$1.0 = Rp1965.6 = ¥ 126.

6. PROJECT EVALUATION

6.1 General

(1) Project Cost

The financial and economic cost are summarized as below.

Scheme	Financial cost 1]		Economic cost	
	F/C (10^6Y)	L/C (10^6Rp)	F/C (10^6Y)	L/C (10^6Rp)
K-1	5625	39763	5222	33454
K-2	5855	41407	5439	34962
C-3	9768	56448	9173	48706

Note: 1] excluded interest during construction and additional distribution pipelines.

The annual O&M costs for dam and appurtenant structures are 0.5% of the direct cost. The annual O&M costs for water transmission and treatment facilities are taken at 1% but the O&M costs for the existing facilities are excluded.

The annual pumping cost is estimated by multiplying the power tariff, 84 Rp/kwh and incremental power consumption, kwh which means due to the difference between "with Project" and "without Project".

The original investment for water transmission and treatment facilities is assumed to be incurred for replacement after the life of 25 years but the replacement cost for the existing facilities is excluded.

(2) Project benefit

Economic benefits of the water supply project is theoretically estimated by means of the willingness-to-pay of the enterprises and residents. However, water tariff corresponding to willingness-to-pay is quite difficult to assess, therefore, the actual expenses disbursed by the suppliers is applied instead of willingness-to-pay.

The water tariff for the industrial water in the study area lies in the range of Rp 700 to Rp 9000 /m^3. Among several suppliers, the PDAM water tariff is the lowest one. In this study, the willingness-to-pay for the industrial water is evaluated by the most conservative water charge, PDAM water tariff. The water charge as the economic benefit

for the industrial water is decided at 2100 Rp/m^3 which rate is for daily water consumption of more than 30 m^3/day. The water charge for the domestic water is conservatively decided at 200 Rp/m^3 which is the PDAM's water tariff for daily consumption of 15 m^3/day and also within 3 % of household income.

The project benefit is obtained by multiplying the water tariff and incremental net supply volume which means the difference between net supply yield "with Project" and "without Project" considering the loss of leakage of water supply facilities including the distribution pipelines.

The incremental net annual water supply volume is calculated by three conditions, 95 %, 75 % and 60 % effective.

From the water demand projection, the water use ratio between domestic, and industrial water is determined by 25% and 75% of annual supply volume, respectively.

6.2 Economic Analysis

The results of the economic evaluation are summarized as below.

Economic Analysis (Unit : 10^6 Rp)

	Scheme								
	K-1			K-2			C-3		
	Effective Supply Volume (%)			Effective Supply Volume (%)			Effective Supply Volume (%)		
	95	75	60	95	75	60	95	75	60
1)	83868	83868	83868	86403	86403	86403	136891	136891	136891
2)	227359	179494	143595	239648	189196	151357	306218	241751	193401
3)	143490	95625	59727	153245	102793	64954	169327	104860	56510
4)	2.71	2.14	1.71	2.77	2.19	1.75	2.24	1.77	1.41
5)	30.92	25.51	20.95	31.23	25.82	21.26	25.11	20.65	16.92

Note :
1) Capitalized cost (C) *
2) Capitalized benefit (B) *
3) Net benefit value (B-C)
4) Benefit cost ratio (B/C)
5) Internal rate of return (IRR)%
* Capitalized by discount rate of 12 %

From the above results, even by applying the most conservative condition of 60 % incremental annual net water supply volume, EIRR of three schemes is higher than 12 % which is considered as the opportunity cost of capital in Indonesia.

6.3 Financial Analysis

(1) Calculation of FIRR

Financial Analysis (Unit : 10^6 Rp)

	Scheme								
	K-1			K-2			C-3		
	Effective Supply Volume (%)			Effective Supply Volume (%)			Effective Supply Volume (%)		
	95	75	60	95	75	60	95	75	60
1)	92524	92524	92524	95291	95291	95291	148845	148845	148845
2)	227359	179494	143595	239648	189196	151357	306218	241751	193401
3)	134835	86970	51071	144358	93906	56066	157373	92906	44556
4)	2.46	1.94	1.55	2.51	1.99	1.59	2.06	1.62	1.30
5)	27.99	23.03	18.87	28.33	23.37	19.19	23.25	19.06	15.57

Note :
1) Capitalized cost (C) *
2) Capitalized benefit (B) *
3) Net benefit value (B-C)
4) Benefit cost ratio (B/C)
5) Internal rate of return (IRR)%
* Capitalized by discount rate of 12 %

(2) Loan repayability

It is observed that the accumulated surplus would become positive just after the operation starts owing to the loan conditions specified.

7. ENVIRONMENTAL ASSESSMENT

The Rawa Danau Reserve which is located in a caldera formed in the upper part of the Cidanau river basin has been authorized since 1921.

The Rawa Danau Reserve which covered 3,791 ha in 1921 has been destroyed by illegal farming. The Master Plan Study (1983) reported that the Rawa Danau Reserve is composed of freshwater swamp forest occupying 1,230 ha with a swamp of 830 ha.

In this Study,the environmental constraint in and around the swamp of Rawa Danau is stated in the Terms of Reference for feasibility study on Cidanau-Cibanten water resources development project in November 1988 that in selection of the Cidanau damsite, its full supply water level shall be settled so as not to submerge the Rawa Danau.

The environmental investigation carried out on the Cibanten river, Downstream Cidanau river, Krenceng reservoir and Beroeng river revealed that there would be no severe adverse environmental effects expected to be caused by the proposed dam development at the Krenceng, Cidanau and Beroeng rivers because of less residential houses and limited agricultural lands, except about 280 families to be resettled by the proposed heightening of Krenceng dam.

8. CONCLUSION AND RECOMMENDATIONS

From the results of the feasibility study, the following matters are concluded and recommended ;

(i) The net supply yield of the present Krakatau's water supply facilities having 2.0 m^3/sec will be limited to 1.94 m^3/sec, while the present water supply is remaining at about 0.8 m^3/sec.

The water source in and around Cilegon area is dominated by the Krakatau's water supply facilities which occupy about 75 %.

The Krakatau Steel and its surrounding industrial estate are growing and changing rapidly. The water demand in 2005 year in and around Cilegon area excluding Serang is estimated to 3.7 m^3/sec.

(ii) The water charge of suppliers for industrial use ranges from 500 to 9000 Rp/m^3. Krakatau's water charge is 500 Rp/m^3, desalination plants are 3000 to 5000 Rp/m^3, and other private suppliers are 2750 to 9000 Rp/m^3.

On the other hand, domestic water and industrial water by PDAM are 175 to 525 Rp/m^3 and 700 to 2100 Rp/m^3, respectively.

(iii) From the results of project evaluation, it was found out that the Scheme K-1 and K-2 are more feasible than C-3.

By fixing the water charge for domestic use at 200 Rp/m^3 and industrial use at 2100 Rp/m^3, the incremental annual net water supply volume at 95 % and water use ratio between domestic and industrial use at 25 % vs. 75 %, the EIRR of scheme K-1 and K-2 comes to 30.92 % and 31.23 %, respectively.

Even by applying the most conservative condition of 60 % incremental annual net water supply volume, the EIRR of scheme K-1 and K-2 still shows 20.95 % and 21.26 %, respectively.

The EIRR for both schemes K-1 and K-2 are considered much high as for a water supply project. Both schemes are justfied to be sufficiently economical.

(iv) However, in the scheme K-2, the diversion of river flow of Beroeng river to Krenceng reservoir might cause various social effect to the downstream Beroeng such as effect to existing water rights, although the irrigation water during the wet season and river maintenance flow during the dry season in its downstream are guaranteed.

From a conservative point of view, the scheme K-1 could be most recommendable within the alternatives.

The K-1 Scheme can supply 3.05 m^3/s in total including the existing water supply capacity of 1.94 m^3/s.

The total project cost is estimated at about 127.5 billion Rupiah (equivalent to 8.2 billion Yen). The total cost covers the construction cost including purification plant and compensation cost for lands and housings but excluding the additional distribution pipelines.

(v) The purpose of this study is to meet with the rapid increase of water demand in the study area aiming for an urgent implementation of the project.

In view of the necessity of the urgent water supply, the K-1 Scheme has been proposed to be implemented as soon as possible.

By the proposed K-1 Scheme above, the maximum water supply will be 3.05 m^3/s. However, as the water demand in the year 2,005 is forecasted at 3.7 m^3/s, the K-1 Scheme cannot fulfill the water demand sufficiently.

It is therefore herewith recommended to implement further studies and construction of the water resources development schemes such as Karian dam, Pasir Kopo dam and Rawa Danau storage dam as other possible scheme besides this Study urgently so as to cope with the water deficit above, and also to cope with the further water demand of the Cilegon industrial estate and its surroundings after the year 2005.

Principal Features for Project

(1) Heightening of Krenceng Dam

1) Reservoir

Catchment area	km^2	1.83
Gross capacity	10^6m^3	14.07
Effective capacity	10^6m^3	12.87
High water level	EL-m	29.00
Low water level	EL-m	18.50
Annual rainfall	mm/yr	2250
Mean runoff	m^3/sec	0.43
Design peak flood	m^3/sec	
25 yrs		128
1.2 × 200 yrs		225
PMF		519

2) Dam

Type		Impervious random fill
Crest elevation	EL-m	32.00
Height	m	24.0
Crest length	m	2911
Embankment volume	10^6m^3	1.27
Slope in U/S		1:3.0
D/S		1:2.5

3) Spillway

Type		Gated overflow
Crest elevation of weir	EL-m	25.00
Net width of weir	m	15.5
Chuteway		
Slope		1:2.5
Length	m	46.128
Width	m	18

Dissipator		
Type		Hydraulic jump
Length	m	31.50
Width	m	18
Ele. of bottom	EL-m	7.00
Gates		
Type		Roller gate
dimension		2 Nos. × 7.75 width × 4.3 height

(2) Water Conveyance and Treatment Facilities

1)	Intake and Sand Trap Basin*	1 unit × 77.6 m length × 6.5 m width × 1.8 m depth
2)	Cidanau Pump Station*	2 units × 550 kw
3)	Booster Pump Station*	4 units × 1150 kw
4)	Krenceng Pump Station**	4 units × 310 kw
5)	Surge Tank***	2 units
6)	Water Treatment Plant*	3 units × 0.5 m^3/sec

Notes: * added facilities
** replaced facilities
*** including added and replaced facilities

TABLES

Table 1 Members of DGWRD, Counterpart, Advisory Committee, JICA and Study Team

	Name	Organization	Position
(1)	Members of DGWRD		
	Ir. Djoko S Sardjono	DGWRD	Director of Planning Directorate
	Ir. Moh. Sidharto	DGWRD	Chief, Sub. Dit. of River Basin Development
	Ir. Budi Santoso/ Ir. Bambang Pramono	DGWRD	Chief of Section II, Sub. Dit. of River Basin
	Drs. Ch. Nasri	DGWRD	Sub. Dit. Kerjasama Lintas Sektoral Dit. Bina Program-Pengairan
	Ir. Soenarto Soendjaja	DGWRD	Kepala Sub Directorat Evaluasi Proyek
	M. Yusuf Kardi M. Sc.	CJCB	Project Manager of P3SA
(2)	Members of Counterpart		
	Ir. Djodi Sukardjo Sugondo, M.Sc	CJCB	Team Leader
	Hary Witanto, Be	CJCB	Dam Planner
	Ir. Agni Handoyoputro, Dipl. HE	CJCB	Hydrologist
	Baihaki Umar, B.Sc	CJCB	Geologist
	Ir. Suprayitno	CJCB	Survey Engineer
	Poniman S.BE	CJCB	Design Engineer
	Yadi Siswadi, M. Sc/Hernawanto, SE	CJCB	Construction Planner
	Anwar Santosa R.BE	CJCB	Environmentalist
	Nugroho P.B.Sc	CJCB	Economist
(3)	Member of Advisory Committee		
	1) Shigeki Matsuura/ Ryohei Kitazume	Ministry of Construction	Chairman
	2) Hitoshi Yoshida	"	Member
	3) Takashi Ikeda	"	Member
(4)	Coordinator of JICA		
	1) Masahiro Kobayashi/Mitsuru Suemori		JICA (Tokyo)
	2) Eiichiro Cho		JICA (Tokyo)
	3) H. Takata/Hagiwara		JICA (Indonesia)
(5)	Members of Study Team		
	1) Tetsuro Okaji		Team Leader
	2) Kazuo Tsuzuki		Dam Planner
	3) Tomeo Ohta/Yasukazu Kobayashi		Hydrologist
	4) Masahiro Hayashi		Geologist
	5) Katsuyuki Aoyagi		Survey Expert
	6) Makoto Ikushima		Design Engineer
	7) Eiichiro Seki		Construction Planner
	8) Takashi Yamazaki		Environmentalist
	9) Masatoshi Akagawa		Project Economist

Table 2 Five (5)-day Mean Inflow Discharge at Cidanau Weir

(Unit: m3/sec)

Year	Period (day)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1980	1st - 5th	9.02	7.63	10.49	5.16	1.9	8.89	3.78	5.07	6.12	1.98	21.75	64.63	12.20
	6th - 10th	9.22	11.72	7.95	4.09	0.42	10.17	6.52	10.38	62.58	1.47	25.6	73.43	18.63
	11th - 15th	9.38	11.6	32.45	15.05	2.04	4.36	6.51	15.84	66.5	5.88	31.05	75.87	23.04
	16th - 20th	9.07	11.72	22.15	11.21	4.42	7.34	10.99	29.73	28.67	14.2	35.87	97.76	23.59
	21st - 25th	9.02	11.78	5.29	7.57	12.4	8.74	6.11	12.25	5.73	15.9	42.38	68.39	17.13
	26th - 31st	6.86	14.65	3.35	4.61	9.63	5.49	5.29	4.09	3.78	19.05	49.61	91.21	18.14
1981	1st - 5th	143.78	42.67	28.32	28.78	14.89	6.52	9.97	18.6	5.04	96.83	10.68	29.59	36.31
	6th - 10th	167.61	49.8	4.05	28.48	10.24	8.54	2.94	7.15	15.09	33.15	9.34	26.9	30.27
	11th - 15th	66.59	32.67	5.24	26.98	6.84	11.8	6.44	5.13	16.4	11.46	56.21	19.97	22.14
	16th - 20th	70.21	24.47	8.51	23.48	10.07	22	12.86	3.65	3.8	8.17	157.94	7.96	29.43
	21st - 25th	32.2	4.33	5.41	20.12	7.49	9.99	17.02	8.72	2.63	4.25	60.02	13.4	15.46
	26th - 31st	33.02	43.04	22.74	18.03	2.12	9.78	22.06	10.29	22.8	20.99	21.64	72.94	24.95
1982	1st - 5th	49.48	6.42	21.14	24.15	12.58	5.62	3.25	3.88	1.95	2.92	1.13	3.15	11.31
	6th - 10th	26.97	2.63	73.45	24.62	8.29	8.78	2.95	2.95	1.33	1.29	12.36	0.98	13.88
	11th - 15th	10.12	4	29.24	16.71	7.78	5.92	2.88	1.89	1.23	0.84	3.98	5.15	7.48
	16th - 20th	41.99	3.63	39.29	40.02	4.48	5.88	4.14	1.61	1.05	2.22	1.8	6.45	12.71
	21st - 25th	36.65	7.71	56.8	12.54	3.94	4.37	5.11	1.31	2.22	2.17	6.13	6.78	12.14
	26th - 31st	7.07	10.93	15.69	17.23	4.46	3	9.21	1.03	2.48	1.22	5.88	16.55	7.90
1983	1st - 5th	15.68	18.28	12.53	11.42	4.78	9.32	18.42	3.31	1.14	0.87	16.39	44.79	13.08
	6th - 10th	16.16	21.76	6.29	10.11	4.7	7.94	11.4	1.57	1.76	0.67	13.21	23.81	9.95
	11th - 15th	14.29	6	5.37	8.8	14.13	6.23	5.87	2.78	1.96	0.75	17.05	10.13	7.78
	16th - 20th	25.58	6.53	4.6	10.47	7.12	9.07	7.77	3.44	1.63	0.85	90.38	10.25	14.81
	21st - 25th	46.39	7.22	4.57	8.87	9.33	11.23	5.69	9.1	1.63	5.81	1.49	8.64	10.00
	26th - 31st	26.34	9.6	6.81	10.93	6	11.91	6.5	2.04	1.25	12.64	50.62	13.61	13.19
1984	1st - 5th	13.13	17.21	13.6	27.51	13.54	14.43	5.3	5.79	3.86	24.07	3.73	46.23	15.70
	6th - 10th	3.19	28.98	24.73	6.62	24.73	8.04	11.33	4.46	11.56	10.2	6.39	44.47	15.39
	11th - 15th	14.45	13.05	29.99	8.87	36.17	7.25	7.62	3.43	14.49	4.69	11.28	18.37	14.14
	16th - 20th	16.08	9.61	24.88	7.79	13.42	6.04	4.98	3.5	11.67	5.54	11.43	16.23	10.93
	21st - 25th	16.33	6.64	44.2	10.14	9.18	7.22	6.4	3.24	10.14	5.35	8.25	7.7	11.23
	26th - 31st	18.98	17.45	50.95	15.02	24.37	3.22	7.21	4.19	8.05	6.53	8.69	33.45	16.51
1985	1st - 5th	21.96	11.95	13.08	4.25	15.15	5.23	4.75	12.42	2.74	4.04	9.46	33.72	11.56
	6th - 10th	19.4	11.84	42.17	5.48	11.79	4.76	4.82	12.07	2.78	6.16	8.98	28.56	13.23
	11th - 15th	37.45	14.6	32.83	10.57	9.33	5.76	5.32	7.34	10.2	13.03	9.98	9.68	13.84
	16th - 20th	12.81	7.56	11.11	21.81	7.82	7.11	5.69	6.28	7.87	16.73	6.94	4.41	9.68
	21st - 25th	8.72	13.14	6.93	15.98	8.38	7.34	13.79	4.77	5.53	21.81	8.6	4.08	9.92
	26th - 31st	13.47	14.16	5.11	17.61	6.73	6.71	15.19	3.51	5.15	10.44	15.24	4.25	9.80
1986	1st - 5th	15.11	28.46	11.96	24.45	12.69	5.92	2.81	6.07	1.89	7.88	21.24	11.94	12.54
	6th - 10th	48.59	18.48	10.04	24.03	9.79	5.53	3.19	7.26	3.09	5.27	32.92	4.67	14.41
	11th - 15th	51.29	24.43	8.07	18.98	9.8	5.06	4.65	8.59	5.97	8.81	53.45	14.23	17.78
	16th - 20th	26.19	20.85	6.83	17.98	9.4	5.17	3.21	5.66	6.65	9.6	23.06	22.26	13.07
	21st - 25th	53.9	17.23	29.23	11.07	5.97	5.94	2.49	2.89	6.82	6.08	9.45	11.96	13.59
	26th - 31st	51.05	13.74	53.76	8.67	5.28	3.66	4.93	2.31	9.29	15.9	12.24	7.32	15.68
1987	1st - 5th	11.51	17.83	36.37	11.65	22.55	6.91	5.4	2.92	1.22	1.16	1.54	1.95	10.08
	6th - 10th	44.13	28.18	36.32	15.09	17.38	7.01	4.13	2.14	1.13	1.13	2.66	3.34	13.55
	11th - 15th	61.24	25.46	19.54	16.16	19.87	7.63	3.32	2.36	1.13	2.81	5.79	7.32	14.39
	16th - 20th	34.2	20.36	8.49	15.64	16.83	7.59	2.46	1.82	1.13	2.15	5.31	9.12	10.43
	21st - 25th	21.03	42.99	10.47	6.91	8.75	6.91	2.56	1.53	1.13	2.53	3.29	13.2	10.11
	26th - 31st	20.56	44.32	10.85	11.22	7.99	6.1	3.17	1.28	1.13	1.55	2	7.33	9.79
1988	1st - 5th	3.34	38.29	15.24	47.82	17.99	7.23	4.65	2.39	2.01	3.32	8.32	33.61	15.35
	6th - 10th	1.79	48.05	24.94	23.5	19.95	13.23	3.18	4.39	2.65	2.67	10.41	21.84	14.72
	11th - 15th	1.96	34.22	15.25	16.91	15.6	14.51	2.11	3.48	3.47	2.61	13.72	31.22	12.92
	16th - 20th	4.87	50.13	14.61	16.79	21.4	12.64	2.49	3.21	3.06	4.65	12.61	58.7	17.10
	21st - 25th	7.52	25.29	16.7	19.45	17.94	10.34	2.14	3.43	3	5.25	18.37	28.63	13.17
	26th - 31st	15.99	7.87	22.49	14.13	8.59	7.25	2.22	2.23	2.89	4.98	31.08	14.3	11.17
1989	1st - 5th	10.35	9.84	57.46	7.82	7.82	7.63	3.17	2.67	3.89	3.17	3.88	5.28	10.25
	6th - 10th	7.94	36.72	39.68	7.82	7.82	9.29	6.28	1.79	2.39	2.67	3.33	6.51	11.02
	11th - 15th	6.52	24.09	21.83	7.82	7.82	9.3	10.52	2.26	4.34	2.19	5.15	9.45	9.27
	16th - 20th	8.52	74.81	18.76	7.82	7.82	6.35	12.33	1.44	5.45	1.89	4.85	10.6	13.39
	21st - 25th	9.03	30.83	10.8	7.82	7.82	3.75	8.72	1.63	3.54	2.01	5.35	9.9	8.43
	26th - 31st	7.36	82.69	7.54	7.82	7.82	3.24	4.44	2.46	1.93	4.69	4.05	10.03	12.01
Mean		26.71	21.70	20.64	15.14	10.76	7.74	6.51	5.22	7.20	8.32	19.09	23.30	14.36

Table 3 Five (5)-day Mean Inflow Discharge at Krenceng Dam

(Unit: m3/sec)

Year	Period (day)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Main
1980	1st - 5th	0.27	0.43	0.34	0.14	0.25	0.26	0.09	0.27	0.53	0.25	0.41	0.11	0.28
	6th - 10th	0.46	1.11	0.53	0.15	0.22	0.13	0.09	0.43	0.46	0.28	0.23	0.15	0.35
	11th - 15th	0.68	1.14	0.36	0.66	0.25	0.17	0.1	0.66	0.74	0.28	0.29	0.12	0.45
	16th - 20th	0.67	1.8	0.38	0.23	0.24	0.11	0.12	0.87	0.26	0.19	0.73	0.41	0.50
	21st - 25th	0.67	1.07	0.16	0.39	0.17	0.14	0.11	0.12	0.18	0.28	0.17	1.23	0.39
	26th - 31st	0.76	0.54	0.21	0.25	0.12	0.12	0.12	0.1	0.33	0.22	0.15	1.23	0.35
1981	1st - 5th	3.96	0.92	1.52	0.32	0.49	0.15	0.14	0.38	0.42	0.77	0.32	0.71	0.84
	6th - 10th	2.72	0.81	0.77	0.37	0.38	0.13	0.13	0.4	0.39	0.77	0.64	0.46	0.66
	11th - 15th	1.65	1.19	1.18	0.22	0.48	0.28	0.49	0.24	1.09	0.59	0.97	0.39	0.73
	16th - 20th	0.96	1.19	0.74	0.31	0.67	0.47	0.74	0.34	0.26	0.25	2.28	0.39	0.72
	21st - 25th	0.68	1.07	0.39	0.32	0.25	0.21	0.82	0.34	0.23	0.28	0.4	0.78	0.48
	26th - 31st	0.95	2.88	0.6	0.24	0.19	0.27	1.29	0.23	0.36	0.42	1.07	1.49	0.83
1982	1st - 5th	0.9	1.1	0.68	0.64	0.55	0.57	0.19	0.25	0.11	0.15	0.09	0.1	0.44
	6th - 10th	2.07	0.52	0.86	0.52	0.49	0.43	0.15	0.19	0.11	0.1	0.15	0.09	0.47
	11th - 15th	3.25	0.67	1.4	0.49	0.38	0.31	0.15	0.09	0.1	0.1	0.14	0.1	0.60
	16th - 20th	2.09	0.51	1.36	0.8	0.26	0.26	0.38	0.07	0.1	0.23	0.14	0.1	0.53
	21st - 25th	1.49	0.41	1.02	0.53	0.26	0.17	0.4	0.05	0.09	0.11	0.14	0.11	0.40
	26th - 31st	1.06	0.5	0.8	0.76	0.32	0.26	0.39	0.04	0.12	0.1	0.13	0.24	0.39
1983	1st - 5th	0.43	0.5	1	0.43	0.58	0.34	0.36	0.05	0.01	0.01	0.09	0.86	0.39
	6th - 10th	0.25	0.51	0.45	0.68	1.07	2.24	0.05	0.04	0.02	0	0.18	0.83	0.53
	11th - 15th	0.18	0.13	0.36	0.14	0.66	0.84	0.04	0.03	0.02	0	0.02	0.27	0.22
	16th - 20th	0.28	0.32	0.15	0.31	0.65	0.5	0.11	0.03	0.03	0.01	1.08	0.18	0.30
	21st - 25th	0.75	0.19	0.16	1.37	0.41	0.28	0.1	0.06	0.02	0.09	3.17	0.13	0.56
	26th - 31st	0.11	1.02	0.6	1.04	0.53	0.62	0.12	0.02	0.01	0.09	9.05	0.15	1.11
1984	1st - 5th	0.28	1.06	0.87	0.41	1.16	0.46	0.56	0.2	0.26	1.1	0.34	0.24	0.58
	6th - 10th	0.54	0.79	2.34	0.56	0.98	0.38	0.39	0.16	0.9	0.31	0.19	0.2	0.65
	11th - 15th	0.19	0.92	3.27	0.37	0.52	0.5	0.21	0.36	0.93	0.52	0.19	0.34	0.69
	16th - 20th	0.3	1.84	2.14	0.56	0.35	0.48	0.19	0.22	0.63	0.42	0.43	0.27	0.65
	21st - 25th	2.07	1.67	4.11	0.42	0.55	0.32	0.38	0.2	0.42	0.5	0.33	0.23	0.93
	26th - 31st	3.25	1.33	3.9	1.06	0.43	0.23	0.34	0.36	0.97	0.26	0.18	0.75	1.09
1985	1st - 5th	0.26	0.23	0.39	0.25	0.24	0.14	0.16	0.58	0.09	0.27	0.19	0.7	0.29
	6th - 10th	0.94	0.2	0.88	0.35	0.18	0.19	0.32	0.22	0.19	0.24	0.34	0.28	0.36
	11th - 15th	0.27	0.17	0.33	0.57	0.2	0.12	0.39	0.14	0.13	0.16	0.14	0.11	0.23
	16th - 20th	0.2	0.11	0.35	1.33	0.14	0.13	0.4	0.14	0.11	0.78	0.1	0.18	0.33
	21st - 25th	0.28	0.42	0.18	0.41	0.12	0.49	0.62	0.11	0.1	0.16	0.14	0.28	0.28
	26th - 31st	0.45	0.11	0.29	0.42	0.18	0.13	0.21	0.13	0.22	0.15	0.24	0.22	0.23
1986	1st - 5th	0.18	0.78	0.61	0.68	0.24	0.14	0.22	0.11	0.14	0.41	0.24	0.14	0.32
	6th - 10th	1.94	0.64	0.37	0.49	0.36	0.25	0.21	0.12	0.33	0.29	0.46	0.11	0.46
	11th - 15th	0.68	1.11	0.55	0.64	0.39	0.51	0.7	0.36	0.32	0.16	0.39	0.51	0.53
	16th - 20th	0.99	0.39	0.44	0.38	0.19	0.21	0.34	0.16	0.17	0.15	0.37	0.65	0.39
	21st - 25th	2.78	0.53	0.41	0.3	0.25	0.12	0.19	0.11	0.12	0.1	0.24	0.15	0.44
	26th - 31st	1.76	0.58	0.29	0.49	0.2	0.14	0.27	0.15	0.14	0.58	0.43	0.22	0.44
1987	1st - 5th	0.37	0.32	0.58	0.29	0.46	0.2	0.14	0.1	0.09	0.09	0.1	0.1	0.24
	6th - 10th	1.42	0.87	0.33	0.23	0.61	0.23	0.12	0.09	0.09	0.09	0.24	0.11	0.37
	11th - 15th	1.13	0.35	0.25	0.24	0.43	0.31	0.1	0.09	0.09	0.09	0.13	0.16	0.28
	16th - 20th	0.41	0.46	0.22	0.23	0.34	0.18	0.1	0.09	0.11	0.09	0.09	0.66	0.25
	21st - 25th	0.53	0.3	0.29	0.21	0.17	0.18	0.1	0.09	0.09	0.09	0.09	0.14	0.19
	26th - 31st	0.57	1.78	0.31	0.72	0.17	0.15	0.1	0.09	0.09	0.09	0.09	0.09	0.35
1988	1st - 5th	0.09	2.92	0.19	0.37	0.13	0.18	0.19	0.11	0.09	0.09	0.64	0.12	0.43
	6th - 10th	0.17	2.02	0.16	0.22	0.11	0.12	0.13	0.12	0.09	0.09	0.21	0.12	0.30
	11th - 15th	0.17	0.37	0.15	0.17	0.13	0.11	0.08	0.14	0.09	0.51	0.16	0.88	0.25
	16th - 20th	0.27	0.18	0.15	0.16	0.16	0.09	0.1	0.12	0.09	0.32	0.11	0.21	0.16
	21st - 25th	0.19	0.16	0.19	0.19	0.13	0.09	0.08	0.11	0.09	0.15	0.12	0.09	0.13
	26th - 31st	0.77	0.16	0.17	0.14	0.1	0.09	0.09	0.1	0.09	0.36	0.11	0.09	0.19
1989	1st - 5th	0.09	0.5	0.8	0.08	0.05	0.04	0.13	0.14	0.12	0.09	0.09	0.09	0.19
	6th - 10th	0.1	0.5	0.69	0.1	0.04	0.16	0.13	0.18	0.16	0.09	0.09	0.17	0.20
	11th - 15th	0.13	0.21	0.51	0.1	0.02	0.21	0.14	0.14	0.12	0.09	0.09	1.14	0.24
	16th - 20th	0.14	0.62	0.24	0.04	0.03	0.18	0.13	0.14	0.09	0.09	0.1	0.38	0.18
	21st - 25th	0.27	1.75	0.08	0.03	0.04	0.18	0.12	0.13	0.09	0.09	0.09	0.17	0.25
	26th - 31st	0.16	1.49	0.1	0.03	0.04	0.18	0.15	0.29	0.09	0.09	0.09	0.47	0.27
Mean		0.86	0.81	0.72	0.41	0.33	0.28	0.25	0.19	0.23	0.25	0.50	0.36	0.43

Table 4 Five (5)-day Mean Inflow Discharge at Beroeng Inatke Weir Site

(Unit: m3/sec)

Year	Period (day)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1980	1st - 5th	0.25	0.39	0.31	0.13	0.23	0.23	0.08	0.25	0.48	0.23	0.38	0.1	0.26
	6th - 10th	0.42	1.01	0.48	0.14	0.2	0.12	0.08	0.39	0.41	0.26	0.21	0.14	0.32
	11th - 15th	0.62	1.03	0.33	0.6	0.23	0.16	0.09	0.6	0.67	0.26	0.27	0.11	0.41
	16th - 20th	0.61	1.64	0.34	0.21	0.22	0.1	0.11	0.79	0.23	0.17	0.66	0.37	0.45
	21st - 25th	0.61	0.97	0.15	0.36	0.15	0.12	0.1	0.11	0.17	0.25	0.16	1.12	0.36
	26th - 31st	0.69	0.49	0.19	0.23	0.11	0.11	0.11	0.09	0.3	0.2	0.13	1.12	0.31
1981	1st - 5th	3.61	0.84	1.38	0.29	0.45	0.14	0.13	0.35	0.38	0.7	0.29	0.65	0.77
	6th - 10th	2.48	0.73	0.7	0.34	0.34	0.12	0.12	0.36	0.36	0.7	0.58	0.41	0.60
	11th - 15th	1.5	1.09	1.07	0.2	0.44	0.26	0.45	0.22	0.99	0.54	0.88	0.35	0.67
	16th - 20th	0.88	1.08	0.68	0.28	0.61	0.43	0.67	0.31	0.24	0.22	2.07	0.35	0.65
	21st - 25th	0.62	0.98	0.35	0.29	0.22	0.19	0.75	0.31	0.21	0.26	0.36	0.71	0.44
	26th - 31st	0.86	2.62	0.54	0.22	0.17	0.25	1.18	0.21	0.33	0.38	0.97	1.35	0.76
1982	1st - 5th	0.82	1	0.61	0.58	0.5	0.52	0.17	0.23	0.1	0.13	0.08	0.09	0.40
	6th - 10th	1.88	0.47	0.78	0.48	0.45	0.39	0.14	0.17	0.1	0.09	0.13	0.08	0.43
	11th - 15th	2.96	0.61	1.28	0.45	0.34	0.28	0.14	0.08	0.09	0.09	0.13	0.09	0.55
	16th - 20th	1.9	0.47	1.24	0.73	0.24	0.24	0.35	0.06	0.09	0.21	0.13	0.09	0.48
	21st - 25th	1.35	0.37	0.93	0.48	0.24	0.16	0.36	0.05	0.08	0.1	0.12	0.1	0.36
	26th - 31st	0.97	0.45	0.73	0.69	0.29	0.24	0.35	0.03	0.11	0.09	0.12	0.22	0.36
1983	1st - 5th	0.39	0.46	0.91	0.39	0.53	0.31	0.32	0.04	0.01	0.01	0.09	0.78	0.35
	6th - 10th	0.23	0.46	0.41	0.62	0.97	2.04	0.05	0.03	0.02	0	0.17	0.75	0.48
	11th - 15th	0.17	0.12	0.33	0.13	0.6	0.76	0.04	0.03	0.02	0	0.02	0.25	0.21
	16th - 20th	0.25	0.29	0.13	0.29	0.59	0.45	0.1	0.03	0.02	0.01	0.98	0.17	0.28
	21st - 25th	0.68	0.17	0.14	1.24	0.37	0.26	0.09	0.06	0.02	0.08	2.89	0.12	0.51
	26th - 31st	0.1	0.93	0.55	0.94	0.48	0.56	0.11	0.02	0.01	0.08	8.23	0.13	1.01
1984	1st - 5th	0.26	0.96	0.79	0.37	1.06	0.42	0.51	0.18	0.24	1	0.31	0.22	0.53
	6th - 10th	0.49	0.72	2.13	0.51	0.89	0.35	0.35	0.15	0.82	0.28	0.17	0.18	0.59
	11th - 15th	0.18	0.84	2.98	0.34	0.47	0.45	0.19	0.32	0.85	0.47	0.18	0.31	0.63
	16th - 20th	0.27	1.68	1.94	0.51	0.32	0.44	0.18	0.2	0.57	0.38	0.4	0.25	0.60
	21st - 25th	1.89	1.52	3.74	0.39	0.5	0.29	0.34	0.18	0.39	0.45	0.3	0.21	0.85
	26th - 31st	2.96	1.21	3.55	0.96	0.39	0.21	0.31	0.33	0.88	0.24	0.16	0.68	0.99
1985	1st - 5th	0.24	0.21	0.36	0.23	0.22	0.13	0.15	0.53	0.09	0.24	0.17	0.63	0.27
	6th - 10th	0.86	0.18	0.8	0.32	0.16	0.17	0.29	0.2	0.18	0.22	0.31	0.26	0.33
	11th - 15th	0.24	0.16	0.3	0.52	0.18	0.11	0.36	0.13	0.12	0.15	0.13	0.1	0.21
	16th - 20th	0.18	0.1	0.32	1.21	0.13	0.12	0.36	0.13	0.1	0.71	0.09	0.16	0.30
	21st - 25th	0.26	0.38	0.17	0.37	0.11	0.44	0.56	0.1	0.09	0.15	0.13	0.25	0.25
	26th - 31st	0.41	0.1	0.26	0.38	0.16	0.12	0.19	0.11	0.2	0.14	0.21	0.2	0.21
1986	1st - 5th	0.16	0.71	0.55	0.62	0.21	0.13	0.2	0.1	0.13	0.38	0.22	0.12	0.29
	6th - 10th	1.77	0.58	0.34	0.44	0.33	0.23	0.19	0.11	0.3	0.27	0.42	0.1	0.42
	11th - 15th	0.62	1.01	0.5	0.58	0.35	0.46	0.64	0.32	0.29	0.14	0.35	0.47	0.48
	16th - 20th	0.9	0.35	0.4	0.35	0.17	0.19	0.31	0.14	0.15	0.13	0.52	0.6	0.35
	21st - 25th	2.53	0.48	0.37	0.27	0.23	0.11	0.17	0.1	0.11	0.09	0.22	0.13	0.40
	26th - 31st	1.6	0.53	0.27	0.44	0.18	0.12	0.25	0.14	0.13	0.53	0.39	0.2	0.40
1987	1st - 5th	0.34	0.29	0.53	0.26	0.41	0.18	0.13	0.09	0.08	0.08	0.09	0.09	0.21
	6th - 10th	1.29	0.79	0.3	0.21	0.55	0.21	0.1	0.08	0.08	0.08	0.22	0.1	0.33
	11th - 15th	1.03	0.32	0.23	0.22	0.39	0.28	0.09	0.08	0.08	0.08	0.12	0.14	0.26
	16th - 20th	0.37	0.42	0.2	0.21	0.31	0.16	0.09	0.08	0.1	0.08	0.08	0.6	0.23
	21st - 25th	0.48	0.27	0.27	0.19	0.16	0.17	0.09	0.08	0.08	0.08	0.08	0.13	0.17
	26th - 31st	0.51	1.62	0.28	0.66	0.16	0.14	0.09	0.08	0.08	0.08	0.08	0.08	0.32
1988	1st - 5th	0.08	2.66	0.17	0.34	0.12	0.16	0.17	0.1	0.09	0.08	0.58	0.11	0.39
	6th - 10th	0.15	1.84	0.15	0.2	0.1	0.11	0.12	0.11	0.08	0.08	0.19	0.11	0.27
	11th - 15th	0.15	0.33	0.14	0.15	0.12	0.1	0.07	0.13	0.08	0.46	0.14	0.8	0.22
	16th - 20th	0.24	0.16	0.13	0.15	0.14	0.08	0.09	0.11	0.08	0.29	0.1	0.19	0.15
	21st - 25th	0.17	0.15	0.17	0.18	0.12	0.08	0.07	0.1	0.08	0.14	0.11	0.08	0.12
	26th - 31st	0.7	0.14	0.16	0.13	0.1	0.08	0.08	0.09	0.08	0.32	0.1	0.08	0.17
1989	1st - 5th	0.08	0.46	0.73	0.08	0.04	0.04	0.12	0.13	0.11	0.08	0.08	0.08	0.17
	6th - 10th	0.09	0.46	0.63	0.1	0.03	0.15	0.12	0.17	0.15	0.08	0.08	0.08	0.18
	11th - 15th	0.12	0.19	0.47	0.09	0.02	0.19	0.13	0.13	0.11	0.08	0.08	0.08	0.14
	16th - 20th	0.13	0.56	0.21	0.03	0.03	0.16	0.12	0.13	0.08	0.08	0.09	0.09	0.14
	21st - 25th	0.25	1.59	0.08	0.03	0.04	0.17	0.11	0.11	0.08	0.08	0.08	0.08	0.23
	26th - 31st	0.14	1.35	0.09	0.02	0.04	0.16	0.14	0.26	0.08	0.08	0.08	0.08	0.21
Mean		0.78	0.73	0.65	0.37	0.30	0.26	0.23	0.17	0.21	0.22	0.45	0.30	0.39

Table 5 Principal Features for Alternative Single Development Schemes

		A-1 Cibanten Dam	A-3 Down-stream Cidanau Dam	A-6 Cidanau Gated Weir	K-1 Heightening of Krenceng Dam without Diversion	K-2 Heightening of Krenceng Dam with One Diversion	K-3 Heightening of Krenceng Dam with Two Diversions
Reservoir							
Name of river		Cibanten	Cidanau	Cidanau	Krenceng	Krenceng	Krenceng
Catchment area	km^2	73.15	208.25	214.95	13.3	13.3	13.3
Reservoir surface area	km^2	2.1	0.6	0.41	1.8	1.8	1.8
Gross capacity	10^6m^3	21.5	7.11	3.44	14.1	14.1	14.1
Effective capacity	10^6m^3	14.9	2.95	3.44	12.9	12.9	12.9
Development yield	m^3/s	0.45	1.825	1.97	3.10	3.15	3.20
High water level	EL-m	115.0	50.0	21.2	29.0	29.0	29.0
Low water level	EL-m	104.5	44.0	0	18.0	18.0	18.0
Annual rainfall	mm/yr	2,250	3,000	3,000	2,250	2,250	2,250
Mean runoff	m^3/sec	2.0	13.63	14.36	0.43	0.43	0.43
Design peak flood	m^3/sec						
25 yrs		814	346	346	128	128	128
100 yrs		1,033	444	444	171	171	171
1.2 x 200 yrs		1,324	535	535	225	225	225
Dam and Rated Facility							
Diversion Work							
River diversion		Tunnel scheme	Tunnel scheme	Multi-stage diversion	Multi-stage diversion	Multi-stage diversion	Multi-stage diversion
Diversion tunnel, L	m	410	400	-	-	-	-
D	m	5	5	-	-	-	-
Diversion gate	Nos.	1	1	-	-	-	-
Dam		Main dam / Saddle dam					
Type		Rock-fill / Rando m-fill	Rockfill	Gravity	Impervious random-fill	Impervious random-fill	Impervious random-fill
Crest elevation	EL-m	120 / 120	55	24.2	32	32	32
Height (from river bed)	m	45 / 34	35	24.2	16	16	16
Crest length	m	340 / 275	255	299	2,800	2,800	2,800
Embankment/Conc.volume	10^3m^3	947 / 168	474	43	1,281	1,281	1,281
Spillway							
Type		Side overflow	Side overflow	Roller gate	Roller gate	Roller gate	Roller gate
Crest elevation of weir	EL-m	115	50	1.5	24	24	24
Width of weir	m	150	120	61	20	20	20
Gate (wide x height x Nos.)		-	-	17x20x3	8.75x5.5x2	8.75x5.5x2	8.75x5.5x2
Outlet Works							
Intake type		Vertical	Vertical	Horizontal	-	-	-
Steel conduit, L	m	230	285	200	-	-	-
Guard valve	Nos.	1	1	1	-	-	-
Hollow jet valve	Nos.	1	1	1	-	-	-
Diversion Tunnel							
Name of river		-	-	-	-	Beroeng	Beroeng / Anyer
Catchment area at weir	km^2	-	-	-	-	12.1	12.1 / 17.5
Mean runoff	m^3/sec	-	-	-	-	0.39	0.39 / 0.59
Maximum discharge capacity	m^3/sec	-	-	-	-	4.0	4.0 / 4.0
Diverted tunnel, L	m	-	-	-	-	300	300 / 700
D	m	-	-	-	-	1.5	1.5 / 1.5
Water Transmission Facility							
Transmission pipeline, L	km	28.0	Existing	Existing	Existing	Existing	Existing
D	m	0.7	Existing	Existing	Existing	Existing	Existing
Krakatau pump station 2/							
Pump discharge	m^3/s	-	Existing	Existing	1.1	1.19	1.2
Pump head	m	-	Existing	Existing	67.1	67.1	67.1
Additional pump	kW	-	Existing	Existing	1150	1200	1250
Booster pump station 3/							
Pump discharge	m^3/s	-	-	-	3.1	3.15	3.20
Pump head	m	-	-	-	75	76	77
Pump capacity	kW	-	-	-	3550	3650	3750
Krenceng pump station 3/							
Pump discharge	m^3/s	0.45 3/	0.06 3/	0.205 3/	3.1	3.15	3.20
Pump head	m	12.0	12.0	12	20	20	20
Pump capacity	kW						
Connection pipeline 2/, L	m	160	160	160	160	160	160
Water treatment plant 3/	m^3/hr	1,620	220	740	3960	4140	4320

Notes: 1/ means regulated peak outflow at the outlet of Rawa Danau.
2/ Facility replaced due to development scheme
3/ Facility added due to development scheme

Table 6 Principal Features for Alternative Combined Development Schemes

Item	Unit	B-1	B-2	B-3	C-1	C-2	C-3	D-1	D-2	D-3
Scheme combined		K-1 & A-1	K-1 & A-3	K-1 & A-6	K-2 & A-1	K-2 & A-3	K-2 & A-6	K-3 & A-1	K-3 & A-3	K-3 & A-6
Development yield	m^3/sec	3.55	3.40	3.435	3.60	3.445	3.49	3.65	3.49	3.54
Reservoir and Dam Facility		Same as corresponding single development scheme								
Transmission Facility										
Transmission pipeline, L	km	28.0			28.0			28.0		
D	m	0.7 & Existing	Existing	Existing	0.7	Existing	Existing	0.7 & Existing	Existing	Existing
Krakatau pump station 1/										
pump discharge	m^3/sec	1.55	1.40	1.435	1.60	1.445	1.49	1.65	1.49	1.54
pump head	m	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1
Additional pumps	kW	1,130	1,430	1,480	1,180	1,480	1,530	1,230	1,530	1,580
Booster pump station 1/										
Pump discharge	m^3/sec	3.55	3.40	3.435	3.60	3.445	3.49	3.65	3.49	3.54
Pump head	m	65	82	84	66	83.5	85	67.5	85	86
Pump capacity	kW	3,510	4,240	4,380	3,630	4,380	4,520	3,750	4,520	4,650
Krenceng pump station 2/										
pump discharge	m^3/sec	3.55	3.40	3.435	3.60	3.445	3.49	3.65	3.49	3.54
pump head	m	20	20	20	20	20	20	20	20	20
Connection pipeline, L	m	160	160	160	160	160	160	160	160	160
Water treatment plant 1/	m^3/hr	5,580	5,040	5,170	5,760	5,200	5,370	5,950	5,370	5,500

Notes: 1/ Facility added due to development scheme
2/ Facility replaced due to heightening of Krenceng dam

Table 7 Economic Cost and Economic Evaluation for Alternative Single Development Schemes

(Unit : Million)

Description	Scheme											
	A-1		A-3		A-6		K-1		K-2		K-3	
	F/C *5	L/C *6	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C
1) Direct Const. cost	3,473	62,317	2,345	18,000	2,792	13,529	4,021	27,420	4,147	28,609	4,318	30,334
Dam and related facility	2,780	17,654	2,251	16,865	2,487	10,534	1,545	8,801	1,585	9,336	1,668	10,408
Water transmission facility	693	44,663	94	1,135	305	2,995	2,476	18,619	2,562	19,272	2,650	19,925
2) Land acquisition cost	0	210	0	12	0	28	0	3,722	0	3,722	0	3,722
3) Administration *1	0	6,253	0	1,801	0	1,356	0	3,114	0	3,233	0	3,406
4) Engineering Services *2	521	3,116	352	900	419	676	603	1,371	622	1,430	648	1,517
5) Physical contingency *3	599	10,753	405	3,105	482	2,334	694	4,786	715	4,991	745	5,288
6) Grand Total	4,593	82,649	3,101	23,818	3,692	17,924	5,318	40,413	5,484	41,985	5,710	44,266
(Rp) *4	154,300		72,199		75,520		123,375		127,542		133,348	
7) Economic cost *7	138,681		64,968		67,943		107,688		111,439		116,664	
8) Capitalized cost *8	106,165		48,612		51,116		96,189		98,398		101,167	
9) Capitalized benefit *8	97,024		19,405		50,668		243,637		254,418		265,198	
10) Net benefit	-9,141		-29,208		-448		147,449		156,019		164,031	
11) Benefit cost ratio	0.91		0.40		0.99		2.53		2.59		2.62	
12) Economic internal rate of return (EIRR)	11.16		5.22		11.92		24.02		24.22		24.26	

Note : *1 F/C 0%, LC 10% of 1) + 2)
*2 F/C 15%, L/C 5% of 1)
*3 F/C 15%, L/C 15% of 1) + 3) + 4)
*4 ¥1 = Rp.15.6
*5 F/C: Japanese Yen
*6 L/C: Rupiah
*7 Conversion factor : 0.9 / Excluded land acquisition cost
*8 Capitalized by discount rate of 12%
Excluded Land acquistion cost

Table 8 Economic Cost and Economic Evaluation for Alternative Combined Development Schemes

(Unit : Million)

Description	Scheme																	
	B-1		B-2		B-3		C-1		C-2		C-3		D-1		D-2		D-3	
	F/C *5	L/C *6	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C
1) Direct Const. cost	7,007	85,977	6,774	48,576	7,097	42,393	7,134	87,165	6,901	49,763	7,224	43,581	7,304	88,889	6,984	50,835	7,384	45,241
Dam and related facility	4,330	26,485	3,796	25,665	4,032	19,335	4,370	27,020	3,836	26,201	4,072	19,870	4,453	28,092	3,919	27,273	4,155	20,942
Water transmission facility	2,677	59,492	2,978	22,910	3,065	23,058	2,764	60,145	3,065	23,562	3,152	23,710	2,851	60,797	3,065	23,562	3,229	24,298
2) Land acquisition cost	0	5,372	0	5,174	0	5,190	0	5,362	0	5,174	0	5,190	0	5,372	0	5,174	0	5,190
3) Administration *1	0	9,135	0	5,375	0	4,758	0	9,253	0	5,494	0	4,877	0	9,426	0	5,601	0	5,043
4) Engineering Services *2	1,051	4,299	1,016	2,429	1,065	2,120	1,070	4,358	1,035	2,488	1,084	2,179	1,096	4,444	1,048	2,542	1,108	2,262
5) Physical contingency *3	1,209	14,912	1,169	8,457	1,224	7,391	1,231	15,116	1,190	8,662	1,246	7,596	1,260	15,414	1,205	8,847	1,274	7,882
6) Grand Total	9,267	119,693	8,959	70,010	9,386	61,852	9,435	121,254	9,127	71,581	9,553	63,422	9,659	123,545	9,236	72,998	9,765	65,618
(Rp) *4	264,259		209,770		208,269		268,436		213,957		212,456		274,231		217,084		217,949	
7) Economic cost *7	232,998		184,137		182,771		236,767		187,905		186,540		241,974		190,720		191,484	
8) Capitalized cost *8	192,065		156,747		153,174		194,290		156,491		155,149		197,046		157,051		157,279	
9) Capitalized benefit *8	330,235		305,286		313,873		336,925		313,873		321,535		343,026		321,535		328,184	
10) Net benefit	138,170		148,539		160,699		142,635		157,382		166,386		145,980		164,484		170,905	
11) Benefit cost ratio	1.72		1.95		2.05		1.73		2.01		2.07		1.74		2.05		2.09	
12) Economic internal rate of return (EIRR)	18.00		19.91		20.60		18.04		20.22		20.64		18.00		20.36		20.58	

Note : *1 F/C 0%, L/C 10% of 1) + 2)

*2 F/C 15%, L/C 5% of 1)

*3 F/C 15%, L/C 15% of 1) + 3) + 4)

*4 ¥1 = Rp.15.6

*5 F/C: Japanese Yen

*6 L/C: Rupiah

*7 Conversion factor : 0.9 / Excluded land acquisition cost

*8 Capitalized by discount rate of 12%

Table 9 Principal Features for Priority Development Schemes

		K-1	K-2	C-3	
		Heightening of Krenceng Dam without Diversion	Heightening of Krenceng Dam with One Diversion	Heightening of Krenceng Dam with One Diversion	Cidanau Gated Weir
Reservoir					
Name of river		Krenceng	Krenceng	Krenceng	Cidanau
Catchment area	km^2	13.3	13.3	13.3	214.95
Reservoir surface area	km^2	1.8	1.8	1.8	0.41
Gross capacity	10^6m^3	14.1	14.1	14.1	3.44
Effective capacity	10^6m^3	12.9	12.9	12.9	3.44
Development yield	m^3/s	3.05	3.11	3.11	0.325
High water level	EL-m	29.0	29.0	29.0	21.2
Low water level	EL-m	18.0	18.0	18.0	0
Annual rainfall	mm/yr	2,250	2,250	2,250	3,000
Mean runoff	m^3/sec	0.43	0.43	0.43	0.43
Design peak flood	m^3/sec				
25 yrs		128	128	128	346 1/
100 yrs		171	171	171	444 1/
1.2 x 200 yrs		225	225	225	535 1/
Dam and Rated Facility					
Diversion Work					
River diversion		Multi-stage diversion	Multi-stage diversion	Multi-stage diversion	Multi-stage diversion
Diversion tunnel, L	m	-	-	-	-
D	m	-	-	-	-
Diversion gate	Nos.	-	-	-	-
Dam					
Type		Impervious random-fill	Impervious random-fill	Impervious random-fill	Gravity
Crest elevation	EL-m	32	32	32	24.2
Height (from river bed)	m	16	16	16	24.2
Crest length	m	2,911	2,911	2,911	299
Embankment/Conc.volume	10^3m^3	1,270	1,270	1,270	43
Spillway					
Type		Roller gate	Roller gate	Roller gate	Roller gate
Crest elevation of weir	EL-m	25	25	25	1.5
Width of weir	m	18	18	18	61
Gate (wide x height x Nos.)		7.75x4.3x2	7.75x4.3x2	7.75x4.3x2	17x20x3
Outlet Works					
Intake type		-	-	-	Horizontal
Steel conduit, L	m	-	-	-	200
Guard valve	Nos.	-	-	-	1
Hollow jet valve	Nos.	-	-	-	1
Diversion Tunnel					
Name of river		-	Beroeng	Beroeng	
Catchment area at weir	km^2	-	12.1	12.1	-
Mean runoff	m^3/sec	-	0.39	0.39	-
Maximum discharge capacity	m^3/sec	-	4.0	4.0	-
Diverted tunnel, L	m	-	280	280	-
D	m	-	1.5	1.5	-
Water Transmission Facility					
Transmission pipeline, L	km	Existing	Existing	Existing	Existing
D	m	Existing	Existing	Existing	Existing
Krakatau pump station 3/					
Pump discharge	m^3/s	1.05	1.11	1.435	
Pump head	m	67.1	67.1	67.1	
Additional pumps	kW	2unitsx550	2unitsx580	2unitsx740	
Booster pump station 3/					
Pump discharge	m^3/s	3.05	3.11	3.435	
Pump head	m	73.8	75.4	84.2	
Pump capacity	kW	4unitsx1150	4unitsx1200	4unitx1500	
Krenceng pump station 2/					
Pump discharge	m^3/s	3.05	3.11	3.435	
Pump head	m	20	20	20	
Pump capacity 4/	kW	4unitsx310	4unisx320	4unitsx350	
Water treatment plant 3/	m^3/hr	5400	5400	7200	

Notes: 1/ means regulated peak outflow at the outlet of Rawa Danau.
2/ Facility replaced due to development scheme
3/ Facility added due to development scheme
4/ Included one standby.

Table 10 Financial Cost and Financial Evaluation for Priority Development Schemes

(Unit : Million)

Description	Scheme					
	K-1		K-2		C-3	
	F/C *2	L/C *3	F/C	L/C	F/C	L/C
1) Direct Const. cost	4,253	26,929	4,427	28,172	7,386	39,522
2) Land acquisition cost	0	3,722	0	3,722	0	3,750
3) Administration	0	3,065	0	3,189	0	4,327
4) Engineering Services	638	1,346	664	1,409	1,108	1,976
5) Physical contingency	734	4,701	764	4,915	1,274	6,874
6) Grand Total	5,625	39,763	5,855	41,407	9,768	56,448
(Rp) *1	127,513		132,750		208,833	
7) Capitalized cost *4	92,524		95,291		148,845	
8) Capitalized benefit *4	143,595		151,357		193,401	
9) Net benefit	51,071		56,066		44,556	
10) Benefit cost ratio	1.55		1.59		1.30	
11) Financial internal rate of return (FIRR)	18.87		19.19		15.57	

Note : *1 ¥1 = Rp.15.6
*2 F/C: Japanese Yen
*3 L/C: Rupiah
*4 Capitalized by discount rate of 12%

Table 11 Economic Cost and Economic Evaluation for Priority Development Schemes

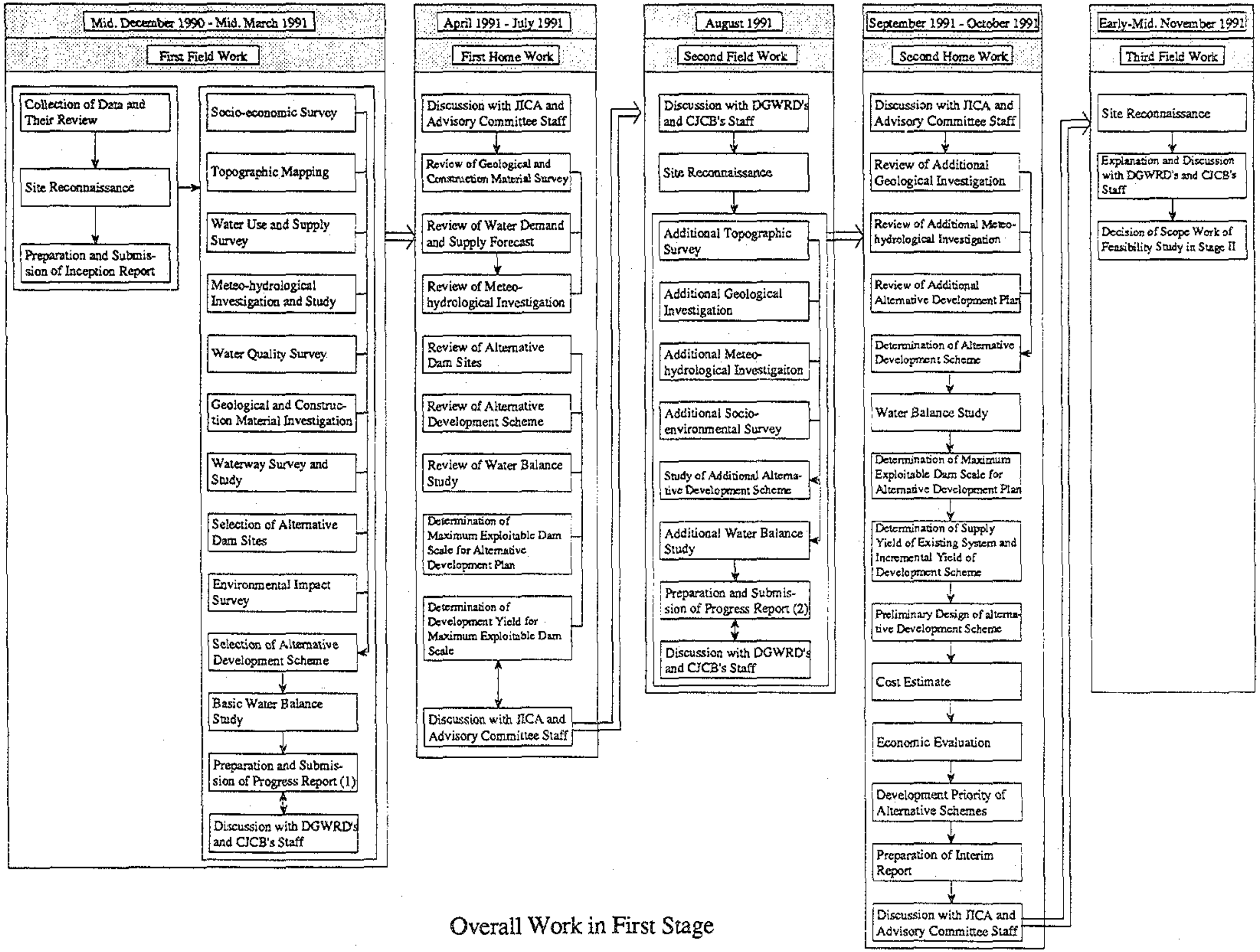
(Unit : Million)

Description	Scheme					
	K-1		K-2		C-3	
	F/C *2	L/C *3	F/C	L/C	F/C	L/C
1) Direct Const. cost	3,956	25,032	4,121	26,170	6,974	36,586
2) Land acquisition cost	0	0	0	0	0	0
3) Administration	0	2,912	0	3,030	0	4,111
4) Engineering Services	606	1,279	631	1,338	1,053	1,877
5) Physical contingency	660	4,231	687	4,424	1,147	6,186
6) Grand Total	5,222	33,454	5,439	34,962	9,173	48,760
(Rp) *1	114,924		119,811		191,861	
7) Capitalized cost *4	83,868		86,403		136,891	
8) Capitalized benefit *4	143,595		151,357		193,401	
9) Net benefit	59,727		64,954		56,510	
10) Benefit cost ratio	1.71		1.75		1.41	
11) Economic internal rate of return (EIRR)	20.95		21.26		16.92	

Note : *1 ¥1 = Rp.15.6
*2 F/C: Japanese Yen
*3 L/C: Rupiah
*4 Capitalized by discount rate of 12%

FIGURES

Fig. 1

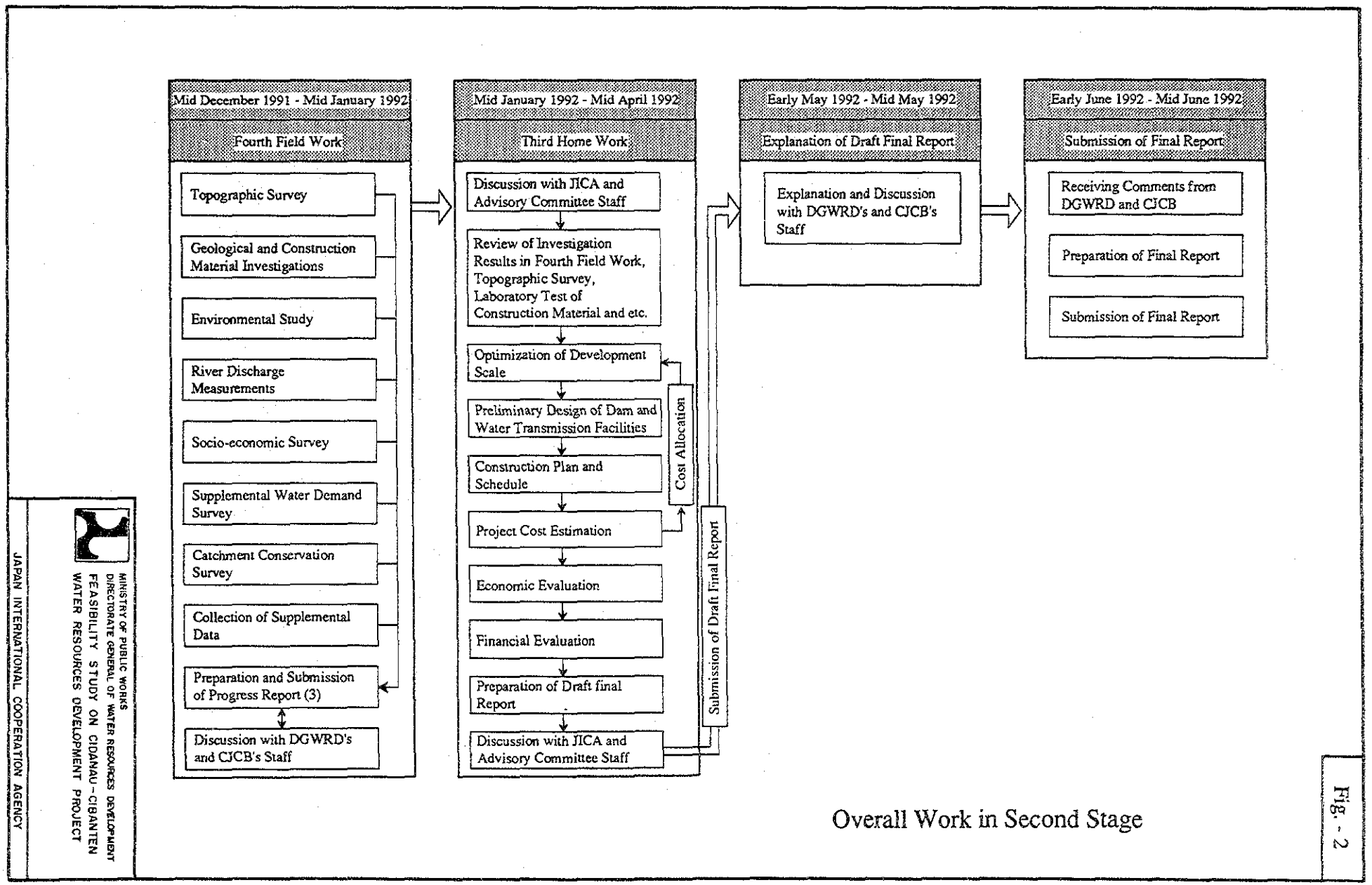


Mid. December 1990 - Mid. March 1991
First Field Work
Collection of Data and Their Review
Site Reconnaissance
Preparation and Submission of Inception Report
Socio-economic Survey
Topographic Mapping
Water Use and Supply Survey
Meteo-hydrological Investigation and Study
Water Quality Survey
Geological and Construction Material Investigation
Waterway Survey and Study
Selection of Alternative Dam Sites
Environmental Impact Survey
Selection of Alternative Development Scheme
Basic Water Balance Study
Preparation and Submission of Progress Report (1)
Discussion with DGWRD's and CJCB's Staff
April 1991 - July 1991
First Home Work
Discussion with JICA and Advisory Committee Staff
Review of Geological and Construction Material Survey
Review of Water Demand and Supply Forecast
Review of Meteo-hydrological Investigation
Review of Alternative Dam Sites
Review of Alternative Development Scheme
Review of Water Balance Study
Determination of Maximum Exploitable Dam Scale for Alternative Development Plan
Determination of Development Yield for Maximum Exploitable Dam Scale
Discussion with JICA and Advisory Committee Staff
August 1991
Second Field Work
Discussion with DGWRD's and CJCB's Staff
Site Reconnaissance
Additional Topographic Survey
Additional Geological Investigation
Additional Meteo-hydrological Investigaiton
Additional Socio-environmental Survey
Study of Additional Alternative Development Scheme
Additional Water Balance Study
Preparation and Submission of Progress Report (2)
Discussion with DGWRD's and CJCB's Staff
September 1991 - October 1991
Second Home Work
Discussion with JICA and Advisory Committee Staff
Review of Additional Geological Investigation
Review of Additional Meteo-hydrological Investigation
Review of Additional Alternative Development Plan
Determination of Alternative Development Scheme
Water Balance Study
Determination of Maximum Exploitable Dam Scale for Alternative Development Plan
Determination of Supply Yield of Existing System and Incremental Yield of Development Scheme
Preliminary Design of alternative Development Scheme
Cost Estimate
Economic Evaluation
Development Priority of Alternative Schemes
Preparation of Interim Report
Discussion with JICA and Advisory Committee Staff
Early-Mid. November 1991
Third Field Work
Site Reconnaissance
Explanation and Discussion with DGWRD's and CJCB's Staff
Decision of Scope Work of Feasibility Study in Stage II

Overall Work in First Stage

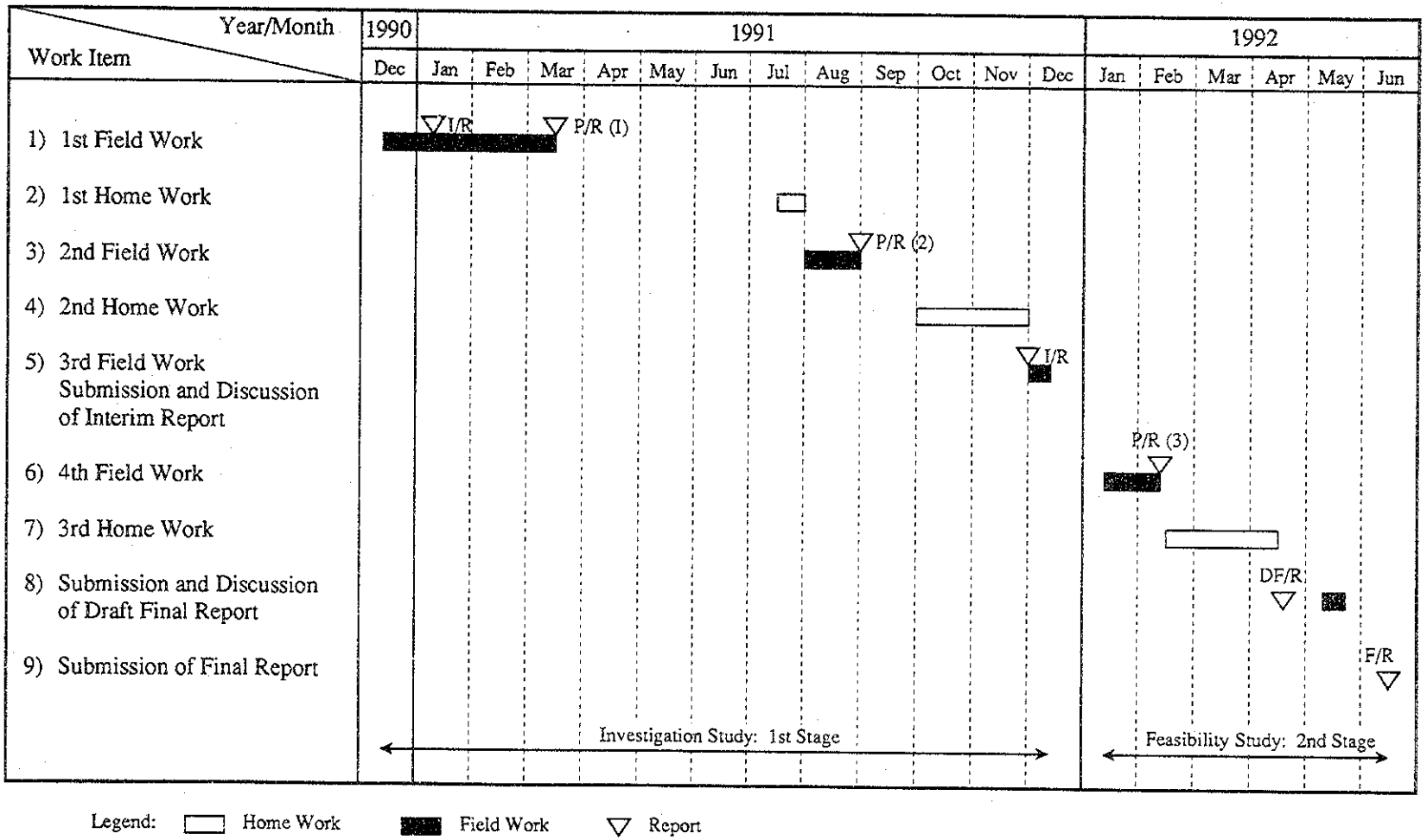
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON CIDANAU-CIBANTEN WATER RESOURCES DEVELOPMENT PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY



Overall Work in Second Stage

Fig. - 2



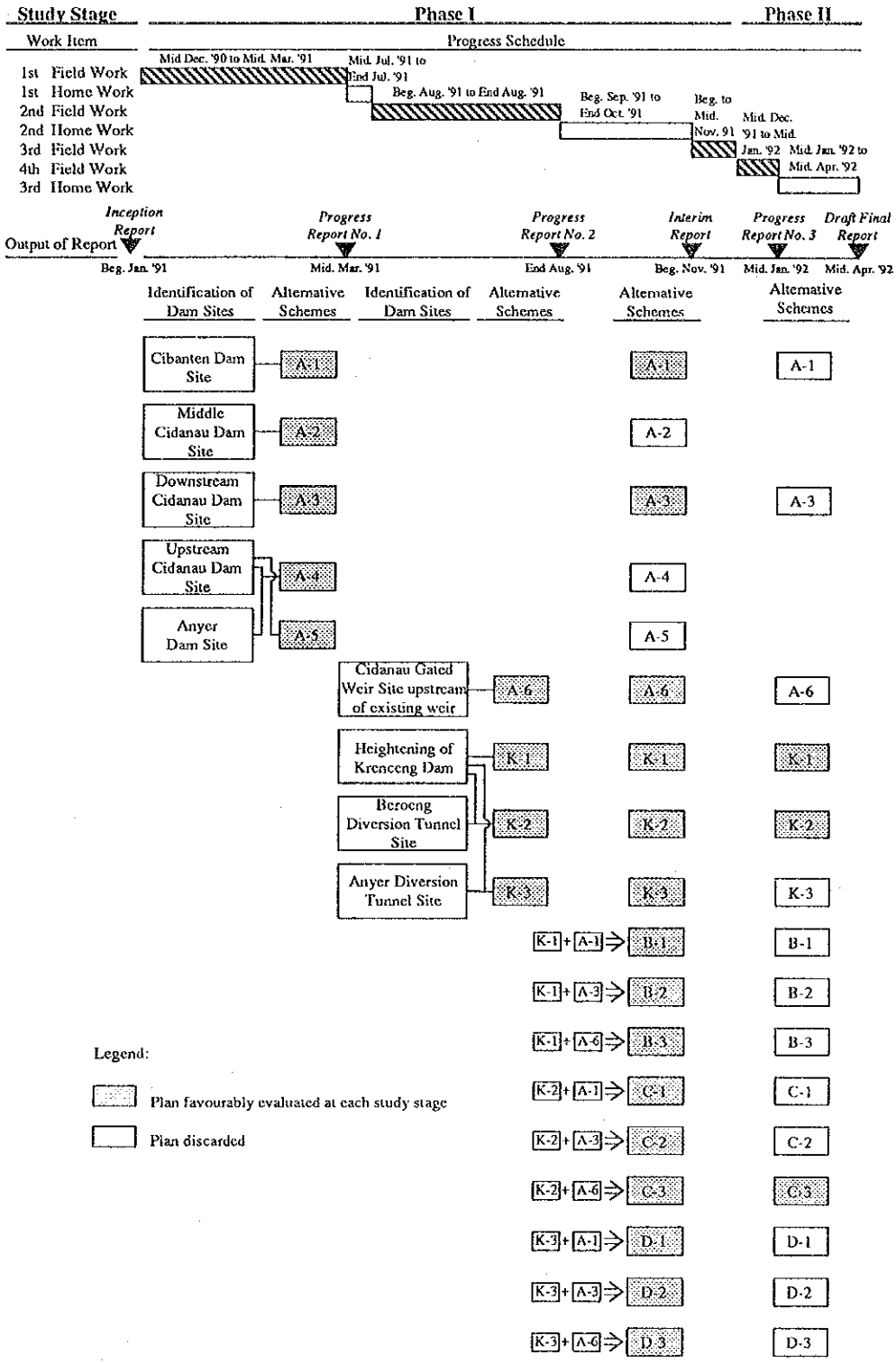
Work Schedule for the Feasibility Study

MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON CIDANAU-CIBANTEN
WATER RESOURCES DEVELOPMENT PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. - 3

Fig. - 4



Flow of Plan Formulation Study

MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
FEASIBILITY STUDY ON CIDANAU-CIBANTEN WATER RESOURCES DEVELOPMENT PROJECT

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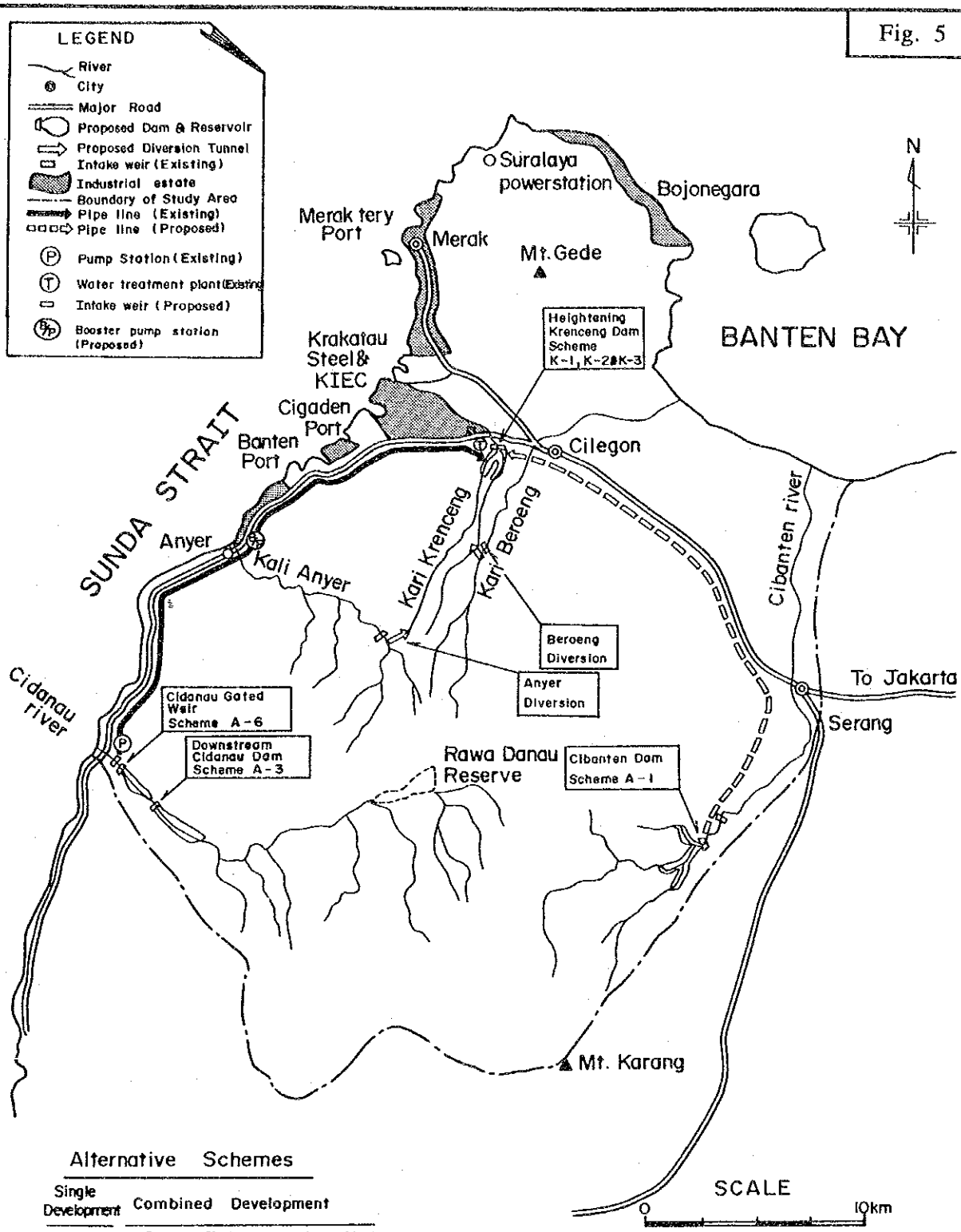
Fig. 5



Alternative Schemes

Single Development	Combined Development	
	Scheme	Single scheme to be combined
Scheme	B-1	K-1 plus A-1
	B-2	K-1 plus A-3
	B-3	K-1 plus A-6
A-1	C-1	K-2 plus A-1
A-3	C-2	K-2 plus A-3
A-6	C-3	K-2 plus A-6
K-1 1)	D-1	K-3 plus A-1
K-2 2)	D-2	K-3 plus A-3
K-3 3)	D-3	K-3 plus A-6

Notes : 1) Without diversion
2) With Beroeng diversion
3) With Beroeng & Anyer diversions

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Location Map of Alternatives

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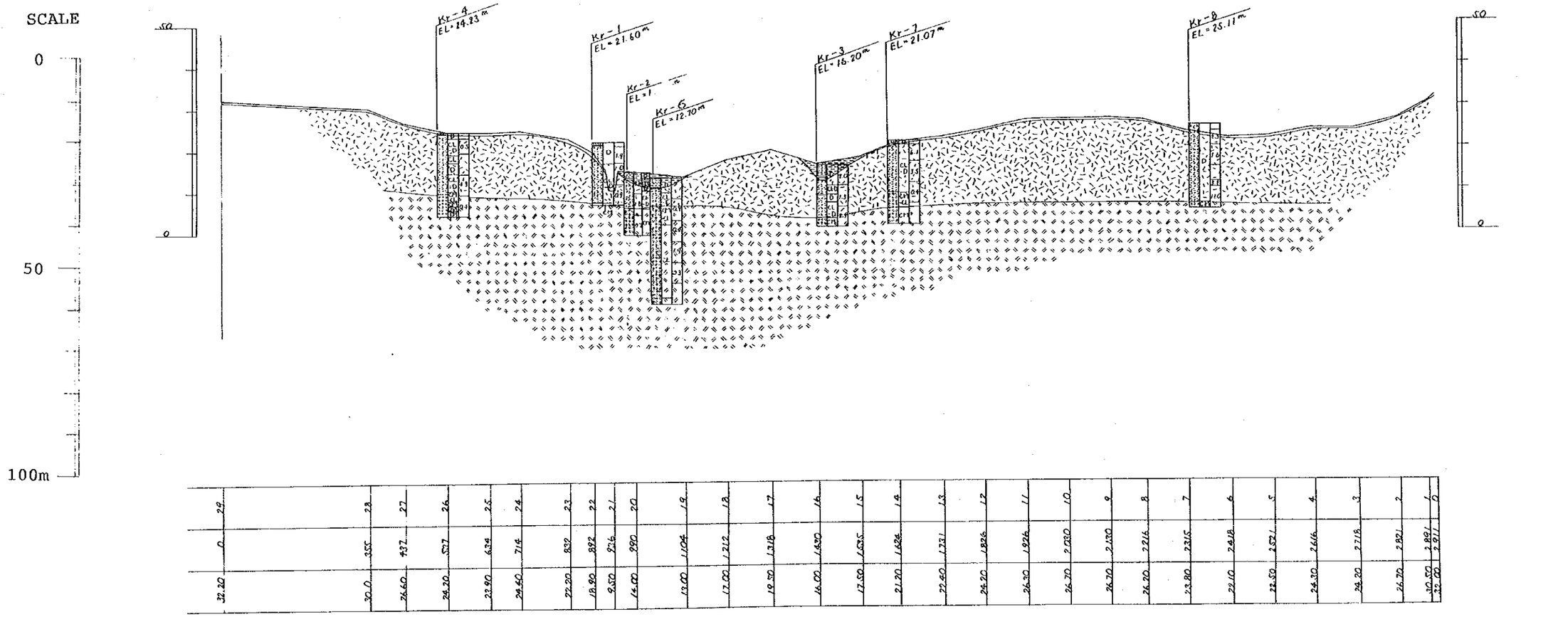
Fig. - 6



LEGEND

- Top Soil
- River Deposits
- Unconsolidated Pumice Tuff
- Pumice Tuff

0 500m 1000m

SCALE

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Geological Profile of Krenceng Damsite

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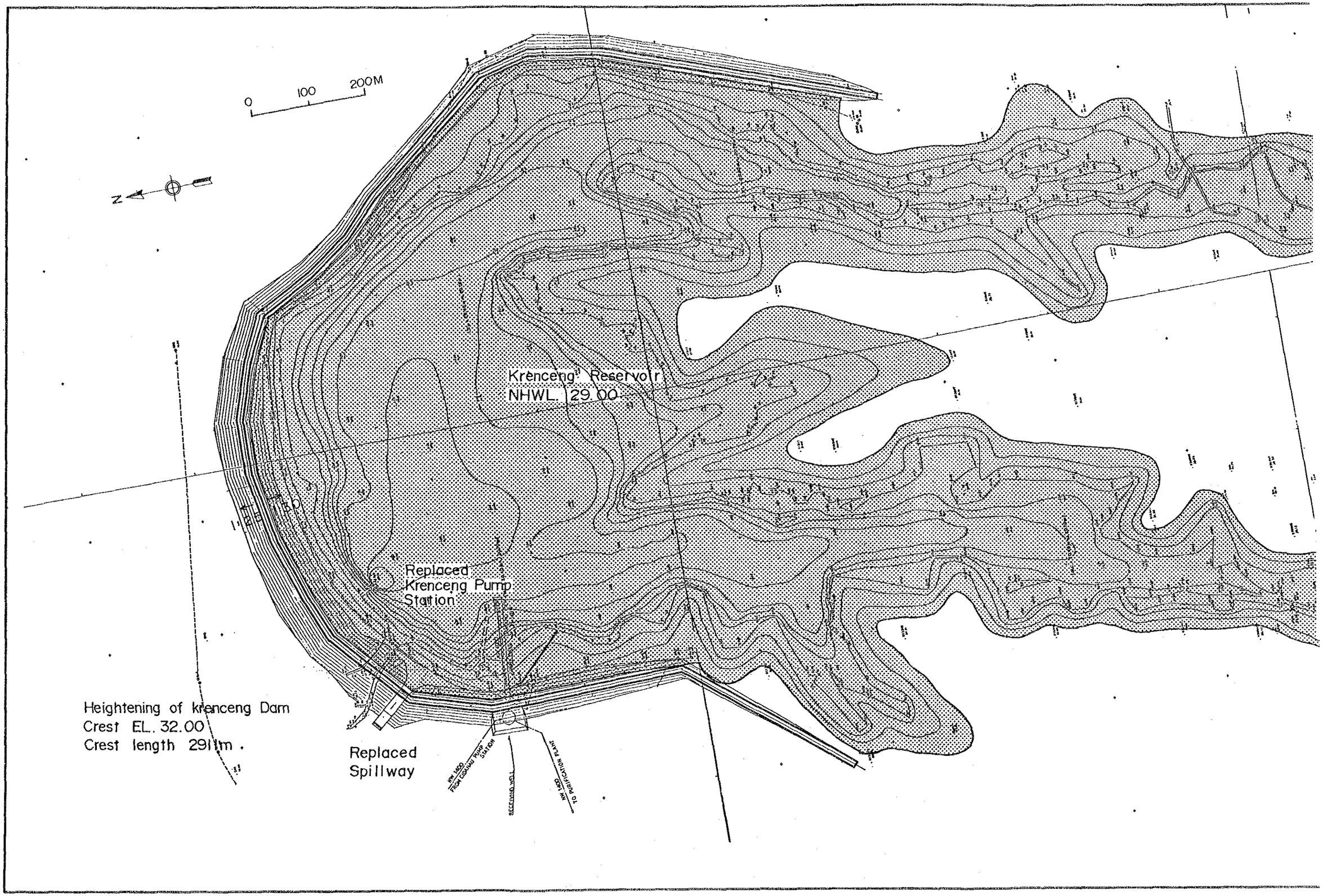
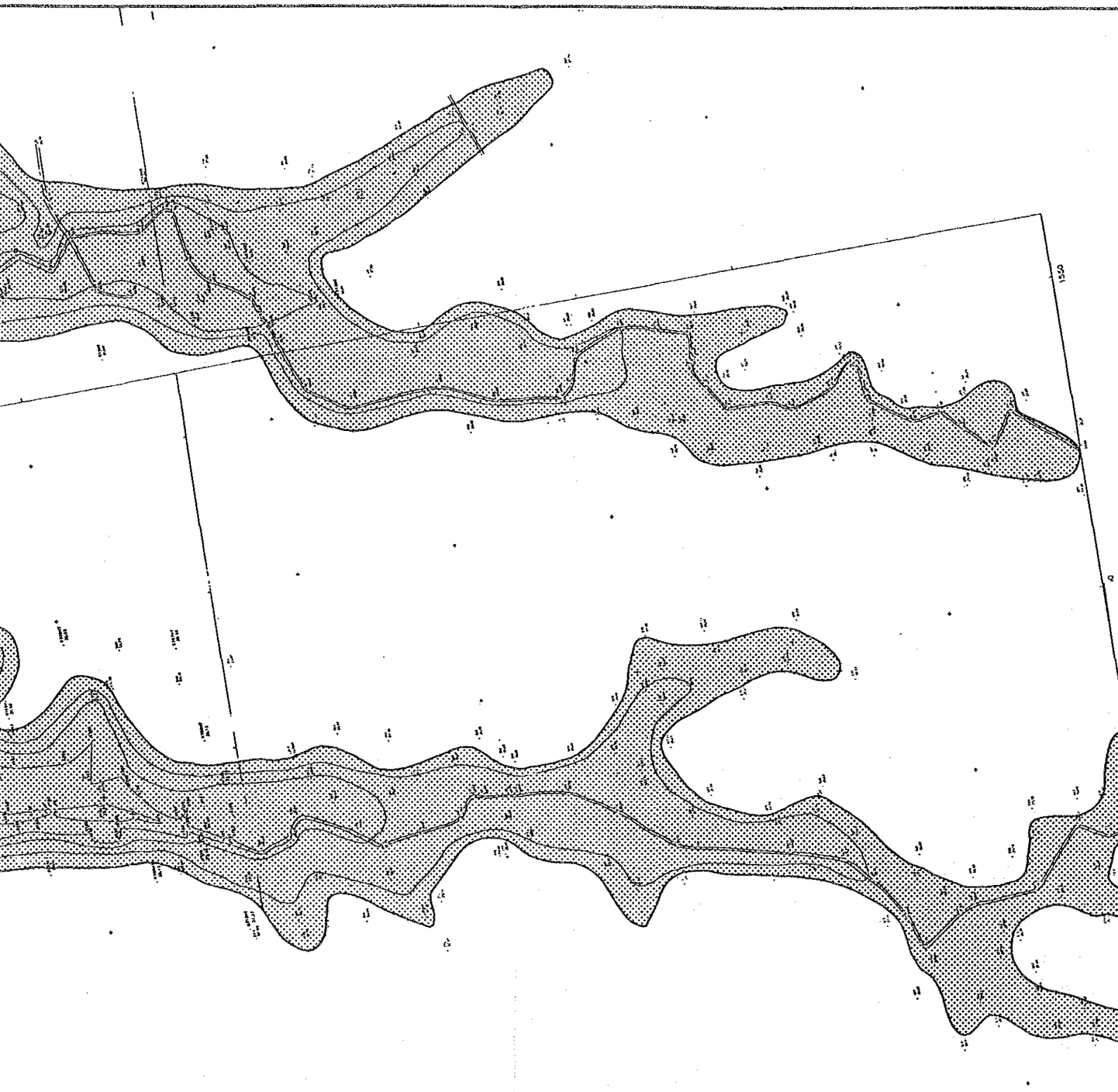
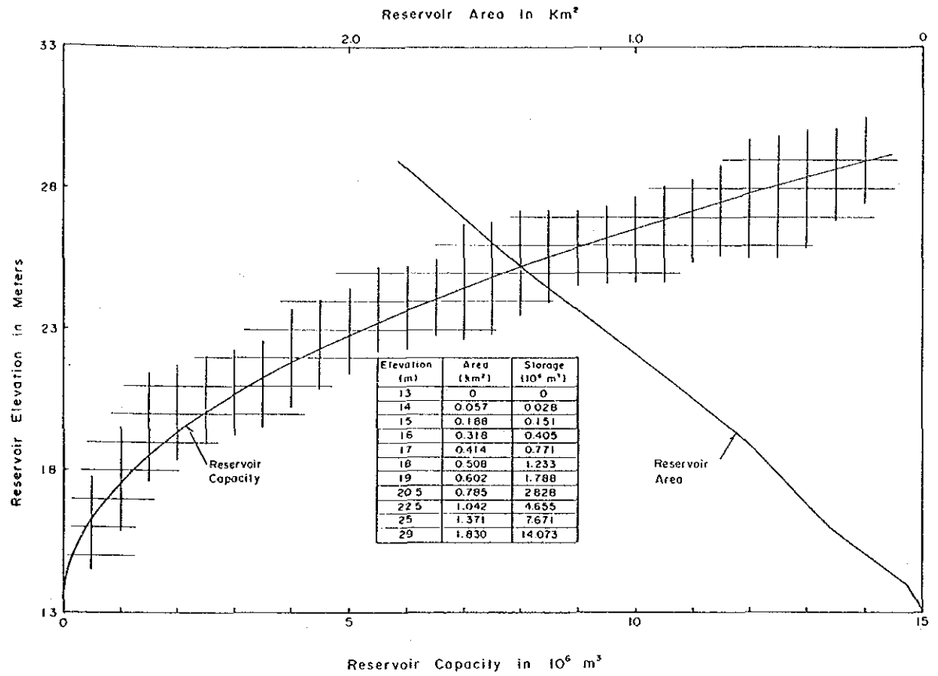

0 100 200M
N
Krenceng Reservoir
NHWL. 29.00
Replaced
Krenceng Pump
Station
Heightening of krenceng Dam
Crest EL. 32.00
Crest length 291m.
Replaced
Spillway
TO PURIFICATION PLANT

Fig. - 7





Elevation (m)	Area (km²)	Storage (10⁶ m³)
13	0	0
14	0.057	0.028
15	0.188	0.151
16	0.318	0.405
17	0.414	0.771
18	0.508	1.233
19	0.602	1.788
20.5	0.785	2.828
22.5	1.042	4.655
25	1.371	7.671
29	1.830	14.073

Modified Area - Storage Curves for Krenceng Dam Site

General Plan of Proposed Heightening of Krenceng Dam and Its Reservoir

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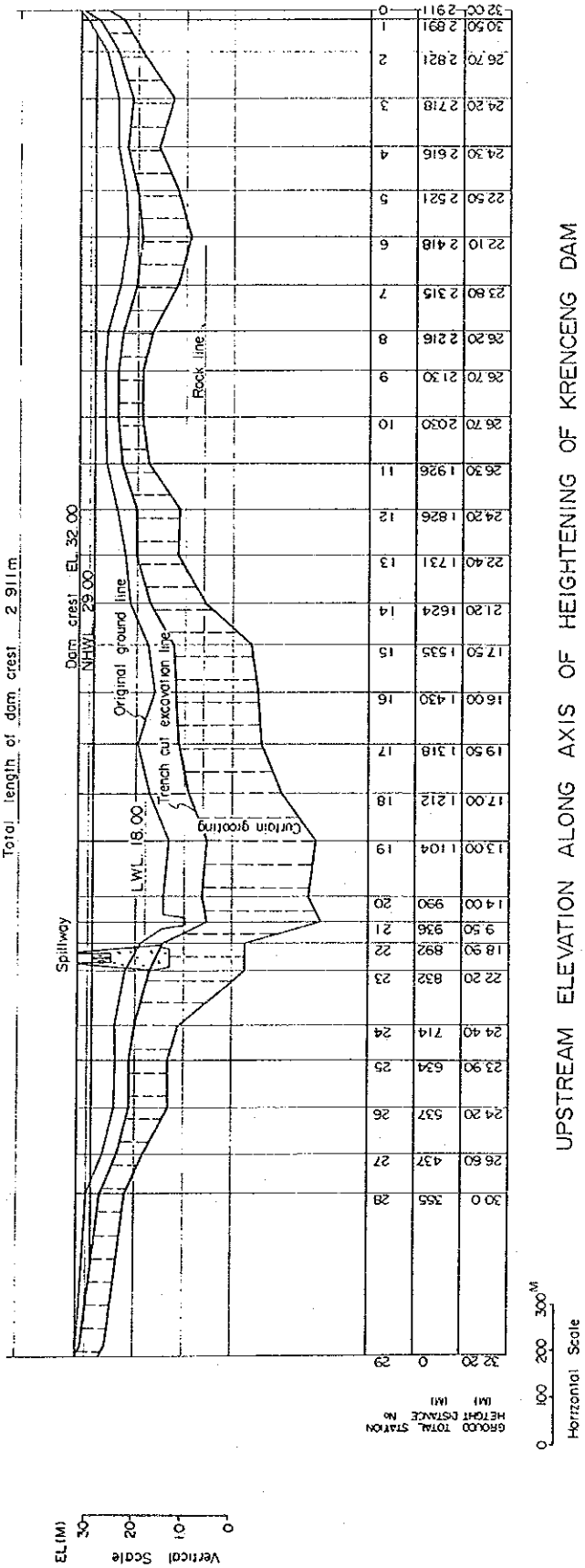
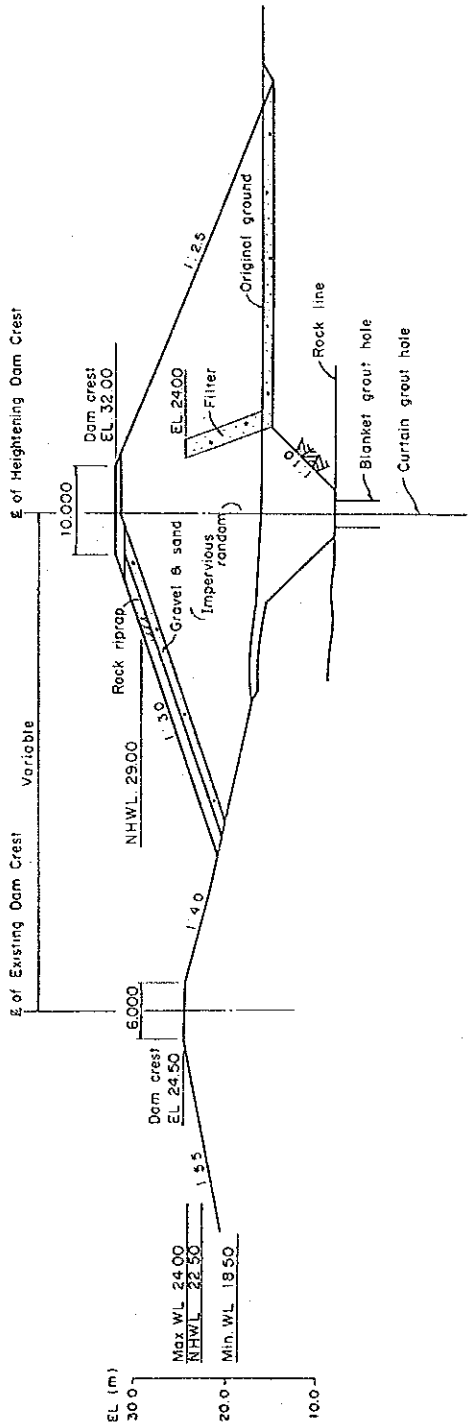
Fig. - 8



UPSTREAM ELEVATION ALONG AXIS OF HEIGHTENING OF KRENCENG DAM



PROFILE OF HEIGHTENING DAM

Profile and Section of Proposed Heightening of Krenceng Dam

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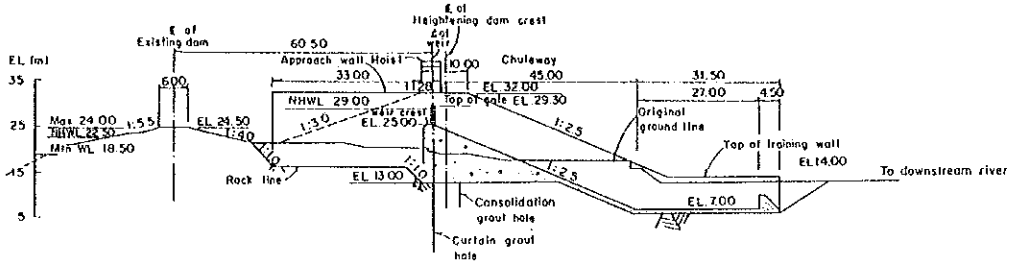
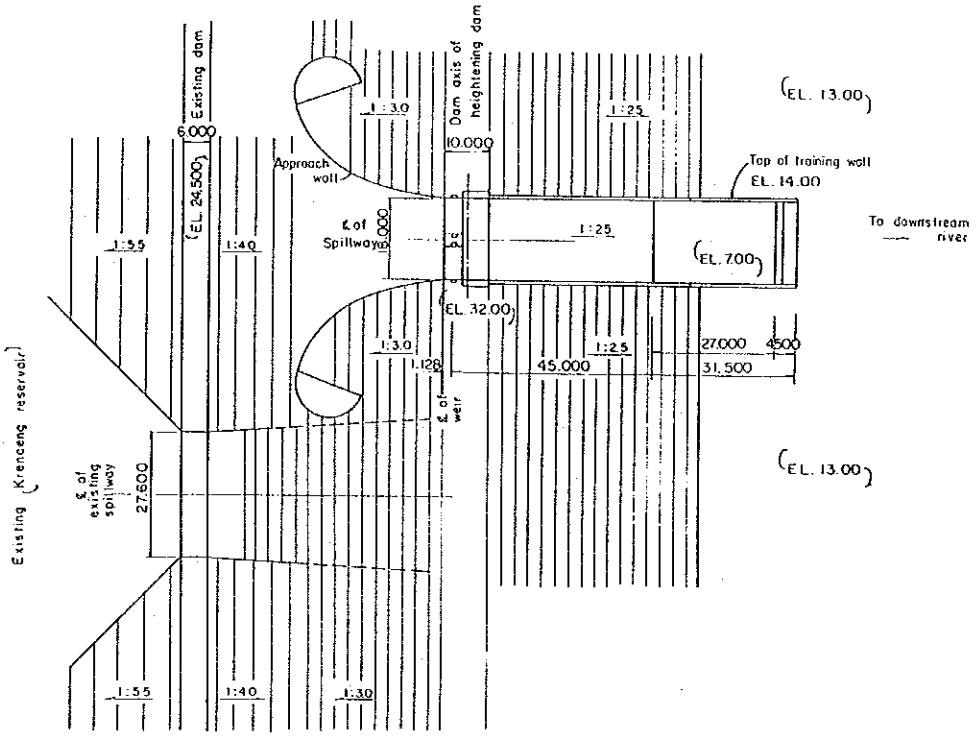
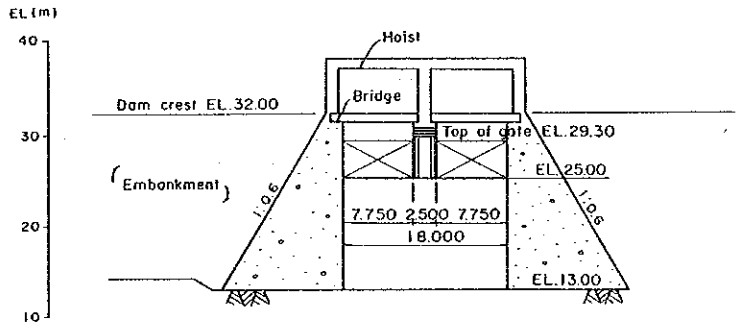
Fig. - 9



PROFILE OF SPILLWAY



PLAN OF SPILLWAY



UPSTREAM VIEW OF SPILLWAY

Plan, Profile and Section of Spillway for Proposed Heightening of Krenceng Dam

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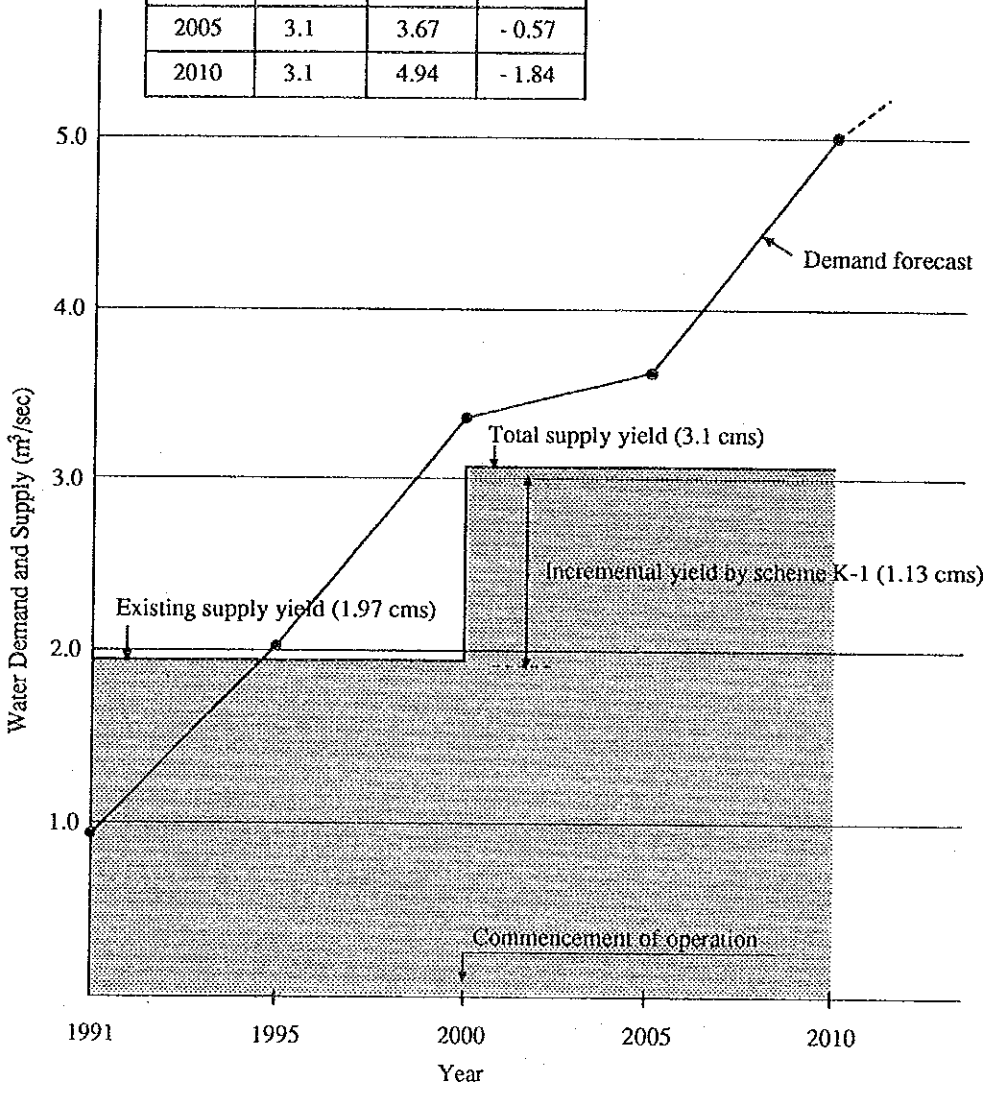
Fig. - 10

Unit: cms)

Year	Supply	Demand	Balance
1991	1.97	0.86	+1.11
1995	1.97	2.06	- 0.09
2000	3.1	3.30	- 0.20
2005	3.1	3.67	- 0.57
2010	3.1	4.94	- 1.84



Water Demand and Supply Program by Scheme K-1

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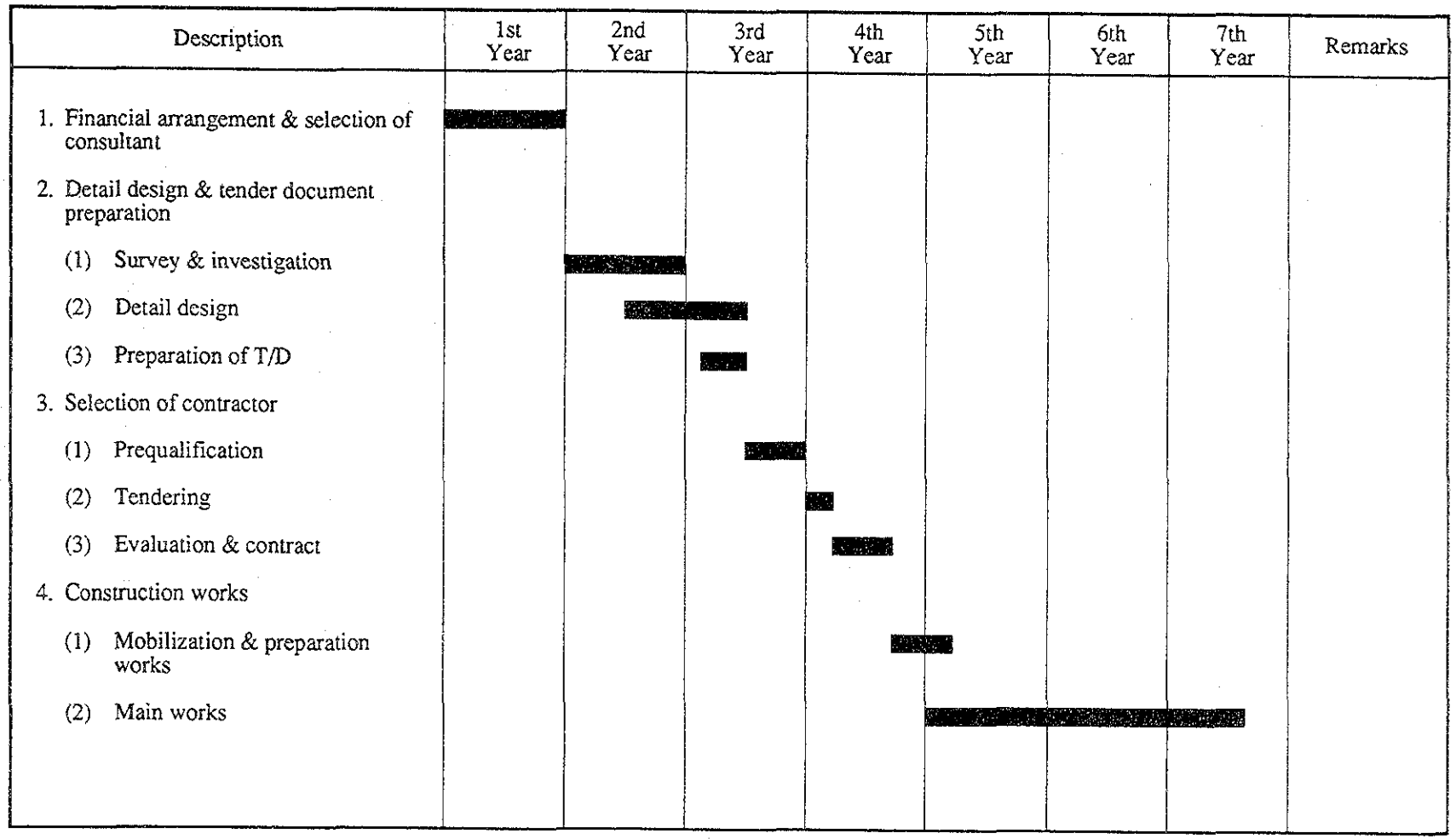

Implementation Schedule

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Fig. - 11

Description	1st Year	2nd Year	3rd Year	4th Year	Remarks
	A M J J A S O N D J F M	A M J J A S O N D J F M	A M J J A S O N D J F M	A M J J A S O N D J F M	
I. HEIGHTENING OF KRENCENG DAM					
1. Mobilization & Preparatory Works					
2. Dam Heightening					
(1) Foundation, excavation , grout					
(2) Embankment					
3. Spillway					
(1) Excavation					
(2) Concrete					
(3) Gate					

Construction Schedule of Scheme K-1 (1/ 2)

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Fig. 12 (1)

Description	1st Year	2nd Year	3rd Year	4th Year	Remarks
	A M J J A S O N D J F M	A M J J A S O N D J F M	A M J J A S O N D J F M	A M J J A S O N D J F M	
II. WATER CONVEYANCE AND TREATMENT FACILITIES					
1. Mobilization					
2. Cidanau Pump Station					
(1) Intake sand trap basin					
(2) Pump house					
(3) Pump installation					
3. Booster Pump Station					
(1) Pump house					
(2) Pump installation					
4. Krenceng Pump Station					
(1) Intake civil structure					
(2) Pump installation					
(3) Pipe installation					
5. Purification Plant					
(1) Operation & control building					
(2) Purification facility, Civil structure					
Equipment installation					

Construction Schedule of Scheme K-1 (2/ 2)

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Fig. 12 (2)